Indigenous knowledge and food security

Tweheyo, Robert

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Robert Tweheyo

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Robert Tweheyo

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Indigenous Knowledge and Food Security:

Enhancing Decisions of Rural Farmers

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by

Robert Tweheyo

Born on July 22, 1966
in Kabale, Uganda

Promotores

Prof. H. G. Sol

Prof. J. T. Lubega

Assessment committee

Prof. J.Nerbonne

Prof. J.Riezebos

Prof. J.J.M. Zeelen

To Fridah, Naomi, Jeremiah, Jerome, Jethro, Jenninah & Jotham

Preface and acknowledgements

Food is a fundamental human right and a significant factor to socio economic development. Nevertheless, food security remains a big challenge in most Sub-Saharan African countries particularly among the rural and low income communities. A number of studies have been carried out and many solutions proposed towards solving food insecurity in Sub-Saharan Africa and Uganda in particular. Key among the solutions is the modernisation of agriculture by use of modern technologies. It is apparent that rural farmers have failed to adopt modern technologies due to high costs associated with them and increasing levels of poverty. Given the rural context, indigenous knowledge would offer cost-effective solutions for achieving sustainable food security. It is important to acknowledge that indigenous knowledge and innovations are core competences of rural farmers and, any planned interventions ought to build on farmers' experiences and knowledge for better results.

The idea of this research originated from the need to empower the vulnerable and food insecure rural communities of Uganda. As a person who grew up in a rural area, I felt I should be part of a solution to rural households' food insecurity. I began by reflecting on how people used indigenous knowledge and local resources to ensure household food security. For instance, storage of food in the granary as a way of preserving it for future consumption. The way planting seeds were selected while still in the gardens by looking at the health traits of the parent plants was not only admirable but also a measure for achieving sustainable food security. Such local solutions are not only affordable, but also sustainable within the local context.

As a reflective practitioner, I sought to engage farmers in a dialogue about indigenous knowledge practices and how they could be documented and shared to contribute to sustainable food security. This research develops a food security decision enhancement studio for providing intervention schemata to Community Development Workers as recipes for enhancing rural farmers' decisions on food security using indigenous knowledge.

Accomplishing a PhD has been extremely challenging and a lonely journey yet a rewarding venture. I am grateful to everyone who supported me and encouraged me to move on.

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Last but not least, I thank God almighty for his abundant love, wisdom and for keeping me safe all this time. Completing this PhD journey would not be possible if it was not His wisdom, love and mercy. Throughout my life, He has always been my strength and my provider in all my endeavours. May His name be glorified forever and ever.

Robert Tweheyo

Table of Contents

List of figures

List of Tables

Chapter 1 Introduction

This chapter presents the problem landscape and research objectives. It further discusses the research approach and provides the outline of the thesis. Section 1.1 describes the concept of food security. Section 1.2 discusses the concept of indigenous knowledge. Section 1.3 highlights the need for indigenous knowledge management. Section 1.4 introduces the concept of decision making. Section 1.5 discusses the decision enhancement approach. Section 1.6 describes the scope of the research. Section 1.7 presents the research problem and objectives Section 1.8 discusses the research approach and section 1.9 presents the thesis outline.

1.1 The concept of food security: Situation analysis

Food is a primary need basic to all human needs and a fundamental human right (Maxwell, 2001; Ingram, 2011). Improved food security is vital in the alleviation of poverty, promotion of people's health and labor productivity, contributes to the political stability of a country and ensures sustainable development of citizens (FAO, 2011). The Food and Agriculture Organization (FAO) defines food security as a "situation when all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs for an active and healthy life" (FAO, 2014; FAO 2009). Food and nutrition security is achieved when adequate food is available, accessed and satisfactorily utilized by all individuals at all times to live a healthy and happy life. This definition implies that nutrition security includes dietary requirements of the consumed food, health care and sanitation in order for one to be able to live a healthy and active life. Traditionally, nutrition security involves the knowledge of the right feeding practices (especially correct infant feeding practices), cooking practices, clean environment, and safe drinking water among others. Nutrition security goes beyond food security by considering adequate access to essential nutrients, not just calories. Nutritional security means guaranteed constant adequate dietary intake that helps the body to resist and recover from disease.

Food insecurity leads to severe health problems for individuals and to the society including malnutrition, obesity, disease and poverty (Hammond & Dube, 2011). Nevertheless, ending hunger and achieving food and nutrition security is goal number 2 out of 17 sustainable development goals.

The FAO's definition of food security promotes four key elements: accessibility, availability, utilization and stability. All the four elements of food security cut across areas of food security and involve the theories of change that work towards improving food security.

The Monitoring and Evaluation Harmonization Group of Food Security Partners (FAO *et al*, 2013), in their Food Security Learning Framework (FSLF) have estimated that meeting global food security challenges will become increasingly difficult in future as the world's population reaches 9 billion by 2050, and pressures on natural and human resources intensify. Over 900 million people worldwide remain food insecure despite recent reports by FAO (2014) indicating global hunger reduction. The majority of food insecure people live in Sub-Saharan Africa and entirely depend on agriculture as their source of livelihood (Burchi & Muro, 2012; FAO, 2014). Whereas many parts of Uganda are relatively food secure (USAID, 2016), some parts of the country experience hunger and chronic food insecurity (Tugume, 2017; UBOS, 2016).

1. There are high levels of childhood nutrition problems and 40% of death among children is due to malnutrition (UBOS, 2013). Over 38% of the children below five years are stunted; 6.7% are wasted, 30% are under-weight and 49% suffer from anaemia (Emorut, 2015). Nine percent of households in most of the rural areas cannot afford more than one meal a day (UBOS, 2013, USAID, 2016; Tugume, 2017). Apparently, something needs to be done to enhance decisions of rural farmers on food security and save them from the disastrous situation they live in.

1.2 Indigenous knowledge

All over the world, indigenous knowledge is increasingly becoming part of the development agenda. Local initiatives are multiplying and the number of development projects integrating indigenous knowledge is increasing (Gorgestani, 2001; Awuor, 2013). Indigenous knowledge refers to the knowledge and know-how unique to a given society or culture which encompasses "the cultural traditions, values, beliefs and worldviews of local people" (UNESCO, 2016). Indigenous knowledge is a tacit knowledge of the local or indigenous people, which is personal, content-specific, and therefore hard to formalize and communicate. It differs from formal scientific knowledge which is an explicit or "codified" knowledge that is transmittable in formal, systematic language (ibid). Indigenous knowledge is viewed by rural communities as one of the core components that contribute to sustainable and equitable development (Akullo, 2007; Awuor, 2013; Kamwendo & Kamwendo, 2014; Eyong *et al*,

2007). In traditional societies, the elders' wisdom combines both ecological and social knowledge and offers solution to specific societal problems (Awuor, 2013). Indigenous knowledge is informal, interactive, and integrated in people's livelihoods (Claxton, 2010).
In the domain of food security, indigenous knowledge refers to knowledge about soil fertility, disease resistant and quickly growing crops, soil conservation, weather forecast, pests and disease control, food preservation, processing and storage as well as water management techniques (Kamwendo & Kamwendo, 2014;). Indigenous knowledge is the actual basis for local-level decision making in areas of seed selection, food storage and processing (Awuor, 2013). It is knowledge that is unique to a given culture or society and denotes deeper understanding of the world around a particular community.

Indigenous knowledge systems play a key role in educating young ones through rituals and oral history and transmitting the wisdom needed to interpret novel observations. In traditional societies, there is no artificial split between nature and culture (Negin *et al,* 2009). Ideally, it is an essential aspect for sustainable resource use and balanced development (Agrawal, 1995). Indigenous knowledge contrasts with the scientific knowledge. Whereas scientific knowledge is generated by universities and research institutions, indigenous knowledge is generated outside the formal education system (Tanyanyiwh & Chikwanha, 2011; Lodhi & Mikulecky, 2010). Indigenous knowledge is dynamic and is continuously influenced by internal creativity and experimentation as well as by contact with the external systems (Lodhi & Mikulecky, 2010). It is knowledge of local community accumulated over generations of living in close contact with the environment and it provides invaluable aid in making best use of natural resources. It is the foundation of rural communities' livelihoods (UNESCO, 2016). On the other hand, scientific knowledge is an explicit or "codified" knowledge that is transmittable in formal, systematic language

While the contribution of indigenous knowledge is recognized in developed countries, use of indigenous knowledge in developing countries is not strongly emphasized as an alternative to conventional knowledge (Cloete & Idsardi, 2012). People who use indigenous knowledge are associated with poverty, backwardness and superstitions (Awuor, 2013). As a result, traditional food crops are labeled as poor peoples' food by rich consumers. The question that arises is whether indigenous knowledge and traditional food crops are really for poor people and what interventions are needed in order for indigenous knowledge to play a key role in the improvement of household food security in rural communities (Cloete & Idsardi, 2012).

Indigenous knowledge is an important part of the lives of the poor while it is also an integral part of the local ecosystem but it is sad that it is an underutilized resource in the development process and in achieving sustainable food security (Mwantimwa, 2008).

Sufficient evidence indicates that indigenous knowledge plays a significant role in socio-economic development and has proven to be a basis for continued survival communities especially in the Sub-Saharan Africa (Ngulube 2002; Knight, 1991; FAO, 2014). It is a valued asset which deserves to be exploited more systematically. This will not only help increase food security, but also reduce poverty, enhance equity, reduce environmental degradation, increase local participation and lead to sustainable development). A few examples where indigenous knowledge is often applied are summarized as follows:

a) Smoking food as a means of preserving it

Smoking is one of the trusted traditional methods of preserving food in most communities in Africa, Uganda in particular. Local people have precise knowledge of smoking food items such as meat, fish, maize and cassava. The common practice is that racks are built in the kitchen on top of cooking fire, and meat or any other given food is placed on the rack and smoked until it is thoroughly dry. The purpose is to prolong its shelf life and preserve it from contamination. This process is very important, not only as a means of food preservation but also as a health-promoting practice. Smoked meat is prepared whenever there is an emergency or in time of food shortage. Traditionally, smoking meat is performed as a means of preserving it because smoke itself acts like an acidic coating on the surface of meat hence preventing the growth of bacteria[1].

b) Traditional granary food storage

Traditionally, some foods especially cereals like millet, sorghum, maize as well as grains such as beans and peas are stored in granaries. Different granaries are used for different types of grains in most of the rural communities in Uganda. The granaries are constructed at a raised level to allow air flow and smeared with cow dung to prevent grains from being attacked by weevils and pests. As a result, food is stored for quite long and thus food security is guaranteed.

Harvested grains are first sun dried to reduce moisture content before putting them in the granary. Specifically, the major purposes of granary storage are four fold: i) first to preserve

[1] www.peakproperity.com/blog/preservingmeat-curingandsmoking/60668

food for a long period of time so that they can be consumed in future in case of food shortage, ii) to preserve seeds for next season planting, iii) to protect food from pests and weevils and, iv) to protect seeds from destruction by rain water.

Although the granary system was primarily used for food storage, it has also served other purposes. It was a means of encouraging people to work hard so that they own granaries. People with many granaries would boast of being food secure which was prestigious in the community (Abioye *et al*, 2013).

c) Selection of indigenous seed varieties

Local people in rural Uganda have knowledge of drought and disease resistant seeds and therefore they have a drought-coping mechanism. They know which seeds do well in certain types of soils and those that do not in certain conditions based on their experiences. They have knowledge about seeds that mature fast and those that are good in responding to famine after long dry spells or other natural disasters. All this knowledge is available indigenously and enables people to make a proper choice of seeds rather than buying from seed stores. This means that the use of agrochemicals and fertilizers is less important to them, or, they are used depending on certain circumstances.

However, it is worth noting that this well-known and useful knowledge is at the verge of extinction not only because of the dominance of the foreign/imported modern knowledge, but also due to the fact that it is not well documented. As the result, the young generation does not have it (Agrawal, 1995). Instead, communities are mobilized and encouraged to use modern knowledge; which is formally taught in schools and institutions. Indigenous knowledge is in danger of disappearing not only because of the influence of global processes of the rapid change, but also the capacity and facilities needed to document, evaluate, validate, protect and disseminate such knowledge are lacking in most developing countries as observed by Nwokoma (2012). Notwithstanding this, there are a number of grounds for believing that indigenous knowledge is vital for rural communities' food and nutrition security in Uganda and other similar developing countries hence the need for preserving it (FAO, 2014; Awuor, 2013).

It is therefore essential to collect indigenous knowledge and document it in a coherent and systematic fashion so that it can be archived in the form of a data base. This can make it

easily shared among the interested parties particularly the farming communities, agricultural extension workers and policy makers for promotion of household food and nutrition security (Agrawal, 1995). Indigenous knowledge, apart from being vital for communities with low income where poverty, malnutrition and hunger are common, would also form a bottom line for sustainable food and nutrition security (UBOS, 2013; FAO, 2014). It is therefore important to encourage rural farmers to preserve and share indigenous knowledge for sustainable food security.

1.3 Indigenous knowledge management

Management of indigenous knowledge is extremely important. Like scientific knowledge, indigenous knowledge needs to be managed so that it is to access, retrieve and shared among farmers in a broader geographical area (Lodhi & Mikulecky, 2010; Eseryel, 2014). The essential steps as declared by World Bank (1998) are the ways of its transformation i.e. recognition and identification, validation, recording and documentation, storage in retrievable repositories, transfer and dissemination.

ICT can play a major role in improving the availability of indigenous knowledge systems and enhancing its blending with the modern scientific and technical knowledge (Mwantimwa, 2008). ICT such as computers and the Internet can be of great help to collect, store and retrieve indigenous knowledge for sustainable use (Meja, 2002). The application of ICT is essential to stimulate the flow of indigenous knowledge and incorporation of modern scientific and traditional knowledge. This will enable indigenous communities to protect and exploit their unique cultures and knowledge through digitization (Eseryel, 2014).

Indigenous knowledge and techno-blending practices to the local setting can help to improve agriculture production and sustainability of food security. The main use of ICT for promoting indigenous knowledge could be as follows: capture, store and disseminate indigenous knowledge so that it is preserved for the future generation; promote cost-effective dissemination of indigenous knowledge; create easy accessibility of indigenous knowledge information systems; promote integration of indigenous knowledge into formal and non-formal training and education; provide a platform for advocating, improving and exploiting benefits from indigenous knowledge to poor farmers (Rahman, 2000; Nonaka, 1991; Eseryel, 2014).

1.4 The concept of decision making

Decision making is a cognitive or social process of selecting a course of action from among several alternative possibilities on the values and preferences of the decision maker(s). Making a decision implies that there are alternative choices to be considered and in such a case, a decision maker may not only want to identify as many alternatives as possible, but to choose the one that: i) has the highest probability of success or effectiveness and ii) best fits with the goals, desires lifestyle and values of the decision maker (Anand, 1993). Whereas classical and neoclassical theorists argue that the main goal of decision making is to be rational by first collecting all relevant information, Herbert Simon argues that this is not realistic and does not correspond with the real world situation (Simon, 1959). According to Simon, decision makers cannot be rational unless they have perfect control over environmental factors as well their mental capabilities. He reasons that rationality is bounded because of uncertainty about relevant exogenous events and inability to calculate the consequences. He therefore introduced the concept of "bounded rationality" as a process model that corresponds with real world practical decision making process (Simon 1976).

In the domain of food security, deciding on which seeds to plant, food processing and storage by making use of indigenous knowledge require a careful choice depending on the individual farmer's capability. Based on the conditions in rural areas, farmers need to be helped to enhance their decisions on food security. In this research, a decision enhancement approach was proposed to help in addressing rural farmers' decision-making challenges in their effort to improve food security (Keen & Sol, 2008).

1.5 Decision enhancement approach

Decision enhancement (DE) focuses on complex decisions referred to as "decisions that matter" (Keen & Sol, 2008). Decisions that matter are characterized as being urgent, substantial, non-avoidable, non-reversible, wicked[2] and uncertain. DE is a management lens or a way of looking out at dynamic and complex decision making processes (Keen & Sol, 2008; Amiyo, 2012; Aregu, 2014). It is an approach aimed at facilitating human problem solving through professional practices that fuse human skills, processes and technology. With appropriate decision enhancement, stakeholders are empowered to collaborate and participate

[2] A "wicked" problem is also described by Pries-Heje et al. (2008) as a problem that is not well defined and can only be expressed in terms of a solution that requires innovative solutions.

in the decision making processes, where team-work and shared goals are primary driving forces (Courtney, *et al,* 2005*).* DE is an extension of decision support systems research. This field of decision support systems is expanded to executive information systems and to knowledge management systems (Gorry & Morton, 1971; Keen & Morton, 1978; Sprague, 1980; Nunamaker, 1996; Knol, 2013; Keen & Sol, 2008). Enhancement goes beyond decision support which adds more opportunities especially involving the use of internet as both an information resource and a communications base for collaboration between farmers and stakeholders (Keen & Sol, 2008). DE also goes beyond decision support by focusing on enhancing processes that influence the quality of decisions (Amiyo, 2012).

DE is a shift from the design of computer and telecommunications-based tools to a far more comprehensive "studio" approach, with inter alia, the integration of visual technology. It rests more on images, dynamic visualization and communicative display (Keen & Sol, 2008). DE focuses on stakeholders in decision arenas and their decisions that matter. In the studio, many people can be invited and this creates a multi-stakeholder platform for salient, credible and legitimate decisions based on research and experience of indigenous knowledge (Irving, 2011; Keen & Sol, 2008).

A studio employs a combination of people, processes and technology. People make decisions; their skills, values, judgment and experience shape the decisions. The decision processes influence the likelihood of making effective decisions. The technology can provide support to both the people and the process (Keen & Sol, 2008). The three perspectives are used to develop of a food security decision enhancement studio for providing interventions for helping farmers to enhance their decisions on food security. This kind of combination facilitates appropriate visual and analytical ways of designing and using the suites of a studio.

Decision enhancement services (DES) are presented by Keen & Sol (2008) as a studio environment that enables and facilitates interactive decision-making processes. A studio is a virtual environment in which people, processes and technology are brought together for collaborative practices to achieve commitment to action in complex decision processes (Keen & Sol, 2008).

In the East African region, there have been good experiences with DES in different sectors including poultry farming (Tumwebaze, 2016), mining enterprise (Habinka, 2012), water asset management (Katumba, 2016), marketing agricultural produce (Aregu, 2014) and

business process agility, (Amiyo, 2012). This development clearly demonstrates the potential of DES to handle complex decision-making challenges in the respective fields. In this research, DE is extended further to the field of food security focusing on indigenous knowledge in the context of rural farmers in Uganda. Keen and Sol (2008) argue that DES are delivered through a studio environment to enable knowledgeable stakeholders evaluate different scenarios of possible solutions to a given problem (see figure1.1 below).

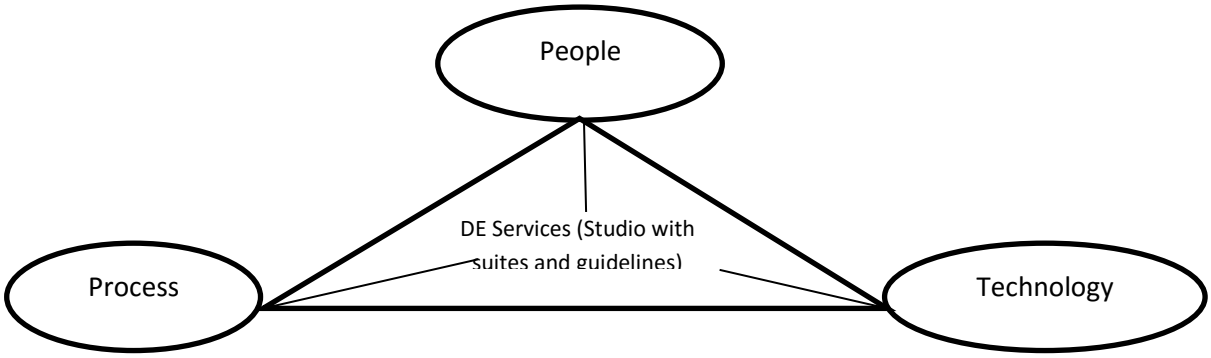

Figure 1.1*: Decision enhancement: The fusion of people, process and technology*

(Adapted from Keen & Sol, 2008)

A combination of people, process and technology makes a substantial impact for example, in this research, deciding jointly on which knowledge mix to exploit in a given environment to achieve food and nutrition security is important. However, it is possible that these three factors may be in conflict. For example, people may resist the processes, the processes may limit people especially if they inhibit free expression or impose what people see as artificial procedures. Technology may not fit with the needs of either people or processes.

People, processes and technology may come together to form a studio. Studios are environments designed around the process. A studio is not necessarily a physical room; it is often implemented as a web portal, or via video conferencing. In short, it is a space (virtual) in which a problem domain can be approached. It includes technology suites, integrated sets of tools focused on enhancing the process and the peoples' contribution to decision making. The studios' suites, experts and facilitators, are brought in to help people get value from it as illustrated in figure 1.1 above. It is what constitutes key elements for enhancing the quality of the decision (Keen &Sol, 2008).

DES provide flexibility to stakeholders in exploring alternatives that lead to cost-effective decisions before committing to a particular choice. The aim of DES is to improve on the decision process agility. Decision process agility is the combination of speed, flexibility,

coordination and collaboration driven by innovation. DES must have attributes of adaptability, agility, context dependence, flexibility with respect to the environment (Habinka, 2012). Keen & Sol (2008) argue that for stakeholders to work together effectively, they must build shared understanding. The flexibility seeks to ensure that the studio easily adapts to the changing and volatile decision making environments (Keen & Sol, 2008; Aregu, 2014).

DES in this research are brought in to provide a facilitative and interactive environment for supporting rural farmers' decisions for sustainable food security using indigenous knowledge. Therefore, we envisage that DES will provide a supportive environment to rural farming communities to effectively improve food security by using indigenous knowledge.

1.6 Scope

This research focuses on indigenous knowledge and how it influences rural farmers' decisions on household food security. The proposition for this research was that "even an unstructured recording of indigenous knowledge, when made accessible to rural farmers, can contribute to food security". This would enhance decisions of rural farmers by providing them with an opportunity for sharing indigenous knowledge and significantly improve their household food security. Indigenous knowledge is perceived to have special attributes that make rural farmers value it. DES are meant to enable rural farmers and key stakeholders to evaluate different scenarios prevailing and take appropriate decisions regarding the right knowledge mix one should go with to attain household food security (Keen & Sol, 2008). However, food security as a concept is quite broad and requires multi-dimensional and multi-disciplinary approaches. Therefore, this research was narrowed to cases of indigenous seed selection, post-harvest storage and processing of food as some of the approaches rural farmers use to enhance their household food security. These are the areas where rural farmers are preoccupied with making decisions regarding either the use of indigenous or modern knowledge in the process of guaranteeing household food security. Our study is limited to rural areas of Uganda, specifically Mbarara and Kabale districts. It engages major stakeholders in the food security arena who include: community development workers (CDWs), extension workers (EWs), non- governmental organizations (NGOs), community based organizations (CBOs), community elders and local leaders.

In this research, CDWs were brought in as intervening agents to facilitate rural semi-literate farmers to enhance their decisions on food security. CDWs are Social Scientists who are employed by government or non-governmental agencies at lower levels of local governments to facilitate local people in improving their standards of living. Their major role is to intervene in undesirable situations (including food insecurity) and to cause positive social change: to promote community wellbeing and prevent total breakdown of society's welfare (Karen & Crafton, 2009).

1.7 Research problem and objectives

In Uganda, food security remains one of the most challenging problems for rural communities. There are high levels of childhood nutrition problems leading to high rates of child mortality (UBOS, 2013). Nine percent of households in most of the rural areas cannot afford more than one meal a day (UBOS, 2013, USAID, 2016; Tugume, 2017).

Despite the fact that indigenous knowledge forms the basis for local-level decision making especially on issues of food security among rural communities of Uganda, it is always marginalized. It is often regarded by scientists as backward, conservative, and inferior and taken to be based on sheer ignorance and myths. Whereas the survival of rural communities depends most on indigenous farming practices, government policies and subsidies tend to favor modern commercial farmers at the expense of smallholder rural farmers. Programs adopted to address food and nutrition security in Uganda, for instance NDP11[3] (2015-2020) and NAADS[4], do not incorporate the indigenous knowledge of local people. Moreover, indigenous knowledge is at the verge of extinction because it is not documented and the contemporary generation does not have it. Whereas modern technologies may increase productivity, indigenous knowledge is vital in adapting to climate change and in providing sustainable food to poor rural communities.

The pertinent question for this research is "*how can rural farmers' decisions for improving food security using indigenous knowledge be enhanced"?* To address this question, we sought to design a studio that provides intervention schemata for guiding rural farmers to enhance their decisions on food security. A scheme is an outline of what needs to be done in the process of solving a given problem. Specifically, the study was set to:

[3] National Development Plan11 (2015-2020)
[4] National Agriculture Advisory services

i) Collect specific indigenous knowledge that influence farmers' decisions on seed selection, food storage and processing;

ii) Engage farmers and stakeholders in collaborative decision making in the process of solving the problem of food insecurity;

iii) Design a studio for enhancing farmers' decisions on food security by supporting CDWs in their role of facilitating farmers, helping them to combine indigenous and modern knowledge using the intervention schemata;

iv) Instantiate and evaluate the studio for storing and providing intervention schemata to CDWs.

1.8 Research approach

Sol (1982) defines a research approach as a way of going about one's research which promotes different methods or techniques. A research approach defines how researchers conduct research focusing on the research philosophy, strategy, methodology and techniques that are used throughout the research process (Galliers, 1992). Venable (2006) describes a research approach as a family of research techniques and tools that drive actions and interpretation during the research process. According to Guba & Lincoln, (1994), the nature of the problem and the anticipated solution are some of the determinants in the selection of a suitable research approach. Accordingly, the research approach outlines the research philosophy (the underlying way of thinking) and the research strategy (a plan of action) (Sol, 1982; Blaikie, 1993; Mirembe, 2015; Aregu, 2014). This research adopted the design science research approach within an engaged scholarship research paradigm and followed a strategy of Singerian[5] inquiry in a pragmatic abductive reasoning (Costello & Donellan, 2012; Churchman, 1971).

Research philosophy

Research philosophy is the perspective that a researcher possesses in the processes of knowledge development (Sol, 1982). Sol (op cit) stresses that a research philosophy encompasses important assumptions about the way one views the world and what is believed to be valid research methods. He views research philosophy as perceptions, beliefs and

[5] A practical approach for changing the status quo.

assumptions that influence the way in which research is undertaken. Underlying any form of research is a philosophy of science that informs us of the nature of the phenomenon examined (ontology) and methods for understanding it (epistemology) (Bechara & Van de Ven, 2006).

Epistemology deals with our view on how knowledge is acquired. With epistemology, knowledge gained at one stage creates awareness of what is needed to initiate another cycle. Ontology deals with the nature of reality. Research paradigms describe the underlying philosophical views of groups of people about the world they live in and research they conduct (Oates, 2006). According to Gonzalez & Sol (2012), the common philosophical assumptions of research paradigms available for social sciences and information systems research are: positivism, interpretivism, critical realism and pragmatism, each with a corresponding ontological position.

Positivist research is characterized by understanding of reality by objective testing and singling out the truth. In positivist research, researchers perceive themselves and their research as independent of social and physical reality. Positivist research is based on deduction or theory testing by measuring or observing social realities. Conducting experiments and gathering of quantifiable data are typical methods used in positivist research. Positivist research findings are objectively reported and may be generalized (Chatterjee, 2012; March et *al*, 1995).

Interpretive or constructive research paradigm is used in research that tries to make sense of phenomena through exploration or explanation of peoples' perceptions, language, shared values and meanings in dynamic social context. It is based on the belief that individuals and groups make sense of the social world basing on their experiences, memories and expectations. In interpretive research, multiple realities are acknowledged when different groups or cultures are studied (Denzin & Lincoln, 2003). Meaning therefore is constructed and (over time) constantly re-constructed through experience resulting in many differing interpretations. Since "all knowledge is relative to the knower", interpretivists aim to work alongside others as they make sense of and draw meaning from realities. The focus of the researcher is on understanding the meanings and interpretations of "social actors" and to understand their world from their point of view (Flowers, 2009).

Critical realism research is conducted in a social context, which is also true for interpretive research. In critical research, the researcher challenges prevailing conditions in social settings. Critical realist researchers hold that real structures exist independent of human consciousness and that knowledge is socially created (Sanders *et al*, 2007). According to Blaike (1993), whilst realism is concerned with what kinds of things there are, and how these things behave, it accepts that reality may exist independent of science or observation and that there is validity in recognizing realities that are simply claimed to exist or act, whether proven or not. Critical researchers are motivated by an underlying ethical basis and apart from describing and explaining research environments, they seek to control or improve situations in societies. In common with the intepretivist position, critical realism recognizes that natural and social sciences are different and that social reality is pre-interpreted and also acknowledges that science must be empirically based, rational and objective (Flowers, 2009).

Design science research is described by Hevner & Chatterjee (2010) as "a research paradigm in which a designer answers questions relevant to human problems via creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence". The artifacts are both useful and fundamental in understanding the problem. Design science research (DSR) is concerned with research of man-made or artificial constructs, their composition and use and how and where they are implemented. DSR cuts across many disciplines including information systems, engineering, behavioral and social sciences. DSR requires looking ahead to new possibilities as opposed to looking back to understand (Purao, 2002).

A design science researcher is thus a pragmatist (Purao, 2002; Gonzalez & Sol, 2012). Peirce (931-1958) initially conceived Pragmatism as a method for clarifying the meaning of specific difficult ideas (which he called "intellectual terms"). As a practicing scientist all his life, his goal was mainly to clarify terms as a means of furthering and expediting scientific investigation, and not just as an academic exercise. He had a more rationalistic and realistic goal than some of the enthusiasms of later pragmatist like William James and John Dewey (Peirce, 1931-1958). Pragmatism is based on the notion that, the most important determinant of the research philosophy is the research question. It is not committed to any one system of philosophy or reality (Gonzalez & Sol, 2012).

Engaged scholarship research is described as "a participative form of research for obtaining the advice and perspectives of key stakeholders (researchers, research users, clients, sponsors and practitioners) to understand a complex social problem" (Van de Ven, 2007). According to Van de Ven (2007), engaged scholarship research has a number of facets: a form of inquiry where researchers involve others and leverage their different perspectives to learn about a problem domain; a relationship involving negotiation, mutual respect and collaboration to produce a learning community and an identity of how scholars view their relationships with their communities and their subject matter. Such intensive interaction and collaboration can be characterized as an "action research" approach with design science principles. According to Oates (2006), a combination of paradigms is possible if research being undertaken is not representative of one paradigm and the choice is well justified.

Denzin & Lincoln (2003), highlight on how different kinds of knowledge may be derived through observing a phenomenon from different philosophical perspectives. Accordingly, developing a philosophical position requires a researcher to make logical assumptions concerning the nature of society and science as different philosophical positions yielding different results (Mirembe, 2015).

This research uses an engaged scholarship research paradigm with design science research philosophy based on an interpretive and pragmatic epistemological stance with a critical realist ontological position (Van de Ven, 2010).
Engaged scholarship requires engaging others from different disciplines who contribute different perspectives and models for understanding the problem domain being examined (Van de Ven, 2007). We argue that interpretivism and critical realism are thought of as suitable for engaged scholarship research because of the focus on different stakeholders' perspectives overcoming the difficulties associated with positivism (Knol, 2013). Engaged scholarship is collaborative and dialogical action research between academics, practitioners and the affected community (Van de Ven, 2007; Costello & Donellan, 2012). According to Van de Ven (2007), engaged scholarship is a more practice-oriented, focused and relevant research in social sciences.

Engaged scholarship emerged as a result of concerns about academic research becoming less relevant in solving social problems and the widening gap between scientific knowledge and practice (Costello & Donnellan, 2012; Van de Ven, 2007). Engaged scholarship expands the

capabilities of scholars to study complex problems and create the kind of knowledge that advances both science and practice (Van de Ven, 2007). The choice of engaged scholarship was inspired by the need for action-oriented solutions to the problem of food insecurity among the rural communities. In this research, we engaged farmers as domain practitioners, and key stakeholders including: extension workers, local leaders, area elders, local NGOs, community based organizations (CBOs) and civil society organizations (CSO) in problem identification and in finding problem solutions.

According to Van de Ven (2007), critical realism in DSR is guided by the following underpinnings:

i) Reflexivity: no inquiry can be impartial and objective without a balanced representation of all stakeholders' viewpoints. Engaged scholars need to be far more reflexive in their studies than positivists and empiricists.

ii) Abduction: a process of forming an explanatory hypothesis or, a method of forming a general prediction without any positive assurance that it will succeed. Abductive reasoning yields the kind of daily decision-making that does its best with the information at hand, which is often incomplete.

iii) Knowledge creation: science is a process of knowledge development that is based on evidence from the world rather than merely reflecting the scientists' views.

iv) Model development: a core activity in an engaged scholarship process. Models stand in a mediating relationship between theories and data. Model centeredness is a key element of critical realism.

v) Relevance and rigor: relevance and rigor apply to different studies because their purposes, processes and contexts are different. Relevance of knowledge should be judged in terms of how well it addresses the problematic situation (see figure 1.2).

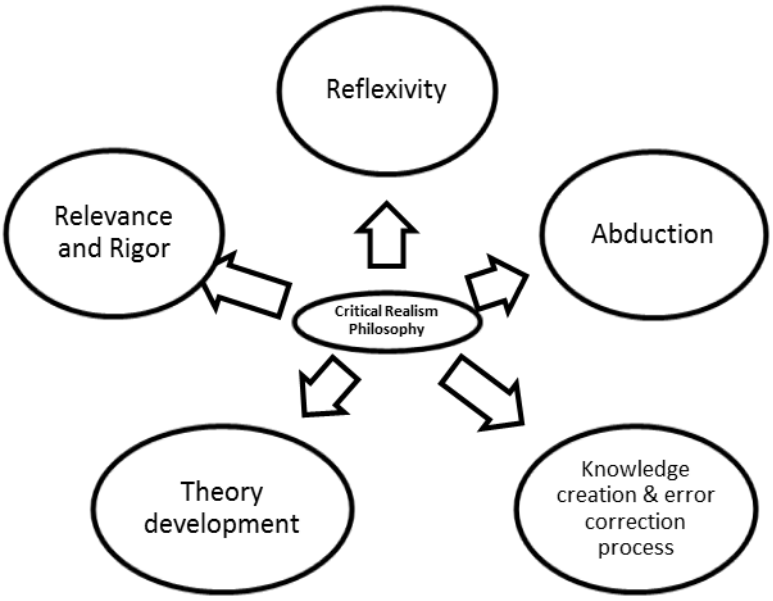

***Figure 1.2**: Critical realism research philosophy (Adapted from Van de Ven, 2007)*

Research strategy

Given the context of developing countries and the volatile nature of decision making among rural farmers, a strategy based on a pragmatist framework[6] of Singerian inquiry and abductive reasoning was adopted for this research (Churchman, 1971; Mitroff, 1971). Abductive reasoning is a knowledge generating mechanism that focuses on engaging stakeholders in a holistic, participative, dialogical and interdisciplinary problem-solving style (Churchman, 1971). It is a problem-solving style which seeks to develop theories that explain observations in the context of uncertainty. Peirce (1931-1958) referred to abductive reasoning as logical inference that goes from observation to propositions that offer the most probable explanation (theory building). This is illustrated in figure 1.3.

[6] Practical knowledge relating to the context of problem at hand.

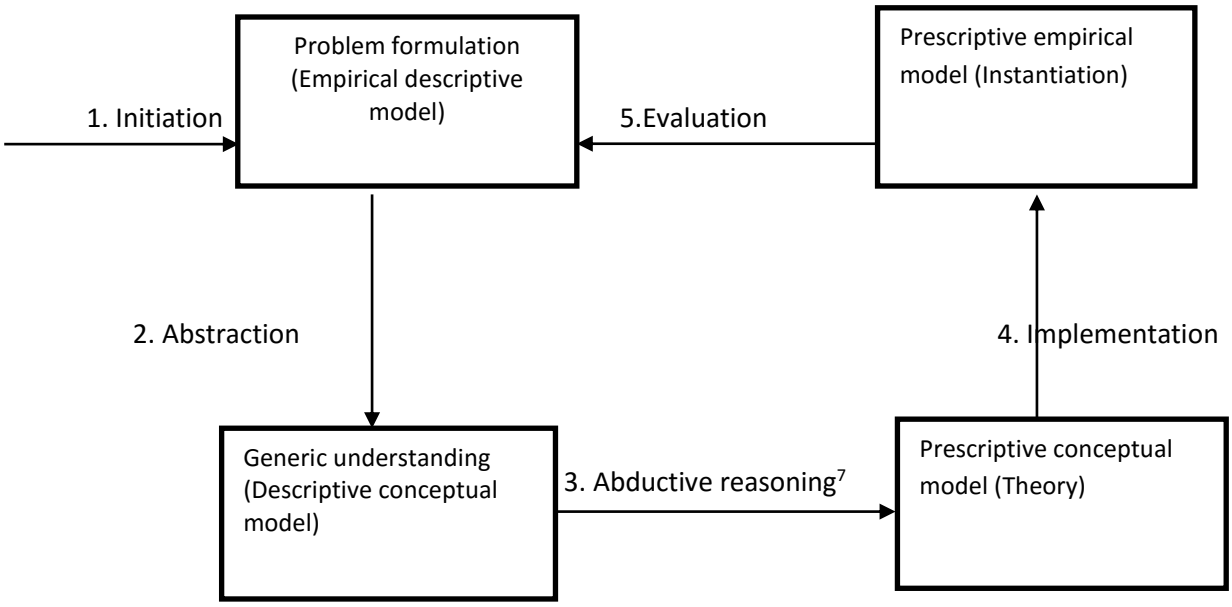

Figure 1.3: *Pragmatic abductive reasoning research strategy (Sol, 1982; Churchman, 1971; Gonzalez, 2014)*

As earlier indicated by Pierce (1931-1958) and of recent by Wieringa (2014), abductive reasoning is inference to the best explanation. According to Riegler (2001), abductive reasoning is the process of forming an explanatory hypothesis. Abduction is chosen because it entails creative thinking (engaging farmers and stakeholders in small groups dialogue and discussions) generating possible solutions of food insecurity basing on the knowledge and experiences of farmers (Churchman, 1971). Myers (1977), call this "action research" which aims to contribute both to practical concerns of people in problematic situations and to the goals of social science by joint collaboration with a mutually acceptable social framework. According to Kaptin (1992), abductive reasoning does not necessarily mean inference to the best explanation but a meaningful hypothesis through informed guessing. It is preference to any hypothesis that would explain the observations/facts. Based on the ideas of Singerian inquiry (Churchman, 1971), farmers and stakeholders were engaged in the process of identifying possible solutions to the problems of food security using locally available resources. Hevner *et al.* (2004) describe how theories are developed in design sciences research to explain human behavior (also see Hevner & Gregor, 2013). The findings and observations made from the exploratory study lead to propositions that could possibly explain the observed phenomena.

[7] Deriving explanatory propositions.

The strategy of abductive reasoning follows five major stages of the research process: initiation, abstraction, theory formulation, instantiation and evaluation (Sol, 1982), see figure 1.3.

Initiation

The initiation was basically a reconnaissance phase that focused on scoping and formulating the problem of food security and the role of indigenous knowledge in achieving food security in the rural context. The concepts of food security and indigenous knowledge were defined. The decision enhancement approach was introduced to deal with identified complex problems of food security (Keen and Sol, (2008). Looking at three case studies: seed selection, granary food storage system and food processing, the indigenous ways of addressing food security gaps are identified. The cases chosen informed us of how indigenous knowledge is applied by rural communities to attain sustainable household food security.

Abstraction

The abstraction phase aimed at identifying issues surrounding indigenous knowledge and food security. In this phase, literature was reviewed to gain a generic understanding of food security and indigenous knowledge from different perspectives. An exploratory study was conducted to get additional insights related to the problem domain and to get deeper understanding of the experts' views. The results of the exploratory study were analyzed to determine the relationship and the importance rural farmers attach to indigenous knowledge in the process of enhancing food security. Alternative suggestions of how indigenous knowledge could be stored and shared amongst farmers for sustainable use as well the decisions they thought could be enhanced were discussed. In addition, factors determining the choice of indigenous or modern knowledge by rural farmers were identified and analyzed. The output of this stage was a descriptive conceptual model. The model lead to the requirements for designing the Food Security Decision Enhancement Studio (FSDES).

Theory building

The theory building stage was abductive reasoning which entailed looking at and analyzing the generic understanding from the exploratory study (Courtney et al, 2005). It was a probational adoption of propositions as explanation for the observed facts. This phase whose output was a conceptual model, focused on the most plausible solutions of food insecurity. The ideas that came out of subsequent brainstorming sessions during focus group discussions

formed propositions that generally would solve the problem of food insecurity. It was an evolutionary process of variation, selection and retention of conjectures to form a theory (Van de Ven, 2010). The design artifact to address food security problems is articulated using Sol's 'ways of' frame work (Sol, 1988) and the outcome of which, is a "food security decision enhancement studio" (FSDES). In the design, we define the services to be delivered to the rural farmers, activities to be performed and the people responsible for which activities were to be enhanced. During interactions with farmers and stakeholders, it was realized that collecting indigenous knowledge alone was not enough because farmers could not do it themselves given their education background. We decided to provide intervention schemata to CDWs to enable them to facilitate rural farmers' decisions on food security using the studio. The theory formulation represents a change in orientation from problem identification and definition to problem solving.

Instantiation

This phase involved prototyping and implementation of the design into an ensemble[8] artifact. In this research, FSDES is implemented into a studio prototype with the enclosed intervention schemata and presented to CDWs to fill it with farmers' indigenous knowledge in order to help them to enhance their decisions on food security. The outcome is an empirical prescription which implies putting the conceptual prescription into practice by deploying the studio to provide intervention schemata to CDWs to collect indigenous knowledge and modern knowledge to enhance farmers' decisions. This was achieved by presenting the initial instantiation to CDWs to use in the real context, while adapting the intervention schemata.

Evaluation

Evaluation of the FSDES was done to ascertain its perceived usefulness and perceived usability in the process of providing intervention schemata for enhancing rural farmers' decisions. The FSDES was evaluated and tested to ascertain its added value to the performance of CDWs in addressing rural farmers' decisions. Evaluation was done by holding seminars and workshops in the research sites and taking participants through the studio. Evaluation was participatory where CDWs and farmers were given opportunity to give their views. Feedback from participants was gathered using questionnaires and informal interviews with experts (Keen & Sol, 2008; Van de Ven, 2010).

[8] An artefact that integrates stakeholders' views and values. It is shaped by the interests, values and assumptions of intended users and key stakeholders

1.9 Thesis outline

This thesis is organized into seven chapters. Chapter one presents the background to the research problem and introduces key concepts in the problem domain. The concept of indigenous knowledge and its significance in contributing to rural communities' food security is elaborated. The research question is formulated. The chapter further presents the research approach that guided the study.

In chapter two, a detailed literature review on food security and indigenous knowledge is presented. Theoretical underpinnings of household food security are discussed. Cases of indigenous knowledge as applied by rural communities are presented in this chapter. The chapter further presents literature on decision making approaches.

Chapter three gives the description of the exploratory study, data collection approach, findings and challenges as obtained from the study cases. Research design, methodology and research instruments used in the exploratory study are elaborated. The exploratory study informed the study of how indigenous knowledge was understood by rural communities. Data from the exploratory study lead to the requirements for designing the FSDES.

Using the insights from chapter two and three, the Food Security Decision Enhancement Studio (FSDES) is designed. The design follows Sol's 'ways of' framework. The chapter further presents the studio which has four suites: the assessment, collaboration, communication and knowledge management suites. Each suite has recipes which provide detailed instructions on how it works.

In chapter five, the instantiation of the FSDES and considerations taken into account are discussed. The chapter describes first, how the initial instantiation of FSDES was implemented into a prototype and second, its presentation to CDWs to fill it with indigenous knowledge and farmers' lived experiences guided by the intervention schemata. The chapter presents examples of farmers' own best and worst experiences as they are shared as a basis for effective decision making. In this chapter, we further present how CDWs adapt the FSDES and refine the intervention schemata to fit the context in which the artifact is deployed.

Chapter six discusses the evaluation of FSDES. The chapter describes the approach used to evaluate FSDES with regard to its usefulness and usability and gives a detailed analysis of the evaluation analysis.

Finally chapter seven provides a reflection of the entire research process focusing on relevance and rigor. It gives concluding remarks on indigenous knowledge and how it enhances rural communities' food security. The major research findings, research contribution and generalizability of findings are presented in this chapter. The chapter ends with recommendations and directions for future research.

Chapter 2 Literature Review

This chapter presents theoretical perspectives of indigenous knowledge and food security. It also provides literature on the trend of food security at global, regional, national, community and household levels. The chapter further presents selected examples in which indigenous knowledge is applied by rural farmers/communities. The role of ICT in indigenous knowledge management is also discussed. Section 2.1 presents theoretical understanding of the concept of food security. 2.2 discusses the relevance of indigenous knowledge to rural communities' food security. 2.3 presents specific examples of indigenous knowledge application. 2.4 discusses high-tech agriculture and its impact on rural communities' food security. Section 2.5 presents the role of ICT in indigenous knowledge management. 2.6 articulates decision-making approaches. 2.7 presents collaborative decision processes and, 2.8 provides concluding remarks.

2.1 Theoretical perspectives of household food security

Food is one of the basic needs for human survival, and access to it is a fundamental human right (Kamwendo & Kamwendo, 2014; Escamilla, *et al,* 2012). Food security as a concept originated in the mid-1970s in the discussions of international food problems at a time of global food crisis. It was defined in the 1974 World Food Summit as "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (UN, 1975). Since then, the concept of food security has been refined and redefined on several occasions over the years, each definition changing and reflecting on the persistent global conditions as well as views of researchers, analysts and economists (FAO *et al*., 2015). However, FAO (2002) expands the definition of food security as "*a situation when all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life".* Adams & Taylor (2012) refer to food security as the ability of individuals, households and communities to acquire food that is healthy, sustainable, affordable, appropriate and accessible.

Based on the above definitions, food security is based on four dimensions: availability, stability, utilization and access to food (FAO *et al*, 2015). In reality, activities to enhance food security in the context of local communities should emphasize food productivity,

stability, availability and improved access to local food (Awuor, 2013). The dimensions of food security are illustrated in Table 2.1:

Food security dimensions	**Implication**	
Food availability	Production	The type and amount of food produced locally
	Distribution	Amount of food of a certain type that will be available to a certain group of people at a specified time
	Exchange	Amount of food exchanged through barter, trade, purchase etc.
Food accessibility	Affordability	The price of food versus a household's purchasing power
	Allocation	Instruments that determine where, when and how food can be accessed
	Preference	Socio-cultural and other values that influence the demand for specific kind of food
Food utilization	Nutritional value	The amount of daily recommended nutrients, vitamins, proteins, minerals, calories, etc. in the consumed food
	Social value	Cultural and social components of consumed food (food should be socially and culturally acceptable)
	Food safety	All factors related to ensuring food free from contamination and from being hazardous to people's health
Stability		Stable food supply throughout (proper storage and preservation methods)

Table. 2.1*: Dimensions of food security (Adapted from FAO et al, 2015)*

According to Ingram (2011), the notion of food security is broad and requires a multidimensional approach to get what it entails and to ensure its sustainability at household, community, national, regional and global levels. Various explanations of household food

security put emphasis on 'secure access at all times to sufficient food'. The term 'enough food' is taken as a 'minimum level of food consumption' (FAO *et al,* 2015; Ingram, 2011). The concept of access is a phenomenon resulting from Sen's theory of food entitlements: production, trade, labor and transfers (Sen, 1981). An individual's entitlements are rooted in his/her endowments (resource bundle). According to Sen (1981), an individual can suffer entitlement failure: what he owns, what he produces, what he inherits and what he can trade in.

Chambers (1988) argues that poor people do not distinguish between food entitlements and environmental entitlements. They have vested interest in conserving their natural resource base for sustainable food security and will do so if given the opportunity. Maxwell reaffirms this by saying that poor people will always modify their attitudes toward food in order to preserve their asset base or in any ways to protect their livelihoods (Maxwell, 1990). Putting food security within the broader context of livelihood is not about how people fail to feed themselves but rather about the positive strategies they follow to feed themselves; what production systems they are part of and under what terms they participate; whether they fit into local resource management systems and the kind of flexibility their overall livelihoods provide them with (Chambers, 1988).

Burchi and De Muro (2012) note that the 925 million people who are food insecure worldwide, majority of them are in rural settings who directly or indirectly depend on agriculture for their livelihood. Malnutrition and obesity are manifestations of widespread food insecurity (USAID, 2016; UBOS, 2014).

2.2 Indigenous knowledge and rural communities' food security

Indigenous knowledge which is also referred to as local knowledge, has been steadily growing interest in the academic world, both within the social as well as natural sciences (Awuor, 2013; Kamwendo & Kamwendo, 2014). Scientists and policy makers are becoming aware of the contribution indigenous knowledge (IK) can have to sustainable development and more so to food security (Kilongozi, *et al.,* 2005).

Indigenous knowledge reflects the dynamic ways in which the residents of an area understand their natural environment and how they organize folk knowledge of flora and fauna, cultural beliefs and history to enhance their livelihoods (Gutierrez, & Fernandez, 2010). According to Hall & Midgley (2007), development approaches and interventions that do not consider

people's indigenous knowledge and experiences have proved to be of limited effectiveness in addressing mass poverty and promoting human welfare. They further argue that development does not mean a rejection of all past practices but rather building on them to ensure sustainability.

Harnessing the indigenous knowledge of local people creates a sense of respect and ownership of interventions designed for addressing the local communities' problems (*bottom up approach*) and in turn creates positive and sustainable results (Ingram, 2011; Ranganathan, 2004). Interventions that build on the local practices (or those that integrate new technologies with local practices) enhance farmers/communities' decision making capacity (Kamwendo & Kamwendo, 2014; Awuor, 2013; Ranganathan, 2004). Ghale & Upret (2000) argue that indigenous farming systems upon which the majority of poor farmers depend, are being replaced by costly and unsustainable external technologies, a situation that is damaging the resources of rural poor farmers and their production capacity.

Rural people possess a wealth of knowledge such as knowledge of the quality and relationship among crops, soil texture, climate change, pest control and water management among others (Smelser & Baltes, 2001). For example, knowing that before grains and seeds are stored, they must be dried to reduce moisture content. A very sharp and resonate sound produced while cracking the grain confirms that the grain is dry enough and safe to store. Grains could even be dried in the rainy season by simply hanging them, such as hanging the maize cobs on the rack constructed above cooking fire. Imported moisture testers and dryers would supplement indigenous practices thereby broadening the choices of the rural poor farmers (Ghale & Upreti, 2000).

Local farmers plan their land use to sustain food production using their indigenous practices. Terracing, fallowing, ridging and mixed cropping have been practiced by local people since time immemorial. In a study conducted by Agea and his associates in Masaka, it was established that a number of rural people still use their indigenous practices in sustaining their subsistence farming and household food security. Fresh cassava and potato tubers for example, are buried in soil to increase their shelf life (Agea *et al*, 2008).

In developing countries, agriculture is still dominated by peasant smallholders using their indigenous practices and family members as source of labor. It is therefore unlikely that any intervention that does not recognize local people's traditions will bear positive effect (Awuor,

2013). Traditional smallholder farming is famous for its endurance and resilience to environmental hazards (Ting, 2015). Accordingly, agriculture policies should focus on the safety of the agro-ecosystem and, priorities and preferences should support smallholder farmers. Indigenous knowledge is now considered one of the cornerstones that can guarantee survival of rural communities especially in food and nutrition security (Awuor, 2013). Therefore, there is no doubt for believing that indigenous knowledge is vital for rural communities' food and nutrition security (FAO, 2014). However, it is apparent that the younger generation underestimates its utility just because of their own limited awareness. It is important to note that indigenous knowledge is a key path-way to rural farmers' transformation and it is potentially a reliable alternative to modern technology especially in the process of achieving food security (Kamwendo & Kamwendo, 2014).

The contemporary focus on local knowledge and perceptions, however, has not yet resulted in a systematic discussion of the role played by society in food security. Whereas there is a great deal of evidence about the importance of local knowledge and perceptions of local people in determining the level of food security, this evidence lacks an accompanying theory which might lend it to open criticism across a spectrum of scholars (Car, 2006).

It is important to note that subsistence farmers need to be helped to transform from subsistence to commercial agriculture but in a systematic way. Transformation ought to be gradual and in a logical order and not via a rapid foreign imposition. Food security is not only about producing more, but also wasting less by minimizing the damage on the environment (FAO, 2014). Whereas enhancing rural farmers' decisions on food security may be the prime motive of this study, other benefits might accrue. For instance, replenishment of natural biodiversity and sustainability of the ecological components using indigenous knowledge (FAO, 2014).

In today's knowledge-based society, local knowledge and innovations are considered core competences of the local people (Ranganathan, 2004). Rural areas always have their special local resources especially the intangible assets, such as cultural resources and local knowledge embedded in the long history (Feng, *et al,* 2009). It is argued that indigenous knowledge is always bound with action. It is seen to exist in a local context anchored to a particular social group in a particular setting at a particular time (World Bank, 1997). Sesay *et al* (2013), refer to indigenous knowledge as a store of experiences and knowledge of an indigenous society on technologies, practices and beliefs that form the basis for decision

making to achieve stable livelihoods (see Awuor, 2013). Indigenous knowledge is in some occasions tacit because it is usually embedded in peoples' experiences, intuitions, senses and implicit rules of thumb (Nonaka & Krogh, 2009).

According to Claxton (2010), biodiversity, indigenous knowledge and sustainable development are closely linked. He argues that indigenous peoples' practices and techniques constitute what scientists call "principles of permanence" that permit continuous cropping all year around without the use of chemicals that do not degrade the environment. In the Sahel region for instance, traditional methods of land management have greatly helped to mitigate severe effects of climate change (Eyong *et al*, 2007). In Nepal, indigenous knowledge is considered one of the richest resources because of its geographical diversity (Sharma, 2007).

Okori *et al*, (2010) discuss socio-economic factors influencing food security in Uganda but do not talk about the social infrastructure like local people's social networks which also play significant role. This research gives due attention to local people's social networks like group labor exchange and other local practices that greatly contribute to food security.

Indigenous knowledge is thus seen as an important compliment to contemporary knowledge. It should be taken into account as the starting point to the construction of an alternative agricultural science where the needs and knowledge of the rural communities are part and parcel of the new alternative agricultural science (Gutierrez & Fernandez, 2010).

The majority of farming communities in Ghana depend on traditional knowledge systems in production and processing of food (Kumasi, 2011). The Masai pastoral communities in Kenya have greatly benefited from a range of indigenous knowledge systems in ensuring their animal health, forage plants and range management that have improved their productivity and food security (Kilongozi *et al,* 2005).

In Kenya, communities have made clay pots for storing drinking water using their indigenous knowledge. These pots keep water cool and clean and as a result, household hygiene has greatly improved because these pots keep water safe from re-contamination and therefore diarrheal diseases are prevented (Boven & Morohashi, 2002).

In India, local people have traditional environmental conservation practices based on various religious beliefs. Particular patches of forests for example, are designated as sacred places

under customary law and therefore protected from any product extraction by the community. In Sierra Leone, indigenous farmers have a wealth of knowledge on the production of crops in their communities that could be useful for a robust yam breeding program (Sesay et al, 2013).

In Uganda, rural people have communal farming groups to boost their food and nutrition security. Five to ten women form a group and take turns to till, plant, weed and harvest each member's garden so as to produce more in a season than one individual would if she did everything alone (Byenkya & Opedum, 2008). Most cultures in Uganda have early warning systems for weather prediction based on indigenous systems, for example, observing migratory patterns of certain bird species, water bodies of particular wells or streams, earthquakes, rainbow, and certain species of trees among others (Byenkya & Opedum 2008). They possess indigenous practices that enrich their diet and hence their health profile.

2.3 Specific areas of indigenous knowledge application

a) Food preservation among rural communities

Food preservation is an effective way of prolonging its shelf life or preventing it from being wasted or getting spoiled. Communities around the world have been employing food saving methods for centuries in order to prolong its shelf life (Kamwendo & Kamwendo, 2014). In North America, local tribes were the first to eat pemmican, a mixture of smoked meat. It was widely adopted as a high energy food by Arctic and Antarctic explorers as it is a concentrated mixture of fat and protein.

Smoked meat is a method of preparing red meat (and fish) which originates in pre-history (Eyong, 2007). Its purpose is to preserve these protein rich foods which would otherwise spoil quickly, for long periods. The smoking process has two properties; it dehydrates and is anti-bacterial. In modern days, the enhanced flavor of smoked foods makes them a delicacy in many cultures[9]. Smoking meat and fish has been practiced for ages. Indigenous cultures around the world have used smoke for drying meat and fish and to drive away the flies. The absorbed smoke acts as a preservative (Awuor, 2013).

In Brazil, traditional communities used to cook their meat and leave it immersed in fat for preservation. In a related manner, Bakkwa, a Chinese salty-sweet dried meat, was

[9] www.enwikipedia.org/wiki/smokedmeat

traditionally made with the leftover meat from festivals and banquets. Meat from these celebrations is trimmed of fat, sliced, marinated and then smoked.[10]

Indigenous knowledge that enhances food and nutrition security is thus instantiated in meat preservation by smoking it. Meat smoking was performed as a means of preserving it because smoking makes meat thoroughly dry so that it is kept for a long period of time[11]. Besides, smoking meat removes saturated fat and thus reducing the intake of cholesterol and less risk of cardiovascular diseases that may come along with fresh meat consumption. Therefore smoking meat makes it healthier and more nutritious (Awuor, 2013).

The specific purposes of smoking are, but not limited to:

1. It is one way of preserving meat for a long period of time so that it might be consumed at a future date especially when it is scarce.

2. Traditionally, eating dry meat is deemed healthy because it is one way of reducing intake of cholesterol in the human body, thus, good nutrition.

3. Socially, smoking meat preserves it for someone who is not currently at home, or abrupt and special visitors, a sign of togetherness and respect.

4. It is also done as a preventive measure against famine. Traditionally, people paid special attention to drought because a long dry spell/ season/ year meant famine the next season/ year. Therefore, people would prepare adequately to prevent famine outbreak.

However, it is important to note that, while there are direct and indirect benefits of meat smoking, there are health concerns as well for example, putting meat on top of fire for long gets contaminated with carbon monoxide which is not good for human consumption.

b) Traditional food storage methods

Food storage is one way to treat and manage food-stuffs like cereals to reduce on post-harvest losses. (Rice *et al*, 2003; Awuor, 2013). Food storage is a traditional domestic skill and an industrial practice.[12] Food is stored by almost every human society and it serves several purposes.

[10] World environment day@unep.org

[11] www.peakproperity.com/blog/preservingmeat-curingandsmoking/60668

[12] www.en.wikipedia.org/wiki/food_storage

First, storage of harvested and processed plant and animal food products is done to ease distribution to consumers. Secondly, storage enables a balanced diet throughout the year; thirdly, it reduces kitchen food waste by preserving unused or uneaten food for later use. Food is stored for eventual use in catastrophes, emergencies and periods of food scarcity or famine. It was also practiced for religious reasons and to protect it from animals and theft.

Traditionally, some foods especially cereals like millet, sorghum, maize as well as grains are stored in granaries. Different granaries are used for different food stuffs. The granaries are constructed in such a way so that they are at a raised level and smeared with cow dung to allow easy entry of cool air; and also to prevent food stuffs from attack by weevils and pests (Abioye *et al*, 2013). As a result, food may be stored for a long period of time, and household food security is guaranteed. Every food-stuff is sun dried to reduce moisture content before storage. In the granary, farmers add native herbs/plants to protect their grains against weevils/insects (Gueye *et al*, 2013).

Specifically, the purposes of granary storage are four fold: first to preserve food for a long period of time so that it could be consumed in future in case of food shortage, second to preserve seeds for next season planting, third to protect seeds from pests and weevils and fourth to protect seeds from destruction by rain water.

Seed storage structures and granaries used by small scale farmers continue to draw heavily on traditional technologies. Storage can play a significant role in influencing small scale farmers' decisions about the diversity of crops and varieties they adopt and maintain (Louette& Berthanel, 1997). In Senegal, traditional clay granaries have proved to be effective based on the knowledge that non-winnowed maize stored in a granary takes long to be infested with insects (Gueye *et al*, 2013).

This grass-root knowledge should not be left to disappear but instead be preserved and be made to constitute another agricultural revolution on the basis of so called "people's science" (Fatnowna & Pickett, 2002). Sufficient evidence from literature reveals that effective traditional food security regulations and bylaws have been abandoned and are not considered important by extension officers and policy makers; a situation that has escalated post-harvest losses and nutritional problems (Tweheyo & Katushemererwe, 2004). Admire & Tinashe (2014) argue that insect pests cause 30% of the post-harvest losses of grains in Sub-Saharan

Africa due to poor storage systems. Lack of suitable storage structures and the absence of storage management technologies often force small-holder farmers to sell their produce immediately after harvest (Admire & Tinashe, 2014). Chambers (1989) argues that rural households' ability to classify, choose, improvise, adapt, and test indigenous technology illustrated by examples of potato storage technology, seed variety selection, agro forestry, tool making, the invention of complex cropping patterns, soil conservation, water harvesting, and use of native species reflect their rich indigenous knowledge for enhancing household food security. When rural farmers are seen in this light, as experimenters and innovators, other peoples' views also change: what rural people need is less a standard package of practices and more a basket of choices. Rural farmers are professional specialists in survival, but their skills and knowledge have yet to be fully recognized (Thrupp, 1989; Gutierrez & Fernandez, 2010; Gorjestani, 2001; Ghale& Upreti, 2000).

c) Selection of indigenous seed varieties

Seed selection is the choice of seed for the next season's crop. This can be done at different times in different places and may assume different forms (Rice *et al,* 2003; World Bank, 2013; Louette & Smale, 2000). Seed selection is not a single event but an iterative, continuous process. It is usually done after harvest either at home, or in the field (Rice *et al,* 2003). Indigenous people have knowledge of drought and disease resistant seeds. They can easily tell varieties of seeds that do well in certain types of soils from those that do not perhaps depending on weather conditions. They know those that mature fast and hence are good for fighting famine after long dry spells or other natural disasters. All this knowledge is present locally and it enables locals to make proper choices for seeds. This means that use of agrochemicals and fertilizers may be irrelevant to them (Awuor, 2013; Kamwendo & Kamwendo, 2014).

The way farmers select their seeds varies enormously; most farmers take part of the grain bean crop after harvest while others make their choice in the field. Farmers who select after harvesting may put aside part of their harvest so that they can also make a careful selection for a particular seed appearance (Linnemann & Bruyn, 1987).

Although the seed varieties developed by plant breeders are appreciated by market-oriented and relatively large farmers, local farmers prefer varieties with good yields and which are reliable throughout the year despite adverse environmental conditions. Rural farmers believe that their indigenous seeds are less associated with health threats (Gueye, *et al,* 2013). For

this purpose, they often use a mixture of varieties that are compatible to their farming systems. Subsistence farmers also attach much importance to specific taste and culinary quality, and the by-products that can be used as forage, building materials and mulching for gardens are appreciated too. As a result, seeds of their own indigenous varieties are carefully selected by farmers themselves for the properties of their choice and also for the characteristics such as healthiness, shape, size and appearance as well as those that suit individual wishes better than seeds of modern varieties which are produced for a large group of consumers (Gueye, *et al,* 2013).

For farmers to think of buying seed, they must be convinced that the type of seed meets their satisfaction better than their own produced seed but quite often, farmers prefer their own seed for adaptation to their farming systems (Linnemann & Bruyn, 1987). Indigenous seeds are selected based on the following attributes: maturity time, resilience to adverse climatic conditions, sweetness/taste, germination rate, sustainability (can be replanted in the subsequent season), healthy ears/traits, cost of seed during planting season, and price after harvesting. They are also selected based on storability, open pollinated seeds, quality texture, marketability, disease and pest resistance, yield and the fact that they do not, need chemical fertilizers (organic in nature).

In Rwanda for instance, farmers' are able to recognize different potato varieties according to plant and tuber traits. They can further recognize important differences in taste, texture, storability, marketability, disease and pest resistance and response to moisture stress (Byenkya & Opedum, 2008).

In Zambia, farmers' evaluation of high yielding hybrid maize varieties and their description of the positive and negative characteristics of the locally adapted open-pollinated varieties has led to a more effective national maize growing program (Mwende, 2011).

Ghale & Upreti, (2000), argue that despite its perceived usefulness, indigenous knowledge is often marginalized and given little attention in the mainstream studies, research and development institutions. Many professional experts tend to scoff or criticize such knowledge systems, viewing them as nonsensical, superstitions, irrational and mythical (Thrupp, 1989). Projects attempting to incorporate local knowledge are always seen as unsystematic, unscientific and therefore unacceptable.

Overlooking indigenous knowledge therefore, is likely to guarantee failure in people's development (Sharma *et al*, 2009). It is essential to listen to local people's views and knowledge and build on them in a coherent and systematic fashion. Indigenous knowledge needs to be archived in comprehensive data-bases in order not to lose it. This knowledge should be adequately stored and shared among interested parties (stakeholders) such as policy makers and community development practitioners for promotion of household food and nutrition security (Agrawal, 1995). Recognizing indigenous people and encouraging them to determine how their indigenous knowledge should be shared with outsiders and protecting intellectual property rights of their specialized indigenous knowledge is very important. This could enhance and sustain peasant resource management, increase agricultural productivity and hence household food security. It is important to respect and understand people's indigenous knowledge and to build on them from within (Smelser & Baltes, 2001, Agrawal, 1995, Twikirize *et al,* 2013). This old, widespread and useful knowledge should be documented to enable the young generation benefit from it.

The awareness of the value of indigenous knowledge is growing precisely at a time when it is under great threat of exotic and high-tech innovations. It is in danger of disappearing not because of influence of global processes of rapid change, but also because the capacity and facilities needed to document, evaluate, validate, protect and disseminate such knowledge are lacking in most developing countries (Nwokoma, 2012). Besides, there has not been any explicit government intervention to manage indigenous knowledge for sustainable food security.

2.4 High-tech agriculture and rural communities' food security

The growing concern over increasing levels of food insecurity and the need to satisfy global demand for food have led to innovative technologies which are seen as the only way for increasing food production (Ting, 2015). With globalization, several multinational corporations are now pushing modern technologies on developing countries such as genetically modified seeds, chemical fertilizers and pesticides with the aim of increasing food productivity (USAID, 2016). However, sustainability of food production has become an increasingly debatable issue (Eyong, 2007). There is a big concern over the sustainability of modern technologies. Apparently, many communities calling for food sovereignty are

protesting the imposition of western technologies on to their indigenous systems which they think might endanger their health (Kamwendo & Kamwendo (2014).

Ting (2015) argues that it is possible to increase the current supply of food, but only at the cost of increasing vulnerability in the future perhaps by over-exploiting the natural resource base or at the cost of the reduced quality of entitlements. Ideally, food is supposed to be one of the most basic human needs within a hierarchy of concerns (Mcleod, 2007). Lower level needs are dominant until satisfied and that's when higher order needs come into operation. Mcleod's argument implies that, when one is starving, needs for self-esteem or status will be less important; only food matters (Maslow's hierarchy of needs). Ghale & Upreti (2000) argue that household food security leads to national food security but national food security may not necessarily lead to household food security because food security must be reflected at house level. It is difficult to attain national food security when there is no food security at household level (Kamwendo & Kamwendo, 2014).

Use of agro-chemicals and fertilizers is adversely impacting on peoples' health and on the environment, while genetically modified foods are causing nutritional problems in the society (Gueye *et al*, 2013; FAO, 2012). There is a serious decline in soil organisms and soil nutrients as a result of misuse of industrial chemicals (Ting, 2015). Beneficial insects and fungi suffer due to excessive and loose use of pesticides making crops more susceptible to pests and diseases (Ting, 2015). Consequently, this reduces food productivity. In addition, many insects and fungi commonly seen as enemies of food production are actually valuable for pollination. They further contribute to biomass, natural nutrient production as well as natural enemies to insects and crop diseases (Briggs, 2005). It may not be a wise decision to let indigenous knowledge disappear and replaced by market-oriented external technologies and interventions due to globalization which may not help the poor farmers (Awuor, 2013; Thrupp, 1989). Retaining indigenous knowledge and its use and only gradually adopting innovations would in turn preserve environmental damage potentially caused by high-tech alternatives to indigenous knowledge (UNESCO, 2016). Producing plentiful, high-quality food in a sustainable manner would be a vital step towards food and nutrition security. All people must have access to the right quantity and quality of foods, and to foods that are safe and acceptable (Adams & Taylor, 2012).

2.5 The role of information communication technology (ICT) in indigenous knowledge management

While indigenous knowledge is gaining recognition, the need for ICT is needed to capture, manage and share indigenous knowledge (Lodhi & Mikulecky, 2010). The process of organizing and leveraging knowledge embedded in peoples' experiences, competences, talents, ideas, practices, intuitions, skills, wisdom and capabilities in addition to documented and codified sources is what is termed knowledge management (Meja, 2002). Management of indigenous knowledge is meant to develop cost effective and sustainable survival strategies for food security, poverty alleviation and income generation for poor rural communities.

Technology should be introduced where necessary, to make indigenous knowledge more resilient in the face of new threats such as those posed by climate change and genetically modified organisms (GMOs) (Lodhi & Mikulecky, 2010). ICT can play major roles in improving the availability of indigenous knowledge systems and enhancing its blending with the modern scientific and technical knowledge (Mwantimwa, 2008). Information communication technologies such as computers and the Internet can help to manage indigenous knowledge. The application of ICT is essential to stimulate the flow of IK and incorporation of modern scientific and technological understandings to traditional knowledge. This will enable indigenous communities to protect their unique cultures and knowledge through digitization.

While ICT can help to inform experts and policy makers about indigenous knowledge of local communities what they know and have, it can also improve understanding of local conditions and provide a productive context for activities designed to help the communities (Eseryel, 2014; Lodhi & Mikulecky, 2010; World Bank, 2004).

Hunter (2013) argues that the value and significance of indigenous knowledge is being realized by many communities around the world and the need for ICT to preserve it is also increasing. ICT is needed to enable, control and share indigenous knowledge within the local context and according to unique and specific local needs (Dyson, 2006). In the globalized era, a number of countries are using ICT to develop digital libraries of indigenous knowledge in various local languages to prevent it from misuse through commercial patents (Lodhi & Mikulecky, 2010).

Puri (2007) contends that ICT-based knowledge has been advocated by several donor agencies to create knowledge-intensive societies necessary for economic survival in the era of globalization. However, the absence of ICT in some developing countries like Uganda denies local people access to many opportunities including national and global markets for their produce (Dyson et al, 2007; Aregu, 2014). This justifies the need for increased ICT infrastructure in developing countries.

According to Ngulube (2002), the central purpose of knowledge management is archiving and sharing it with other people. He gives a sequence of steps in knowledge management identification, capture, codifying (by transferring it on to paper), validation (through discussion with others), contextualizing and decontextualizing (agreeing on common positions) and archiving. Storage of indigenous knowledge is not limited to text documents or electronic formats but could also include the studios (an interactive environment for sharing knowledge). While documenting and archiving indigenous knowledge is needed, awareness creation through seminars and conferences is also important (user-oriented community). This is true probably because of underutilization of indigenous knowledge due to lack of awareness about its contribution to food security (Coombs & Hull, 1998).

Maja (2002) argues that ICT enables knowledge sharing among community members which helps them to learn more and make further innovations. ICT enhances searching, storing and retrieving of useful information.

Knowledge management plays a key role in decision making and therefore must be subjected to measurable improvements (Nonaka, 1991; Eseryel, 2014). A dynamic community can use e-mail for example, to build knowledge, learn, make decisions and enhance wisdom through a cycle of knowledge combination and knowledge qualification (Courtney *et al*, 2005). Ngulube (2002) argues that the proper storage and management of indigenous knowledge must be ensured if this knowledge is to be made available and accessible to those in need of it. Collection should be done by ethnographers, anthropologists and other related professionals like social scientists. According to Averweg (2010), resource centers should be created for managing and disseminating indigenous knowledge to local farmers, policy makers whoever is in need of it.

Recognizing indigenous people and encouraging them to share their indigenous knowledge amongst themselves is essential. Local people should be empowered to decide which specialized knowledge should remain within the local domain (to protect their intellectual

property rights) and which one should be shared with outsiders (Agrawal, 1995). This is very important and could enhance and sustain natural resource management, increase agricultural productivity and food security by protecting local farmers' property rights. It is important to respect and understand people's indigenous knowledge systems and to build on them from within (Smelser & Baltes, 2001, Agrawal, 1995, Twikirize *et al*, 2013).

Hunter (2013) argues that, while indigenous knowledge is gaining recognition, the need for ICT must also go high to capture, manage and disseminate indigenous knowledge. It is also needed to enable, control and share indigenous knowledge within the local context and according to unique and specific local needs. He maintains that a number of countries are using IT to develop digital libraries of indigenous knowledge in various local languages to prevent it from misuse through commercial patents. Puri (2007) argues that ICT based knowledge has been advocated by several donor agencies to create knowledge-intensive societies necessary for economic survival in the era of globalization.

Maja (2002) reiterates that ICT plays a very crucial role in knowledge management by improving knowledge sharing among community members which helps them to learn more and make further innovations. ICT enhances knowledge sharing processes. It links people with relevant knowledge directly (Ranganathan, 2004).

ICT bridges the geographical and perceptual gap between communities (World Bank, 2005). Mark and Rensselaer (no date) argue that ICT is vital in sustaining and stimulating communities' traditional ways of knowing. According to Lishan (1998), ICT could indeed act as a source of empowerment and knowledge exchange by enabling young people, old, employed and unemployed to exchange traditional and modern knowledge and by creating a platform for interaction among members of the community in form of collaborative processes (Eseryel, 2014; Nonaka, 1991).

Chapman *et al*, (2004) affirm that ICT enables individual farmers to make informed choices regarding the opportunities and constraints associated with agriculture- based strategies. IFPRI (2004) contends that the links between food security, markets and ICT are obvious. Information communication technologies improve information exchange. ICT facilitates sharing and disseminating knowledge among rural farmers, and this in turn enhances food production and hence food and nutrition security (FAO, 2010).

2.6 Decision making approaches

A decision is an outcome of the interplay between problems, solutions, participants and choices, all of which arrive independently and change continuously (Wang, 2008). Decision making is the process choosing the best from many alternatives based on the values and preferences of a decision maker (Simon, 1955; Kalantari, 2010). Making a decision implies that there are alternative choices from which one chooses judging which one has the highest probability of success and effectiveness and which fits the goals, desires, lifestyle and values of the decision maker (Knol, 2013; Aregu, 2014; Kalantari, 2010). Simon's model of decision making consists of three steps; intelligence which entails defining the problem and collecting information concerning it, design that involves developing several possible alternatives, and choice which is choosing the preferred solution (Simon, 1957; Aregu, 2014).

Decisions are choices that can shape an individual or an organization's future (Keen & Sol, 2008). The effectiveness of a decision is more closely related to the effectiveness of the organization than any other factor (Bekker, 2016). Every decision making process produces a final choice. The output can be an action or an opinion of choice. "Decision making is the process of making a choice between different options and committing to take a course of actions" (Sol, 1982). Classical and neoclassical theorists assume rationality in decision making processes first by collecting all the relevant information regarding the issue under investigation, generate all possible alternatives and examine the consequences of those alternatives and finally choose the optimal alternative.

However, Simon (1955) argues that rationality in decision making is unrealistic because decisions are made in a complex environment that is influenced by a number of factors and constraints: time, limited information and individual's limited capacity (Simon, 1955; Sol, 1982; Kalantari, 2010; Campitelli & Gobet, 2010; Ssemaluulu, 2012). He thus advocates attention to bounded rationality arguing that human beings can only be partially rational and their ability to make decisions is limited to available information but where there is enough data to make good enough or satisficing[13] rather than optimal choice (Simon, 1955; Sol, 1982; Kalantari, 2010; Aregu, 2014). Simon reasons that, the human mind has a critical challenge in coping with the complexities of the world, and thus constructs a simple mental

[13] A decision-making strategy that entails searching through the available alternatives until an acceptable threshold is met.

model of reality and tries to work within that model (Simon, 1957; Sol, 1982; Kalantari, 2010).

According to Sol (1982), decision makers often use rules of thumb and are likely to repeat what has worked in the past. Simon's model indicates that decision makers tend to rely on heuristic procedures[14] in order to adapt to their environment (Campitelli & Gobet, 2010). Sol (1982) puts it that decision makers always avoid extensive use of big data because too much information does not necessarily mean 'better' decisions.

According to Keen & Sol (2008), DES comprise of four major aspects; decisions that matter, studios, suites and stakeholders. Decisions that matter are made in response to problems that severely affect the decision makers. Studios are facilitative environments, face-to-face links via telecommunication links that enhance active inclusion in building collaboration for effective processes to handle decisions that matter. A studio has technology suites. The suites are packed with services that focus explicitly on enhancing farmers' food security improvement decisions.

2.7 Collaborative decision processes

Due to the complexity of decision making process, decision making must be collaborative and this plays an essential role in the design and communication at all levels in problem solving processes. Collaborative decision making refers to a situation where different people working together toward achieving a common goal. It is defined by Konate *et al,* (2015) as a joint effort toward a common goal; a process in which stakeholders with different perspectives of a problem, can constructively explore the differences and can search for solutions that go beyond their own limited visions. It ideally involves a free exchange of ideas to allow creation of most innovative and strategic decisions (Kolfschoten *et al*, 2011). Within collaborative decision making, there are many processes and best practices that can be employed and shared to ensure the best outcomes.

Collaboration can be taken as a process or as a sequence of steps performed by a group of people to achieve a goal. A collaboration process provides a mechanism for engaging stakeholders in an effort to identify and address food security problems (Lasker, *et al*, 2001).

[14] Common sense rule or method that helps one solve problems faster than he would if he did all the computing (Kahneman, 2003)

Stakeholders are taken in this study as key players with skills, values, judgments and experience to make food security enhancement decisions. Stakeholders provide strength to collaboration decision making and execution (Konate *et al*, 2015). Poor stakeholder involvement is a challenge to problem solving (Amiyo, 2012). Collaboration stimulates comprehensive thinking. In the case of rural food insecurity, relevant stakeholders need to be involved to appropriately brainstorm, i.e. share their experiences on how they apply indigenous knowledge (Konate *et al*, 2015).

Ranganathan (2004) argues that the strength of virtual community is that for any problem, there is a high possibility that at least one other person has encountered the same problem and perhaps has a solution. In collaborative decision making, multiple views are gathered in one place, which helps to go beyond experts, who may have limited perspective or vested interest. Furthermore, a lot of ideas are generated through brainstorming and these ideas have to converge. Convergence is defined as the merging of distinctly separate things into unified whole. To make better decisions, everyone whose involvement will help produce high quality decisions should be brought on board (Kolfschoten *et al*, 2011; Konate *et al*, 2015).

Group support system (GSS) may also be used to help in collaboration engineering. A GSS is a collection of collaborative software tools used to structure meeting activities (Harder *et al*, 2005). Kolfchoten *et al* (2011) describe collaboration support as tools, processes and services that support groups in their joint effort. In knowledge oriented organizations, there is often a need for collaboration support tools. Tools and technology for group support exist in a variety of shapes, from complex computer systems (groupware) and group support systems, to simple boxes with cards and pencils. Briggs *et al,* (2009) refer to collaboration tools as instruments or apparatus used in performing an operation for moving a group towards its goal, for example, whiteboards, flipcharts or collaboration software systems.

Collaborative decision-making means merging of various separate ideas into one cohesive output. A facilitator takes the role of process leader offering group guidance in their choice of collaborative activities, instructing and guiding them in the use of collaboration support techniques and tools (Vreede *et al*, 2003; Gaffney, 2009). The style and skillfulness of the facilitator has significant effect on the outcome of the collaboration process[15].

[15] http://www.infodesign.com.au/ftp/Facilitator.pdf.

This research will involve CDWs as facilitators to guide rural farmers. The actions of the facilitator in supporting the group; offering tools and techniques and guiding the group in using these tools are termed "facilitation interventions" (Kolfschoten *et al*, 2011).

2.8 Conclusion

It is observed in the literature that indigenous knowledge provides cost-effective and sustainable ways of food and nutrition security for rural communities. It is established that rural farmers still depend on their traditional farming practices. Literature further reveals that documentation and management of invaluable indigenous knowledge still deserve a lot of attention as it is at the threat of biotechnology innovations and genetically modified organisms. Besides, it is observed that indigenous knowledge is always marginalized in favor of high-tech modern knowledge. Farmers have no clearly defined channels through which they can share their lived experiences on indigenous knowledge practices. This implies that policy makers simply assume that exotic knowledge, which is also referred to as scientific knowledge, works for everybody including rural poor farmers. However, sufficient evidence from literature shows that this has not been the case, see (USAID, 2016; Emorut, 2015).

Based on the reviewed literature, it is noted that there are gaps regarding indigenous knowledge information flows between farmers themselves and policy makers. Accessibility and sharing of indigenous knowledge among farmers and food security experts is still inadequate. It is also observed that rural farmers need to be helped by making indigenous knowledge more available and accessible in the process of improving food security. Besides, it is noted that there is dire need for farmers and stakeholders' collaboration for experience and knowledge sharing. It is further noted that interventions are needed to enhance rural households' food security and that these should build on peoples' indigenous knowledge for positive results. In chapter three, the exploratory study conducted with rural farmers and stakeholders is presented.

Chapter 3 Exploratory study

This chapter describes the methodology and results of the exploratory study on the selected rural farmers and stakeholders. The exploratory study informed us of the decision making practices of rural farmers and the contexts in which they are made to ensure food security in their households. Section 3.1 presents a description of study cases. Section 3.2 discusses data collection procedures. Section 3.3 gives a presentation and discussion of results. Section 3.4 discusses findings from the farmers' perspectives. Section 3.5 describes the organization of focus group discussions. 3.6 discusses the key findings from FGDs. 3.7 presents a generic understanding from the exploratory study and introduces a food security decision enhancement studio for enhancing rural farmers' decisions.

3.1 Description of study cases

The aim of the exploratory study was to understand how indigenous knowledge was used by rural farmers to improve on household food security. Throughout the literature review, it was noted that a number of factors influence household food security (poverty, illiteracy, inadequate information and poor coordination between farmers and extension providers to mention a few). It was realized that, rural farmers' decision making to improve food security is often done in an environment that is complex and volatile.

As noted in chapter 1, this study we focused on three cases, namely: seed selection, food storage and food processing as major areas of the exploratory study because they were seen as areas where critical decisions on food security take place and also to scope our research. For instance, seeds planted have a significant effect on the crop yield and crop yield in turn determines storage methods so as to avoid post-harvest losses and maintain household food security. Similarly, processing of food is critical to rural households as it has direct bearing on the form and quality of food to be consumed. This requires one to decide whether to use indigenous or modern methods of food processing depending on resources available.

Rural farmers were considered to be: i) individual farmers or family members, ii) groups or associations of farmers engaged in different farming activities such as growing of food crops, rearing of animals, fish farming, and poultry among others. Farmers may engage in one or many farming activities.

The research sites were taken from the districts of Mbarara and Kabale in Uganda. The two areas were selected because of their predominantly agricultural nature and also for being typical rural districts of Uganda. Kabale is predominantly a food growing area while Mbarara combines both food production and livestock farming.

The major criterion that guided the selection of farmers was that, one had to be a community member and engaged in farming activities and also taking part in household food security decision-making processes. In the event where the main decision maker was absent, his or her spouse or any adult member of the family was selected to participate in the study.

Interviewing was the main method of data collection which was supplemented by focus group discussions (FGDs) and field observations. Interviews were a one-to-one interaction with farmers using the interview guide. Key stakeholders in the field of food security were engaged in interviews to obtain their views, experiences, expertise and opinions. Stakeholders in rural communities' food security comprised of CDWs, family members, extension workers, local leaders, Community Based Organizations (CBOs), National Agriculture Advisory Services officials (NAADS), village elders and Civil Society Organizations (CSOs). The stakeholders targeted in the study were selected basing on their skills, knowledge and responsibility held in the community.

Figure 3.1*: Stakeholders in the food security domain*

3.2 Data collection methods and tools

Selection of study participants

Purposive sampling, as described by Weisberg *et al*, (1989); and Mirembe (2015), was used to select farmers to participate in the exploratory study. In purposive sampling, only those respondents considered to have the required information are selected (Vanderstoep & Johnston, 2009; Tongeo, 2007; Aregu, 2014). Table 3.1 illustrates the number of farmers that participated in the study in each of the two research areas:

Research site	**Number of respondents**	**Percent (%)**
Mbarara (Katyazo)	36	54
Kabale (Kitunga)	31	46
Total	67	100

Table 3.1: *Number of farmers interviewed per research site*

In addition to farmers, key stakeholders in the field of food security were selected and engaged to participate in the study as key informants. They included National Agricultural Advisory Services (NAADs) coordinators, extension workers, CDWs, local government councilors (at district & sub-county levels), local council 1 chairpersons and local NGOs as shown in the table below:

District	CDWs	Extension workers	NAADS coordinator	Councilors	Local NGO staff	Local council chairperson	Total
Kabale	3	2	1	1	2	1	10
Mbarara	2	1	-	1	1	1	6
Total	5	3	1	2	3	2	16

Table 3.2: *Categories of stakeholders interviewed*

Data collection

Data from farmers and key stakeholders were collected using interview and observation guides, which were designed based on literature and the main research objectives. The interview and observation guides were carefully constructed to capture salient issues with regard to indigenous knowledge and how it is applied to achieve household food security.

Prior to actual data collection, a pre-test, of data collection instruments was conducted among 10 students of Social Work and Social Administration at Kyambogo University and five farmer groups representatives in Mbarara District. This was done to ensure the reliability of research instruments. The pre-test helped to refine the instrument by ironing out inconsistences and poorly phrased statements. Semi-structured instruments were made open and flexible to allow probing. The interview guide focused on farmers' background, farming activities engaged in, decisions made and source of information required (particularly on seed selection, food storage and processing). It was also designed to capture challenges farmers face and how they overcome them. Use of ICT in decision making processes was key in the guide. Besides, participants were given opportunity to give their opinions with regard to what they thought was important for making better decisions.

As a means to observe ethical issues permission to carry out research from local leaders in the target communities was sought. A letter of introduction from Kyambogo University to introduce the researcher and his assistants to the local authorities was obtained. In addition, informed consent was sought from all participants before they were interviewed. Farmers were contacted using mobile phones to make appointments prior to the beginning of interviews to ease the exercise. The researcher was taken through the research area by the village chairperson. Interviews were conducted in farmers' gardens or homes depending on where we were able to locate the farmer. Each interview lasted between 45 and 60 minutes.

As noted by Vanderstoep and Johnston (2009), a face to face interview technique is ideal for exploratory studies as it allows the interviewer to clarify questions and to ensure that the responses are understood (see also Sekara (2003); Mirembe (2015). Face to face interviews were used because of their better response rate over other forms of interviews (Creswell, 2008; Weisberg, 1989). The interviews focused on understanding indigenous knowledge as

used by rural farmers and the challenges they face in making decisions on enhancing food security.

Data collected from interviews and observations were organized by identifying and correcting errors in the data collection instruments and making necessary adjustments. Interview responses were recorded and then expounded; patterns of responses were identified and categorized. Data analysis was a step from exploration to understanding of the rural farmers' decision making processes (Lincoln & Guba, 1981; Vanderstoep & Johnston, 2009). In addition, focus group discussions were conducted to supplement in depth interviews and to get actual lived experiences of rural farmers.

3.3 Presentation and discussion of results

Demographic profile of farmers

The demographic profile is presented in the table below:

Character	**Frequency**	**Percent (%)**
Sex: Female	42	63
Male	25	37
Total	67	100
Age: 15-24	-	-
25-34	12	18
35-44	15	22
45- 54	27	40
55- 64	10	15
65^{+}	3	4
Total	67	100
Education:		
None	12	18
Primary	32	48
Secondary	17	25
Tertiary	6	9
Total (N=67)		100

Table 3.3: *Participant's Demographic profile*

Table 3.3 summarizes the demographic profile of the participants. The majority of participants (63%) were women compared to thirty seven percent (37%) who were men. A big number of farmers (62%) were in the age bracket of 35 to 54 years. With regard to the level of education, less than half of the farmers interviewed (48%) attained primary education followed by secondary education (25%) and nine percent (9%) who had attained tertiary education. A proportion of farmers (18%) had never gone to school. These results informed us that women take the leading role in food security decision making processes. This is in agreement with the observation of Ibnouf (2012) that, rural women will always look for cost-effective sources of food because of limited income. Table 3.3 further indicates that farming is mainly done by older people (45-54 years) compared to youth (15-34).

Farming activities

It was considered important to understand the different farming activities participants engaged in. It was observed that the majority of the participants (54%), engaged in growing of food crops. This was followed by livestock farming (42%), poultry farming (22%) and then fish farming (2%). This is summarized in Table 3.4.

Activity	**Frequency**	**Percent (%)**
Crop farming	36	54
Livestock keeping	28	42
Poultry	15	22
Fish farming	2	2
N=67	153	120

Table 3.4: *Respondents farming activities*

According to Table 3.4, rural farmers have a diversity of farming activities. One farmer can engage in different farming activities as a way of broadening the chances of maintaining food security and to reduce on the risks of depending on one farming activity. This observation is in agreement with the findings of Eyong (2007). It is also a means of having a variety of food as a cultural obligation for guarding against famine.

Indigenous and modern knowledge use by rural farmers

During interactions with farmers, we sought to understand whether they were using indigenous or modern practices in their effort to attain food security. It was established that quite a number of rural farmers (46%) still prefer exclusively indigenous practices of farming and food security improvement. It was also noted that 33% of the farmers interviewed were combining both indigenous and modern practices. Only 21% were using modern practices exclusively. The table below summarizes our findings:

Knowledge practice	Frequency	Percent (%)
Indigenous	31	46
Modern	14	21
Both indigenous and modern	22	33
N=67	67	100

Table 3.5: *Indigenous/modern knowledge use*

Awareness of the concept "food security"

It was crucial to know whether farmers were aware of what food security meant. The responses clearly indicate that majority farmers (84%) knew the concept of food security while 16% were not aware as demonstrated in Table 3.6.

Is the term food security familiar to you?	Frequency	Percent (%)
Yes	56	84
No	11	16
N=67	67	100

Table 3.6: *Participants' familiarity with the concept of food security*

The fact that the majority of the farmers were aware of the meaning of food security stimulated their desire to engage in making timely decisions on food security. It was further established that food security was always on the top among the priority areas of households.

Membership in farmer group(s)

The study endeavored to find out whether farmers were affiliated with farmer groups. It was important to know whether farmers belonged to groups and whether they were making group decisions. It was established that 96% of the farmers interviewed belonged to farmer groups/ associations as opposed to only 4% who did not belong to any farmer group as demonstrated in Table 3.7.

Membership	**Frequency**	**Percent (%)**
Belong to a farmer group	64	96
Do not belong to a farmer group	3	4
N=67	67	100

Table 3.7: *Percentage of farmers belonging to farmer groups*

This observation concurs with the finding of FAO (2014) that rural farmers have a unique lifestyle in a thriving close-knit group. Quite often a farmer depends on his/her group as a source of knowledge and a helping hand. It was noted that many of the groups we interacted with were informal and their main purpose was to give support to members in terms of finance (credit and savings cooperative), labor exchange and marketing of their produce. It was established that group decision making was mainly limited to the above listed areas. It was further noted that there was need and opportunity to organize and broaden the scope of farmers' collaborative decision making.

Type of ICT device owned by farmers

It was considered important to establish the type of ICT devices farmers owned so as to be able to know their level of technology advancement. 'Table 3.8 shows type of ICT owned by farmers.

Type of technology	**Frequency**	**Percent (%)**
Mobile phone	67	100
Computer	6	9
Radio	53	79
Other (specify)	0	0
N=67		

Table 3.8: *Percentage of Respondents owning ICT devices*

It was noted that mobile phones were the major communication device available to majority of rural farmers. Some of the farmers reported accessing internet using their smart phones, while some did not have smart phones. It was important to probe further to understand the major purpose why farmers owned smart phones. The following responses came out as the major purposes:

a) Communicating with their colleagues, extension workers and CDWs on important farming issues.

b) Making inquiries on market for produce, crop and animal diseases.

c) Seeking help from extension workers and other experts.

d) Sharing information on WhatsApp.

These responses indicate that ICT is already adopted in rural communities. This observation concurs with what Aregu (2014) observed that, usage of ICT in developing countries, enables local people access to information sharing and other opportunities including national and global markets for their produce. In a similar way, Hunter (2013) argues that ICT is essential in enabling sharing and control of indigenous knowledge within local context and according to unique and specific needs.

Storage methods used by rural farmers

It was deemed important to establish the kind of storage methods used by rural farmers to reduce post-harvest losses associated with poor storage of food stuffs. Table 3.9 summarizes our findings.

Storage method	**Frequency**	**Percent (%)**
Modern cemented store	10	15
Local store constructed with local materials	32	48
Granary	5	8
Clay pots	18	27
Baskets	15	22
Sacks	20	30
N=67		

Table 3.9: *Different methods of food storage used by farmers. Total is more than 100% due to farmers using more than one type of storage.*

Table 3.9 shows that rural farmers use a wide range of food storage methods as a way of preserving harvested food and maintaining food security in homes. Both indigenous and modern methods of food storage were used. It was further established that there was a combination of storage methods being used. As earlier noted in literature review, storage is both a traditional and an industrial practice (Rice *et al*, 2003). Food storage serves several purposes but the most notable ones included: disaster preparedness, reduction of post-harvest losses and ensuring sustainable food security (Rice *et al*, 2003; Kumasi, 2011). The main reason for using indigenous storage methods in the study communities was cost-effectiveness. Other reasons were culture and reliability of indigenous methods.

Source of seeds for planting

There was interest in finding out the source of seeds which farmers planted during planting seasons. Table 3.10 gives the summary of our findings:

Source	**Frequency**	**Percent (%)**
From previous harvest	57	85
From fellow farmer	17	25
Bought from seed store	7	10
From the market	3	4
From NAADs	49	74
N=67		

Table 3.10: *Farmers' source of planting seeds. Total more than 100% due to multiple sources.*

Observations from Table 3.10 indicate that the majority of farmers (85%), used seeds they had selected themselves from their previous harvests. 74% got seeds from seed distributing agencies like NAADS, and twenty five percent (25%) got seeds from their fellow farmers. The rest reported getting planting seeds from agro-vet shops (10%) and from the market (4%). Although NAADS distributed free seeds to farmers, not all farmers we interacted with were getting seeds from NAADS. The majority of farmers preferred to plant their own seeds because sometimes they found seeds from NAADS very expensive as they required fertilizer

application and chemical spray against diseases which was not the case with local seeds. Besides, distributed seeds at times were found to be of poor quality compared to local seeds. They attributed this to the fraud procurement process where the people responsible for supplying seeds buy from their friends without considering the quality of seeds. Deciding on which seeds to plant and where to get them from is a critical event in the farming decision making process. Literature indicates that farmers will always use a mixture of varieties that are compatible to their farming needs. This finding was in line with what Gueye *et al* (2013) had observed.

Post-harvest food handling methods

In the interviews with individual farmers, we sought to establish ways by which food is preserved after harvesting to prevent it from pests and weevils. The responses are presented in the Table 3.11.

Method practice	**Frequency**	**Percent (%)**
Spraying with insecticide/ chemical application	11	16
Mixing grains with cow dung ash	21	31
Mixing grains with red pepper powder	29	43
Mixing grains with native herbs	25	37
Using cow's urine	2	3
N==67	88	

Table 3.11: *Food treatment methods used by farmers. Total is more than 100% because farmers use different methods.*

The majority of farmers (43%) mix grains and legumes such as maize, sorghum, and beans with red pepper powder. Farmers argued that unlike chemicals, red pepper is effective in preventing grains from weevil infestation and does not have health hazards. Natural herbs were used by a number of farmers citing effectives in preventing food crops against weevils as the major reason. Cow urine was not so popular because it makes food especially beans hard to cook and losing taste. Using chemicals was less used due to cost implications and fear of health risks associated with them.

Post-harvest handling is one of the crucial stages in the food security decision making process. Farmers carefully store food using different methods to reduce losses and damage of food after harvest.

Rona, one of the interviewee, remarked:

> "I dry and crash to powder a kilo of red pepper and mix the powder properly with one bag of beans and then cover the beans well or put them in the granary and cover. I can keep these beans for four months without being attacked by weevils and pests. After four months, I add more red pepper if I still want to store but usually, I use or sell the beans after that period."

Accordingly, treatment is always done after harvest and before storage for a number of reasons: i) to prevent food stuff from attack by pests, ii) to preserve planting seeds for the subsequent planting season and, iii) to preserve food for future consumption and household food security. Louette & Berthanel (1997) made similar observation. Post- harvest handling of food-stuffs is one of the major ways of ensuring sustainable food security (Awuor, 2013).

Farmers' sources of information during decision making

In chapter two, it was noted that information plays a significant role in decision making as Simon (1957) states. The source of information farmers get to enable them make effective decisions on household food security was seen important in the process of enhancing food security. Table 3.12 provides a summary of our observations.

Source of information	**Frequency**	**Percent (%)**
Fellow farmer	63	94
NAADS Coordinator/Extension worker	26	39
Village elders & family members	15	22
CDW	41	61
Media (TV, Radio, News papers	2	3
N=67		

Table 3.12: *Source of information for farmers' decision making*

Table 3.12 indicates that farmers get information from different sources. It was established that majority of farmers (94%) got information from their fellow farmers. It was further noted that rural farmers depended on one another and each farmer offers a helping hand to others. It was established that experts like extension workers do not easily reach out to every rural farmer. NAADS coordinators provided less information than expected because of politics. At one point in the course of this study, they were suspended on allegations of corruption. CDWs instead, provided information better than extension workers and NAADS coordinators because CDWs are in every sub county and they are able to reach out every household. At a meeting with CDWs in Kabale, it was noted that because of the limited number of extension workers, CDWs were asked to work as extension workers; providing agricultural information to farmers. By training, CDWs are social workers or social scientists who work with communities to improve their welfare. They are civic educators who help citizens and build them into strong and more resilient communities (Rwomire, 2011). CDWs provide supportive information concerning markets for food items, reminding farmers to plant in time and what to plant depending on location of the farmer.

The media scored the least position because rural farmers in Uganda hardly get time and resources for the media. The media's timing of agricultural programs especially radio and televisions is not convenient to rural farmers who spend most of their time in gardens.

Decisions taken by rural farmers to improve food security

During our initiation phase in chapter one and two, it was observed that rural farmers are faced with complex and numerous activities that require making timely decisions to ensure improved food security. In the interviews with farmers, we wanted to acquaint ourselves with the decisions farmers take to improve household food security. Their responses were summed up in the following statements:

- Growing fast maturing crops.
- Engaging in income-generating activities/projects such as making and selling handcrafts (baskets, mats among others) and doing business.
- Careful selection of seeds that are of high value and which are disease and drought resistant.
- Proper storage of food to avoid post-harvest losses.
- Keeping animals like cows, goats, sheep, poultry together with growing of crops and fruits (mixed farming).

From the above observations we note that farmers need help to enhance their decisions on food security.

Bariyanga[16], an elder at Hakatojo village, Mbarara, said:

> "It is not common in this village to find someone engaging in only one activity and attaining food security. We have to diversify our farming activities. We grow crops, keep animals such as goats, cows, sheep as well as poultry to ensure that we have food security. If you do not do that, chances of being frustrated are high."

Factors influencing farmers' decisions on indigenous/modern knowledge use

It was thought worthwhile to understand factors that influence farmers' decisions on indigenous or modern knowledge choice. The responses we got were summarized and presented in the following statements:

- Cost-effectiveness and performance.
- Accessibility, affordability &availability of the knowledge/method.
- Health and environmental concerns.

Mwijukye, the local council chairperson of Katyazo village Mbarara, stressed that

> "People in this area would be interested in modern knowledge, but its cost and reliability are always a hindrance. For instance, buying one bottle of pesticides to spray half an acre of sweet potato garden against army worm is not affordable to many in this village. As a result we resort to our indigenous knowledge such as mixing goat's urine with wood ash and spray our gardens at no cost."

These responses are in agreement with what is revealed in literature that farmers are always careful in making choices based on what has worked before (Chambers, 1989; Gueye *et al*, 2013). It was established that farmers were much influenced by previous yields, cost effectiveness, environmental and health concerns with regard to indigenous/modern knowledge use.

[16] Not the real name. Pseudonyms are used for confidentiality to permit free discussions

3.4 Key findings from farmers' perspectives

In this section, we move from exploration to understanding of farmers perspectives. It was noted that rural farmers' decisions to ensure household food security are paramount in their day to-day activities. It also emerged from the exploration that women are more engaged in household food security decisions than men. More farm work is done by women, and they were seen as key decision makers of food security. Given the fact that the education levels of rural farmers (particularly women) were low, their capacity to make effective decisions needed to be enhanced. We further noted that indigenous knowledge was dominant in all key farming activities particularly in seed selection, food storage and processing although modern technology was also in use. It was interesting to find out that farmers in rural areas operate in informal groups through which they learn from each other.

However, it was established that groups were mainly for labor exchange and information sharing and collaboration were limited to their small groups. There was inadequate collaboration between farmers and key stake holders. Communication and information exchange was limited to their mobile telephones mainly sending and receiving messages to and from their fellow farmers. It emerged that rural farmers' decisions to achieve sustainable food security are hampered by a number of challenges which included:

i) Inadequate information about indigenous knowledge. There was no indigenous data base which would provide cost-effective knowledge alternative to rural farmers in addition to modern technology. As a result, indigenous best practices were not being shared.

ii) The majority of rural farmers have limited resources which constrain their effort to make effective decisions.

Mutuuza, a peasant farmer in Nyamabare village Kabale, had this to say:

> "As you see me here, I have a small piece of land. How much do you think I earn to be able to afford modern methods of farming? I am not able."

This implies that indigenous knowledge is the most feasible alternative for poor rural farmers if it was available to them.

iii) Inadequate coordination among farmers and stakeholders. Though there was a favorable environment for collaboration among farmers, it was not the case with stakeholders. There

was inadequate mobilization and morale among stakeholders. As a result, opportunities for knowledge and experience sharing between farmers and stakeholders were limited.

Kamarembo, a farmer in Kakisizi, Kabale said:

> "We would be sharing our experiences on indigenous knowledge amongst ourselves. But we are not coordinated to do so. I wish we were mobilized to share our experiences. It would improve our food security."

iv) Climate change. Climate change makes rural farmers unable to predict weather and to plan accordingly as seasons keep changing from time to time due to environmental degradation.

v) Insufficient willingness by policy makers to incorporate indigenous knowledge in food security programs such as NAADS and National Development Plan (NDP).

vi) Limited education. This hinders rural farmers' ability to interpret and analyze information for adequate decisions.

viii) Poor communication between farmers and stakeholders, making information sharing and feedback among farmers and stakeholders difficult.

3.5 Focus group discussions (FGDs)

After obtaining results from the interviews with farmers, we planned to have four focus group discussions (FGDs) which were conducted in the two separate research sites (Mbarara & Kabale). According to Hevner & Chatterjee (2010) focus group discussions are appropriate for DSR for the following reasons: i) flexibility for handling design topics and domains, ii) they allow direct interaction and conversation with participants about design issues, iii) they provide large amounts of rich data pertaining to design and use of the artifact. Group discussion is used to get a collective view within a social context through interactive discussions on a topic introduced by the researcher.

FGDs are usually conducted as open conversations in which each participant may comment, ask questions to other participants, or respond to comments by others, including the moderator (Lyon & Trost, 1981). Interaction among respondents is encouraged to stimulate in-depth discussions. Denzin &Lincoln (1998), argue that FGDs are a better way of exploring

complex issues. Dushku (2000) puts it that group interviewing constitutes another level of data gathering and another perspective on research problems that may not be accessible through a one-on-one interviewing

For this research, FGDs were used to obtain collective views on the findings got from individual farmers interviews. The major purpose was to understand participants' attitudes, beliefs, shared understanding, insights, views and opinions and how all these variables were influenced by others in the discussions (Denzin & Lincoln, 1998; Litoselliti, 2003; Lyon & Trost, 1981).

FGDs with rural farmers were organized in the research sites of Mbarara and Kabale. Besides, discussions with stakeholders (CDWs and extension workers), were also arranged and held to get more information about farmers decision making practices to improve food security. The venues chosen for our discussions provided an environment for participants to open up and freely share their views and to have meaningful interactions.

Focus group methodologies require six to twelve participants per group and discussions are conducted under strict procedures (Morgan, 1993, Denzin & Lincoln, 1998; Dushku, 2000; Lyon & Trost, 1981). We selected two groups in each site and each group had 10 participants. Participants were selected based on their farming experience, food security knowledge and their willingness to participate in discussions. Based on the principles of engaged scholarship, key stakeholders in the field of food security were involved.

In addition to FGDs with farmers, workshops with stakeholders were organized to get more information on farmers' decision making processes. CDWs, village elders and family members were engaged in discussions. Selected participants were contacted one by one on the phone to confirm availability and willingness to participate in discussions a day before. Those who were not able to participate were replaced. We then proceeded with our preparations for the meetings, (see appendix B) arranging venues for the meeting and putting all logistics in place.

Procedure for focus group sessions

The topic of discussion was introduced to participants who were requested to freely discuss it emphasizing that their views, opinions, experiences and suggestions were very important to the quality of research. This was followed by a 15-minute presentation by the researcher highlighting on the findings from interviews with individual farmers.

According to Lyon & Trost (1981) it is important to begin with a general topic which will relax participants and pave the way to step up to more specific areas. Freitas *et al* (1998) argue that introductory questions allow participants opportunity to reflect on their own previous experiences and create a platform for discussion. Participants were allowed to deliberate on the questions with minimal interruption from the researcher who could only come in to direct the discussion from one point to another and to ensure smooth discussions. A digital recorder was used to record the discussions as they went on but the researcher was also taking notes particularly on the expressions of participants and key observations. The discussions lasted for two to three hours in all the sessions.

3.6 Presentation of findings from FGDs

From the focus group sessions it was noted that rural farmers engage in complex decision making at various points in the chain of food production, storage and processing to ensure food security for their families. It was also revealed that decisions to guarantee household food security are highly consequential; meaning that decisions taken by them at first point will affect the decisions at subsequent points. For instance seed selection affects the yields and the amount of yields affect decisions for storage and processing.

As participants narrated their experiences with regard to seed selection, food storage and processing it emerged that rural farmers use more indigenous knowledge than modern farming technologies. It also emerged that some farmers were combining both indigenous and modern knowledge. Although farmers were encouraged to adopt modern farming technology, farmers were still using their indigenous knowledge to achieve food security. The main reason for this was that indigenous knowledge is cost-effective for them. Besides, the quality of NAADS seeds and animals that are distributed to farmers was often doubted because many times, the seeds do not germinate compared to indigenous ones.

During FGDs with farmers, it was established that farmers usually trust seeds they themselves select from the garden by identifying their health traits while still in the garden as they grow. This agrees with what Gueye *et al* (2013) observed that for farmers to think of buying seeds, they must be convinced that the types of seeds they buy satisfy their needs better than their own seeds. In line with this argument, one participant from Kitunga, Kabale District retorted: (translated from Rukiga to English):

> "I see people getting bothered about money for buying planting seeds during planting season. Planting seeds cannot be my problem because I keep my own seeds which are well selected from my own harvests. I know how to do it to get better results."

It emerged from the discussions that decisions concerning storage of food were contextual depending on the amount of food to be stored, the type of food and also the location of the farmer. For instance, the granary storage method is dying out because of two major reasons: theft and low production. Regarding theft, it is now risky to store food in a granary built outside the house because thieves usually come and steal food from the granary. Participants were concerned that production has generally reduced, and because of this they store the little food harvested indoors using locally made baskets (*Ebiteebo or ebitukuru*). Clay pots, sacks and old drums were mentioned as other methods of storage used by rural farmers. Beans and peas are mainly stored indoors because of the market demand.

Regarding food crops like Irish potatoes, sorghum, millet and maize which are produced on large scale, farmers have adopted new types of stores which are constructed like houses using local materials. They have wide ventilators and a rack is erected inside such that food-stuffs stored do not get into contact with the floor and get damaged by mold, termites and red ants. Besides, the way the structure is made allows enough air to flow in and out to keep temperatures regulated in a way unfavorable for pests. Participants gave various ways of treating their food-stuffs. Many of the participants said they preferred indigenous methods of treatment due to health reasons, cost and ease to use.

Participants expressed fears about the modern chemicals used for treating food crops. They believed that indigenous treatment methods do not have health problems. Some of the indigenous methods for treating food stuff included: native herbs like dry cyprus leaves, red pepper; cow urine, cow dung and wood ash among others. These findings concur with what was observed by Rice *et al*, (2003).

Food processing is yet another critical stage in the food security attainment process where participants reported making key decisions in order to guarantee household food security. Processing takes many forms depending on the type of food. Participants reported having different methods of processing food. There are indigenous and modern methods available for processing of food. Indigenous methods mentioned were reported to be cost-effective for

local people but they are being replaced by modern methods. Discussions focused on milling millet, sorghum, processing and preserving meat.

One participant from Katyazo village, Mbarara District had this to say:

> "Millet milled on a grinding stone makes *kalo* (millet bread*)* so delicious. I like it because of its texture and flavor compared to the one milled by the machine. There is a way millet milled by the machine loses texture and taste compared to millet processed by a grinding stone. Besides, a grinding stone is available all the time. I cannot fail to eat "kalo" because there is power failure or there is no money in my pocket" (*translated from Runyankole to English).*

However, participants in all the sessions expressed disappointments over a number of challenges they face during the food security decision making process. The challenges mentioned were: undocumented indigenous knowledge, poverty, diminishing soil fertility leading to diminishing yields, theft of food and livestock. It was found out in group sessions that people no longer keep goats because of thieves. Another important challenge raised during focus group discussions was the absence of extension workers to provide services to farmers and guidance. Instead, there are NAADS officials, who were not reliable for political reasons hence no longer trusted by farmers.

Despite the fact that all participants were affiliated with various farmer groups, collaboration amongst farmers and stakeholders was limited. Participants complained of having limited opportunity to meet and share their experiences. This was mainly attributed to poor mobilization and lack of time as farmers spend most of their time working in gardens. NAADS staff who are supposed to mobilize farmers, only come when they are distributing items like seeds, livestock and others. Besides, emphasis is usually put on their distributed items. A participant was heard saying that 'NAADs is for rich farmers'. Lack of information on alternative ways of improving food security as well as effective collaboration were also mentioned as major challenges adversely affecting farmers' decisions.

3.7 From exploration to generic understanding

From the exploration, insights on how rural farmers were highly engaged in making decisions that matter for their survival, and the quality of these decisions needed to be enhanced were

gained We also gained deeper understanding on how farmers' efforts to improve food security were characterized by decisions that are complex, consequential, uncertain, non-reversible, non-avoidable and wicked (Keen & Sol, 2008). Farmers' decision making processes required coordination across all stakeholders for effective collaboration and innovative solutions.

It was further observed that rural farmers preferred working in groups that supported each other in the circumstances that surrounded them. Rural farmers attached great importance to knowledge and experience sharing, despite a number of constraints they faced in their rural context. It was profoundly realized that rural farmers may not always make optimal decisions but rather satisficing decisions due to circumstances surrounding them. This was in line with what (Simon 1995) says.

These insights informed us of the need for a food security decision enhancement artifact that would aim at enhancing rural farmers' decisions and strengthening their ability to overcome the challenges that hampered their efforts to promote household food security. We realized that rural farmers needed to be helped to overcome their decision making challenges. Best indigenous practices that promote food security needed to be documented and shared among farmers and stakeholders for sustainable use.

Furthermore, it was noted that the existing food security approaches (e.g. National Agricultural Advisory Services (NAADS), Plan for Modernization of Agriculture (PMA), Food and Nutrition Policy (FNP), and Operation Wealth Creation (OWC) provided minimal support to poor rural farmers because they are silent on the use of indigenous knowledge. They are mainly supportive to large and commercial farmers. Based on the aforementioned insights from the exploratory study, a food security decision enhancement studio (FSDES) was proposed to provide intervention outlines for enhancing rural farmers' decision making processes. Informed by the abstraction and exploratory study findings, it was realized that our starting point of collecting indigenous knowledge alone was not enough. The idea was expanded to include providing intervention schemata to CDWs to facilitate rural farmers using the studio, to enable them to address food security decision making challenges using indigenous knowledge.

Intervention schemata are a set of procedures outlining what the intervening agents (users) should do to properly use the studio. They are used in this research as schemes/recipes detailing what to do in order to use or when using the studio and its suites. The schemata can

be adapted and updated by the user to fit any given setting in the process of using the studio (FSDES). The Schemata work as sets of guidelines for using the FSDES. The schemata go a bit further than the scripts and ThinlLets in providing guidance to the users of the studio.

The FSDES would provide intervention schemata to CDWs to help rural farmers (who are generally semi-literate), to enhance their decisions on food security.

Specifically, the FSDES is expected to:

1. Provide a repository of intervention schemata to CDWs as recipes in their facilitation role of guiding rural farmers to enhance their decisions on household food security.
2. Provide an environment for collaboration between farmers and stakeholders in the decision making process.
3. Create a platform for knowledge and experience sharing among farmers and stakeholders in the decision making process.
4. Provide statistical facts for guiding interventions.
5. Provide a repository for indigenous knowledge and experiences of farmers for other farmers to learn from and improve their decision making processes.
6. Enable instant communication between farmers and stakeholders on crop and animal disease outbreaks, and provision of feedback to farmer queries for food security improvement.

In chapter four, the design of a food security decision enhancement studio (FSDES) is presented. The aim is to increase decision-making process agility among rural farmers.

Chapter 4 Design of the food security decision enhancement studio (FSDES)

In the previous chapters, a generic understanding of rural farmers' food security challenges and decisions made to ensure sustainable food security was gained. This chapter moves to the design of a food security decision enhancement studio. The FSDES provides intervention schemata to CDWs as guide on how to enhance rural farmers' decisions for household food security. In section 4.1 the design of the FSDES following Sol's 'ways of' framework is presented. Section 4.2 articulates the way of thinking. Section 4.3 addresses the way of governance. Section 4.4 presents the way of working and section 4.5 describes the way of modeling.

4.1 Overview of the FSDES design

The objective of this chapter is to express the design of the Food Security Decision Enhancement Studio (FSDES) for providing intervention schemata to CDWs as a set of guidelines to help them in the facilitation of rural farmers to enhance their decisions on food security. The intervention schemata are stored in the knowledge management suite and can easily be accessed by the user when logged in the studio. The user is free to adapt the schemata to fit the environment where the studio is being used.

The food security assessment tool for example can be changed depending on which part of the country the user is located. Wieringa (2014) argues that designed artifacts are intended to solve problems of stakeholders as well as providing answers to knowledge questions. Gregor & Hevner (2013) further argue that construction of socio-technical artifacts such as decision support systems is a purposeful intervention for helping people to overcome their real life challenges. The focus of this research was to address a real-life problem of food insecurity through purposeful intervention (Van de Ven, 2007; Gregor & Hevner, 2013).

The FSDES consists of four suites each containing specific services: the Assessment Suite, the Collaboration Suite, the Communication Suite and the Knowledge Management Suite. Each suite contains services and schemes to be followed by the CDWs as they intervene to support rural farmers to enhance their decisions on food security (see section 4.2.3).

The FSDES provides an environment for collaborative decision making and enables visualization of information about success stories and farmers' best practices particularly, on

selection of seeds, storage and processing of food. These processes are visualized as they are carried out by farmers using indigenous knowledge in unique and innovative ways. Figure 4.1 below represents an overview of the FSDES.

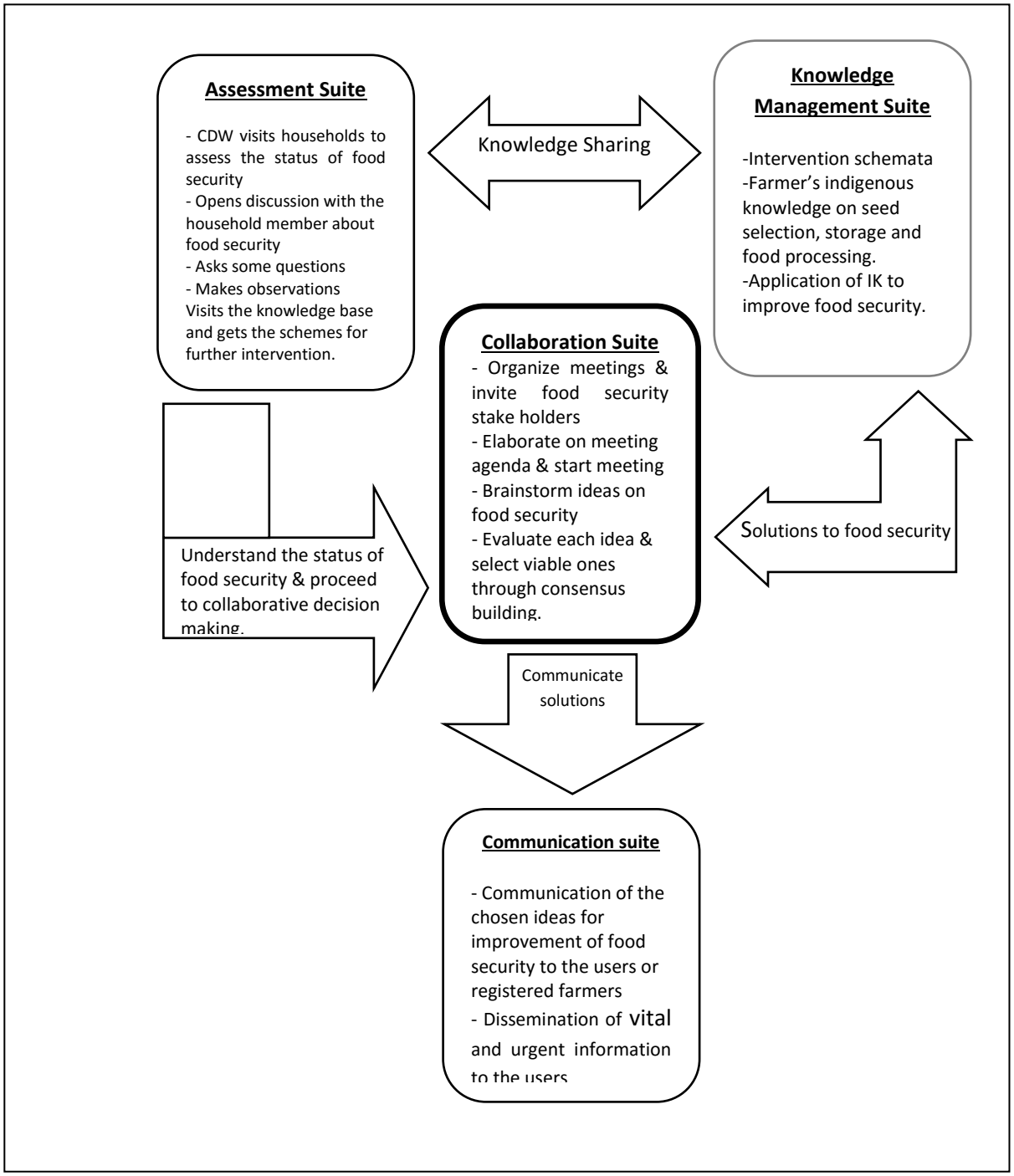

Figure 4.1: *overview of the FSDES*

4.2 The "ways of" framework

The FSDES is expressed by the underlying "ways of" framework namely: way of thinking, way of governance, way of working and way of modeling (Wijers & Sol, 1989; Sol, 1988; Habinka, 2012; Amiyo, 2013). The"ways of" framework, see figure 4.2, is used to assess methodologies and articulate artifacts (Habinka, 2012; Amiyo, 2012; Katumba, 2016; Mirembe, 2015; Aregu, 2014; De Vreeds & Briggs, 2005).

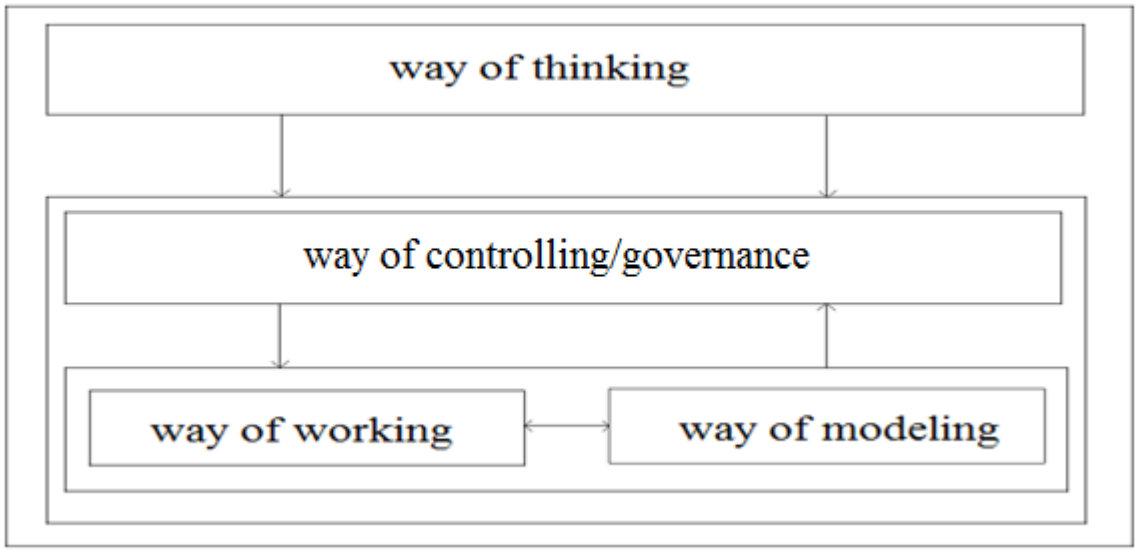

***Figure 4.2**: A framework for assessing design approaches (Sol 1988)*

4.2.1 The way of thinking

The way of thinking expresses the philosophical perspectives that are advanced to explain rural farmers' decision making processes for enhancing household food security. It articulates the underlying principles advanced in support of rural farmers' food security decision enhancement processes. Keen & Sol (2008) argue that the development of an interactive environment called a 'studio' for handling complex and uncertain problems in innovative ways is a significant contribution to society. In this respect, the line of thinking was that the FSDES should be able to provide an enabling and supportive environment for CDWs and stakeholders to engage rural farmers in collaborative decision making.

The FSDES is designed to enable interventions by CDWs using intervention schemata which expand their toolset for helping rural farmers enhance their decisions on food security. Intervention schemata are recipes to the intervening agents or facilitators to get to know what

to do in the process of helping rural farmers enhance their decisions on food security. Intervention schemata are developed and stored in the knowledge base of the designed artifact as recipes for the CDWs to facilitate farmers to enhance their decision making processes.

In the exploration and abstraction phases, we noted that rural farmers face a number of decision making challenges that constrain them from making effective decisions for improving food security. These challenges were: poor coordination between farmers and stakeholders, lack of information about indigenous knowledge, marginalization of indigenous knowledge by scientists, lack of effective communication, inadequate resources and unpredictable weather (climate change).

As one of the ways of addressing the aforementioned challenges, it was considered important to design the FSDES as a generic solution (Keen & Sol, 2008). The way of thinking with the FSDES is based on the interaction of three major elements namely: people, process and technology (Keen & Sol, 2008).

The **"people**" aspect refers to the rural farmers and others involved in food security decision processes. People make decisions basing on their indigenous knowledge experiences, values, skills and judgments (Keen & Sol, 2008). Rural farmers are often involved in decision making processes to ensure that they attain sustainable household food security amidst a number of challenges they face. These challenges greatly affect their decision making processes and decision outcomes (Tumwebaze, 2016). The FSDES is meant to provide a platform for sharing and assessing indigenous knowledge.

It was earlier noted from literature and the exploration phase that stakeholder coordination and collaboration have significant outcomes in terms of knowledge and experience sharing and therefore decision making processes. The FSDES is designed to provide an enabling environment for collaboration between farmers and stakeholders in the process of improving food security. It is further meant to provide an environment for knowledge and experience sharing between farmers and stakeholders. CDWs are facilitators in the FSDES who come in to help semi-literate and illiterate rural farmers to enhance their decisions using the intervention schemata which are provided and stored by the studio.

The proposition of this study was that, given the rural conditions and the context in which rural farmers operate, indigenous knowledge when made accessible to farmers could possibly be of great significance and a low cost alternative for improving food security. In such a context, group decision making became a potential solution where everyone with a stake in the field of food security participated.

It was further noted that some farmers had an accumulation of vast experiences in seed selection, storage and processing of food using indigenous knowledge. The FSDES may provide opportunities for sharing these experiences amongst farmers. It provides a platform for collaborative decision making and a channel of communication which enhance shared understanding on best and worst practices. The best and worst practices are documented and visualized in the studio for the benefit of all farmers and stakeholders. The worst experiences are shared so that they are as much as possible taken care of or avoided by other famers. The best experiences are shared for other farmers to learn and replicate them on their farms.

The studio environment enables engagement of key stakeholders (Keen & Sol, 2008). Extension workers, local leaders, local NGOs, CDWS village elders and family members come together in collaborative meeting to brainstorm on indigenous knowledge experiences in a bid to enhance food security. Specific tasks and activities to be performed by each category of actors/stakeholders are clearly defined in Table 4.1. Group decision making if well organized, could provide solutions to food security problems because it leverages each one's views and experience regarding appropriate knowledge combination. According to Keen & Sol (2008), multi-stakeholder collaboration if well-arranged, enhances knowledge sharing, increases commitment and translates into innovative and joint actions.

The **'technology'** aspect provides enabling tools for enhancing farmers' decisions on food security improvement. Technology may ease the process of making decisions by providing suites which contain services and accompanying recipes in form of intervention schemata for using the services. According to Keen & Sol (2008), technology can provide multiple types and levels of support to both people and processes focusing on sustainable food security. Technology can adequately support food security decision making processes (Tumwebaze, 2016) but can only do so if it is used as a tool which can be constantly modified to adopt additional knowledge and experiences of farmers in their local context (Timmermans, 2017; Aregu, 2014). FSDES is designed to provide appropriate tools for visualization and imaging of information on farmers' best practices that inspire other farmers to simulate and promote

food security and also to avoid worst practices. In this research, we argue that participants engaged in brainstorming, while viewing pictures and images of what they are discussing about are more likely to get focused. Images reduce people's cognitive load and tend to make people understand faster and better (Keen & Sol, 2008).

The '**Process'** aspect influences the likelihood of key players in the field of food security to make effective decisions. Keen & Sol, (2008) define a decision process as that process that has one and only one purpose: "making stakeholders have impact in handling decisions that really matter in their sphere of responsibility". Our focus was to improve on farmers' decision making processes. Decision processes in FSDES involve sequence of steps or activities which should be followed to enhance household food security.

Specifically, we considered "process" as an interconnected sequence of events that occurs over time leading to the desired outcomes for rural farmers. In FSDES, our major concerns were decision making processes rural farmers went through to ensure household food security. Processes like seed selection, food storage and processing which are critical decision making points of rural farmers were our main focus.

Rural farmers were seen going through a number of processes to ensure sustainable food security. Seed selection for example, follows a number of processes: consideration of traits of various seeds, the time each seed takes to mature, taste, color, cost and accessible markets until the farmer makes a decision that suits his or her preferences. The same processes go on with storage and processing methods. Decision making among farmers is often repetitive in nature and usually follows past experiences (Simon, 1957; Sol, 1982).

Accordingly, what worked in the past was most likely to be repeated by the farmer in the decision making processes (Sol, 1982). The aim of the FSDES was to provide an enabling environment for rural farmers to engage in decision making processes to improve food security. The FSDES is expected to enable agile processes for food security decisions; a combination of speed, flexibility, coordination, collaboration and innovation (Keen & Sol, 2008). According to Keen and Sol (2008), decision enhancement rests on interaction of people, process and technology together with their suites and recipes. Table 4.1 shows different key players in FSDES and their corresponding roles. CDWs as facilitators use the artifact to collect indigenous knowledge from farmers and post it to the knowledge base so

that it can be shared among the interested parties in their generation and assessments of courses of action.

Player	Roles	Examples
Domain practitioners	• To take decisions aimed at improving food security • To participate in knowledge and experience sharing • To brainstorm on topics of discussion • To share information concerning seed selection, storage and processing • To use FSDES through the support of CDWs to search for more information • To network and discuss issues on good practices through chatting in the studio	Rural farmers, farmer groups
Facilitators	• To be responsible for setting up and ensuring the functionality of FSDES • To make regular visits to rural farmers/ households • To conduct assessment on status of food security in homes using the intervention schemata • To provide support to rural farmers who need information from the studio • To intervene to provide assistance to farmers using the intervention schemata in the studio so as to overcome decision making challenges associated with limited information. • To engage farmers and stakeholders in collaborative decision making • To browse into the knowledge suite to get intervention schemata on how to advise farmers	Community Development Workers (CDWs)

	accordingly • To convene a village meeting with farmers and stakeholders • To lead brainstorming sessions: facilitate and guide group decision making • To encourage active participation • To take record of indigenous experiences and store in the knowledge base for reference to other farmers • To build consensus	
Domain experts	• To participate in collaborative decision making meetings and provide technical support/advice to farmers • To conduct farmer trainings	Extension workers (Agriculture and Veterinary officers)
Other Stakeholders in food security decision enhancement (FSDES)	• To participate in knowledge sharing sessions and offer advice on food security issues • To encourage rural farmers to use available resources for sustainable food security • To mobilize farmers for collaborative decision making • To lobby and push pro-people polices to the policy making platforms • To provide advisory services	Local leaders, CBOs, CSOs, village elders, social work practitioners
Administrator	• To ensure functionality of the studio and handles enquiries of farmers	Systems technician

Table 4.1: *Key players (actors) in the FSDES and their roles*

4.2.2 The way of governance

The way of governance expresses the managerial aspects of FSDES. It describes the aspects used to govern the studio environment that is supportive to rural farmers in the decision making processes. It further describes how various stakeholders interact and participate in the studio in order to enhance rural farmers' decisions.

To ensure that the FSDES addresses challenges rural farmers face, quality control measures for regulating interactions between farmers and stakeholders are provided by the intervention schemata in form of schemes, guidelines and recipes. Guidelines describe measures and methods for managing collaborative decision making processes (Keen & Sol, 2008; Kolfschoten & Vreede, 2006; Amiyo, 2012). The methods to measure quality aspects are specifically prescribed for ensuring smooth collaboration and effective decision making. Teamwork and consensus building among the actors are emphasized (Keen & Sol, 2008).

Guidelines further specify the direction, rules and steps to be followed when guiding rural farmers to enhance household food security. Guidelines also stipulate how interactions are to be carried out with due respect to each other's views and participation (see Table 4.2). Given the context of farmers in developing countries, the FSDES is meant to be controlled by the CDWs. They are guided by intervention schemata that are contained in the knowledge base of the studio which are modified and adapted as they are used in practice (see Table 4.2). Intervention schemata are aimed at expanding the CDWs' tool set and to improve on their efficiency while interacting with rural farmers. The CDWs can make adjustments on the schemata to fit the context in which the FSDES is being used.

Keen & Sol (2008) refer to way of governance as governance architecture, which may include principles, instructions, and rules of procedure as well as the shared understanding. The guidelines define tasks to be performed in an orderly manner during assessment and collaboration sessions in order to come to a shared understanding. Farmers and stakeholders coming together promotes shared understanding, creates transparency, lessens bureaucracy and reduces suspicion associated with extension services. Besides, collaboration leads to teamwork, effective knowledge sharing and commitment to action, (Kolfschoten &Vreed, 2009; Konate et al, 2014).

Communication in the FSDES is a two way flow of information. Farmers are able to communicate to experts (enquiring about something that is not clear and getting feedback

from the expert. When communication is effective, it helps to deepen networks between parties involved and it improves teamwork and commitment to the decisions made. Information sharing plays a significant role in decision making processes as observed by Figliuolo (2015); March & Simon (1958); and Simon (1957). In a multi-actor environment, it is imperative to consider and respect each actor's perspective while focusing on innovation. According to Figliulo (2015), coordination among actors depends on the ability to understand each other and to work together as a team.

4.2.3 The way of working

The way of working describes how planned interventions are to be carried out and how stakeholders interact and coordinate in the FSDES. It further articulates activities which need to be performed in the FSDES to enhance farmers' decisions. The activity flow diagrams describe the way of working. Decision making among farmers focuses on a number of activities at different levels of food production and processing. Following the design considerations and the way of thinking described in previous sections, four suites are identified to provide the required services in the FSDES. The four suites are: Assessment, Collaboration, Communication and Knowledge Management Suite. The suites contain specific services that are vital for enhancing farmers' decisions with the help of CDWs. In the FSDES there are intervention schemata stored in the knowledge management suite for supporting the CDWs as they collect indigenous knowledge and facilitate rural farmers to enhance their decisions on food security (see Table 4.2). Farmers and stakeholders are helped by the CDWs to use the FSDES and to share knowledge experiences related to food security improvement.

Assessment suite

The assessment suite provides recipes for appraising the status of food security in a given community by the CDW. It is a fact-finding process which should be performed on a regular basis. The suite provides procedures for acquiring vital information concerning the actual food security. The procedure assists the CDW in carrying out analysis of the farmer's best practices at the farm and in identifying gaps for appropriate interventions to improve food security. An assessment tool and sequential steps are provided in the intervention schemata to help the CDW in assessing and facilitating farmers as he/she adapts the schemata depending on the particular setting.

The assessment suite also provides statistical information on the status of food security. It shows computational analysis of assessment results got from rural communities and gives the CDW a starting point for intervening to address the situation.

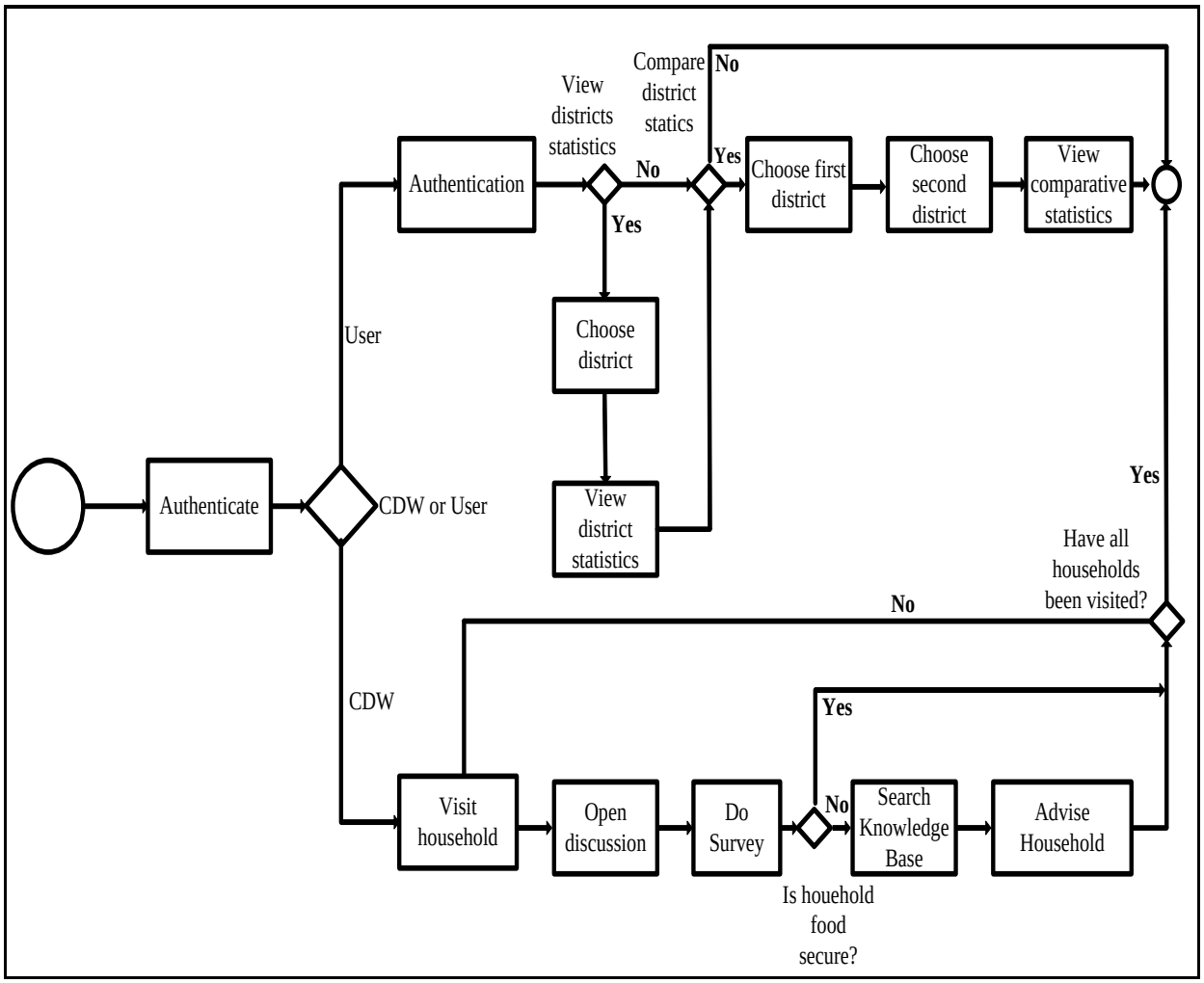

Figure 4.3: *Assessment activity flow diagram*

The statistics (percentages, graphs and pie charts) inform the CDW about which village, parish or household is doing better or worse. Statistics further inform the CDW about which household is unable to get the required meals in a day, which crop is most preferred in a given village and so forth. The assessment statistics form the agenda for the food security stakeholders' collaboration meeting. The CDW is guided by intervention schemata and recipes which are presented in Table 4.2.

Collaboration suite

The collaboration suite in the FSDES provides steps for engaging farmers and stakeholders in food security decision making. The collaboration suite describes steps that are crucial for collaborative decision making. FSDES offers an environment for collaboration among farmers and between farmers and stakeholders. It is a platform where farmers and stakeholders freely exchange ideas on food security improvement and come up with innovative and strategic decisions. Collaborative decision making enables farmers and stakeholders to share knowledge and information on best and worst practices as experienced by farmers. The initiator of the topic for discussion can invite people of his choice to the chartroom to discuss about the proposed topic by giving their views in a brainstorming manner.

As noted by Eseryel (2014), collaboration promotes sharing of experiences and practices in a specific context. During collaboration decision making, farmers are encouraged to brainstorm ideas, tell their stories on indigenous knowledge experiences from which the best ideas are agreed upon by consensus and shared understanding. The purpose of sharing indigenous knowledge experiences by farmers is to learn from each other the best and worst practices. Domain experts like extension workers and agriculture officers can provide technical advice by joining discussions in the studio. Collaboration stimulates comprehensive thinking and is a means of identifying best practices for addressing food security problems (Lasker *et al*, 2001). In the FSDES, CDWs take the role of intervention facilitators. The role of intervention facilitator is to provide support to rural farmers with no or low education background on how to use the studio (Table 4.2). A facilitator (CDW) gives assistance to farmers by using the intervention schemata to provide technical assistance to farmers and stakeholders who may want to use the studio themselves.

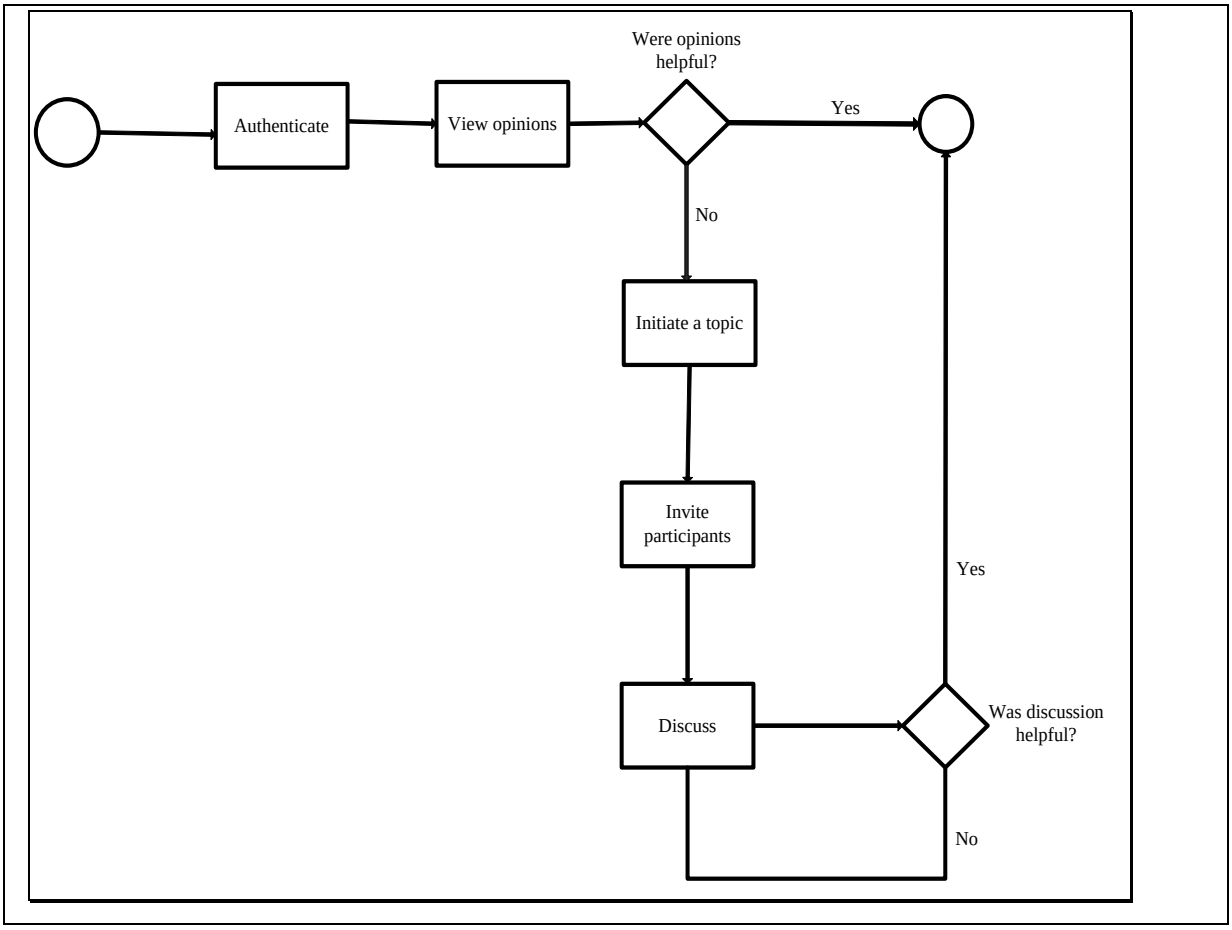

Figure 4.4: *Collaboration flow diagram*

Communication suite

The communication suite bridges the gaps among farmers, and between farmers and stakeholders. Information generated from collaboration sessions concerning food security (seed selection, storage and food processing) is instantly communicated and shared among key stakeholders. The FSDES provides a communication suite which facilitates sharing of information among rural farmers and stakeholders. It also provides a platform that enables farmers to make inquiries and get feedback from experts and fellow farmers instantly. Disease outbreaks are also instantly communicated in form of alerts.

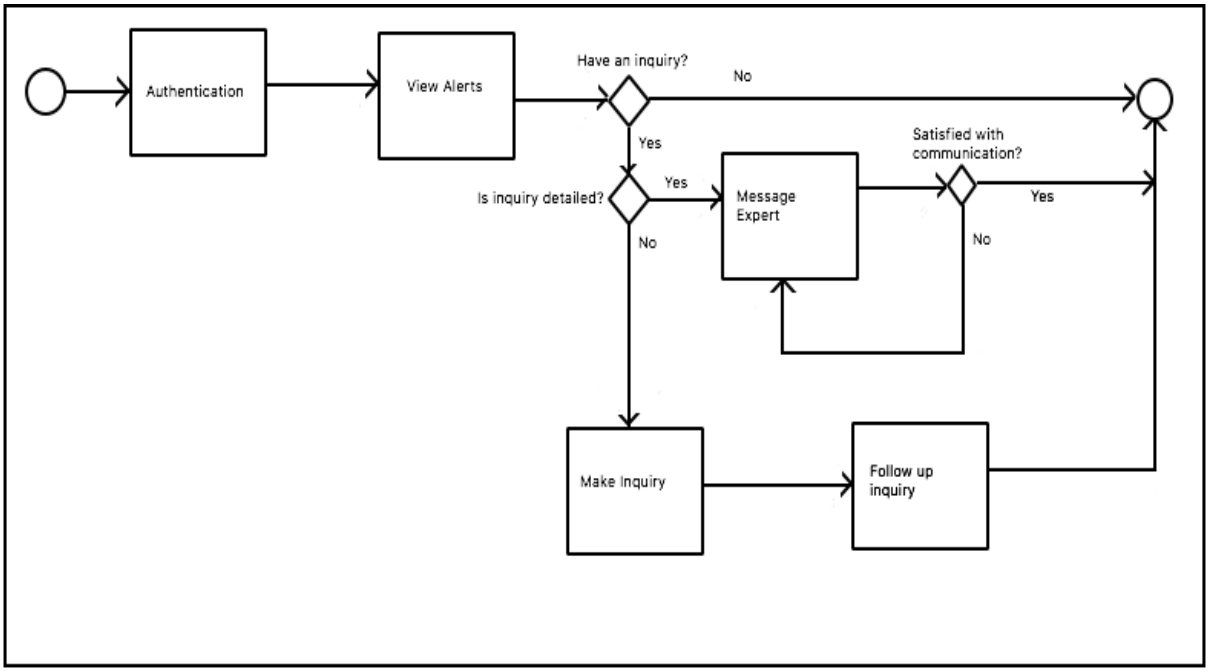

Figure 4.5: *Communication flow diagram*

As pointed out by Habinka (2012), involvement of several actors in solving a complex problem requires real time communication and instant messaging. Information sharing plays a significant role in decision making and problem solving processes (March & Simon, 1958; Simon, 1957).

Knowledge management suite

The knowledge management suite plays a key role in the food security decision enhancement studio (FSDES). It is a place where a combination of knowledge and farmer experiences are stored. It also stores the intervention schemata for CDWs to refer to as they facilitate farmers to enhance their decisions. These schemata may ease the work of CDWs if used appropriately. In the FSDES, knowledge is generated by farmers telling their success stories and experiences which are discussed and entered or stored into the knowledge base.

Farmers' knowledge concerning seed selection, food storage and processing are stored and can be retrieved when necessary for sustainable use in the promotion of food security. Sharing of information is jointly done in collaboration sessions. This makes retrieval and updating easier through collaboration sessions as this is a kind of learning from one another.

Before starting to use the studio, the CDWs or the farmers who can use the studio are required to read the intervention schemata first to be able to know what needs to be done but also need to adapt it depending on the circumstances or location.

Figure 4.3 - 4.6 show the flow of the activities in the assessment, collaboration, knowledge management and communication processes.

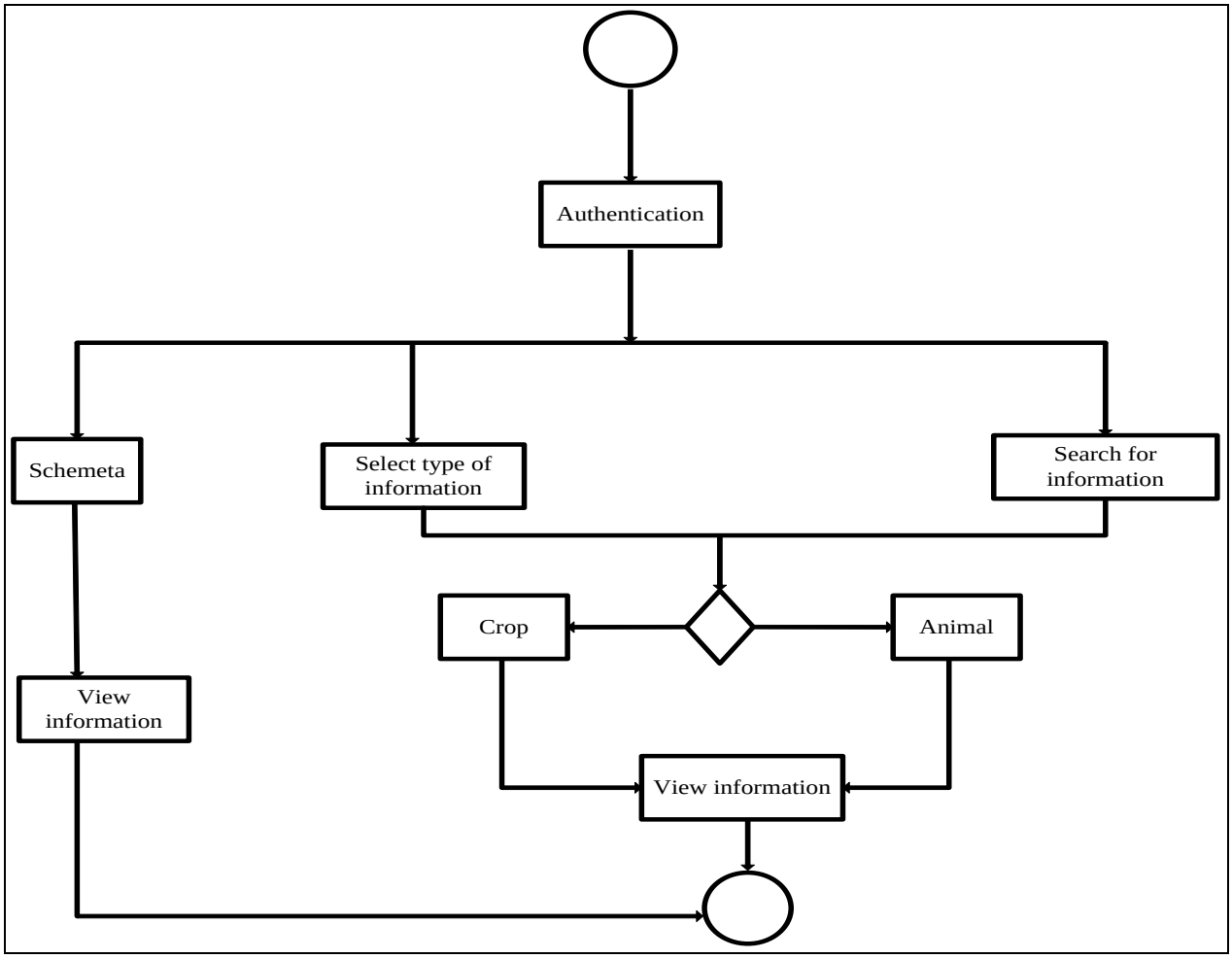

Figure 4.6: *Knowledge flow diagram*

The food security decision enhancement (FSDES) provides intervention schemata to CDWs and it is used depending on circumstances and the audience:

<table>
<tr><td>Assessing the status of food security</td><td>Assessment schemes (Establish the status of food security and get facts first)</td></tr>
<tr><td rowspan="2">Developing a systematic way of periodic checking on the farmer/household to assess the status of food security</td><td>Scheme A
(i) Conducting Assessment on food security</td></tr>
<tr><td>• Select criteria for visiting households (e.g. sequential or sampling)
• Go to the farmer/household
• Build rapport (introduce yourself and the purpose of visit)
• Talk to him/her about food security issues
• Observe farming and food security practices
• Check uniqueness and relevance of practices/ knowledge possessed by the farmer
• Login the studio and go to the knowledge base
• Check in the repository for additional knowledge
• Share the knowledge attributes with the farmer and have a consensus</td></tr>
<tr><td></td><td>(ii) Assessment of food security
Log in the studio
• Go to the assessment form
• Use it to get facts about food security from the farmer/ family member (this will generate assessment statistics automatically)
• Share indigenous knowledge attributes with the farmer and have a consensus
• Go to the assessment suite and look at the assessment statistics
• Use the statistics about food security with the farmer/farmer groups to see the strength and weaknesses.
• Plan for the village meeting with farmers and stakeholders to brainstorm on food security.
• NB. These steps may vary depending on the situation of food security on the ground and the CDW’s decision.

(iii) Assessment form (should be adapted accordingly)

Top of Form

Introduction

This assessment tool is meant to help you in the process of establishing the status of food security among rural communities/farmers. It is designed to assist you get the facts concerning the problems of food security and decisions taken by farmers to address the situation. You will find it easy to use whenever you feel there is need for intervention to help farmers enhance their decisions for improving food security. It will also ease the process of your interaction with</td></tr>
</table>

farmers by providing you with key questions to ask.

District

Type of farming

Crop farming

Type of crop/animal

-- Select type of crop/animal --

Type of farmer

- *Medium Scale Farmer*
- *Small Scale Farmer*

---

1. What factors influence you in the seed/animal breed selection process?

- *Maturity Period*
- *Disease & Drought resistance*
- *Previous yields*
- *Size*
- *Other*

2. Which type of Irish potato do you prefer most?

- *Victoria*
- *Kaabeera*
- *Rutuku*

	○ *Kachwekano* ○ *Other* ○ *Not Applicable* *3. Which type of beans do you prefer?* ○ *Rushare* ○ *Nambale* ○ *Misingiro* ○ *Kahuura* ○ *Other* ○ *Not Applicable* *4. Which type of bananas do you prefer?* ○ *Mbwaziruma* ○ *Njagata* ○ *Mivuba* ○ *Mbogoya* ○ *Kabaragara* ○ *Other* ○ *Not Applicable* *5. Which type of millet do you prefer?* ○ *Kahendarwiko* ○ *Kishekurwa Mpangare* ○ *Katomi*

	○ *Mahega* ○ *Other* ○ *Not Applicable* *6. What is your main source of planting seeds (planting materials)?* ○ *Previous harvests* ○ *Fellow farmers* ○ *Market* ○ *Other* *7. Which storage methods do you prefer for your harvested food stuffs?* ○ *Store constructed with local materials* ○ *Granary* ○ *Clay pots* ○ *Baskets* ○ *Other* *8. Which of the following methods do you use to preserve your food stuff against pests?* ○ *Spraying with chemicals* ○ *Local herbs and ash* *9. Instances of missing meals due to inadequacy of food* ○ *Yes* ○ *No* *10. Household able to have 3 meals in a day* ○ *Yes*

	No *11. Visible signs of malnutrition among children e.g. inflamed cheeks, hair color, underweight, bulged abdomen etc.* *Yes* *No* *12. Dietary diversification (Do households have a balanced diet?)* *Yes* *No* *13. Perceptions of the household head about adequacy of the food eaten in terms quality and quantity.* *Positive* *Negative* *Not Sure* *14. Food security safety nets available e.g. food in the granary/store, livestock owned, income generating activity etc.* *Yes* *No* *15. Local means of food processing available e.g. grinding stone, winnowing basket, mortar etc.* *Yes* *No* *Submit* *Bottom of Form*
Ensure Collaborative Decision making	**Scheme B** **Conducting Collaboration Meetings for improving food security**

<table>
<tr><td>(joint effort towards a goal)</td><td></td></tr>
<tr><td>Collaboration barriers</td><td>Need to be aware of possible collaboration barriers and be prepared to manage each one of them in collaboration decision making:
• Dominance
• Conflict
• Lack of goal alignment
• Lack of self-efficacy
• Formation of sides
• Unclear goals or questions
• Free riding
• Lack of overview
• Not having right participants with knowledge about food security</td></tr>
<tr><td>Areas of Collaboration</td><td>• Selection of right seeds and animal breeds to improve food security
• Right storage methods that promote food security
• Cost-effective methods of food processing that improve food security
• Effectiveness of indigenous knowledge in improving food security</td></tr>
<tr><td></td><td>Scheme C

Collaborative problem solving can be in 3 phases

<table>
<tr><td colspan="3">Build relationships for future collaboration</td></tr>
<tr><td>Diverge:
➢ Generate new knowledge
➢ Exchange information and share new knowledge</td><td>Converge:
➢ Reduce to distil information that is important for decision making
➢ Clarify to create shared understanding
➢ Organize information to reduce complexity</td><td>Reflect:
➢ Evaluate and compare alternatives
➢ Build consensus and commitment to decisions</td></tr>
<tr><td colspan="3">Interact and communicate</td></tr>
<tr><td colspan="3">Coordinate</td></tr>
</table>
Scheme D
Facilitation skills for enhancing rural farmers’ skills on food security:
• Encourage active participation
• Recognize active participation & lack of interest
• Lead brainstorming sessions on food security
• Create effective agenda</td></tr>
</table>

	• Hold attention and create focus • Understand expectations • Move the group forward • Build consensus about indigenous knowledge that promote food security • Invite constructive criticisms • Deal with individual differences • Facilitate and guide the group effectively

Using generated assessment statistics, develop agenda for stakeholders collaboration decision making (brainstorming and knowledge sharing)	**Scheme E** (i) **Collaboration sessions for improving food security** Design the meeting or workshop to brainstorm about food security • Invite participants • Create agenda • Prepare tools/ techniques • Guide the meeting • Give clear instructions • Use language that is at the group level • Encourage participation & invite different perspectives on food security • Set ground rules (better if they are set by the group at the start) e.g. respect for each other, speaking in turns, equal speaking time, accommodate different perspectives • Allow experts and experienced participants to share their expertise on food security • Ask open questions • Identify & resolve conflicts on different experiences on indigenous and food security • Spend time to get to know each other • Keep time • Wrap up & create rapport • Be impartial & objective. Facilitators have no say and opinion **Scheme F** (ii) **Collaboration sessions for improving food security** Arrange for a village meeting • Draft meeting agenda using insights from food security assessment statistics • Have a list of stakeholders (extension workers, local leaders, village elders, farmer groups, production officers, local councilors, NGOs, CSOs, CBOs) • Think who to invite and what their stakes in food security are • Get a suitable way of contacting stakeholders (SMS, e-mail, phone call) • Find a suitable venue and determine sitting arrangement (semi-circle or in circular form facing each other)

	• Begin the meeting with a cup of tea/soft drinks where necessary • Have a moment of prayer and introduction of participants • Avail the agenda to participants • Elaborate on food security assessment statistics and the implications they have • Set the rules of procedure and give guidelines for the meeting • Proceed to discussions on indigenous knowledge and food security • Build consensus **Scheme G** **Stakeholder collaboration sessions for improving food security** • Go to the chartroom in the collaboration suite • Develop the agenda • Have a topic of discussion on food security clear • Invite participants to brainstorm on the topic • Give time frame • Inspire participants to contribute ideas in relation to the topic • Ensure freedom of expression by discouraging personal attacks • Generate as many alternative ideas on seed selection, storage of food and processing as time allows (diverge). **Scheme H** **Divergence/ collecting information on food security and convergence** • Set scope, formulate sharp questions to indicate the required information on indigenous knowledge and food security • Allow experts and experienced participants to share their expertise on food security • Ask open questions • Limiting the amount of ideas often leaves with just obvious ones • Use small groups to discuss ideas before sharing them • List all the ideas provided • Create shared understanding of different perspectives on food security • Visualize different perspectives and explain reasons for different perspectives • Create Categories for the generated ideas on food security (seed selection, food storage & processing) • Identify where each of the ideas fall (organize) • Eliminate the irrelevant ones (evaluate) • Assess generated ideas on food security in their category and get the most feasible ones (converge) • Discard those that are not feasible to food security • Share best and worst experiences • Have shared understanding (build consensus) • Read the contents of the consensus to participants • Have a vote of thanks to participants • Adjourn the meeting

	Scheme I **Supporting convergence** • Define clear scope • Organize participants perspectives on food security in cluster • Select key ideas • Summarize sets of similar ideas in one phrase • Merge similar ideas • Identify and resolve statements • Filter ideas base on quality criteria • Make convergence visible for all; on flipchart, whiteboard or beamer • **Scheme J** **Consensus building on food security** • Distinguish differences of meaning & differences of information on food security • Different mental models • Ensure knowledge sharing, shared understanding and mutual learning about indigenous knowledge and food security • Different goals • Different taste • Conflict resolution, negotiation, trust building • Use clear and democratic decision making rules (communicate these in advance) • Have very clear and precise objectives for tangible results e.g. outcomes, decisions, commitment, consensus, awareness, team-bond etc.)
Communication suite	**Scheme K** **Enhancing real time communication between farmers and stakeholders in the process of improving food security**
Ensure free information flow between farmers and stakeholders	• Check clarity of resolutions from collaboration sessions • Edit and have clear message • Have the resolutions for improving food security circulated to concerned stakeholders • Get feedback from farmers and stakeholders on indigenous knowledge and food security • Log in the studio and update the knowledge base • Ensure farmers' needs are taken into consideration • Communicate any vital information (alerts) to farmers in time using alerts icon • Help farmers to make inquiries about food security by using inquiry icon • Try to have a follow up on farmers' inquiries and provide feedback • Connect farmers to specialized experts and their contacts for technical advice on issues about food security you are not able to handle

Synchronization of online and offline data	**Scheme L** • Start Navicat • Double click FSDES on the left hand pane-a list will show up in that pane • Select fsdes from the list by double clicking on it • Then go to the title menu and select tools; a dropdown menu will show up • Select data synchronization from the dropdown menu • A window will open with two forms: source & destination • Select FSDES from the source side and LOCALHOST from the destination side • In the section of the database, enter fsdes for both and then click compare and deploy button to proceed and then execute button to complete. Once synchronization is done, the loading screen should disappear.

Table 4.2: *FSDES intervention schemata*

As a way of visualizing interactions between farmers and stakeholders in FSDES, a use-case diagram is used to give a general overview of the key players' roles: the users, administrator, facilitator and stakeholders. The use case diagram defines the interactions among farmers, stakeholders and the facilitator to achieve the goal of the FSDES. It also shows how knowledge and stored in the knowledge base through collaborative processes. Users in our case include CDWs who are at the same time facilitators, farmers who are able to log in, and any stakeholder who has the privilege to log in and search for information.

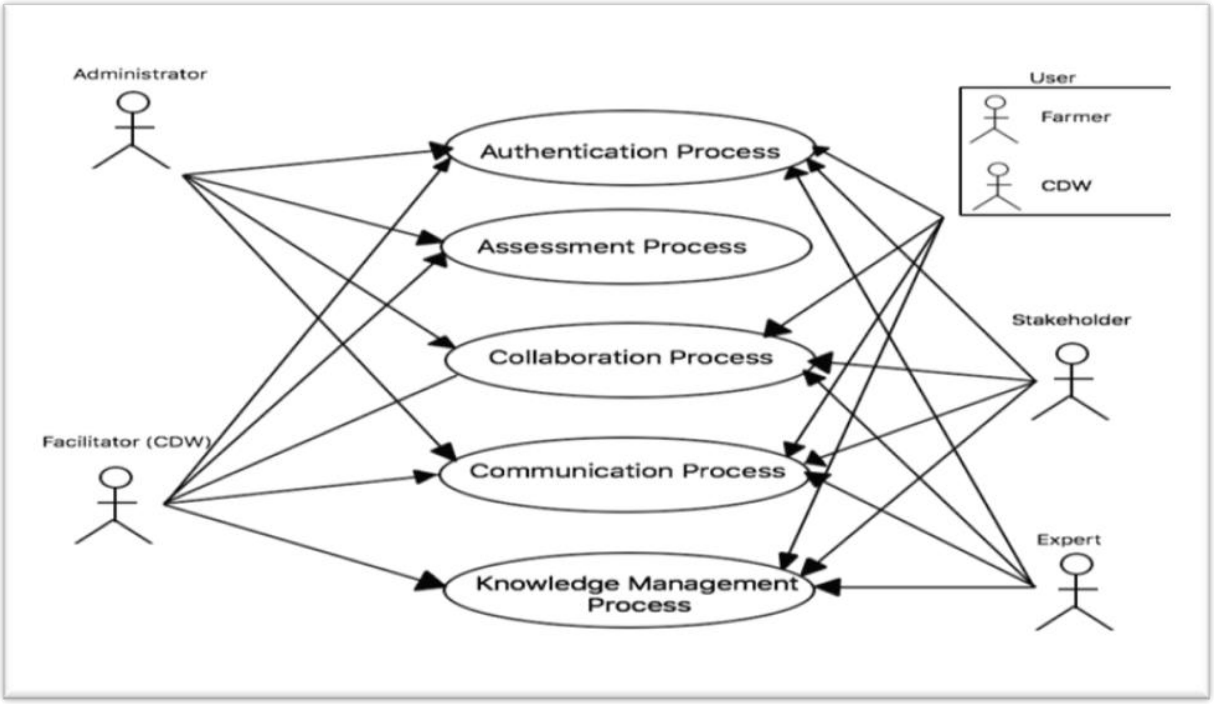

Fig. 4.7: *Use case diagram showing interactions in the food security decision enhancement studio (FSDES)*

4.2.4 The way of modeling

The way of modeling comprises the models and modeling techniques that are used in the application of the FSDES. Different models are used to classify and visualize the process steps and data flows of the various components within the FSDES. The intervention schemata which are also a form of guidelines and recipes for the application of the FSDES are provided. A use case diagram is used to identify the actors in the FSDES and their roles. It further shows five different processes that take place in the FSDES: assessment, collaboration, communication and knowledge management processes (figure 4.8). The intervention schemata for guiding users are contained in the knowledge base. Activity flow diagrams are used to demonstrate the flow of activities performed and processes followed when using the FSDES (see figures 4.2-4.6). Activities that are performed are encoded into an array of Java Script object notation and then converted into graphs, and activity flow diagrams.

As a mechanism of enhancing decision making processes, focus was put on information visualization in form of graphs, plots, spreadsheets, knowledge portions and pictures in the

FSDES. Graphs and pie charts demonstrate and visualize the findings from the assessment carried out and the actual decisions taken by farmers to improve food security. Graphs further summarize information and make it easily understood. They enhance comprehension of information.

In the next chapter, an instantiation of the FSDES is presented for guiding interventions to enhance rural farmers' decisions on food security.

Chapter 5 Realizing implementation of the food security decision enhancement studio (FSDES)

In this chapter the instantiation of the food security decision enhancement studio (FSDES) is presented. Section 5.1 discusses instantiation considerations. Section 5.2 describes the studio network and architecture. Section 5.3 presents the verification of the FSDES and section 5.4 provides the actual instantiation of the FSDES.

5.1 Instantiation considerations

Instantiation of the FSDES focused on collecting and availing indigenous knowledge to the knowledge suite for the benefit of farmers in addressing the challenges of food security identified in chapter 3 and the design considerations in chapter 4. Following the design described in chapter four, FSDES was instantiated into a studio prototype for CDWs to use by collecting and storing farmers' knowledge experiences. Unlike other studio implementation which is usually done by the programmer/researcher (World Bank, 2007), the FSDES is implemented by the users themselves (CDWs). CDWs go to farmers with the studio prototype, login the knowledge suite to access the intervention schemata, interact with farmers, ask questions about indigenous knowledge used to improve the status of food security and submit. The results automatically go the knowledge suite and display as assessment statistics (see figure 5.6). The CDWs go to communities/farmers and interact with them on issues of food security and indigenous/modern knowledge used to improve on it. The CDWs record and store knowledge of farmers in the knowledge base using their laptops, tablets or smart phones.

In the exploration phase, it was noted that education levels of most rural farmers were low, and this constrains their decision-making efforts to improve food security. In order to address this constraint, CDWs were engaged as facilitators to help semi-literate and illiterate rural farmers to enhance their decisions on food security using indigenous knowledge. Borrowing insights from Van de Ven's ideas of engaged scholarship, we focused on having a participatory implementation of the FSDES using the schemata and adapting it to fit the context while taking into consideration views of the users and key stakeholders (Van de Ven, 2007). This agrees with the arguments of Wiskerke and Van der Ploeg (2004) that the

development of a product while putting into consideration user requirements, characteristics and context makes it more relevant and useful.

Instantiation was to be contextualized by modifying the schemata and the assessment questions. Modifications and refinements were meant to suit the context, experiences and expectations of farmers and users. CDWs and some farmers were involved in collecting and filling the knowledge base with indigenous knowledge experiences. An initial instantiation of the FSDES was presented to CDWs to use it as they moved around farming communities collecting and filling indigenous knowledge into the knowledge base.

5.2 Network architecture

The FSDES architecture is based on the principles of Service Oriented Architecture (SOA) as described by Aregu (2014). The SOA makes the FSDES simple, flexible, and good with agile levels of application (Keen & Sol, 2008; Aregu, 2014). The FSDES architecture builds on the applications and principles for implementing decision enhancement services. The studio is both online and offline. The offline mode utilizes XAMPP which is an open source server. When online, it utilises the power of the internet and the World Wide Web to run. When it is offline, it utilises XAMPP open server which creates a web server and a database on the local machine (*see scheme L, table 4.2*). The request to access the offline version is sent to http://localhost/FSDES/. The online version is accessed at http://www.fsdes.com. The request for the offline version skips the internet layer and the online one is sent through the internet layer. The XAMPP webserver stores structured data locally on the user's device using SQL. Once the specific device gets to a place that has internet connection and FSDES is logged in, automatic synronization occurs and data is submitted to FSDES. This allows CDWs and farmers in remote areas to continue inputting data ubiquitously (see figure 5.1).

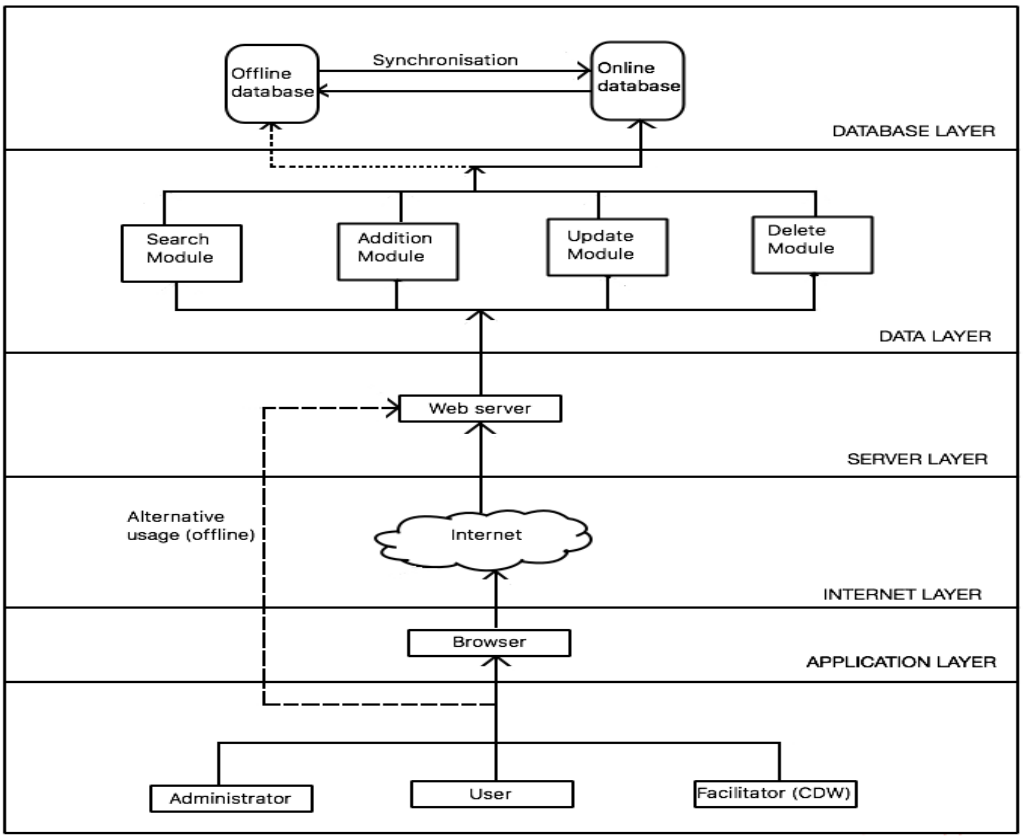

Figure 5.1: *Architectural diagram for the FSDES*

The user, for instance, makes a request through the browser for certain information. The browser forwards this request to the web-server via the internet. The internet layer allows access to the knowledge base irrespective of geographic limitations. The web-server then gains access to the functional layer and matches the request received to the appropriate functional modules while considering the appropriate privileges.

In our case, the user has the privilege to search and view information in the studio. The search function processes the request and accesses the database (which is the knowledge base). It then forwards the response from the database back to the web-server via the internet which then sets it (the response) in the user's browser.

5.3 Programming

Instantiation was done using several programming languages and frameworks. For the front-end, Hyper Text Mark-up Language (HTML5) along with Cascading Style Sheets (CSS3)

were adopted. HTML5, XML and CSS3 were used because they are standard for web development.

JavaScript was used to handle the service requests and submissions on the user's side given that once a page loads, JavaScript runs within the user's browser. This is not only efficient but also increases speed since an entire page does not have to be reloaded to perform particular tasks thus increasing interactivity.

An open-source framework known as *bootstrap* (for CSS3 and JavaScript support) was used to aid in styling the interfaces of the system. In addition, JQuery library (also a JavaScript framework) was used alongside the bootstrap framework to aid with JavaScript programming. A combination of these two frameworks was used to render graphs onto some web pages.

On the server-side, Hypertext Processor, initially referred to as Personal Home Page (PHP), was used to handle service requests and submissions from the user end. PHP was the preferred choice given its open-source nature (Xiao-Jun, 2006) as well as its support for various programming styles and techniques namely: Procedural Oriented Programming and Object Oriented Programming, which provide for diversity in choice. PHP was mainly used to access information from the database and then render this information into the web page directly or pass this information to a JavaScript that had requested it. PHP allowed for the system's pages to have dynamic information. It was also used to perform calculations.

My Sequence Querying Language (MySQL) was the choice of database used. One of the reasons MySQL database was chosen because it supports multi-user access over a network (in this case, the internet). Given that the system would be queried by various users at any particular time, this was a crucial deciding factor.

5.4 Verification of the FSDES functionality

Verification workshops were held with the CDWs and stakeholders in the field of food security to check the functionality of FSDES before it could be fully put to use by the intended users. In the workshops, navigating the studio was done to check the functionality and responsiveness of the suites while trying to fill in the content. Meeting sessions were arranged with the help of District Community Development Officer (DCDO) Kabale, who

mobilized 4 CDWs in the selected Sub Counties. In Mbarara, mobilization was done by the District Probation Officer (DPO) in 2 Sub Counties. A similar verification meeting took place at Kyambogo University with students of Bachelor of Social Work and Social Administration and staff members from the Department of Sociology and Social Administration. Verification checks were done on FSDES to identify possible errors and to take corrective actions. Remarks of participants were recorded during sessions with the help of research assistants and were later taken into consideration.

The exercise began with a brief introduction of the research problem, objectives, findings and the designed studio (the FSDES) a week before the actual verification. This was intended to give participants ample time to read through and get more insights about the FSDES. Besides, the date and suitable time for the next meeting were agreed up on. Each session lasted for three and half hours. It involved navigating through the studio shell checking on functionality of each of the suites (see Table 5.1).

Verification Process

Navigating through the Studio components	Verification procedure
Home page (Establishing whether all links are responsive)	• Check if all links are active and responsive • Check if the signing up part is active • Create an account • Click on all menu icons on home page and check if they are responsive • Try to create your own account by signing up (enter your name, username, e-mail address and password) • Click sign up button and then register by filling in the form that is displayed. • Try signing up as a facilitator and follow the links
FSDES welcome page (Establishing the responsiveness of drop down menu)	• Read through the welcome message and check for errors and meaning of the content • Click on the assessment form and navigate in it. • Try filling and submit Go down the drop-down menu bar and check if whether all links are responsive • Click on view crops and view the information on crops you have entered • Click on animal category • Check if it gives provision for entering information on different types of animals • Try to click add animal icon, then enter animals by name (e.g. cows) and then enter as many types as you know; describe features and characteristics of each type and try upload a picture

	against each type • Click farmer experience and try enter knowledge and experiences of farmers you can think of • Click view farmer experiences to view knowledge and experiences of farmers about particular crops and animals • Click alerts and check if it takes you to "add alerts" and" view alerts" • Click on inquiries and check if you have a provision for recording and viewing farmer inquiries • Click on the link "experts" and check whether you are able to add expert and his contact and also to view the list of all experts • Log out by clicking on the shadow picture on the top of the right corner of the welcome page to be able to log out of the admin side • Click public domain to be able to back to the home page
Users' welcome page: Assessment Suite	• Sign up and register as a user by filling in the form provided • Click and read the welcome message. • Go to assessment suite on the menu bar • Check if it is active • Click on the assessment results for general and districts results • Check if the statics make sense • Check statistics per district
Collaboration Suite	• Click collaboration to check if it takes you to collaboration meeting, farmers' views and chartroom • Check to see whether collaboration meeting takes you to a link for farmers' views • Check whether chartroom is active and can take you to a chat screen • Try to give your opinion by typing in the space that shows
Communication Suite	• Check whether communication suite leads you to "alerts", "make inquiry", "follow ups" and "experts" • Click on alerts icon to check if it leads you to posted alerts by other farmer and stakeholders • Click "inquiry" and check if there is a provision for a user to make an inquiry • Click "follows up" to see if you can see the status of your earlier inquiry. • Click "experts" to check if you can access the list of experts and their contacts
Knowledge Management Suite	• Check on the intervention schemata. Does it contain accurate steps to CDWs for facilitating farmers? • Navigate the assessment form. Are assessment questions okay? • Click "knowledge base" and check whether it leads you to crops, animals and search engine links • Click on crops link and check if you are able to view different types of crops. when you Click on any one type of crops, you will be able to view types of that particular type of crop

	• Click on any type of any particular crop and check whether you are able to view the farmers' rating of that crop • Check whether you are able to view farmer knowledge and experiences with that particular crop • Click on animal link and follow similar procedure to check and view livestock; their types, preferences of farmers and rating of each type of livestock. • Check if you are able to view stories as they are told by farmers regarding seed choice and storage. • Click on search engine to check whether it leads you to the form. Fill the form and submit it for quick search of crop or animal of your choice and get information about it.

Table 5.1: *FSDES Verification walk through*

Verification was intended to check the functionality of the FSDES and also to orient the users on how to use it. In the process of navigating the FSDES and verifying the functionality of the suites, more clarifications were made to the participants with regard to what they are expected to do. It was observed that participants were eager to use the studio that had been introduced to them during the design phase in chapter 4. In the verification process, focus was put on checking the consistency in the FSDES and the schemata. Participants were also given an opportunity to ask questions and to suggest adjustments/improvements as they walked through the FSDES. Inactive icons of the studio were activated and intervention schemata refined as suggested by the participants. After verifying the functionality of the studio it was installed on the computers of CDWs to go to farmers and fill it with farmers' indigenous knowledge experiences and to continue adapting the schemata where necessary.

5.5 Description of the FSDES and the intervention schemata

As already pointed out, the FSDES is instantiated by CDWs with the help of the intervention schemata (Table 4.2). The intervention schemata guide the CDWs in their effort to help rural farmers address food security decision-making challenges described in chapter 2 & 3. The schemata include an outline of steps to follow while facilitating rural farmers' decisions on food security. The intervention schemata are developed and stored in the knowledge management suite. The FSDES consists of four suites, which appear on the left hand corner of the dashboard: Assessment, Collaboration, Communication and Knowledge Management suites (see figure 5.2).

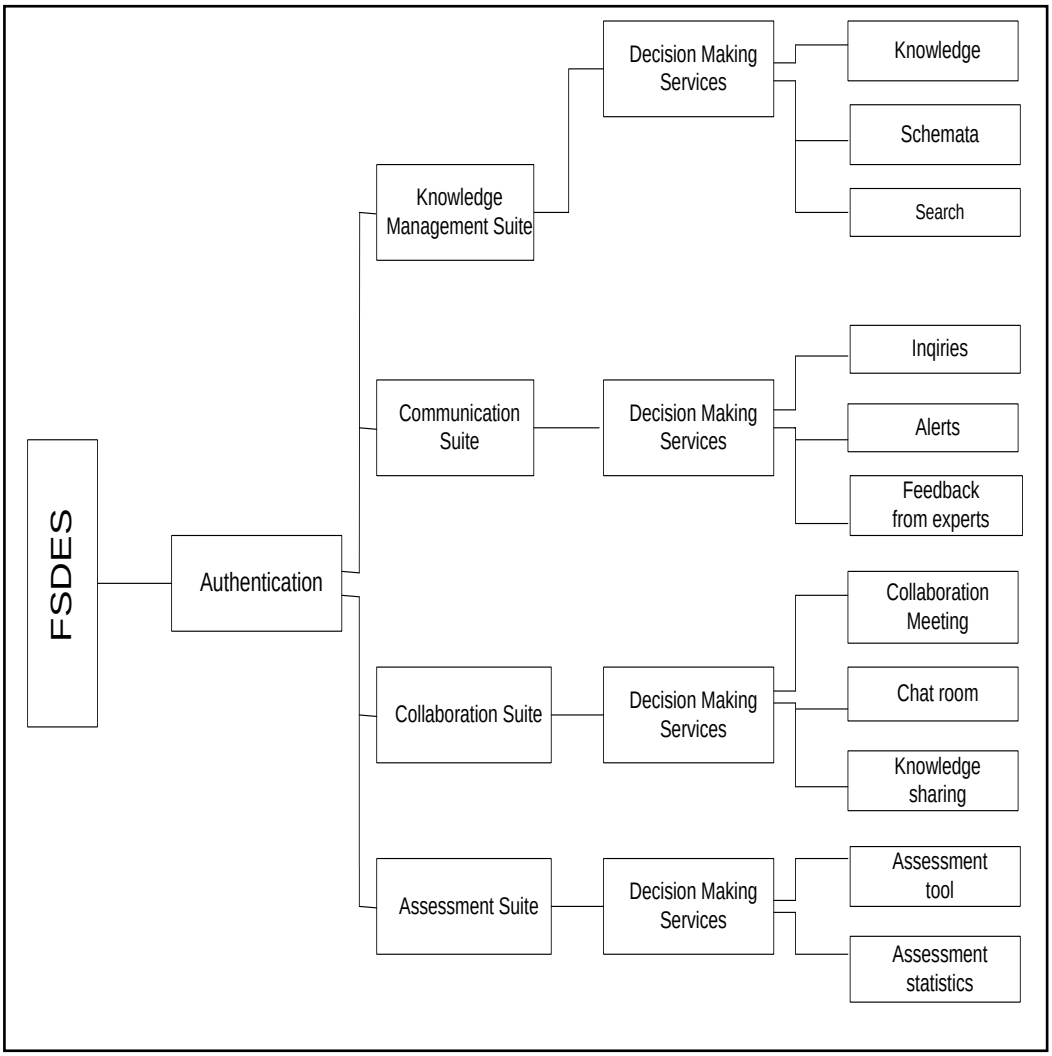

Figure 5.2*: FSDES prototype layout*

Each suite contains specific services aimed at guiding the user in the process of decision making processes. The FSDES is hosted under the domain name *www.fsdes.com* (see figure 5.1). Users can create their own accounts before they start using the FSDES. Users are basically CDWs but farmers who have the capability can as well be users. Key stakeholders

who may wish to participate in the intervention work of enhancing rural farmers decisions can register and become users.

CDWs play two major roles in the studio. They are administrators and at the same time they are users. They are users because they facilitate farmers by guiding them on how to use and benefit from the studio. As administrators, they regulate the operation of the studio; they update the studio with new information and erase information that is no longer useful to farmers. With time, some farmers can become facilitators of their fellow farmers thus making FSDES more sustainable (Keen & Sol, 2008). Administrators log in as facilitators to be able to update information (see figure 5.1).

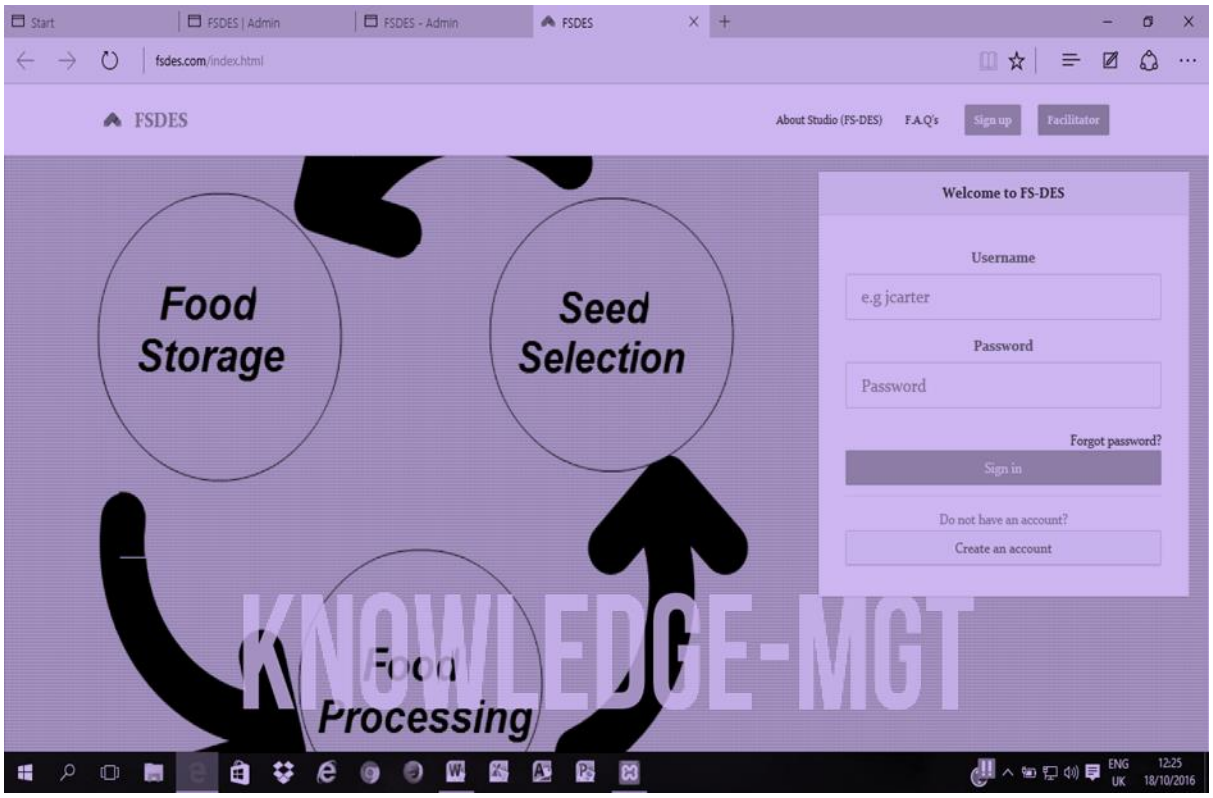

Figure 5.3: *The FSDES interface*

The FSDES focuses on three core areas: seed selection, food storage and food processing. The user interface welcomes the user with the animation of the suites which are contained in the studio. Besides, the interface has a link of what FSDES is about and frequently asked questions (FAQs) on the right top hand corner. Most important on the interface is the sign up link and a registration form for the users and the facilitator. A potential user has to register by filling in the form that displays after clicking the sign up link and then sign in by filling the

username and the password. When a registered user logs in, a dashboard with a summary of information contained in the FSDES is visualized.

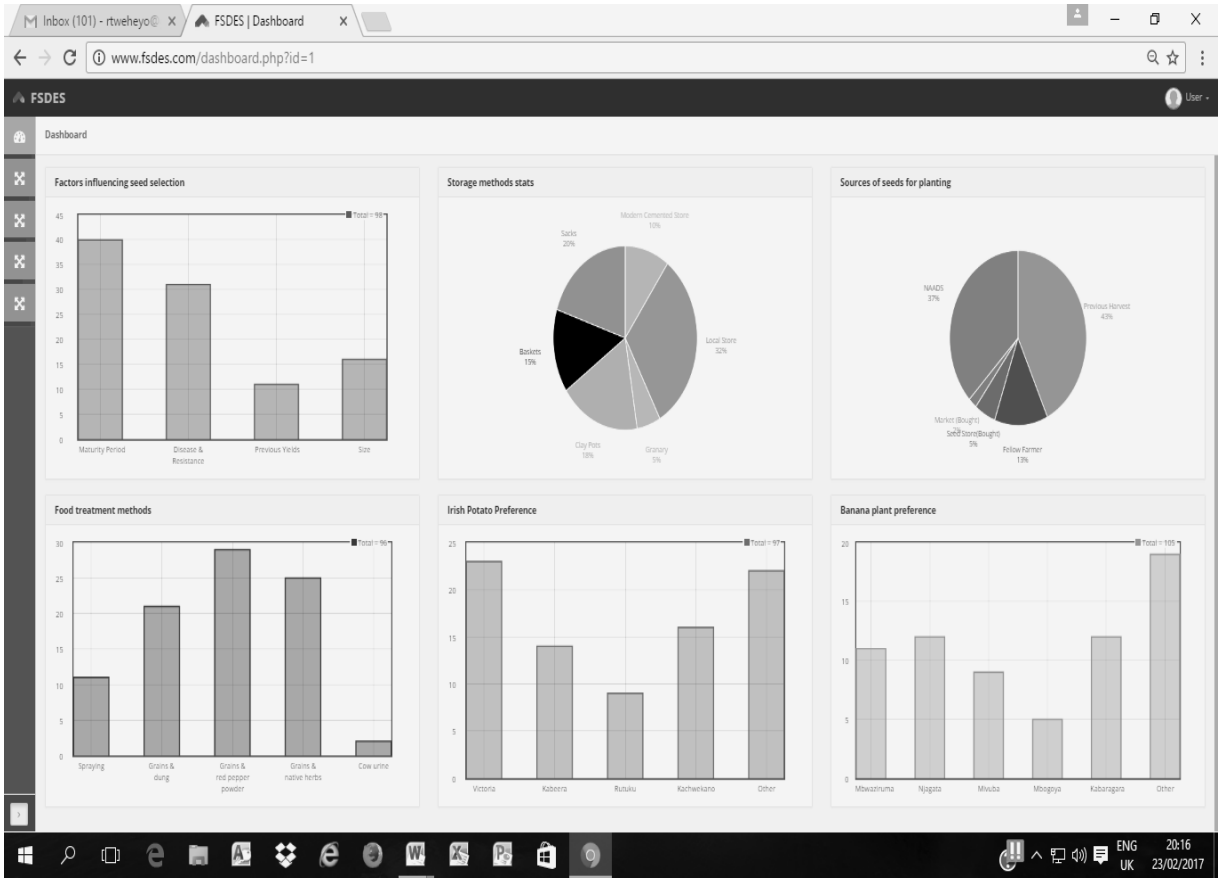

Figure 5.4: *FSDES user dashboard*

The dashboard presents statistical information about the status of food security in form of graphs and pie charts and visualizes it to the users. On the right top corner, a dropdown menu appears for users to select whatever information they wish to look at by clicking the menu bar. On the left hand side of the dropdown menu bar, there are four suites which are contained in the studio and are displayed as Assessment Suite, Collaboration Suite, Communication Suite and Knowledge Management Suite. Each of the suites on the menu bar a link that is clickable and expands the drop down menu displaying other services enclosed in the suite. The link which has a grey background becomes active up on putting a cursor on it and shows a white color and a green box behind it up on clicking it. This enables the user to track or search for the needed information/service in that particular suite. When a particular item on the menu bar is clicked, a corresponding web page containing the content of the selected menu item is loaded and displayed. In each of the suites, the major issues considered

during instantiation were farmer's knowledge experiences and how they influence their decisions in the process of achieving household food security. A detailed description of the suites and services they provide is presented in this section.

Assessment Suite

The assessment suite contains facts about the situation of food security on the ground in rural communities. Assessment is a vital aspect of defining the status of household food security as noted by Payne (2014). The assessment suite guides CDWs in the process of establishing the status of household food security in a given area. It contains relevant questions to be asked and observations to be made in order to get the required information from community members.

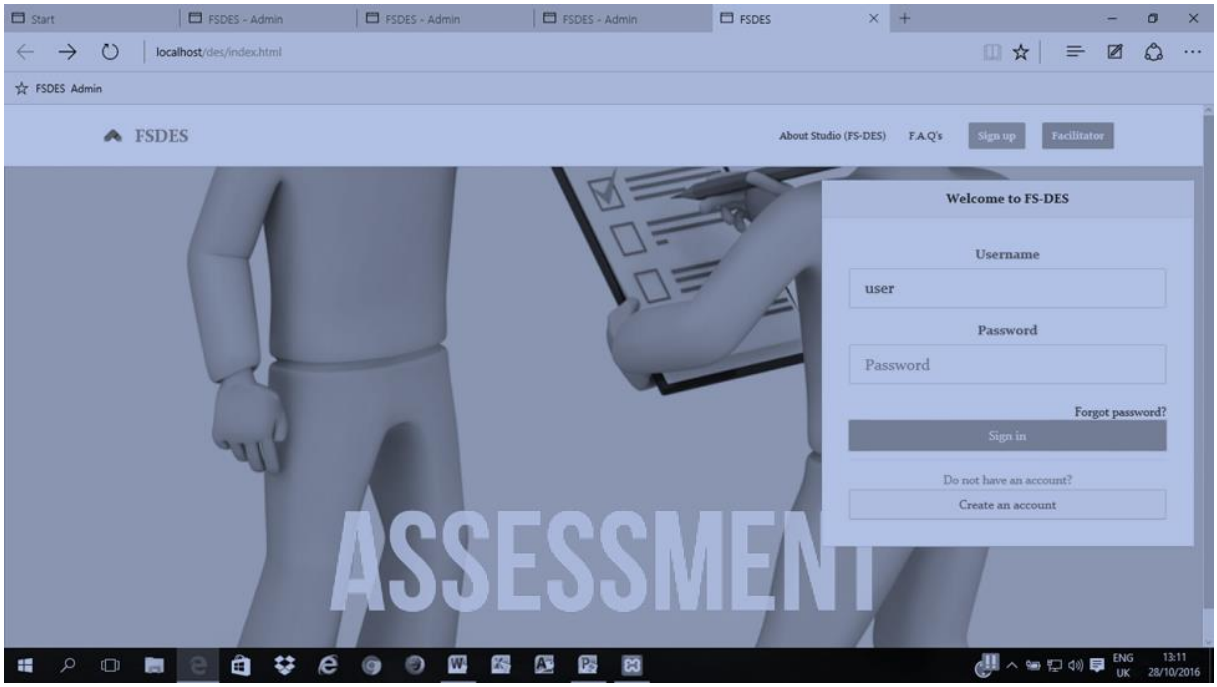

Figure 5.5: *Assessment exercise*

To be able to guide farmers and communities better, a periodic assessment of the status of household food security is required to inform the CDWs of the actual status. For this reason, an assessment form is designed as part of the intervention schemata for CDWs to use in the assessment exercise. This is designed in such a way that it can be refined by the users to fit the context in which it is being used. The CDW accesses this form when he/she logs in as a facilitator but can also get the form from the intervention schemata in the knowledge base. The assessment results are automatically generated and summed up statistically in form of

percentages, pie charts and graphs for a given district. The statistics will guide the CDWs on critical areas that need urgent attention as he/she intervenes to help farmers enhance decisions to address the situation. Statistics results are put high on the agenda in a village collaboration meeting between farmers and key stakeholders sharing knowledge and experiences on how food security problems can be jointly solved.

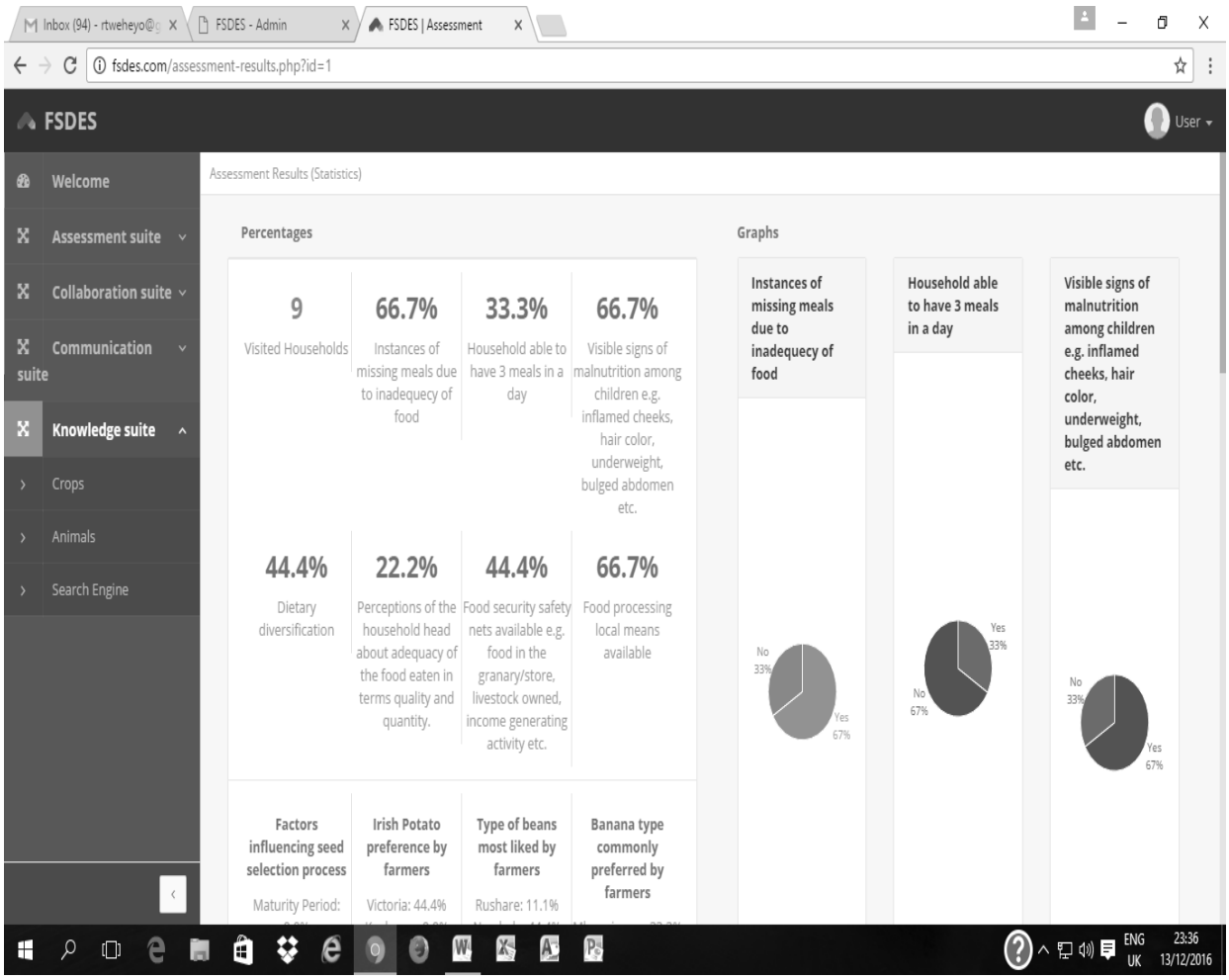

Figure 5.6: *A screen shot of assessment statistics*

The suite presents results that are interpretable and analyzable for effective decision-making. By simply looking at the statistics, the CDW is able to know which district, village or household has the highest incidences of missing meals, malnourished children and which farmers use indigenous /modern knowledge of food storage and food processing. The results will inform the CDW and farmers on how they are performing in comparison with their neighbors. CDWs together with key stakeholders will the use assessment statistics to tell which household or village needs urgent interventions. Stakeholders like local NGOs and

government agencies are able know which district is doing better or worse and this will enable them to make decisions as well as the required interventions.

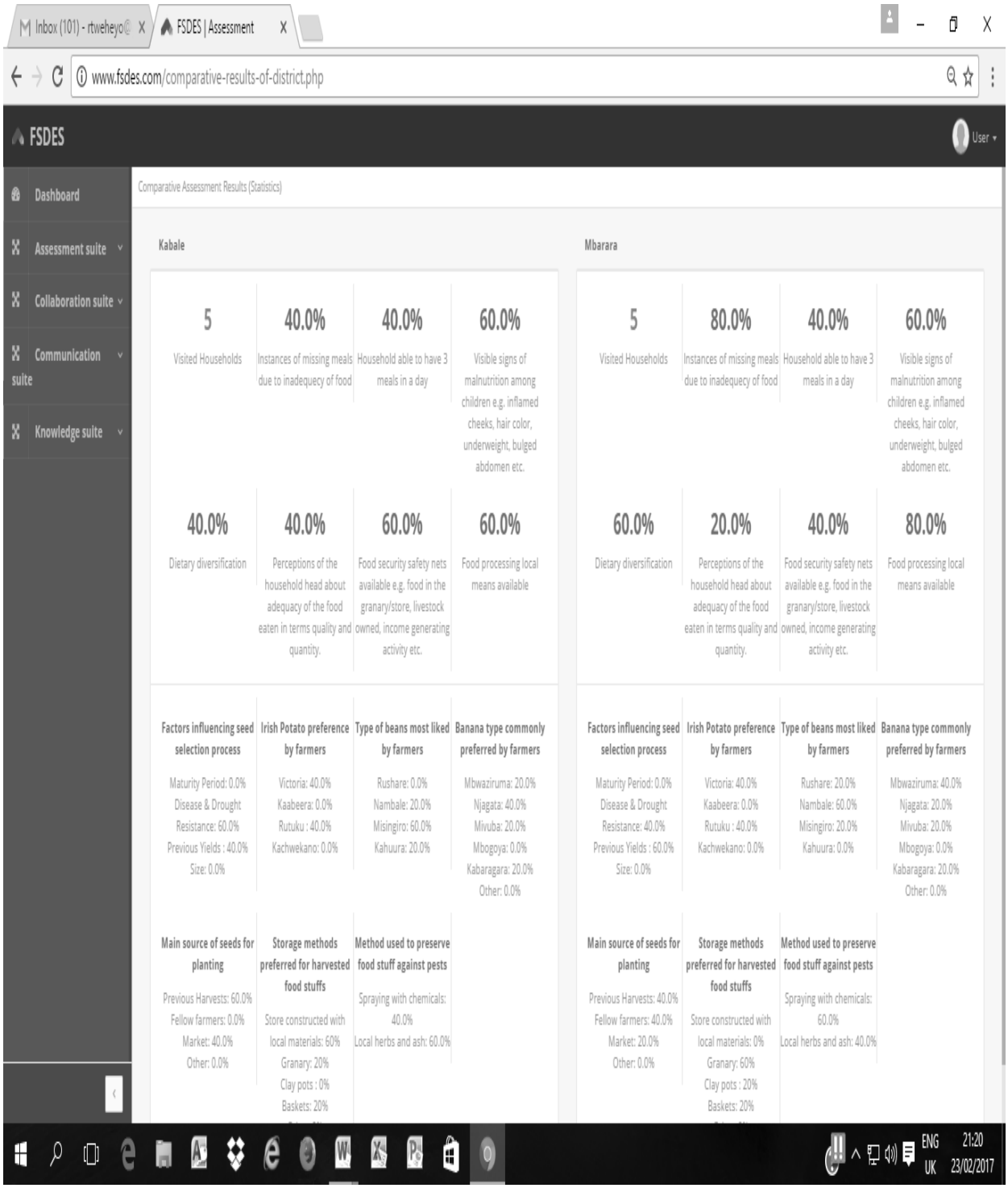

Figure 5.7: *A screen shot of comparative statistics*

In the assessment suite, it is possible compare two districts in terms of the status of food security by selecting any two districts of choice. Assessment statistics form topics of

discussion in collaboration sessions between farmers and key stakeholders in the food security decision making process. Farmers and food security stakeholders have the opportunity to brainstorm on assessment results discussing the best and worst practices by individual households. It is also an opportunity to share experiences among farmers and stakeholders. The assessment exercise will also assist the CDW to carry out analyses of the farmers' best practices and identifying appropriate interventions that can offer improvements in household food security.

Collaboration Suite

The Collaboration Suite provides a platform for engaging farmers and stakeholders in a discussion about food security issues in a brainstorming manner. Every registered farmer can post his/her opinions suggesting ways in which food security could be made better. The link allows any registered user to initiate a topic of discussion and to invite the views of other farmers and stakeholders. It represents a decision-making style where every registered user can join the discussion sessions in a way of brainstorming by instant messaging. It offers a platform for engaging farmers as domain practitioners in food security and key stakeholders in a group discussion. Collaboration builds teamwork and enables knowledge and experience sharing as a means of identifying alternative ways for addressing food security problems, see (Lasker *et al,* 2001). Collaboration literally means working together with others to achieve a common goal (Kolfschoten *et al*, 2011). FSDES has a provision for farmers to give their views regarding issues of their concern and also to participate in a discussion by chatting using the chat room that is provided on the dropdown menu bar. When the collaboration suite icon is clicked, a link for collaboration meeting and farmers' views are displayed, (see figure 5.8).

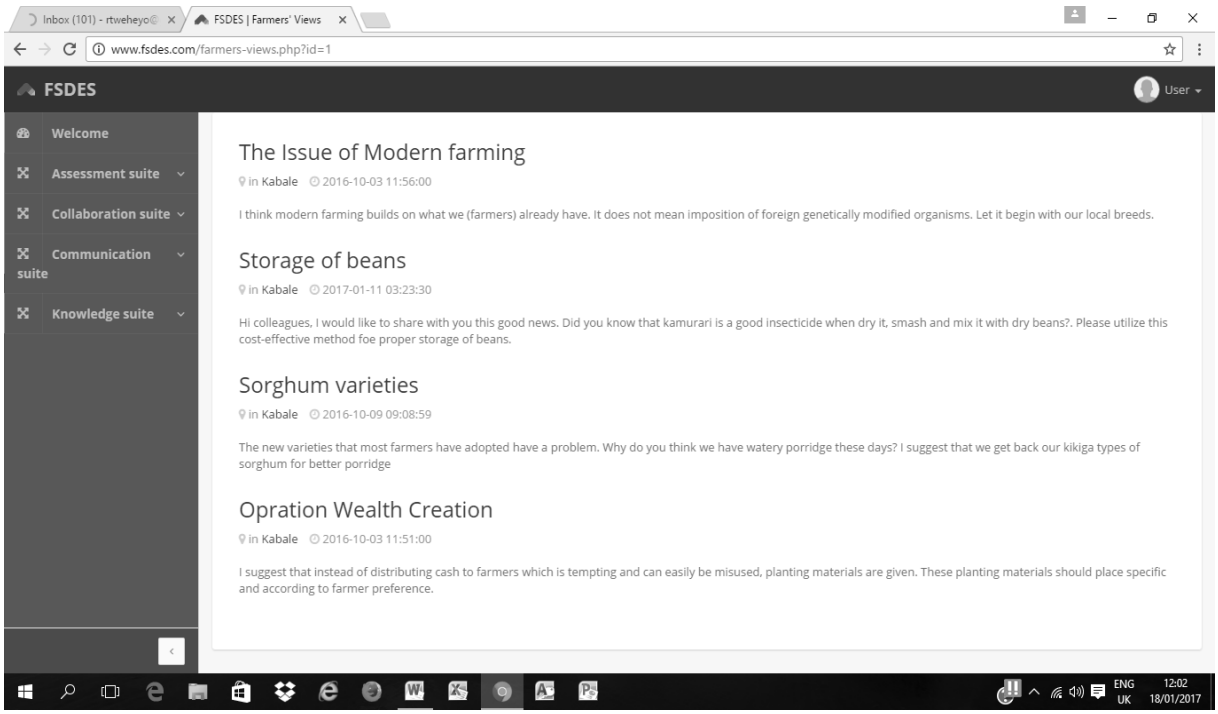

Figure 5.8: *Farmers views in a discussion forum*

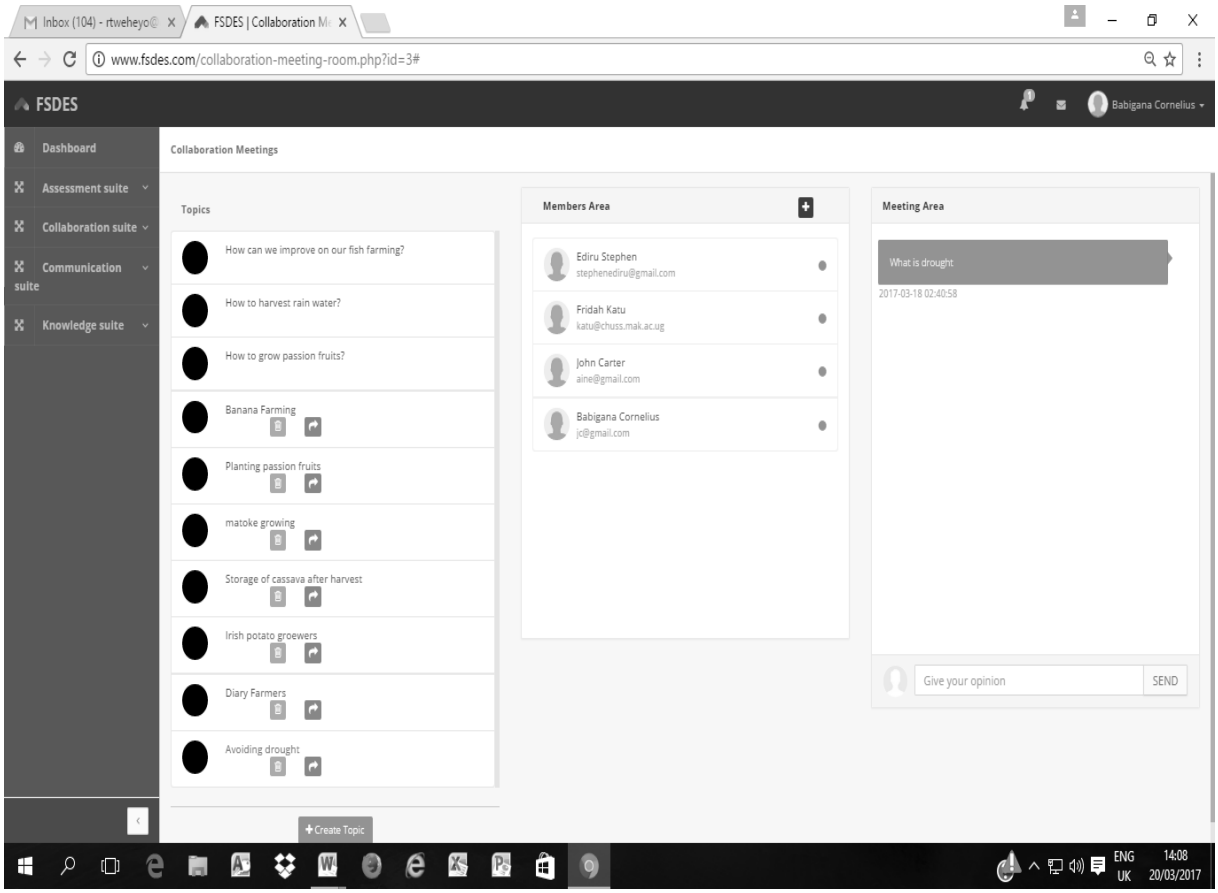

Figure 5.9: *A screen shot of a chat room in the collaboration suite*

Upon clicking the farmers' views icon, one is able to see the views of others and can join the discussion by scrolling down and writing his/her views in "give your comments" space provided at the bottom of the page.

In the chartroom, any registered user can initiate a topic for discussion and can invite people of his/her choice to chat with in a way of sharing knowledge. In the FSDES, CDWs take the role of facilitator. Their role as intervention facilitators is to guide farmers and stakeholders on how to collaborate in decision making (Kolfschoten *et al*, 2011). They give instructions on how to brainstorm, generating alternative ways for improving food security.

Communication Suite

In the FSDES, the Communication suite has four services namely; a provision for alerting farmers and stakeholders on upcoming events or disease outbreaks, making inquiries, making follow ups on their previous inquiries and contacting specialized experts. Any disease outbreaks or strange occurrences encountered by the farmer or domain expert can be communicated through the alerts link for farmers to be aware of and get prepared for them (see figure 5.10 below). The alerts may be accompanied by a picture showing how the outbreak of a given disease looks like.

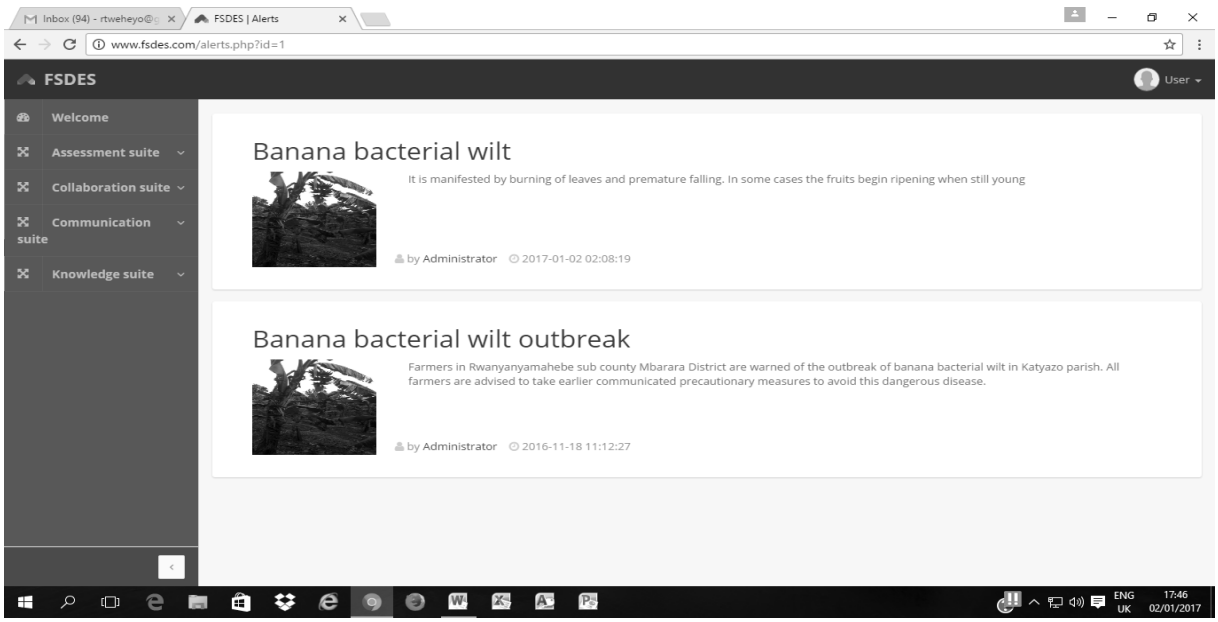

Figure 5.10: *Alerts communicated to users*

Registered users (farmers in particular) are able to make inquiries to fellow farmers or to experts regarding issues of concern in their field of farming and be able to receive feedback/response. The inquiry portal has a subject, the question in detail, a provision for uploading the picture if necessary and then submits the inquiry (see figure. 5.11 below). A farmer is able to make a follow up of his/her previous inquiry by clicking the follow up link to see whether there is response in relation to the inquiry made earlier. Farmers and stakeholders are able to contact experts in various fields of specialization by clicking on the link for experts contact and make further inquiries in their field of farming. Computers and mobile phones are helpful in achieving this task.

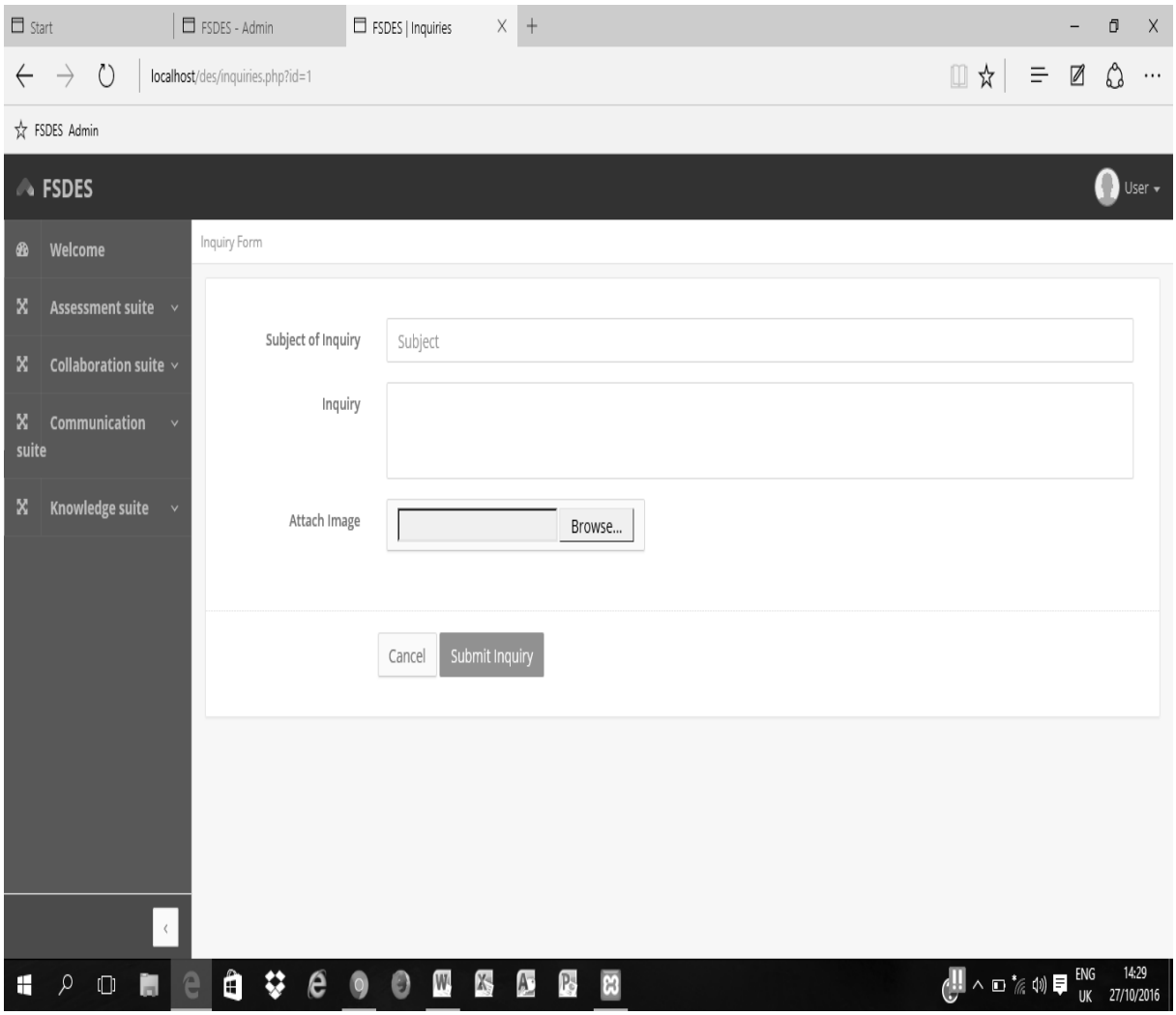

Figure 5.11*: A screen shot showing a provision for making an inquiry*

Knowledge Management Suite

The knowledge suite which stores the intervention schemata, constitutes other important sub suites including indigenous knowledge experiences on crops, animals and the search engine.

The knowledge management suite can be accessed by clicking on "knowledge management" on the drop down menu bar. Crops and animals contain a repository of farmers' experiences in crop and animal farming. Clicking on the crop icon, different food crops with their information concerning other famers' experiences will display. Each of the displayed crops has types and the user can choose any crop type of his/her choice. In order to view everything that other farmers say about that particular type of the crop including its rating in comparison with other types of that crop category one has to follow the link by clicking say Irish potato to view information on all its types. The same information can be accessed with animal farming following similar steps. The search engine helps the user to quickly search for information on a particular crop or animal of his choice without going through all the steps mentioned above (see figures 5.12 - 5.17 below*).* The FSDES provides a checklist to CDWs in sharing these experiences with farmers and stakeholders.

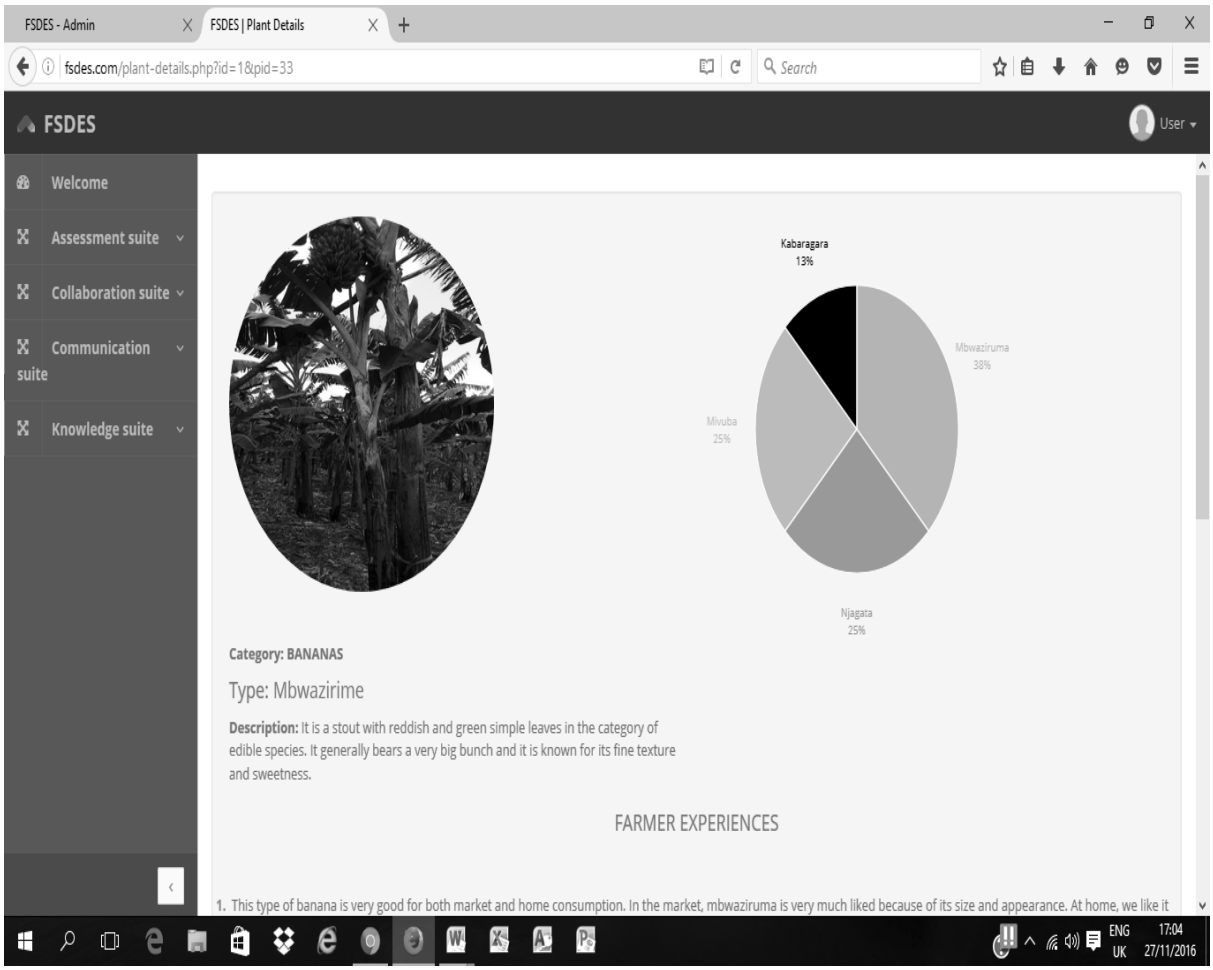

Figure 5.12: *Farmer experiences with Mbwaziruma type of banana*

Farmer's experiences are basically on selection of seeds, breeds of livestock, planting materials, post-harvest storage of food and any other farmer experience of interest in the promotion of household food security. Farmers' indigenous knowledge and experiences are visualized in the knowledge base as text statements together with stories as they are told.

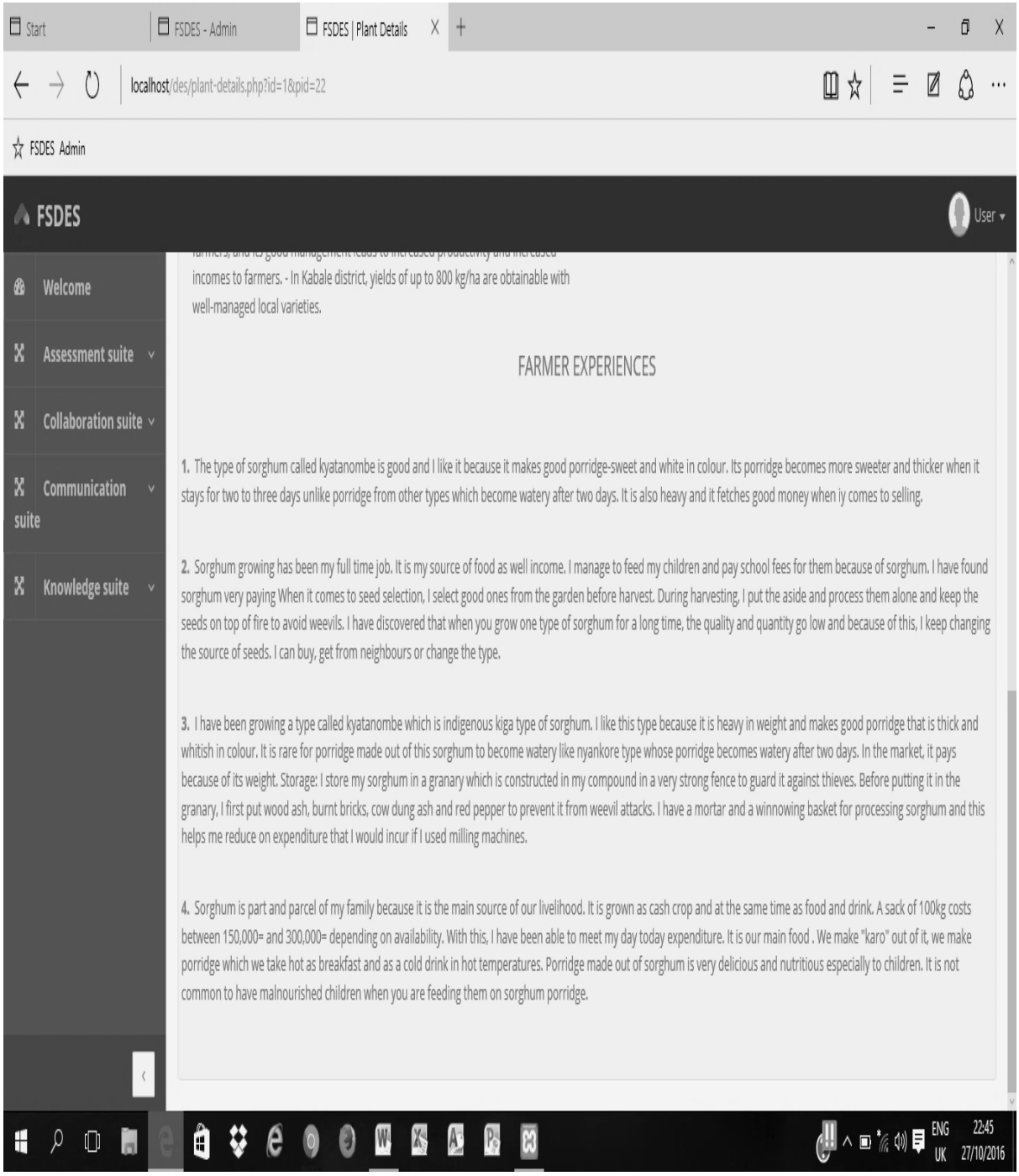

Figure 5.13: A screen shot indicating lived experiences of farmers with sorghum

The search engine helps the user to search for the type of farming, the type of crop or animal of his/her choice.

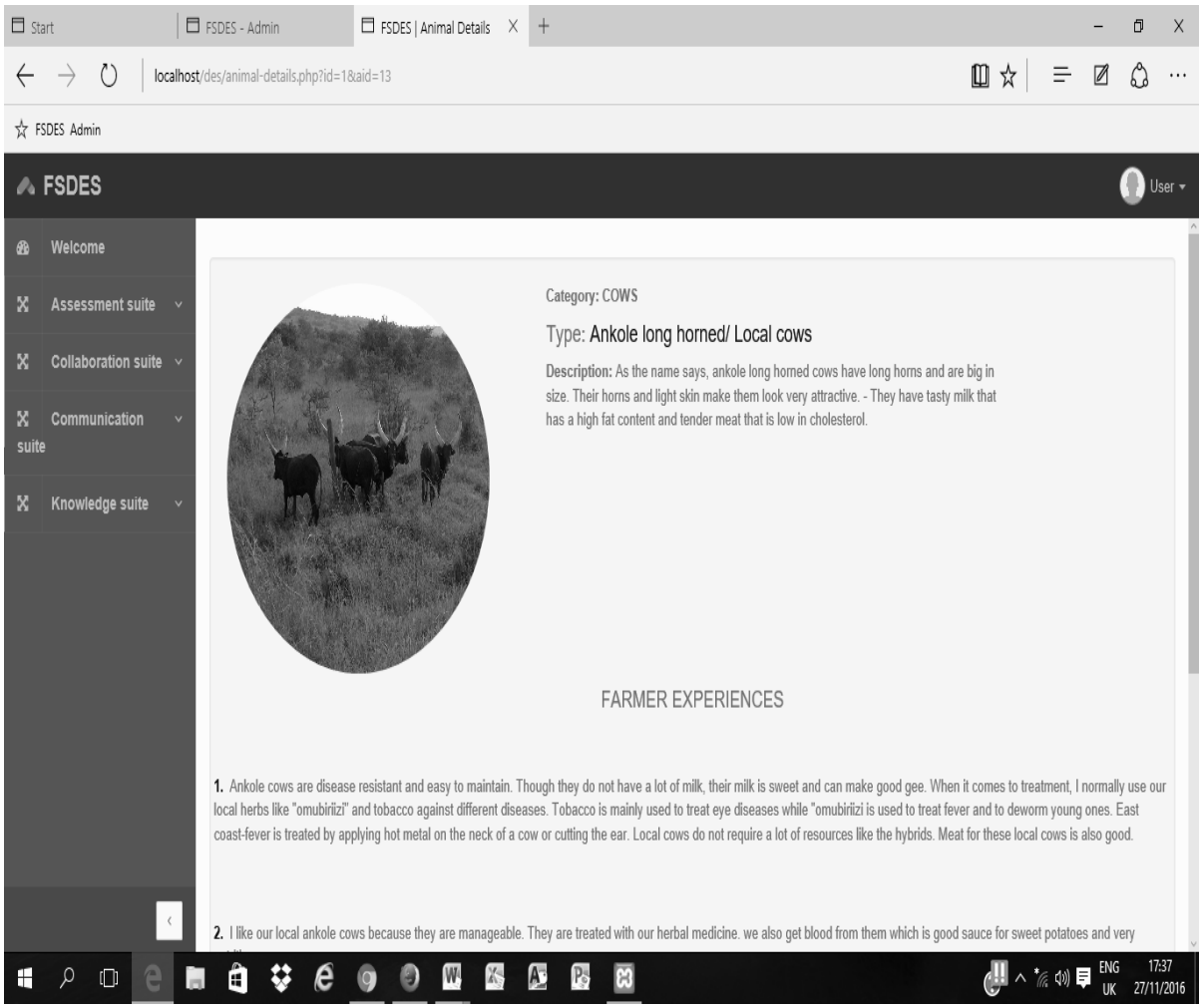

Figure 5.14: *Farmer experiences with indigenous/local cows*

The interaction of CDWs, farmers and stakeholders in their groups creates an environment for knowledge and experience sharing. This provides an opportunity to CDWs to gather unique farmers' indigenous knowledge experiences for updating the knowledge base.

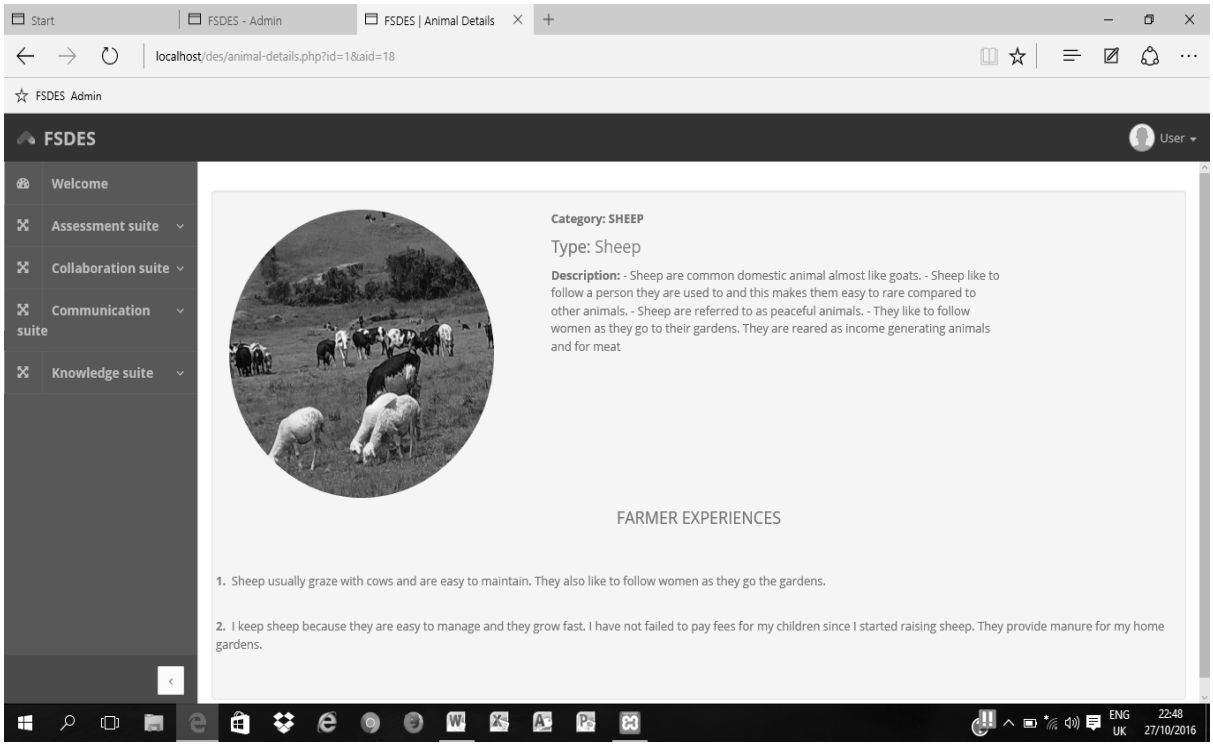

Figure 5.15: *A screen shot of farmers' experiences with local sheep*

Farmers telling stories about their rich experiences with local breeds of crops and animals.

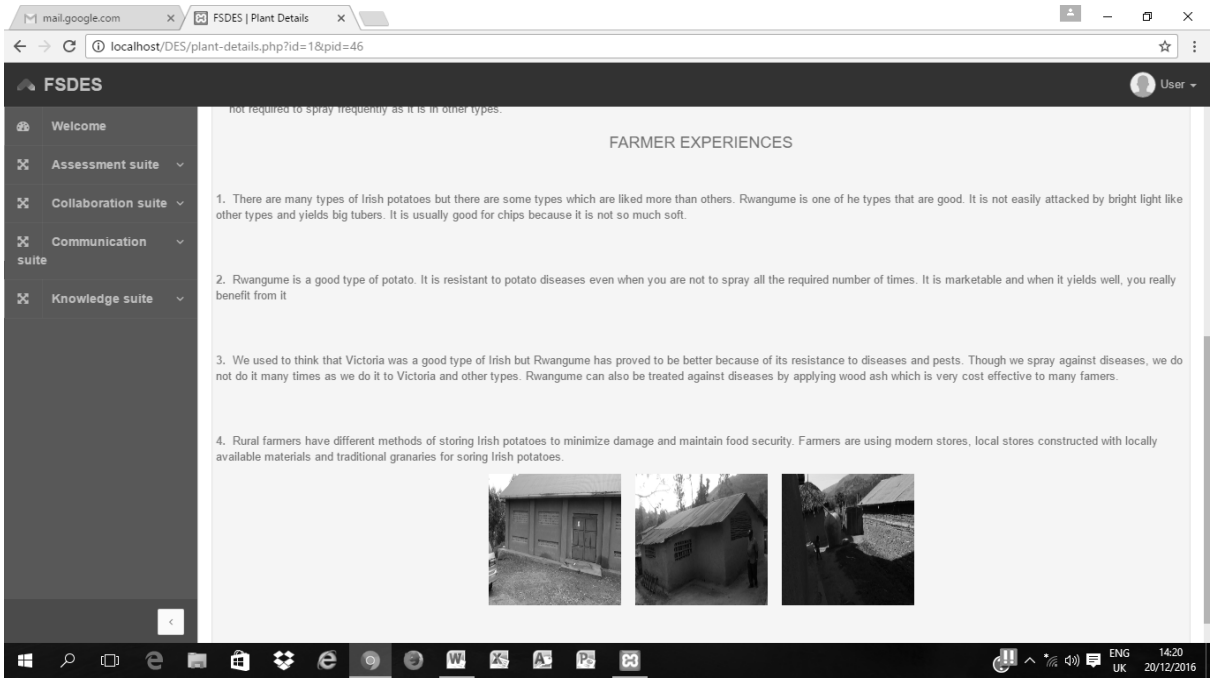

Figure 5.16: *screen shot indicating farmers' experiences on Irish potato growing and storage methods*

Farmer's knowledge is also shared in the studio during brainstorming sessions. Documented knowledge experiences benefit other farmers who may not have such experiences for promoting food security for instance how to construct food storage facilities using locally available resources.

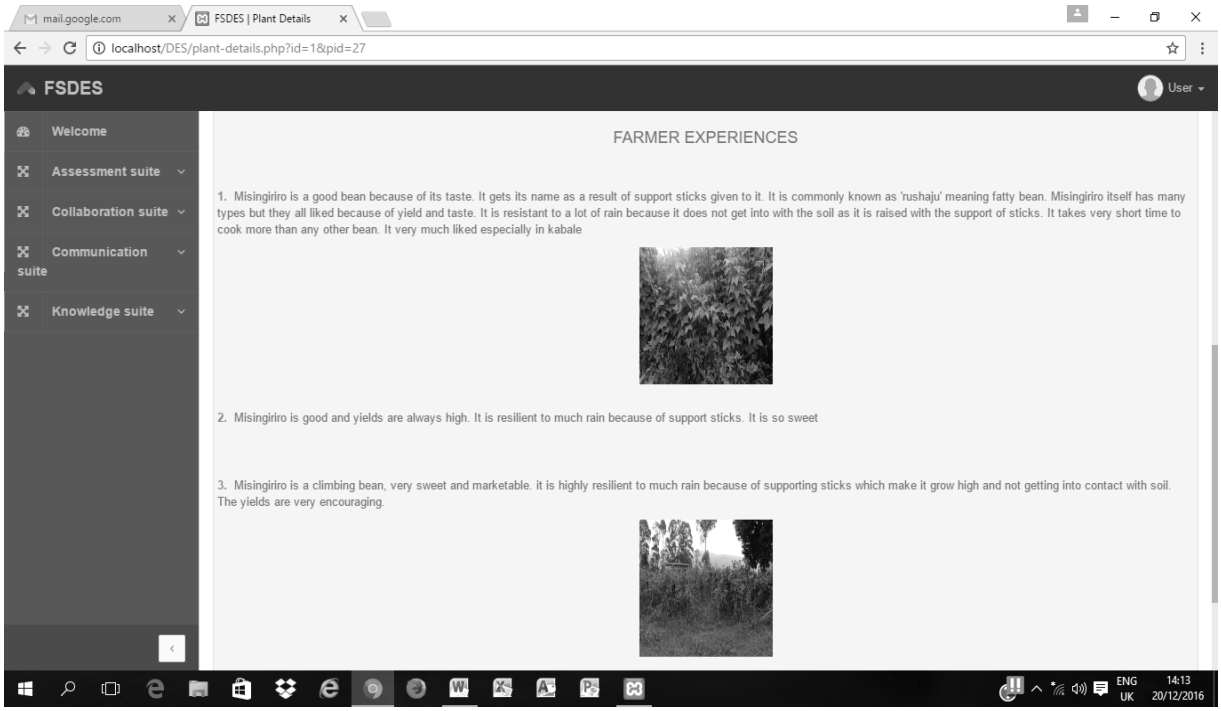

Figure 5.17: *Farmers' experiences with Misingiriro (climber) type of bean which is supported by sticks to prevent it from creeping on the ground*

In this way, the FSDES helps in documenting, storing and sharing indigenous knowledge and farmer experiences with other farmers for sustainable use. The evolving nature of the FSDES with changing schemata makes it a potential artifact for enhancing farmers' decisions.

Sensitization workshops arranged by the researcher to orient farmers and stakeholders on how the FSDES works and its environment before its full operation were significant.

The FSDES is installed both online and offline to enable those in areas with limited internet connectivity to access it with ease. The offline version is supported by XAMPP open web-server and can be accessed without internet connectivity.

In chapter 6, evaluation of the FSDES is presented to ascertain its perceived usefulness and perceived usability by users and experts.

Chapter 6 Evaluation of the FSDES

This chapter describes the procedure followed in the evaluation and discusses the results from the evaluation of the FSDES to ascertain its perceived usefulness and usability. Evaluation of the FSDES was done with the intended users (CDWs), domain practitioners, experts and stakeholders in the field of food security. Section 6.1 describes evaluation considerations. Section 6.2 presents the evaluation approach and the methodology used. Section 6.3 describes the user evaluation. Section 6.4 presents user evaluation results. Section 6.5 describes the expert evaluation. Section 6.6 discusses expert evaluation results and section 6.7 presents the discussion of insights gained from the evaluation process.

6.1 Evaluation considerations

Artifact evaluation is an essential component of rigorous design science research (DSR) and it is a crucial contribution to science and practice (Pries-Heje *et al*, 2012; Peffers *et al* 2008; Hevner *et al*, 2004). March and Smith (1995) argue that DSR comprises of two primary activities: "build and evaluate" implying that the utility, quality and efficacy of the design artifact must be rigorously evaluated (Venable, 2012).

According to Hevner (2007) purposeful artifacts are built to address unsolved human problems and evaluated with respect to the utility provided in addressing those problems. The evaluation of a design artifact must be demonstrated via well-executed evaluation methods based on the requirements of the context in which they are implemented. Wieringa (2014) argues that in design science research, the solution to a real world problem is a design and there are many different solutions. These solutions are evaluated by their utility with respect to the stakeholder's goals, and there may not be one single best solution (ibid).

Artifacts should be evaluated in terms of functionality, completeness, consistency, accuracy, performance, reliability, usability, effectiveness, fit with the organization and other relevant quality attributes (Hevner *et al,* 2004; Pries-Heje *et al*, 2008; March & Smith, 2005; Hevner, 2007). Evaluation provides evidence that a new technology developed in design science research "works" or achieves the purpose for which it was designed (Veneble *et al,* 2012).

Evaluation and presentation of DSR outcomes are essential to the efficacy and professional success of design science researchers (Hevner *et al* 2004). Sonnenberg & Brocke (2012) argue that, while it is essential in DSR to prove the usefulness of an artifact, a rigorous DSR process also requires justifying and validating the artifact before it is put into use. Keen & Sol (2008) argue that usefulness, usability and usage are key aspects of effective decision enhancement. Other researchers have extended evaluation criteria to include completeness, consistency, accuracy and reliability (Helfert *et al*, 2012).

The usefulness aspect in this research addresses the value addition of the FSDES to food security decision processes i.e. does it enhance rural farmers' decisions? Does it provide added value to the intervention work of CDWs to enhance rural farmers' decisions? The usability aspect focuses on the extent to which the FSDES is easy to learn and to use by CDWs, farmers and other intervention agents. The quality of users' experience while interacting with the product or artifact (satisfaction aspect of the users) was crucial for our study. The usage aspect focuses on the actual application of the FSDES to enhance farmers' decisions on food security improvement processes (Keen & Sol, 2008).

Engaging farmers and stakeholders in identifying, diagnosing and prescribing the alternative ways of improving food security (action research) was followed throughout the course of this research (Van de Ven, 2007; Costella & Donellan, 2012). To obtain accurate feedback from the evaluation exercise, key areas upon which views and conclusions of farmers/practitioners, experts and users were to be based were identified. Evaluation of the FSDES was done by the users (CDW, farmers and experts) in the field of food security.

6.2 Evaluation approach

Profile of user evaluation participants

Evaluation participants were selected from potential users and domain practitioners to participate in the evaluation of the FSDES. Users were basically CDWs at the Sub County level who by qualification had to be graduates with bachelor's degree from a recognized university. Besides, we considered and co-opted Community Based Organizations staff as CDWs in areas where it was difficult to get CDWs. Agricultural researchers and local NGO staff were also selected. In addition, 5 staff members at Kyambogo University from the Department of Sociology and Social Administration were selected to participate in the

evaluation of the FSDES. This was intended to get varying views from people of different backgrounds (Table 6.1).

Domain practitioners were farmers with at least a certificate of education (UCE) and above. We considered a sample of 26 as representative of the potential users of the FSDES. In addition, domain experts were requested to evaluate the FSDES and give their opinions. These included: veterinary officers, extension workers and agriculture officers as well as information systems experts (Table 6.2).

Snowball sampling was used to select the evaluation participants who satisfied the set criteria with the help of District Community Development Officers (DCDOs) in Mbarara and Kabale. Through their networks they were able to mobilize the relevant stakeholders in the field of food security to participate in an evaluation of FSDES. The selected participants were in the following categories:

i) Community development workers at Sub County level.

ii) Extension workers including veterinary officers and agriculture officers at district and Sub county levels.

iii) NGO staff engaged in community development activities and advocacy. Researchers working with agriculture related organizations (NARO).

Table 6.1 shows the categories of user evaluation participants

Category	**Kabale**	**Mbarara**	**Total participants**
Community Development Workers (CDWs)	7	5	12
Local NGO staff	2	1	3
Academics			5
Domain practitioners	4	2	6
Grand total			26

Table 6.1: *categories of user evaluation participants*

Expert	Affiliation	No. of participants
Extension workers	Mbarara District Local Government	3
Veterinary officer	Mbarara District Local Government	1
Agriculture officer	Kabale District Local Government	1
Information systems officers	Kyambogo University	2
Grand total		7

Table 6.2: *Expert evaluation participants*

Evaluation instruments

The main instruments of evaluation were the questionnaire and interview guide. A questionnaire was used to get users and stakeholders' views and opinions concerning the FSDES perceived usefulness and usability. It had two sections: the usefulness and usability. It also had the qualitative and the quantitative parts. The quantitative section consisted of well-phrased qualitative statements about FSDES and arranged in a five point Likert scale to measure the respondents' attitude to each statement (Venable, 2012; Bekker, 2016).

The qualitative section comprised of Yes/No questions as well as open-ended questions to allow participants give their open comments and opinions about the utility of the FSDES. We adopted evaluation statements from previous researchers (Van de Kar, 2004; Venable, 2012; Habinka, 2012; Yonazi, 2010; Aregu, 2014; Tumwebaze, 2016) and adjusted the statements to make them fit the context of our research. Each statement is measured against a 5 point Likert scale (Venable 2012; Bekker, 2016) ranging from:

1= Strongly disagree, 2= Disagree,

3= Neutral/Not sure, 4= Agree, 5= Strongly disagree.

The five point Likert scale provided evaluators with different options for expressing their opinions. The mean and standard deviation were computed for each of the statements. The maximum and minimum observations on the five point Likert scale for each statement are

indicated in the analysis tables. This is used to determine the general and most common opinions of the participants and whether there is general consensus or variations among participants.

The qualitative section was meant to get qualitative opinions of evaluators in form of detailed explanations about the usability and usefulness of FSDES. Questions in the qualitative section were open ended to allow evaluators give their independent views about the utility of FSDES. Qualitative opinions of evaluators supplemented the quantitative feedback and this enabled us to identify areas of FSDES that needed modification and those that needed improvement to make the FSDES better. We analyzed qualitative data using content analysis to identify and develop themes and their relationships highlighting the participants' views and opinions on the utility of the FSDES.

6.3 Evaluation sessions

In order to have meaningful results, evaluation sessions with selected participants were arranged. Each participant was invited by the researcher on a phone call and the purpose of invitation was clearly explained.

Workshops were held in the two research sites to get feedback from participants regarding the usefulness and usability of the FSDES. The workshops began with the researcher giving a brief introduction of what the research was about, the problem landscape, and the exploratory study findings. The design of FSDES and its instantiation as one of the solutions to address the challenges of food security were elaborated together with the purpose of evaluation. The researcher further elaborated on the FSDES and the different suites it contains highlighting on the function of each suite in providing information and guidelines to the users.

In the first session, participants were given a brief power point presentation demonstrating the entire research project. Participants were then allowed few minutes to reflect on the presentation and react by asking questions. The next step was to ask the participants to practice the FSDES for two weeks by navigating through the suites checking on the functionality, the arrangement of information and giving comments on areas they thought needed improvements. They were also asked to suggest necessary changes that would make the design of FSDES more appropriate and user friendly. This made the evaluation exercise more participatory where users were given the opportunity of modifying the intervention

schemata as they used it in its real context. Users were given the task of identifying areas that needed improvement while using the studio.

Thereafter, participants were given the evaluation questionnaire seeking their opinions regarding usefulness and usability of the FSDES. This was done for a period of two weeks. Besides, informal interviews to get more feedback from participants were also held at different intervals.

Table 6.3 demonstrates suites in the FSDES, their purpose and tasks of evaluators.

Suite	**Purpose**	**Evaluation task**
Assessment suite	- A process of getting facts concerning household food security -To provide computational statistics and visualize them to enhance decision making -To inform the CDWs of the areas that require urgent interventions	-Relevance of assessment tool -Does it capture salient information about food security? -Is there any information left out -Are the questions meaningful? -Are assessment statistics conveying the message? -What should be changed?
Collaboration suite	Interactions and knowledge sharing For visualizing farmers' views concerning food security Brainstorming platform	-Participate in the discussions -Participate in group chat -Share your views with the group concerning food security -Initiate a discussion topic on any issue of interest related to food security. -Any change needed?
Knowledge suite	Decisions concerning alternative knowledge and experiences on food security enhancement (seed selection, storage and processing Intervention schemata to CDWs	-Check in the knowledge base to view farmers' knowledge and experiences on crop and animal farming Check in the knowledge base and give views of your own experiences -Check in the knowledge base and search for knowledge on crop or animal of your choice -Check in knowledge base to view the intervention schemata and see whether they add value to the work of CDWs. -Are there changes needed? Additions? -Are intervention schemata relevant? -What needs to be changed? -Put adjustments/modifications

Communication suite	Inquiries, alerts and information exchange/dissemination	-Check in the knowledge base and view alerts made by experts and farmers -Make an inquiry on any issue of concern -Use the link for follow up to check whether your inquiry has been answered -View a list experts and their contact in case of any question. Any suggested changes?

Table 6.3: *Evaluation tasks for the users and stakeholders*

6.4 User evaluation results

In this section, the results of the FSDES testing and evaluation in terms of its usefulness and usability are presented. Table 6.4 provides the quantitative evaluation results of FSDES according to mean, standard deviation, and ratings as observed on the five point Likert scale for each statement.

According to the results, participants' opinions regarding the usability and usefulness of the FSDES were positive. Table 6.4 gives more details of user evaluation.

N = 26 Evaluation statement		Response parameters			
		Mean	**Std. Dev.**	**Min**	**Max**
	Usefulness				
1	The FSDES enables effective decision making.	3.97	0.89	1	5
2	The FSDES enables users to share knowledge experiences.	4.29	0.51	3	5
3	The FSDES provides a platform for farmers to air out their views.	4.30	0.66	3	5
4	The studio enables participants to explore knowledge alternatives for improving food security.	4.40	0.68	3	5
5	The studio facilitates shared understanding among key stakeholders.	4.41	0.55	3	5
6	The intervention provided are useful	4.33	0.67	3	5
7	Using the FSDES improves my performance in guiding farmers to improve food security.	4.13	0.75	2	5
8	The FSDES provides alternative ways of improving food security.	4.18	0.65	2	5
9	The FSDEs provides a conducive environment for making effective decisions.	4.22	0.59	3	5
10	Over all, I find the FSDES a very useful artifact for enhancing farmers' decisions	4.54	0.55	2	5
Usability					
11	The screen layout is good.	4.3	0.82	1	5
12	The arrangement of information is good.	4.16	0.68	2	5
13	The tasks can be performed in a straight forward manner.	4.37	0.49	4	5
14	The language used in the suites is understandable.	4.44	0.50	4	5
15	The user interface is clear and understandable.	4.18	0.61	2	5
16	I find the FSDES easy to use.	4.25	0.80	2	5

17	The intervention schemata provided is clear and easy to use	4.13	0.82	2	5
18	The design of the FSDES is intuitive.	4.18	0.65	3	5
19	I am able to access information in the FSDES.	4.16	0.77	1	5
20	I have experienced difficulties in using the FSDES.	3.28	1.38	5	1
21	The information generated by the FSDES is enough and relevant to enable farmers make agile decisions.	3,62	1.28	1	5
	Grand mean	**4.2**	**0.70**		

Table 6.4*: User evaluation results*

According to the results presented in table 6.4, the users' evaluation regarding the usefulness of the FSDES were generally positive. The grand mean of 4.2 indicates that the majority of participants agreed that the FSDES was a useful artifact for enhancing rural farmers' decisions on food security. The results also show a standard deviation of 0.70 implying that the deviations from the mean were relatively low. The maximum and minimum ratings observed provide more information regarding the respondents' strong agreement on the utility of the FSDES.

With respect to the usability of the FSDES, results further show that it is usable and easy to learn using it. The mean and standard deviation with regard to usability, do not differ from those of usefulness implying that respondents also had few disagreements regarding the usability of FSDES. Looking at statement 10 for example (Table 6.4) which is negatively stated, majority of the respondents disagreed that they experienced difficulties using FSDES. The maximum and minimum observations against that statement indicate that strongly disagree was the most common answer. The positive rating could possibly be attributed to participatory development of the artifact in the design, implementation and utilization in its real context.

Qualitative evaluation remarks

Generally, evaluation results show positive rating of the FSDES in terms of its usefulness and usability towards enhancing decisions of rural farmers. The usefulness and usability aspects of the FSDES are demonstrated in the following remarks given by participants:

The FSDEs is a useful artifact for helping CDWs to mobilize and organize rural farmers to collaborate and to know each other, to appreciate how indigenous knowledge works and

exchange ideas in the decision making process. The studio enables farmers to communicate amongst themselves and stakeholders in decision making process. This is demonstrated by vignette 1 below:

Vignette 1 (Effectiveness and efficiency in the intervention role of CDWs)

Didas[17] is a Community Development Worker (CDW) of Rwanyamahembe Sub-County, Mbarara District. He has been a CDW for the last 7 years. His major role as a CDW is to sensitise people in his community/sub-county on how to improve their standards of living. He is specifically responsible for:

i) Sensitizing local communities on development aspects such as education, health, income generation and sustainable food security.
ii) Overseeing government development projects such as National Agriculture Advisory Services (NAADS) and monitoring their progress.
iii) Arbitrating on domestic issues like making sure that the children are protected, that they are in school and remain in school, etc.

Didas started using FSDES in September 2016 after it was installed on his laptop. According to Didas, he had never had an opportunity to see any system related to his work before. He confessed that he was excited to learn of the FSDES. He stated that previously, he used his laptop for word processing to write reports and searching for some information on the internet only. So, he was so happy with the FSDES with its guidelines on how to have local solutions of food insecurity. "It was an exciting moment opening the Assessment Suite and finding food security assessment guidelines. I didn't know that there could be something useful to my work in electronic format!" Didas remarked.

According to Didas, the FSDES has made him efficient and effective in the following ways:

a) He is able to assess the status of food security in his Sub-County and share results with farmers for self-appraisal and also, policy makers, and other stakeholders.

[17] Didas is not the real name. We use pseudonym in our examples for confidentiality and to permit free discussions.

b) He has gained knowledge and understanding on various local solutions to food security problems, which he can share with farmers and at the same time, use them to guide people in his Sub County. "The knowledge I have gained will enable me perform my duties better than before." Didas affirmed. What Didas considers as very important is that knowledge posted on FSDES stays there for consultation and reference all the time. According to Didas, this is very important as he will consult the FSDES knowledge base for his intervention work to guide farmers on how they can improve household food security again and again.
c) Ease of communication amongst food security stakeholders. Didas is convinced that FSDES is an invaluable tool of communication. When the solution of banana bacterial wilt disease was announced by the Ministry of Agriculture in December 2016, Didas immediately posted the announcement on FSDES. Little did he know that he would receive calls from fellow CDWs and farmers for details about the announcement. That incident excited Didas and made him confirm that FSDES is an important tool for collaboration and communication between farmers and experts.99

Similarly, Jesca[18], a CDW in Biharwe, Mbarara District says: "the FSDES is a resourceful tool that eases work for the community development workers. We do not have to move to experts all the time for consultations and to look for information to give to our communities. We can now have discussions with experts from different areas at the same time using the chat room in the collaboration suite. We can get information from farmers and experts at the same time and pass it on to other famers by using the FSDES. We can have a chat and group discussions over a given topic without a physical meeting but using the FSDES. In areas where we have worked since the beginning of this research and mobilized farmers to collaborate, food security is beginning to improve".

It was stated that the FSDES captures indigenous knowledge of farmers. For instance, there are farmers who are commonly known as "plant doctors" can share their knowledge and have it documented as well as storing it in the knowledge base of the FSDES for the benefit of other farmers. Such farmers know various medicinal plants and their uses for example, plants that can help remove the retained placenta in a cow after giving birth to a calf; those that protect crops against diseases; weevils; plants that are put in the garden to scare away birds

[18] Not the real name

from crops and those that prevent thieves from stealing food crops. This is explained by vignette 2.

Vignette 2 (FSDES is a learning studio): Improved knowledge for decision making

Daniel and Sadress[19] are both small scale farmers in Kitunga, Kabale District. The duo grow crops, sorghum, Irish potatoes, sweet potatoes and beans. They both keep cattle and goats to diversify their income and as a measure to sustain household food security. Daniel bought his animals while Sadress received a heifer from World Vision, a charitable NGO working with rural communities of Kabale to boost their standards of living. Daniel and Sadress use both indigenous and modern knowledge in their farming enterprise. From 2016 when the FSDES was instantiated to date, Daniel and Sadress have attended five farmer group collaboration meetings. From group meetings, they testify that they have learnt how to improve their farming by selecting seeds for planting when still in garden, how to use local herbs to prevent weevils and minimise post-harvest losses, the knowledge they did not have before. While interacting with Daniel, he remarked:

> "I have learnt new knowledge from our CDW through the FSDES. The monthly meetings we have with our community development worker help me learn from what other farmers do. We meet with experienced model farmers and learn from them ideas and new techniques of farming which have helped us to improve food productivity and food security. We share indigenous knowledge and experiences on how to improve our household food security cheaply. We are encouraged to share our stories about what we do in our gardens and homes in the process of improving food security. For instance, I have learnt through FSDES that "kamurari" (red pepper) is a good preservative for beans against weevils. Since then, I no longer get a problem of weevils"

Sadres manages her cow, which is an improved breed, using both indigenous and modern knowledge learnt in collaboration meetings. She now knows which herbs are used to treat and deworm cows in case she has no modern medicine from vets. She now gets 10 litres of milk in the morning and 8 in the evening compared to 7 and 4 litres of milk which she used to get

[19] Not the real names. Pseudonym is used in our examples for confidentiality and to permit free discussions.

before. She agrees that the FSDES has enabled her to learn new tactics of farming from fellow farmers and experts through knowledge sharing. By using a smart phone, she is able to consult and get help from experts instantly.

Evaluation participants also commented that the FSDES provides alternative knowledge to farmers by enabling sharing of experiences by farmers about food security improvement. For example, one CDW in Mbarara commented that, while interacting with farmers he came to know about a plant called "Omubiriizi" (a medicinal plant/herb for human and livestock) can be administered to a cow that has failed to pass out the placenta after delivery as an emergency measure, while waiting for a veterinary doctor. This is one of the best practices for other farmers to know that could be enhanced by FSDES.

Participants acknowledged that the FSDES will be most useful to the "Operation Wealth Creation" (OWC) program by informing the coordinators about which inputs (seeds/livestock breeds) are needed in which particular areas. The practice of OWC has been supply-driven; distributing seeds and planting materials without considering farmers' preference. FSDES can tell which type of a crop or animal is needed in which area.

Participants commented that in addition to CDWs, it was important to bring on board other people in the Sub County, for example extension workers, to give support to CDWs and to participate in the intervention work of sensitizing rural farmers to enhance decisions on food security. Church leaders for example need to come on board to mobilize people on issues of food security since they interact with many people who willingly go to church for prayers every Sunday.

Our assumption had been that CDWs alone could be the primary users of FSDES to enhance farmers' decisions. However, it came to our attention in the early deployment of FSDES that other people needed to be brought on board including extension workers and religious leaders. It emerged to be a shared responsibility between CDWs and extension workers.

As a result of deployment of the FSDES and its ongoing use in the real context, it was realized that some of the assessment questions in the intervention schemata were not applicable to different settings. For instance, questions 2, 3, 4 and 5 (Scheme A (iii) Table 4.2) could not be applied uniformly across all settings. Consequently it was discovered that the assessment tool needed to be iteratively adjusted to fit different contexts.

It was also noted that before the FSDES, collaboration meetings had poor attendances due to issues of transport facilitation. The fact that FSDES has a provision for virtual meetings, demands for allowances will no longer apply. As a result, the collaboration suite was a better alternative. The group approach provided by FSDES is useful in mobilizing farmers and stakeholders. Before a group approach in communities was failing due to high demands of transport and lunch allowances.

The FSDES is a useful tool for documenting rural farmers' best practices relating to food security.

Vignette 3 Usefulness of the FSDES

The Sub County chief of Rwanyamahembe while closing the evaluation session remarked:
"The FSDES is a useful tool for capturing and sharing indigenous knowledge between farmers and stakeholders. It is a channel through which the voices of rural farmers can be heard by experts. It would even work better if all villages had internet connectivity and farmers had access to ICT devices like smart phones and tablets. Besides, farmers need training in ICT usage particularly on how the FSDES works".

At the inception of this research, we assumed that farmers were willing to freely share their specialized indigenous knowledge experiences for instance on animal disease treatment but this was not the case. In the process of CDWs interacting with farmers, and filling the FSDES with knowledge, it was discovered that indigenous knowledge was secretive. Owners of indigenous knowledge do not simply share it anyhow with others except for a fee. It took more time for the CDW to convince such people to share their knowledge and in some occasions, a fee had to be paid in order to get what we wanted. It was noted that sensitization of farmers first was paramount before embarking on documenting their knowledge experiences. It was further noted that appreciating indigenous knowledge of rural farmers and rewarding them for it was key.

It was also further noted from the deployment of the FSDES that our locally devised brainstorming manila cards work better than we expected. We found cards effective during brainstorming sessions. Some timid farmers participated in brainstorming by writing down their views rather than talking in a group which in a way, yielded substantial results.

Besides participants' positive comments, they also highlighted factors that were likely to hinder the effective utilization of the FSDES. Among those mentioned were: low levels of skills on information technology and inadequate access to required devices like laptops, tablets, smart phones coupled with low levels of internet connectivity in rural areas. They suggested urgent action to address the mentioned issues for the FSDES to work better.

6.5 Expert evaluation

The FSDES was presented to experts by the researcher to evaluate it and give their opinions with regard to usefulness and usability. The researcher gave a brief introduction indicating how it is designed to provide intervention schemata for supporting CDWs by expanding their tool set in the process of enhancing farmers' decisions on food security. Expert participants in the evaluation workshop included 3 extension workers at Sub County level in Mbarara District, 1 veterinary officer Mbarara District, 1 agriculture officer Mbarara, and 2 staff members from IT department Kyambogo University. In total, 7 participants were selected to participate in the evaluation exercise as shown in Table 6.2 above.

After the introduction and studio walk through, participants were asked to log in the studio and navigate through while experimenting the functionality. This was followed by a brainstorming session where participants were asked to comment on the appropriateness of the FSDES and the intervention schemata/guidelines in relation to supporting the CDWs' work of enhancing farmers' decisions.

At the end of the workshop, participants were requested to go on experimenting with FSDES for a period of 2 weeks to be able to study it further and provide accurate evaluation in terms of its usefulness and usability. An evaluation questionnaire was sent to everyone's' e-mail for filling in. After 2 weeks, a mail reminding those that had not sent their evaluation feedback was extended to the concerned evaluators. To our surprise each one complied.

6.6 Expert evaluation results

The FSDES perceived usefulness and usability were evaluated by food security experts and information systems experts. As already stated above, a total of 7 experts participated in the evaluation exercise. Expert evaluators included agriculture officers/extension workers,

veterinary officers and information systems experts. Table 6.5 provides details of the expert evaluation results.

	Usefulness statements (N= 7)	Mean	Std. Dev.	Min.	Max.
1	The FSDES addresses rural farmers' decision making challenges with regard to food security	4.4	0.55	4	5
2	The FSDES can be applied in a broader context to cover many areas of food security	3.8	1.10	2	5
3	The intervention schemata provided by the FSDES can expand CDWs tool set in facilitating rural farmers to overcome food security decision making challenges	3.6	0.90	2	4
4	The FSDES is potentially useful in addressing the problem of communication among farmers and stakeholders with regard to food security	3.8	1.10	2	5
5	I would not hesitate recommending FSDES to farmers and stakeholders in the field of food security	4.4	0.89	3	5
6	The FSDES supports collaboration between farmers and stakeholders	4.4	1.22	2	5
7	The FSDES addresses key challenges farmers face in decision making	3.8	1.09	2	5
8	The intervention schemata provided by the FSDES add value to CDWs' task of supporting farmers	4.4	1.34	2	5

9	The FSDES enables interaction among farmers and stakeholders and experts	4.0	1.22	2	5
10	The FSDES helps to collect, store and disseminate indigenous knowledge hence preventing it from extinction	5.0	0	5	5
11	The assessment tool is able to capture the actual situation of food security on the ground	4.0	1.22	2	5
	Usability statements				
12	Information is well displayed on the screen	3.4	1.51	1	5
13	Information is arranged logically	3.6	1.14	2	5
14	The FSDES design is clear and easy to interpret	3.4	0.89	2	4
15	Tasks in the FSDES are easy to carryout	3.4	0.89	2	4
16	The intervention schemata is easy to use	3.6	0.89	2	4
17	Language used in the FSDES is clear	3.2	1.30	1	4
18	Information display on the screen is good	3.6	1.14	2	5
19	The FSDES can be learned with ease	3.6	1.14	2	5
20	Over all, FSDES is usable	3.6	1.14	2	5
	Grand mean	**3.83**	**1.0**		

Table 6.5: *Experts evaluation results*

The expert's perceptions of the FSDES usefulness and usability were essentially positive with a grand mean of 3.8 and standard deviation of 1.0 indicating that there was consensus the FSDES was useful and usable. The study participants noted that the FSDES was useful in capturing and sharing farmers' indigenous knowledge for sustainable use in the process of enhancing food security among the rural communities. The experts further concurred with the statement that the FSDES provided useful intervention guidelines for helping farmers to overcome their decision making challenges with regard to enhancing food security. They reiterated that the artifact was not only useful in providing intervention schemata to assist the users to better facilitate farmers, but also useful in documenting best practices of farmers and making it possible to be shared with other farmers and stakeholders.

It was further noted that the FSDES was potentially a useful platform for farmers to communicate their views and exchange useful information amongst themselves and domain experts in the process of improving food security. Besides rural communities' food productivity was likely to improve due to the interventions of CDWs to help address decision making challenges of rural farmers.

The experts also gave their opinions on how the FSDES could be made more useful and usable.

- Ensure access to portable computers, smart phones, tablets and other required devices.
- Ensure network/internet connectivity in rural areas.
- Ensure that the remuneration of CDWs commensurate with their workload and added responsibility.
- Transport challenges in rural areas must be tackled to ease movement of CDWs to all households and be able to do proper assessment of food security.
- Inadequate computer skills among the intended user should be addressed (more training required).
- Education and sensitization of farmers should be boosted.
- Not all farmers have smart phones and in order to make them affordable, government should give tax waiver to importers of smart phones and computers.
- It is imperative for the government to develop strategies for addressing the problem of climate change.
- One of the users commented that the intervention schemata were too long and needed to be reduced in consideration of time.

6.7 Discussion of results

Overall evaluation results show that the FSDES is a usable and useful artifact for facilitating rural farmers in their decisions on food security. The standard deviation of 0.70 indicate that there were few disagreements (few deviations from the mean) and the majority of participants agreed that the FSDES is useful in addressing the problem of food insecurity. The standard deviation of 1.0 against grand mean of 3.83 further shows a consensus among the experts regarding the usefulness of the FSDES.

The minimum and maximum ratings as observed on the 5 point Likert scale indicate that majority of respondents agreed that FSDES is a useful intervention artifact. It provides a platform for collaborative decision making which hitherto has been problematic due to mobilization challenges.

The evaluation results further indicate that the FSDES is usable given the fact that it provides intervention schemata which can be iteratively modified by users to fit the context). The CDWs confirmed that the FSDES is usable and the intervention schemata are clear when iteratively adjusted to fit different contexts.

The positive responses on usability and usefulness of the FSDES (Table 6.5) indicates that the FSDES is usable and useful in enhancing farmers' decisions. The open comments of the evaluation participants also provided much information and enlightenment to the participants which helped us to make improvements on the FSDES.

The evaluation results further indicate that the FSDES is useful because it provides a platform for knowledge and experience sharing among farmers and stakeholders. As it was observed in literature and abstraction phases, the current food security policies do not pay much attention to the importance of indigenous knowledge and the need for sharing it among farmers and experts. The FSDES bridges this knowledge gap.

Experts further observed that documenting and storing indigenous knowledge and practices as they are applied by farmer creates better understanding of farmers and the importance of indigenous knowledge. Besides, the FSDES enables timely communication between farmers and stakeholders/experts thus promoting collaborative decision making on matters of food security.

Evaluation results provided us with the opportunity to make iterative adjustments to accommodate experts' suggestions. This gave us the basis to conclude that FSDES has the potential to achieve its intended objective of enhancing rural farmers' decisions. Furthermore, food security experts agreed that FSDES is useful in providing support to the CDWs in their role of enhancing rural farmers' decisions on food security.

Nevertheless, there were concerns raised regarding inadequate internet connectivity in some of the rural areas of Uganda which were likely to affect smooth implementation of the FSDES. Throughout the explanatory phase, it was noted that internet coverage in rural areas

was inadequate but as we interacted with local leaders, we learnt that plans for improving internet connectivity were already in the work plans of the districts visited. In order to meet this challenge, a standalone version has been developed to use in areas with inadequate internet connectivity. It is also important to note that internet usage is steadily going up. Recent studies indicate that the number of people using internet in Uganda has increased from 8.5 million in 2014 to 11.9 million in 2016 (UBOS, 2016). Hence, the use of FSDES online demonstrates technological advancement in the field of food security particularly among the rural communities in Uganda.

The feedback from the evaluation exercise indicates that FSDES is of immense help if the users were adequately supported and equipped with modern devices (laptops, tablets and smart phones including transport facilitation. Since CDWs/CDOs are already established at Sub County level in Uganda and responsible for community development and welfare, it would be much easier to facilitate and motivate them in terms of transport and better remuneration to use FSDES for supporting farmers to better enhance their decision making processes. Food production was likely to improve and work performance of CDWs was already improving as a result of the implementation of the FSDES.

In chapter seven, a reflection of the entire research project and concluding remarks are presented.

Chapter 7 Epilogue

This chapter presents a reflection on the major findings of this research, its generalizability and approach. Furthermore, contributions made by this research are pointed out. The chapter concludes with suggestions for future research. Section 7.1 presents thesis overview and reflection on major research findings. 7.2 provides a reflection on the research approach. Section 7.3 presents the generalizability of the FSDES. Section 7.4 discusses the contributions made by the research and 7.5 gives recommendations and directions for further research.

7.1 Thesis overview and reflection on research findings

The motivation for this research, which was prompted by increasing levels of food and nutrition insecurity among rural communities in Uganda and other developing economies, was to a large extent fulfilled. Inspired by Hevner & Chatterjee (2010), design science research philosophy was chosen to understand real-life phenomena, and to abduct the requirements for designing applicable solutions that could serve rural communities in Uganda better (chapter 1).

This research sought to address the problem of food security decision making challenges among the rural communities in Uganda and similar developing countries, by realizing specific objectives in chapter 1. It was established that statistics on food security were worrying. For instance, more than 30% of Ugandan population was reported to be food insecure (Tayebwa, 2017) and a number of households could not afford more than one meal a day (UBOS, 2016; USAID, 2016). As a result, there were high rates of malnutrition, distress, poverty and disease leading to high death rates (Tugume, 2017). Food insecurity among poor rural communities was highly attributed to policies that do not consider the resource base of the poor and which favor commercial farmers among other factors. The FSDES is designed to provide solutions to these problems (chapter 4).

The government of Uganda and other developing countries seem to be putting more attention and resources on modern technologies such as use of fertilizers, application of pesticides and insecticides in an attempt to commercialize and modernize agriculture, which the rural poor

in Uganda cannot afford. Indigenous knowledge is still playing a crucial role in rural communities' food security and should not be ignored and despised by policy makers. Rural farmers need to be given support in their decisions of using indigenous knowledge to improve on food security (chapter 1 & 2).

From the review of literature, it was clear that food security has been an issue to many countries since 1948 when the concept of "right to food" was included in the Universal Declaration of Human Rights. "Right to food" was included after realising that globally, lack of adequate food posed serious health and social challenges (Denise, 2012). While a number of studies have been conducted and a number of recommendations made, access to sufficient and safe food by all people has remained a huge problem (FAO, 2014; Ingram, 2011; Maxwell, 1998). Specific to rural communities is poverty, which is a major issue in relation to food security. In addition, inadequate information sharing, poor coordination between farmers and stakeholders were among the hindrances to rural communities' food security. Literature review also revealed that rural farmers still depend on their traditional farming practices. Key issues from literature were abstracted regarding attempts that had been made to manage indigenous knowledge and the existing knowledge gaps were identified (chapter 2).

It was noted that indigenous knowledge plays a big role in the decision-making processes of achieving food security among rural farmers. It was also noted from literature that planned interventions for enhancing rural communities' food security should build on indigenous knowledge (Kamwendo & Kamwendo, 2014; Ingram 2011). To further understand the real problem of food security among rural farmers, an exploratory study was conducted (chapter 3) to gain deeper understanding on how rural farmers depended on traditional farming practices and indigenous knowledge as their source of livelihood (seed selection, food processing and storage).

Based on the above observations, the main research question was formulated: "*How can rural farmers' decisions for improving food security be enhanced using indigenous knowledge?"* To address this question, key issues relevant to the research question were abstracted from literature and exploratory study (chapter 2 & 3).

It was noted in literature review that key among the attributes that influenced farmers' decisions were: seed resistance to drought and diseases, the maturation period the type of seed takes, the previous amount of yields of a specific type of seed, and the yield size of the seed or breed. Focus was put on areas of seed/breed selection, storage of harvested food and processing because these areas were found to be key in food security decision making processes. Furthermore, farmers were more often applying knowledge that worked well in the previous season but also, learn from their fellow farmers' experiences.

Results from the exploratory study (chapter 3) clearly indicate that rural farmers still regard indigenous knowledge as an environmentally friendly and cost-effective way of food production, processing and storage. Rural farmers have confidence in local seeds, processing and storage methods because they have lived, tried and tested them.

It was important to note that farmers in rural areas were organized in informal groups from where they learnt from each other (how to make organic manure using solid and liquid waste from plants and animals, treating food crops using specific herbs and ash, treating animal diseases and local storage methods among others). It was established, from the exploratory study (chapter 3), that rural farmers' groups were used mainly for labor exchange, but information sharing and collaboration were limited to their small groups. Inadequate collaboration between farmers and key stake holders was the major hindrance to effective decision making and food productivity.

Based on the engaged scholarship of Van de Ven, (2007), participation of farmers and stakeholders in knowledge and experience sharing were thought of as key ingredients for collaborative decision making and food insecurity problem solving.

The FSDES (chapter 4 & 5) provides an enabling platform for collaboration between rural farmers and key stakeholders in decision making processes to improve food security. The studio environment enables CDWs, local leaders, local NGOs, CBOs and rural farmers in collaboration meetings to brainstorm on indigenous knowledge experiences in a bid to arrive at better solutions that enhance food security. Collaborative decision making helped to bring in different views and experiences from participants which were significant for addressing the problem of food insecurity. The views and perspectives of the participants formed the requirement for the design of a food security decision enhancement studio (chapter 3).

The FSDES is designed to provide intervention schemata to CDWs for facilitating rural farmers to take important and effective decisions on food security (chapter 4). CDWs work as agents of development at lower levels of local governments in Uganda and they are positioned in all Sub Counties. Furthermore, supporting CDWs with intervention schemata in their intervention role of facilitating farmers to enhance their decisions on food security was crucial in this research.

The FSDES was instantiated into a prototype which was given to CDWs. CDWs with their first hand experiences influenced the initial instantiation of the FSDES, and the initial version of the intervention schemata was changed and refined to fit different environments (chapter 5). Some of the assessment questions were found not applicable across all situations and were changed to fit the environment where the assessment was being used (chapter 5). In chapter 6, evaluation of the food security decision enhancement studio (FSDES) was done by farmers and users. This was achieved by engaging farmers, CDWs and experts in evaluating the FSDES. Evaluation criteria were based on the challenges and design considerations discussed in chapter 3 & 4.

Evaluation of the FSDES is integrated in its development and use in the real life context reflecting on the usage, assumptions, beliefs and values of the practitioners and stakeholders. Evaluation continues at different levels of use and iterations of the FSDES as well as refinement. It was observed that quite a number of decision-making challenges rural farmers faced before the implementation of FSDES were steadily reducing and the usefulness of the FSDES was being realized.

The utility of the FSDES is demonstrated in the quantitative and qualitative evaluation results of the FSDES. The FSDES was tested and rigorously evaluated (chapter 6). It was empirically evaluated by illustrating its perceived usefulness and usability as shaped by the interests, values and assumptions of a wider community of users, experts and stakeholders. Evaluation participants included intended users (CDWs), experts, farmers and academics.

In the evaluation process, we observed that:

- The FSDES was shaped and refined (chapter 5) in its actual implementation in the real context. For instance, experts commented that the FSDES was not only an artefact for enhancing farmers' decisions but also for documenting best practices of farmers.

- The FSDES was generally rated as a useful and usable tool for providing intervention schemata to enhance rural farmers' decisions. It can therefore be deployed as a useful tool in Uganda and other similar developing countries.
- The CDWs commented that FSDES was easy to learn and easy to use. This was important for rural farmers at their level of education. However, some evaluation participants expressed fear about the sustainability of the FSDES given the low education levels of rural farmers and poor ICT infrastructure.

Evaluation results generally indicated that the FSDES was helping to address food security decision-making challenges by bringing together different stakeholders to brainstorm and share knowledge on how to enhance their decisions. For instance, rural farmers were able to contact experts and fellow farmers when faced with a decision dilemma; and receive feedback instantly. In addition, all food security stakeholders were able to communicate disease outbreaks to fellow farmers and experts; and could receive assistance. However, during interactions with farmers and stakeholders, it was further noted that documenting indigenous knowledge not only makes it accessible to future generations, but also to farmers for sustainable use to enhance food security.

Overall, the original starting point of this research for disclosing indigenous knowledge was expanded to include providing the schemata (guidelines) to CDWs on how to use the studio to better enhance rural farmers' decisions on food security. The FSDES addresses the challenges identified in chapter 3 and answers the research question and expands it by supporting the CDWs' intervention role. From the above insights, it can be deduced that the main research question was answered and specific objectives achieved.

7.2 Reflection on the research approach

A rigorous research approach was applied in this research as indicated in chapter 1. The principles of design science research philosophy (Hevner & Chatterjee, 2010) under the umbrella of the engaged scholarship research paradigm were applied (Van de Ven, 2007). A research strategy of Singerian inquiry (Churchman, 1971) in a pragmatist framework of abductive reasoning was followed (Gonzalenz & Sol, 2012). In design science research, the prime focus may not only be on discovering reality, but also on what and how the solution to a given problem works (Hevner *et al,* 2004). The design science research philosophy was

pursued in order to build an innovative ICT artefact (the FSDES) to provide intervention schemata for enhancing rural farmers' decisions to solve real problems of food insecurity. Therefore, DSR enabled the researcher to design, instantiate and apply the FSDES for supporting interventions intended to facilitate rural farmers to overcome decision making challenges on food security (Gregor and Hevner, 2013). This greatly facilitated the design process intended to address real problems of rural farmers hence advancing both science and practice (Hevner et al, 2004; Sein *et al*, 2011).

Engaged scholarship was crucial in this research because it enabled the researcher to have the participation of stakeholders throughout the research process and this helped to bring in multiple perspectives which were vital in solving the problem of food insecurity. Engaging key stakeholders helped to alleviate the preconceptions of the researcher and helped in the generation of knowledge relevant to the improvement of food security (chapter 1 & 3). The engaged scholarship research paradigm was relevant for this research because of its focus on stakeholders' perspectives (Knol, 2013). The study was collaborative at each stage and aimed at studying jointly on how indigenous knowledge was used by rural farmers to improve food security. It was a participative and intervention-oriented form of research for obtaining views of stakeholders to bring about a desired change. The study was based on the notion that knowing and solving a complex social problem demands involvement of multiple actors with their varying perspectives (Pettigrew, 2001; Van de Ven, 2007; Costello & Donellan, 2012; Hevner et al, 2004; Gregor & Hevner, 2013; Van de Ven, 2010). This research engaged farmers and stakeholders in group discussions to get collective views in the real context (Rogers *et al*, 2011; Myers, 2009).

Nevertheless, it was not an easy task for the researcher to mobilize and engage all the key stakeholders into food security discussions. Quite often, time for meetings was a major problem as farmers, CDWs, experts and local leaders were busy in their daily work schedules. Besides transport facilitation from their work stations to meeting venues presented a big burden to the researcher's budget. Another challenge encountered by the researcher during discussions was that, some of the participants were very dominant, others timid while others seemed to be comfortable with the status quo. It was an uphill task for the researcher as a team leader, to have views of all and to lead them to consensus. The skilfulness of the researcher and enthusiasm of participants to have the desired change made the study to achieve its intended objectives.

An epistemological choice of pragmatism and ontological critical realism were relevant in grounding this study and in appreciating the theories, constructs and perceptions of other actors in the problem domain (chapter 2). This was helpful in designing and implementing a practical solution that would be useful to practitioners (chapter 4 & 5). Given the nature and intricacy of the research problem, the research followed five steps of initiation, abstraction, theory building, implementation and evaluation (Sol, 1982). This guided the study in appreciating and conceptualizing the problem before embarking on the solutions. This approach helped in ensuring that the design of FSDES was shaped by the users in a real environment.

Farmers and stakeholders' views formed the desired depth of exploration, yielding robust findings which were generalized to rural farmers in Uganda and other developing countries. This generic understanding informed the design considerations for the FSDES. The design of the FSDES is described by using the "ways of" framework (chapter 4) introducing a new way of thinking, governance, working and modelling with respect to decision enhancement for rural farmers (Sol, 1988; Selingmann *et al*, 1989). The ways of framework was used to transform the identified design issues into an artefact that explicitly solves the identified food security problems. The design was participatory (chapter 4), with the involvement of farmers and key stakeholders to model the required activities and components of the FSDES (assessment, collaboration, communication and knowledge management).

To enable the application of FSDES, it was instantiated (chapter 5) following insights from the prototyping approach of indigenous knowledge sharing and principles of service oriented architecture (Lodhi & Mikulecky, (2010; Kamoun, 2007).

The utility of the FSDES was tested and rigorously evaluated before it was put into full use. Evaluation methods included: focus group discussions, questionnaire, and expert evaluation using evaluation workshops. The evaluation results underscore the relevance of this research. It was perceived as a useful and a usable artefact for enhancing decisions of rural farmers on food security using indigenous knowledge as alternative to modern knowledge.

The study used the lens of decision enhancement (Keen & Sol, 2008) to enhance decisions of rural farmers on food security. This approach made the research more innovative regarding the way indigenous knowledge is being captured. CDWs, farmers are involved in discussions, brainstorming on how indigenous knowledge works and in this way it is constantly validated

and updated before storing it in the knowledge suite. The FSDES resolves decision-making challenges that have been affecting rural farmers in Uganda and other developing countries with similar characteristics. The intervention schemata expand the tool set for CDWs on how to effectively use the studio to enhance rural farmers on food security using indigenous knowledge.

7.3 Research generalizability

The goal of design science research is not only to address a specific problem in question but also to explore generalizability and the utility to other similar cases (Venable, 2012, Sein *et al,* 2011). According to Wieringa (2014), DSR iterates over solving and answering knowledge questions as well as contributing to knowledge and practice. He further argues that generalizability in DSR is possible in contextualized settings. DSR artefacts can be generalized to suit particular cases beyond specific domains. Generalizability answers the question of whether the artifact can provide similar results when used in a different situation by different people, and what structural changes need to be made to suit the generalized situation. In this research, the architecture of the FSDES is such that it can be used beyond the domain of food security to other domains where indigenous knowledge is relevant and can contribute immensely in solving real life problems. Given the insights from the evaluation of the FSDES with users and experts, the intervention schemata can be adapted to suit another domain. The knowledge suite can be altered and be used beyond the domain of food security to other context specific domains of social development such as: health, environmental conservation, water and sanitation. The collaboration suite can also be adjusted to be applied in another domain beyond food security and to non-indigenous knowledge human development strategies.

In the course of this research, focus was on getting insights from rural farmers' decision making practices in their effort to attain sustainable food security. The insights can be generalized to other similar domains (health and environment) in developing countries because these problems tend to have similar characteristics (Fellegi; 1996; FAO, 2014). Some of these problems include:

- Uncoordinated rural farmers.
- Unstructured decisions on critical areas of food security: seed selection, food storage and processing (Simon, 2001).

- Indigenous knowledge being individually possessed, secretive and is hardly shared amongst farmers.
- Decisions made by rural farmers are associated with their livelihoods and therefore relate to what Keen and Sol (2008) define as decisions that matter.

Thus, this research extends the decision enhancement approach to the field of food security to other developing economies within and beyond East Africa. The successful application of the decision enhancement approach to different contexts in East African region (Aregu, 2014; Habinka, 2012; Tumwebaze, 2016; Amiyo, 2012; Mirembe, 2015), implementation and evaluation of the FSDES demonstrate potential utility of the approach in providing support to other domains in the region.

7.4 Research contributions

According to Hevner *et al*, (2004), the contribution of design science research should be seen in the novelty, generality and significance of the designed artefact. The type of contribution according to Gregor & Hevner (2013) can be seen at three levels: situated implementation of an artefact at level 1; emerging design theory, that is, knowledge as operational principles/architecture at level 2 and a well-developed design theory about embedded phenomena at level 3. In DSR, making a clear contribution to the real world application environment from which the research problem is drawn is crucial (Hevner *et al*, 2004). According to Hevner & Chatterjee (2010) DSR contributions to the knowledge base might include any additions or extensions to original theories and methods used in the research (new artefacts, design products and processes) and experiences gained from performing design cycles and field testing.

In this research, the FSDES is a contribution itself at level 1. The FSDES uses the theory and methods from decision enhancement and the studio concept of Keen & Sol (2008). Decision enhancement was applied in the new application domains of indigenous knowledge and food security especially in rural communities of Uganda. The FSDES provides intervention schemata for enhancing rural farmers' decisions on food security. At level 2, this research extends DSR to an engaged and collaborative approach in the application of indigenous knowledge combined with modern knowledge to solve the problem of food insecurity. The research extends decision enhancement with the use of intervention schemata in addition to

stakeholders' collaboration. At level 3, the study contributes to society by adding value to the real world problem of food security. The FSDES is a generic but a flexible solution, available for other similar social problems when the knowledge base and the schemata are altered according to the specific domain.

The researcher therefore, maintains that this is the first attempt to develop a food security decision enhancement studio for providing interventions aimed at helping rural farmers to improve their decision making practices and also, guiding them on how well they can exploit indigenous knowledge.

7.5 Recommendations and direction for further research

Like other scientific studies, the findings of this research create opportunities for further inquiries. The study recommends more investigations that advance DE and DSR in the broader field of food security especially looking at other dimensions that determine food security such as poverty, health and climate change. In the course of this research it was established that malnutrition and death among children under five years were alarmingly high (UBOS, 2016; Tugume, 2017). The study further recommends inquiry into early childhood malnutrition and the role indigenous knowledge can play in providing alternative solutions among the rural communities of Uganda. Besides, participation of men and youth in food security promotion at household and community levels need to be investigated further. Last but not least, this research proposes the following areas for further attention:

1. Rolling out the FSDES to other regions of Uganda. Due to resource constraints of the researcher, the FSDES is currently working in some parts Kabale and Mbarara Districts.
2. Evaluation of the FSDES at later stages of implementation and use to measure the long term impact on food security. Can the FSDES support the growing number of indigenous knowledge users? The FSDES was evaluated in its early startup and development stages. There is need for continuous evaluation as additional modifications are expected to be made by the users in different environments over the years.
3. The position of CDWs as facilitators of rural farmers. Our focus in this research was on CDWs as rightful facilitators to enhance rural farmers' decisions on food security. It is important to investigate the possibility of engaging more stakeholders like extension workers

to support the CDWs in facilitating rural farmers to enhance their decisions on the improvement of food security.

4. Although the FSDES was implemented with the CDWs, their capacity needs to be strengthened by giving them more training and equipping them with modern IT devices like portable computers, tablets and internet modems which require support of public-private partnership.

5. It is important that small scale rural farmers be linked to local markets and agribusiness processors in the East African region. This will provide an opportunity for rural farmers to market their products and enhance their financial capacity to promote food security.

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Appendices

Appendix A: List of acronyms

ADR	Action Design Research
AR	Action Research
API	Application Programming Interface
CBOs	Community Based Organizations
CDOs	Community Development Officers
CSOs	Civil Society Organizations
CWDs	Community Development Workers
DCDO	District Community Development Officer
DES	Decision Enhancement Services
DPWO	District Probation and Welfare Officer
DSR	Design Science Research
DSS	Decision Support System
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
FNP	Food and Nutrition policy
FSDES	Food Security Decision Enhancement Studio
FSLF	Food Security Learning Framework
GSS	Group Support System
ICT	Information Communication Technology
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
IS	Information Systems
IT	Information Technology
MDGs	Millennium Development Goals
MGT	Management
MYSQL	My Structured Query Language
NAADS	National Agriculture Advisory Services
NARO	National Agriculture Research Organization
NDP1	National Development Plan 1
NDP11	National Development Plan11
NGOs	Non-Governmental Organizations
OWC	Operation Wealth Creation
PDPO	Principal Probation and Welfare Officer
PHP	Personal Home Page
PMA	Plan for Modernization of Agriculture
SDGs	Sustainable Development Goals
UBOS	Uganda Bureau of Statistics
UCE	Uganda Certificate of Education
UML	Unified Modelling Language
UN	United Nations
UNGA	United Nations General Assembly
UNICEF	United Nations Children Fund
USAID	United States Agency for International Development
WFP	World Food Program

Appendix B: Data collection instruments

i) Interview guide

Introduction

I am conducting research on indigenous knowledge and household food security. The study intends to explore the contribution of indigenous knowledge to food security and how decisions of rural communities can be enhanced. You have been chosen to participate in this research by answering the following questions. Please feel free to answer the questions and do not hesitate to ask where you do not understand. The interview will last for 30 minutes. Do you agree to participate? Yes---------- No--------
Thank you.

Robert Tweheyo

For research assistants: Successfully Completed Yes { } No { } Reason ----------

Proceed the next person.

1. Gender of the respondent

☐ a) Female

☐ b) Male

2. Education level

☐ a) None

☐ b) Primary

☐ c) Secondary

☐ d) Tertiary

3. Age

☐ a) 15—24

☐ b) 25—34

☐ c) 35—44

☐ d) 55—64

☐ f) 65—74

4. Marital status

☐ a) Single

☐ b) Married

☐ c) Separated

☐ d) Other (specify) ----------

5. Is the term food security familiar to you?

☐ a) Yes

☐ b) No

6. If yes, briefly state what it is?----------

---

7. What decisions do you make to ensure your household is food secure?

8. What farming activities are you engaged in?

☐ a) Crop farming

☐ b) Animal keeping

☐ c) Both a & b

☐ d) Poultry

9. In your farming, which knowledge/methods do you commonly use?

☐ a) Indigenous knowledge

☐ b) Scientific/modern knowledge

☐ c) Both

10. What factors influence your decision to choose the method/knowledge you use in your day to day farming activities?

11. Can you briefly narrate the experiences you have with both indigenous and modern knowledge in production and processing food in your household?

12. What good attributes have you noticed with indigenous knowledge over modern knowledge?

13. What challenges do you face in making decisions regarding knowledge utilization in your effort to ensure household food security?

14. How would you want to be helped to better enhance your decisions on food security?

15. In the last 3 months, have you seen any of the following officers visiting you to advise on how to enhance household food security?

☐ a) Extension worker

☐ c) Community development worker

☐ d) NAADs coordinator

16. Do you belong to any group of farmers?

☐ a) Yes

☐ b) No

17. If yes how does the group help you enhance your decisions on household food security?

18. Do you regularly hold group meetings?

☐ a) Yes

☐ b) No

19. If yes what major issues do you discuss in the meetings?

20. Do you own any of the following ICT devices?) tick all that you have)

☐ a) Computer

☐ b) Smart phone

☐ c) Radio

☐ d) A tablet

What do you use the device you have for? ----------

21. What is the level of your ICT usage skills?

☐ a) Very good

☐ b) Good

☐ c) Fair

☐ d) Poor

22. Which decisions do you take to enhance your household food security?

23 which methods do you use to preserve your food stuffs (grains and cereals) against pests?

- ☐ a) Insecticide
- ☐ b) Cow dung ash
- ☐ c) Red pepper
- ☐ d) Herbs
- ☐ e) Cow urine

24 Who provides information you may need in the decision making process?

25 Which methods do you use to store your food stuffs after harvest?

- ☐ a) Modern cemented store
- ☐ b) Local store constructed with local materials
- ☐ c) Granary
- ☐ d) Clay pots
- ☐ e) Baskets
- ☐ f) Other, specify.....

26. Where do you usually obtain seeds for planting (planting materials)?

27. What factors influence your decisions of using indigenous knowledge?

Which decisions do you usually take to enhance food security?

Thank you for your time.

End

ii) Stakeholders interview guide

What is the situation of household food security in your area?

In which ways do you advise community members to enhance their household food security?

What is the level of indigenous knowledge utilization in this community?

What is the perception of indigenous knowledge compared to scientific knowledge?

How do you assess peoples' capacity in terms of making decisions for enhancing household food security?

How often do you meet with community members to make decisions on food security improvement?

Do you make collaborative decisions on food security?

What experiences have you had with collaborative decision making?

iii) Observation checklist

Farming activities rural farmers are engaged in.

Methods/knowledge used (indigenous/modern).

Level of indigenous knowledge utilization.

Decisions made and the processes followed.

Factors influencing their decisions.

Collaborative processes.

Intervention and facilitation from experts if any.

How often meetings are convened to enhance decisions.

iv) Focus group discussion guide

Would you tell me what it means for a household to be food secure?

What is the situation of food security in your homes?

What kind of decisions do you make to ensure that your households are food secure?

What factors influence your decisions in choosing between indigenous and scientific/modern?
Knowledge in the process of improving food security?

What attributes does indigenous knowledge have over scientific knowledge?
What guides your decisions do you make in the following areas?
a) Selecting planting seeds
b) Storage
c) Food preservation

Do you make your decisions in groups or as individuals?

How do you find groups helpful in enhancing your decisions?

Do you get assistance from extension workers and community development workers in enhancing your decisions?

Is there anything else you would like us to talk about in connection with decision enhancement for improving household food security before we leave?

Thank you.

Appendix C: The FSDES Evaluation Questionnaire

i) Users

Dear Sir/Madam

As one of the people who participated in testing the FSDES and filling it with farmers' indigenous knowledge and experiences on food security, you are requested to evaluate its effectiveness in terms of usability and usefulness. Usability refers to the extent to which the FSDES is usable by users i.e. the ease of interactions. Usefulness refers to the value that the studio adds to the performance of the Community Development Workers as they help rural farmers to improve food security. Usage is the actual application of the studio in providing intervention schemata to CDWs. Your opinion regarding these aforementioned areas is much appreciated. Please fill this questionnaire.

Thank you

	Usability statements	**Strongly disagree (1)**	**Disagree (2)**	**Not sure (3)**	**Agree (4)**	**Strongly agree (5)**
1	The studio suites contain relevant information					
2	The suites reflect the actual activities performed by rural farmers					
3	The layout of suites is adequately presented					
4	The language used in the suites is understandable					
5	The interface is clear and understandable					
6	I find FSDES easy to use					
7	I can easily follow the steps looking for the information I want					

8	Using FSDES adds value to my work					
9	I am able to access information in the FSDES					
10	I have not experienced difficulties using FSDES suites					
11	The information generated by FSDES is enough and relevant to enable farmers make agile decisions					

Usefulness statement

12.	The FSDES enables effective decision making					
13	Collaboration suite enables knowledge and experiences sharing among farmers and experts					
14	The FSDES provides a platform for farmers to air their views					
15	The studio enables the participants to explore knowledge alternatives for bettering food security					
16	The studio facilitates to shared understanding among key stakeholders					
17	The studio has positive impact on household food security					
18	Using the FSDES eases my work in guiding farmers to improve foo security					
19	The FSDES enables farmers to enhance their decisions on food security					
20	The FSDES suites provide an environment needed for making effective decisions					

Open-ended evaluation questionnaire

This part of the questionnaire is intended to provide us with your opinion regarding the usefulness and usability of the FSDES. Please be precise and concise.

Usability

1. Outline factors that you think are likely to hinder the effective use of the FSDES

_____

_____

_____

_____

2. What is your suggestion on the FSDES layout?

3. How can the FSDES' usability be made much better? ----------

---

4. Is the intervention schemata easy to use? Yes --------- No ----------
5. Is the collaboration suite relevant to farmers' decision making processes? Yes -------- No -

6. Is the user interface understandable? Yes ------ No ----------
7. Do suites contain sufficient information? Yes -------No ----------

8. Do you think the FSDES generates relevant knowledge to farmers? Yes ------ No -----
9. Would you recommend the FSDES to be used in other parts of Uganda for food security improvement? Yes ---------- No ----------

Usefulness of the FSDES

10. How relevant is information generated by the FSDES to farmers and stakeholders?

_____
_____
_____

11. Do suites provided in the studio reflect the actual processes involved in food security improvement? Yes --------- No----------

12. Can the FSDES improve farmers' decision flexibility regarding food security issues? Yes ---------- No ----------
13. In your opinion, does the FSDES improve performance of CDWs in their effort to support farmers' decisions for food security? Yes ---------- No ----------

Thank you

Evaluation questionnaire

ii) Experts

Dear Sir/Madam/Prof./ Dr. ……

I am a PhD student researching on "Indigenous Knowledge and Food Security. Findings show that rural farmers lack adequate coordination and therefore are not able to share knowledge and experiences in the decision making processes. As a result, a Food Security Decision Enhancement Studio (FSDES) has been designed and implemented to provide intervention schemata to Community Development Workers (CDWs) as a recipe to guide rural farmers address the aforementioned challenges. Basing on your expertise and your stake, you have been selected to participate in evaluating the FSDES with regard to its perceived usefulness and usability by CDWs with regard to enhancing rural farmers' decisions.

- Usability refers to the extent to which the FSDES is usable by users i.e. the ease of interactions.
- Usefulness refers to the value that the studio adds in providing support to Community Development Workers as they help rural farmers to improve food security.

Your opinion regarding these aforementioned areas is much appreciated. Please fill this questionnaire.

Thank you

Robert Tweheyo

Section A. Background information

i) Field of specialization (tick where appropriate)

Information specialist	
Food security related field	
Other (specify)	

ii) Highest level of education

(Tick appropriately)

Bachelor	
Post graduate	

iii) Work experience (tick where appropriate)

Less than 5 years	
Above 5 years	

	Usability statements	Strongly disagree (1)	Agree (2)	Not sure (3)	Agree (4)	Strongly agree (5)
1.	The FSDES addresses rural farmers' decision making challenges with regard to food security					
2.	The FSDES can be applied to a broader context to cover many areas of food security					
3.	The FSDES can enhance CDWs efficiency in guiding rural farmers/communities' to overcome food security decision making challenges					
4.	The FSDES is a useful tool for addressing the problem of communication among farmers and stakeholders with regard to					

	food security					
5.	I would not hastate recommending the FSDES to farmers and stakeholders in the field of food security					
6.	The FSDES supports collaboration between farmers and stakeholders					
7.	The FSDES addresses key challenges farmers face in decision making					
8.	The intervention guidelines provided by the FSDES adds value to CDWs' efficiency in supporting farmers					
9.	The FSDES enables interaction among farmers and stakeholders and experts					
10.	The FSDES helps to collect, store and disseminate indigenous knowledge hence preventing it from extinction					
11.	The assessment tool in the intervention guidelines gives the actual situation of food security on the ground					

Usability statements

12	Information flow in the FSDE is logical					
13	The FSDES design is clear and simple to interpret					
14	The intervention guidelines are easy to use					
15	Language used in the FSDES are clear and reflect day to day activities with rural farmers					
16	Information in the FSDES is easy to access					
17	Some farmers can easily learn how to use the FSDES					
18	Over all, FSDES is easy to use					

iv) Additional Comments

Comment on areas of the FSDES you feel have not been included in the questionnaire.

English summary

Food security is indispensable for acceptable standards of living and every person has a right to be free from hunger and malnutrition. Nevertheless, food security remains one of the most challenging problems in developing countries like Uganda and more so among the rural communities. The inspiration for this research was a result of persistent cases of food insecurity in rural communities of Uganda. Food insecurity is a key indicator to underdevelopment because of its effects on health, education and poverty.

In a rural context, indigenous knowledge is often the basis for local level decision making and an alternative means of promoting food security because of its cost-effectiveness and sustainability. Indigenous knowledge refers to what people know and have known and have done for generations. To address the problem of food insecurity among the rural communities, it is important to build on their knowledge and experiences.

This research focused on enhancing rural farmers' decisions on food security using indigenous knowledge and following the decision enhancement approach of Keen and Sol (2008). Decision enhancement is based on the fusion of people, processes and technology to enable an interactive and facilitative environment for decision making.

Design science research philosophy within an engaged scholarship research paradigm, following decision enhancement of Keen and Sol (2008), were used design a food security decision enhancement studio for providing intervention schemata to help rural farmers enhance their decisions. A pragmatist framework of Singerian inquiry with abductive reasoning research strategy was adopted.

A literature review was carried out to gain a generic understanding from different perspectives and to get deeper insights of the challenges rural farmers face and decisions they take to overcome the challenges. In the exploration phase, it was observed that rural farmers operate in complex circumstances characterised by poor coordination and collaboration, lack of information and knowledge sharing to learn about what other farmers do in order to resolve food security decision making challenges. The exploratory study findings also revealed that the context in which rural farmers make food security decisions was complex and unstructured. It was further noted that rural farmers tend to learn from each other and usually repeat what worked before. It was observed that rural farmers do not always follow a rational model of decision making due to the context in which they work. Based on the

aforementioned challenges, a new way of thinking, working, controlling and modelling was required of the rural farmers to have better solutions for food insecurity. A food security decision enhancement studio (the FSDES) was designed, instantiated and evaluated to provide intervention schemata to CDWs as recipes for enhancing rural farmers' decisions on food security using indigenous knowledge. The intervention schemata guide the CDWs on what to do to be able to use the studio as they intervene to facilitate rural farmers to enhance food security decisions.

The FSDES consists of four suites of different technology enablers. The assessment suite is a recipe for appraising and analysing the status of food security by CDWs to get actual facts on which to base their interventions. The collaboration suite enables interaction between farmers and stakeholders exchanging ideas on how food security can be improved. It enables collaborative decision making by prescribing steps to be followed. Real time information and knowledge are shared in a chat room with instant feedback and discussions. This helps participants to make informed decisions. The communication suite facilitates information sharing which is enabled by instant messaging. It provides a platform for interaction and networking of all stakeholders in the field of food security proving feedback to farmers' queries. The knowledge management suite contains a repository of indigenous and modern knowledge concerning seed selection, food storage and processing including intervention schemata.

The suites, services and recipes are used by CDWs to help rural farmers enhance their decision making processes for improving food security. The FSDES was implemented and used by the CDWs while adapting the intervention schemata to suit the context in which it is deployed. Evaluation was carried out with the CDWs and experts in the field of food security and information systems. It was perceived as a usable and useful artefact which provides intervention schemata for aiding CDWs to organise rural farmers and enhance their decision making practices. The FSDES is being used by CDWs to enhance rural farmers' decisions on food security.

The FSDES itself is the major contribution of this research. The FSDES uses the theory and methods from decision enhancement and the studio concept of Keen & Sol (2008). Decision enhancement was applied in the new application domains of indigenous knowledge and food

security especially in rural communities of Uganda. The FSDES provides intervention schemata for enhancing rural farmers' decisions on food security. The research extends DSR to an engaged and collaborative approach in the application of indigenous knowledge combined with modern knowledge to solve the problem of food insecurity. The research further extends decision enhancement with the use of intervention schemata in addition to stakeholders' collaboration. Besides the study contributes to society by adding value to the real world problem of food security. The FSDES is a generic but a flexible solution, available for other similar social problems when the knowledge base and the schemata are altered according to the specific domain.

Therefore, the notion of decision enhancement on which we based the design of FSDES can be extended to other domains other than food security as discussed in chapter seven.

Samenvatting

Inheemse kennis en voedselzekerheid: verbetering van de beslissingen van boeren

Voedselzekerheid is onontbeerlijk voor een acceptabele levensstandaard, en ieder mens heeft het recht om gevrijwaard te zijn van honger en ondervoeding. Toch blijft voedselzekerheid een van de grootste uitdagingen in ontwikkelingslanden als Oeganda, zeker in plattelandsgemeenschappen. Dit onderzoek is geïnspireerd door aanhoudende voedselonzekerheid in plattelandsgemeenschappen in Oeganda. Voedselonzekerheid is een belangrijke indicator van onderontwikkeling vanwege de effecten op gezondheid, onderwijs en armoede.

In een plattelandsomgeving vormt inheemse kennis vaak de basis voor lokale besluitvorming en biedt deze een alternatieve, kosteneffectieve en duurzame manier om voedselzekerheid te bevorderen. Inheemse kennis verwijst naar wat mensen weten en al generaties lang hebben geweten en gedaan. Om het probleem van voedselonzekerheid in plattelandsgemeenschappen aan te pakken, is het belangrijk om voort te bouwen op hun kennis en ervaring.

Dit onderzoek is erop gericht de beslissingen van boeren over voedselzekerheid te verbeteren door gebruik te maken van inheemse kennis, volgens de decision enhancement-benadering van Keen en Sol (2008). Decision enhancement richt zich erop mensen, processen en technologie samen te brengen om een interactieve omgeving te creëren die besluitvorming faciliteert.

Op basis van een design science-onderzoeksfilosofie en engaged scholarship is een virtuele omgeving ontwikkeld die interventieschema's verstrekt waarmee boeren hun beslissingen over voedselzekerheid kunnen verbeteren. Er is gewerkt vanuit een pragmatisch kader volgens de Singeriaanse benadering met een abductieve onderzoeksstrategie.

Er is een literatuuronderzoek uitgevoerd om inzicht te krijgen in de verschillende perspectieven en in de uitdagingen waarmee boeren te maken krijgen en de beslissingen die ze nemen om deze het hoofd te bieden. In de verkenningsfase is opgemerkt dat boeren onder complexe omstandigheden werken die gekenmerkt worden door een slechte coördinatie en samenwerking, en er wordt geen kennis en informatie gedeeld om te leren hoe andere boeren omgaan met uitdagingen op het gebied van voedselzekerheid. Uit het verkennende onderzoek

blijkt ook dat de context waarin boeren beslissingen over voedselzekerheid nemen, complex en niet gestructureerd is. Verder is opgemerkt dat boeren vaak van elkaar leren en gewoonlijk herhalen wat voordien ook werkte. Daarnaast is vastgesteld dat boeren door de context waarin ze werken niet altijd een rationeel besluitvormingsproces volgen.

Met het oog op deze uitdagingen moeten boeren overgaan tot een nieuwe manier van denken, werken, beheren en modelleren om tot betere oplossingen voor voedselonzekerheid te komen. Hiertoe hebben we een Food Security Decision Enhancement Studio (FDSES) ontwikkeld, geïmplementeerd en geëvalueerd. Hiermee kunnen we interventieschema's aanbieden die boeren als stappenplan kunnen gebruiken om op basis van inheemse kennis hun beslissingen over voedselzekerheid te verbeteren. De interventieschema's dienen als leidraad voor ontwikkelingswerkers die zo boeren kunnen helpen om hun beslissingen over voedselzekerheid te verbeteren.

De FSDES bestaat uit vier suites van verschillende softwareontwikkelaars. In de 'assessment suite' kunnen ontwikkelingswerkers de status van de voedselzekerheid beoordelen en analyseren zodat zij hun interventies op daadwerkelijke feiten kunnen baseren. De 'collaboration suite' bevordert voortdurende interactie tussen boeren en stakeholders; hierin kunnen ze ideeën uitwisselen over het verbeteren van de voedselzekerheid. Deze suite stimuleert gezamenlijke besluitvorming door een stappenplan voor te stellen. In de 'communication suite' worden actuele informatie en kennis gedeeld in een chatroom met instant feedback en discussies; dit helpt de deelnemers om gefundeerde beslissingen te nemen. Instant messaging vergemakkelijkt het delen van informatie. Deze suite biedt een platform voor interactie tussen alle belanghebbenden op het gebied van voedselzekerheid en geeft boeren de gelegenheid om feedback te krijgen op hun vragen. De 'knowledge management suite' bevat een databank van inheemse kennis over zaadselectie, voedselopslag en voedselverwerking, inclusief interventieschema's.

Ontwikkelingswerkers wenden de suites, diensten en stappenplannen aan om boeren te helpen hun besluitvormingsprocessen over voedselzekerheid te verbeteren. De FSDES is toegepast en verfijnd door de ontwikkelingswerkers, die de interventieschema's hebben aangepast aan de context waarin deze zijn ingezet. Er is geëvalueerd met de ontwikkelingswerkers en met deskundigen op het gebied van voedselzekerheid en

informatiesystemen. Zij vinden de FSDES een nuttig en bruikbaar hulpmiddel voor het verstrekken van interventieschema's waarmee ontwikkelingswerkers boeren kunnen organiseren en hun besluitvormingsproces kunnen verbeteren

De belangrijkste bijdrage uit dit onderzoek is de FSDES, waarmee we een prescriptieve oplossing voor het probleem van voedselonzekerheid bieden. Daarnaast dragen we bij aan de descriptieve kennis over het aanpakken van voedselonzekerheid door middel van contextspecifieke interventies. De FSDES kan ook voor andere domeinen van sociaal-economische ontwikkeling worden ingezet. Boeren spelen tevens een rol (als stakeholder en begunstigde) in de gezondheidszorg, milieubescherming, water- en sanitaire voorzieningen. Daarom kan decision enhancement, waarop we de FSDES hebben gebaseerd, ook worden uitgebreid naar andere domeinen buiten voedselzekerheid, zoals besproken in hoofdstuk 7.

Curriculum Vitae

Robert Tweheyo was born on 22nd July 1966 in Kashambya, Kabale District, Western Uganda. He holds a master's degree in social sector planning and management from Makerere University. He attended primary education in Kitanga primary school and went to Rubiriizi Secondary School for ordinary and advanced levels of secondary education. He obtained a degree of Bachelor of Arts in Social Sciences from Makerere University in 1998.

Robert has 25 years' experience of secondary and university teaching. He is the founding head of the Department of Sociology and Social Administration, Kyambogo University. He has also worked at Uganda Christian University and Makerere University as a part-time lecturer. Currently, he is a lecturer of organizational theory and management in the department of Sociology and Social Administration, Kyambogo University. His research interests are in the fields of food security and social development. He has attended and presented research papers at various international conferences.