Constructing Conceptual Framework of Agricultural Knowledge Management System Development for Knowledge Sharing and Integration: The Case of Ethiopian Soil Information Systems

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ABSTRACT

The notion of creating, capturing, and sharing of knowledge has been repetitively raised by many research, development and international donor agencies to transform the agricultural sector in Ethiopia. However, most of the current approaches to knowledge dissemination focus on knowledge that originates from the western view of scientific rationality, while overlooking the role of indigenous knowledge contained by local communities. This study aims at contributing to the discourse on how to develop and use agricultural Knowledge management system (KMS) for supporting the sharing of indigenous knowledge and seamlessly flow of it with scientific knowledge. The conceptual framework of the research is anchored in concepts drawn from the theory of situated learning in communities of practice, namely boundary object and knowledge brokering. Nevertheless, understanding concepts merely are not enough in KMS research, but system must also be implemented to test and measure the underlying concepts, thereby to ensure its sustainability. The research was further investigated to understand the design, use, and consequence of the technological artifact for enhancing knowledge sharing and integration. In building this research, the multi-methodological approach to KMS research in action research perspective was employed. Using the KMS development practice of Ethiopian agricultural transformation agency as a case study, an interpretive analysis using primary and secondary qualitative data acquired through in-depth semi-structured interviews, participant observations, and document analysis was carried out.

The research result yields concepts on the roles and practices of extension agent as a knowledge broker so as to exchange knowledge among participants. The study has also identified a number of boundary objects possessed by relevant social groups. It further implicated the need of developing a shared KMS boundary object relying on concepts investigated in the roles and practices of knowledge brokers and boundary objects. The study further addresses the understanding of the KMS success dimensions including KMS quality, knowledge quality, and service quality which affect the KMS use and user satisfaction. Ultimately, the interplay of the KMS use and knowledge brokering roles has brought shared understanding among participants so as to share and integrate multiplicity of agricultural knowledge. Moreover, the interplay improved the performance of individuals and the agricultural extension system as a whole in making decision through quality knowledge.

The research shall have theoretical contribution in addressing agricultural KMS development and use for the incorporation of variety of knowledge through extending the theory of situated learning in communities of practice and structuration model of technology. The research also contributes methodologically for the application of system development action research for understanding of the process conceptual framework in KMS development and use. Moreover, the research has practical implications for management and KMS developers understanding in developing strategies for the *potential of a shared KMS boundary object and the roles and practices of extension agents as knowledge brokers for knowledge sharing and integration, thereby, empowering the marginalized smallholder farmers and to contribute to the overall socio-economic development.*

Keywords: *social groups, indigenous knowledge, knowledge brokering, knowledge management, farmers, system development, boundary object, KMS success.*

DEDICATION

I dedicated this work to my beloved mother Asres Akalie who insisted since my childhood that I aim high in education. Thank you!

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ABBERVATIONS AND ACRONYMS

ADLI	Agricultural Development Led Industrialization Strategy
AfSIS	Africa Soil Information Service
AGP	Agricultural Growth Program
ATA	Agricultural Transformation Agency
CoI	Community of Interest
CoP	Community of Practice
CIPP	Comprehensive Integrated Package Projects
CPWD	Community-based Participatory Watershed Development
ECX	Ethiopian Commodity Exchange
EIAR	Ethiopian Institute of Agricultural Research
EthioSIS	Ethiopian Soil Information System
Ethio-Telecom	Ethiopian Telecommunication
FTC	Farmer Training Centre
GIS	Geographic Information System
GPS	Global Positioning System
GTP	Growth and Transformation Program
ILRI	International Livestock Research Institute
IPMS	Improving Productivity and Market Success
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
ISD	Information System Development
IVR	Interactive Voice Response
KM	Knowledge Management
LLPPA	Local Level Participatory Planning Approach
MoARD	Ministry of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
NAEIP	National Agricultural Extension Intervention Program
NMA	National Meteorological Agency
NRM	Natural Resource Management
PADETES	PArticipatory DEmonstration and Training Extension System
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
PD	Participatory Design
PLUP	Participatory Land Use-Planning
PRA	Participatory Rural Appraisal
RARCs	Regional Agricultural Research Centre
SAN	Server Area Network
SD	System Development
SN	Social Network
SNNP	Southern Nation and Nationality Peoples
T and V	Training and Visit
TIMA	Teff International Market Access
WFP	World Food Program

CHAPTER

1. INTRODUCTION

1.1 Background of the Study

Agriculture is the mainstay of the Ethiopian economy and other developing countries in Africa. However, yields in these countries have lagged far behind those in developed countries over the ages. According to Zerihun, Wakiaga, and Kibret (2016), the agricultural sector contributes close to 39 percent of the national Gross Domestic Product (GDP), the source of employment for 73 percent of the population of Ethiopia, supplies 70% of the raw-material requirements for local industries, and provides up to 70 percent of foreign currency through exports in 2014/15. The level and speed of economic growth in a country are highly influenced by sustained agricultural sector development (Davis et al., 2010; Warner, Stehulak, & Kasa, 2015). However, the sector is not developed and suffering from low productivity. The underlying reasons include land fragmentation and poor management, poor market integration, climate change, low agricultural technologies involvement, food insecurity, much of the agricultural products are produced by smallholder farmers, and the growing income gap between urban and rural areas (UNDP, 2012; Zerihun et al., 2016).

In light of the above constraints, research and development organizations and international donor agencies put much effort to transform the sector so as to bring sustainable rural economic development. Additionally, the Ethiopian government has been put much effort to increase the production of smallholder farmers by implementing measures to raise and sustain agricultural productivity (UNDP, 2012). One of the main developments implemented is the extension system to transfer knowledge and new technologies to farmers from research. Accordingly, the country has developed and implemented a range of legal, policy, and institutional frameworks to address problems such as climate change, environmental protection, deforestation, and the sustainable utilization of natural resources (Zerihun et al., 2016). However, bringing rural economic development while ensuring conservation and sustainable management of environmental resources is still the most challenging task in which Ethiopia and other agricultural based developing countries have lagged behind (Masinde, 2013; UNDP, 2012).

Among several development and research endeavors, the Ethiopian Agricultural Transformations Agency (ATA) is an initiative by the government of Ethiopia with the primary aim of promoting agricultural sector transformation. In order to achieve this objective, the agency aligns its structure with existing structure of other relevant governmental and non-governmental organizations, the country agricultural extension system, and other private sectors to readdress the existing problem particularly the food insecurity (ATA, 2015). ATA also structures its objective in-line with the transformation agendas of the country's Growth and Transformation Program (GTP). According to Ministry of Finance and Economic Development (2010), the transformation agenda is a mechanism developed aiming to prioritize a set of interventions that catalyze the transformation of the country's agricultural sector. Accordingly, one of the main agendas of ATA in a country is to develop and manage ICTs-based knowledge management systems (KMS) for agriculture such as the Ethiopian Soil Information System (the EthioSIS) and mobile-based hotlines such as 8028 for supporting farmers. This research is interested in understanding of the concepts in the process of agricultural KMS development and use for knowledge sharing and integration.

1.2 Motivation for Conducting the Research

Today, literature is rich in the potential of ICTs as enablers of sustainable socio-economic development (Byrne & Sahay, 2007; Puri, 2007). ICTs are, therefore, increasingly recognized by the governments of developing countries and being implemented to backing-up different economic sectors, especially to increase agricultural productivity as a strategic priority (UNDP, 2012). They are carrying and supporting the economic development by empowering the small-scale farmers with up-to-date knowledge and information about agricultural technologies, best practices, markets, price trends, climate change adaptation, natural resource management and conservation, food security, and the environment (Kipkorir, Songok, & Mugalavai, 2011; Masinde, 2013; UNDP, 2012). In this regard, there are several ICT-based agricultural Knowledge Management Systems, KMS in Ethiopia, for example the Ethiopian Commodity Exchange (ECX) (ECX, 2008), web-based portal for Improving Productivity and Market Success (IPMS) of Ethiopian farmers (Jama, Stuth, Kaitho, & Hurissa, 2004), and the EthioSIS (Ethiopian Soil Information System) of ATA (ATA, 2014). The applied technological advancements and developed tools are potentially capable of supporting the agricultural sector and smallholder farmers (Masinde, 2013). However, their use and relevance are still alien to the local rural communities (Masinde, 2013). Previous researchers have also reported that many agricultural KMSs are unsuccessful to provide the full promised potential of ICTs in developing countries (Byrne & Sahay, 2007; Masinde, 2013; Puri, 2007). Despite much debates on KMS development process such as theorizing, treatment of knowledge, designing, implementation, and use of KMS, there is a dearth of research of a comprehensive empirical nature on agricultural KMS development and use processes.

Information Communication Technologies (ICTs) have a great role for enhancing communication, collaboration, and access to information in various part of life, among others in education, research, health, and agriculture. ICTs have a great influence in agriculture for acquisition, storage, retrieval, sharing, and usage of agricultural knowledge. Indigenous knowledge (IK) and practices can also be captured, shared, and preserved through utilizing ICTs (Nicola-Rocca & Parrish, 2013), thereby support smallholder farmers and other stakeholders to bring agricultural productivity. The Ethiopian extension system and ICT-based agricultural KMS are transferring agricultural knowledge and technology to local farmers from research following one directional top-down hierarchical structure. Consequently, the agricultural extension system and KMS do not allow local farmers to share their knowledge and practice with other local farmers and scientific research communities. However, KMSs have a potential for supporting knowledge management (KM) activities such as knowledge capturing, sharing, storage, and application in problem areas where there are several groups of participants. The study, therefore, will shed light on the wide debate about the understanding of the development and use of agricultural KMS processes for knowledge sharing and integration. In this regard, contribution to the scientific body of knowledge in understanding of the concepts in agricultural KMS process is the ultimate goal and the motivation for conducting this research.

1.3 Statement of the Problem

Rural communities are not merely rely on tangible resources such as funds, labor, land, and other natural resources and raw materials for creating production values but also need knowledge for creating innovation and intellectual property (Chantarasombat, Srisa-ard, Kuofie, & Jennex, 2010). Knowledge has been recently receiving much attention as one of the basic enablers for sustainable development and innovation in agriculture (Sarkhel, 2016).

The notion of knowledge creation, capturing, and sharing has been repeatedly raised by many international donor organizations, among others the World Bank and UNDP for sustainable socio-economic development. Local farmers in Ethiopia have various IK and practice in agriculture (Degaga & Angasu, 2017; Shiferaw, Hurni, & Zeleke, 2013; UNDP, 2012). However, the farmers' IK and ways of sharing it are not adequately probed and documented (Degaga & Angasu, 2017; Masinde, 2013; Sarkhel, 2016). Hence, there is a need to identify the IK and understand how IK is shared by the local communities before it disappears. Despite IK plays a crucial role in agriculture, it is no longer reliable on its own which necessitates its free flow with scientific knowledge and techniques for the enhancement of the agricultural sector (Kipkorir et al., 2011). However, there is little research (Mercer, Kelman, Taranis, & Suchet-Pearson, 2009; Puri, 2007; UNDP, 2012) conducted in addressing the sharing and seamlessly flow of the two knowledge systems in agriculture.

In agricultural KMS development and use, sharing of IK with scientific knowledge is one of the critical success factors (Masinde, 2013; Puri, 2007). The increasing emphasis on the sharing and integration of the two in different aspects of agriculture stems from the fact that the two: indigenous and scientific knowledge complement each other in their strengths and weaknesses, and their combination may achieve what neither would achieve alone (Puri, 2007; Ruheza & Kilugwe, 2012; Tripathi & Bhattarya, 2004). However, the current KM and KMS development approaches in developing countries privilege knowledge originates from the western view of scientific rationality while overlooking the role of IK hosted in rural communities (Byrne & Sahay, 2007; Masinde, 2013; Mercer et al., 2009; Puri, 2007). The weak linkage between the two is compounded by the historically marginalization of IK from the scientific community (Puri, 2007; UNDP, 2012; World Bank, 1998, 2005). Such approaches, thus respond poorly to farmers' needs and expectations (UNDP, 2012). Hence, it is arguable that following such approaches of knowledge trend can led to solutions that do not fit the realities in the content as supported by the famous "*design from nowhere*" (Suchman, 2002). This circumstance has led to a growing interest in the importance of IK and its seamlessly flow with scientific knowledge in KMS development to meet the users' needs and expectations (Masinde, 2013; Mercer et al., 2009; Puri, 2007).

Agricultural KMS development is a complex team activity involving participants from different communities of practice (CoPs), each of them contributing specific knowledge that needs to be incorporated in the IT system. In agricultural KMS, there are participants from different social groups who possess IK and scientific knowledge, for example local farmers and scientific communities, respectively (Masinde, 2013; Puri, 2007). However, little has been realized how agricultural KMSs are developed and used for sharing, free flow, and integration of IK with scientific knowledge. Puri (2007) and Rosenkranz, Vranesic, and Holten (2014) indicated that building a shared understanding through knowledge exchanging between relevant participants across CoPs has been identified as a critical success factor for KMS development. This can allow relevant participants to determine and contribute their knowledge in the development and use of KMS (Germonprez, Hovorka, & Gal, 2011; Rosenkranz et al., 2014). Such situation calls for a new systematic science in KMS development with systematic processes and strict empirical grounding (Rosenkranz et al., 2014) for involving pieces of knowledge that may reside from different participants. The research, thus, focuses on seeking for concepts to develop the process conceptual framework which helps for better understanding of the agricultural KMS development and use for supporting the sharing and linking of the two major knowledge types in agriculture.

Moreover, KMS developers are facing difficulties in building and maintaining information systems (IS) that manage knowledge resources (Jennex & Olfman, 2011). Few attempts were made in the design of KMS for supporting KM processes in agriculture such as Soulignac, Ermine, Paris, Devise, and Chanet (2012). Hence, research in KMS development further addresses the design tasks faced by practitioners besides to the theoretical understanding. The solution of the real problem must be developed (Miah, Gammack, & Kerr, 2012) and there is a need to evaluate the use of the system using the appropriate criteria within socio-technical design science (Jennex & Olfman, 2011; Miah et al., 2012) to measure the success of the KMS and further provide new concepts. Accordingly, this research in action further probes the design of the KMS and evaluates the use of it for supporting knowledge exchange in agriculture.

1.4 Research Questions

Against the background of the above research problems, this research seeks to contribute to the development of the process conceptual framework for agricultural KMS development and use to share and integrate variety of knowledge. The present research is, therefore driven by the following main research question:

How the agricultural knowledge management systems are developed to share the indigenous knowledge and seamlessly flow it with the mainstream of scientific knowledge in agriculture?

In addressing this primary question, there is a need to investigate the roles and practices of relevant participants in agricultural KMS development in particular agricultural experts as knowledge brokers to close the knowledge boundaries across the relevant participants from different CoPs. In the Ethiopian agricultural extension system, there are a group of people named extension agents who are responsible for knowledge transfer and the introduction of technology to farmers from research. They are in charge of creating a link between the agricultural experts or scientists and technologists, on the one hand, and the rural communities, on the other. This study, hence attempts to answer the following sub-question:

1. ***How do the roles and practices of extension agents as knowledge brokers contribute for the sharing and integration of the variety of knowledge in agricultural KMS development and use?***

Investigating the roles and practices of agricultural experts as knowledge brokers are not only sufficient to readdress the aspect of knowledge incorporation in agricultural KMS development, but also there are boundary objects used by the participants, which are important in free flow of knowledge in KMS development (Pawlowski & Robey, 2004; Puri, 2007; Rosenkranz et al., 2014). Boundary objects are any objects such as artifacts, documents, terms, concepts, and other forms of reification around which communities of practice can organize their interconnections (Wenger, 1998). They can serve as an interface between participants coming from different CoPs across knowledge boundaries. Thus, the second sub-question is:

2. ***What are the boundary objects used by participants from different CoPs in agricultural KMS development and use for knowledge sharing and integration?***

Additionally, technological artifacts (systems) for the research concepts such as boundary objects should be developed and evaluated (Burstein & Gregor, 1999; Miah et al., 2012; Nunamaker et al., 1991). Researches such as the works of Germonprez, Hovorka, and Gal (2011) and Fischer and Ostwald (2003) have suggested to probe the design and implementation of technological artifact as a boundary object to develop a shared understanding among relevant stakeholders. However, the design of KMS should be conducted relying on the concepts investigated theoretically (basic research) (Burstein & Gregor, 1999; Jennex & Olfman, 2001; Nunamaker, Chen, & Purdin, 1991; Orlikowski & Baroudi, 1991). Consequently, this research is also interested to investigate the design and implementation of a shared KMS for enhancing the knowledge sharing and integration. Thus, the third sub-question is:

3. ***How a shared technological artifact is designed for supporting knowledge sharing and integration?***

Ultimately, it is crucial to understand the deriving factors which lead to the success of the KMS. Hence, there is a need to understand the use of the developed technological artifact by relevant users. Additionally, the consequences of using the technological artifact and the knowledge broker as mediator for helping participants to share and integrate knowledge are required to be examined for further understanding of the conceptual framework in KMS development and use. Hence, the fourth and the fifth sub-questions are:

4. ***How significant is the role of technological artifact as a boundary object and knowledge broker for improving knowledge sharing and integration?***

5. ***What are the consequences of using the technological artifact as a boundary object and knowledge broker for knowledge sharing and integration?***

1.5 Objectives of the Research

Against the backdrop of the above research questions, this study intends to seek for providing the process conceptual framework for better understanding of the agricultural KMS development, use, and evaluation of its success in improving knowledge sharing and integration in agriculture.

The study specifically aims to:

- identify and document the IK and practices related to soil fertility management;
- examine the challenges for seamlessly flow of the IK alongside the stream of scientific knowledge;
- identify the roles and practices of agricultural experts as knowledge brokers;

- pinpoint boundary objects that can be used for bridging the knowledge boundaries;
- designing and implementation of a shared KMS as a boundary object;
- evaluate the success of the interplay of the KMS and knowledge brokering;
- construct the process conceptual framework for agricultural KMS development and use to support knowledge sharing and integration in agriculture; and
- insight future research directions pertinent to agricultural KMS development and use.

1.6 Significance of the Study

Knowledge sharing and building of shared understanding among the relevant CoPs are important elements of knowledge management particularly significant during the requirement elicitation phase of systems design and development (Rosenkranz et al., 2014). So that all-inclusive knowledge of agriculture can be supplied for users particularly for local rural communities of Ethiopia that could result in an innovative solution to readdress problems of agriculture in developing countries, whereby bring more effective ICTs in agricultural KMS development and use outcome. The findings of the research will, thus, be of significance for different participants including farmers, extension agents, researchers, and KMS developers in particular and Ethiopian agricultural extension systems and society in general by providing an insight of sharing the all-inclusive knowledge through the support of the KMS.

There are several individuals from different social groups possessing different knowledge types in agriculture. The KMS developers in agriculture are facing with several problems in developing, using, and maintaining of the KMS for KM activities through participating relevant users and incorporating their knowledge. This research developed a comprehensive process conceptual framework for agricultural KMS development through probing of the concept formation, system development, and evaluation of the KMS. Hence, recommendations provided in this research from the different system development phases help the developers for understanding of the roles and practices of relevant users, how to involve the participants' requirements, expectations, knowledge, and boundary objects, development and use of a shared agricultural KMS boundary object, and how to measure the critical success factors for the success of the KMS usage.

Relaying on the theoretical concepts investigated on the roles and practices of the extension agents as knowledge brokers, the research designed and implemented the KMS. Hence, the system is significant for the extension agents in order to improve the performance for performing their roles in Ethiopian agricultural extension system to exchange knowledge among relevant users and support local farmers to access and utilize knowledge. Moreover, the findings of the research regarding the skill and knowledge required by the extension agents as knowledge brokers are important to improve the capacity of them for agricultural knowledge exchange and integration. The findings of the study are also significant for agricultural researchers in understanding of the importance of IK, participation of associated rural communities for agricultural development, and the roles and practices of extension agents. Local farmers applied their knowledge and practices and knowledge from other local and scientific communities for their daily agricultural practices. Hence, the KMS with the support of the extension agents is important for farmers to access knowledge from different sources in different format timely. It also helps them to preserve and contribute their own indigenous knowledge. The appreciation and sharing of the IK can result in that the rural community feels respected and, therefore, bring confidence for farmers to participate in various ICT-based initiatives carried out for betterment of them and build solidarity in various communities of practices for sustainable natural resource management and conservation, and socio-economic development as a whole.

In general, the study developed and examined the development of the process conceptual framework for understanding of the KMS development and use in agriculture. The research contributes to the body of knowledge through providing theoretical and methodological implications. Primarily, it contributes to this grounding with an empirical study for the multiplicity of knowledge together with interactions of associated communities of practices for sharing and integration of indigenous and scientific knowledge. It also advances the literature on the roles and practices of agricultural experts as knowledge brokers and shared technological artifact as a boundary object for enhancing knowledge sharing and integration. The research can also contribute methodologically for the application of system development action research for understanding of the process conceptual framework for KMS development and use.

1.7 Research Methodology

The underlying research perspective guiding the study is the interpretative paradigm (Klein & Myers, 1999; G. Walsham, 1995). Interpretive research is vital to understand the detail aspects of KMS system development in agriculture which involves individuals from different social groups' perspective possessing their own knowledge systems since the paradigm assumes that people create and associate their own subjective and intersubjective meanings as they interact with their environment (Orlikowski & Baroudi, 1991). The research is conducted by relying on the underlying initial conceptual framework derived from the theory of communities of practice (Lave & Wenger, 1991; Wenger, 1998), a structurational model of technology (Orlikowski, 1992, 2000), and the KM/KMS success model (Jennex, 2017) for understanding of the process in agricultural KMS development and use for knowledge sharing and integration. The interpretive paradigm in this research is not only limited to investigative the pre-identified concepts from the initial conceptual framework for agricultural KMS development process but also helps to understand the emergent concepts from the data.

The initial conceptual framework and the interpretive paradigm are vital to select and apply the appropriate research approach (Rowlands, 2005). Accordingly, this research applied systems development action research approach (Burstein & Gregor, 1999; Nunamaker et al., 1991). This multi-methodological approach to information systems research in action research perspective consisting four strategies: theory building, experimentation, observation, and system development is employed to understand agricultural KMS development and use for knowledge sharing and integration. In the theory building stage, this research develops the initial conceptual framework from the extant research and experimented using the KMS development practice of Ethiopian agricultural transformation agency as a case area to probe the pre-identified and emergent concepts. Then, relying on the concepts from the experiment, the KMS is developed in the stage of system development. Finally, the newly developed KMS is observed in the research context areas to understand the use and the impact of it and further improve the process conceptual framework.

This research gathered data using primary and secondary methods including in-depth semi-structured interviews, participatory observations, and document analysis. For the interview, subjects from different social groups in agricultural KMS development: agricultural researchers, information system developers, extension agents, and local farmers are selected. The research subjects were purposefully selected based on their knowledge and experience. Totally, 54 informants in two stages are interviewed and observed (i.e., 43 in the first stage, 39 in the second stage, and 28 both in the two stages) see also Table 4.5. Data are analyzed using the interpretive method by making sense, meaning, and interpreting (Walsham, 1995; Walsham, 2006).

1.8 Scope of the Research

There are various types of indigenous knowledge for the different aspects of human life possessed by rural communities in Ethiopia and other parts of the world. However, this study is confined itself to understand only IK practices of agricultural domain specifically to the soil fertility management and conservation in Ethiopia. Thus, the focus of this research in question is to address issues in the identification of IK on soil fertility management and conservation and understanding of the sharing and challenges of freely flowing and integrating IK with scientific knowledge and practices in agriculture. The country is politically administered into fourteen regional states. In this research, two districts from the Amhara Regional State are targeted to gather data from the research subjects (i.e., local farmers and extension agents).

The study selected agricultural KMS development projects of ATA's and other partner organizations: Ministry of Agriculture and Rural Development (MoARD), and Regional Agricultural Research centers (RARCs) as a research case, which is the Ethiopian soil information system. This is because it provides a theoretically relevant organizational context for this research through providing participants from different social groups with differing expertise and domain-specific knowledge, namely local farmers, domain experts/agricultural researchers, extension agents, and system developers.

In KMS development research, there is a need to address issues in concept formation, development, and evaluation of the developed system as suggested by Burstein and Gregor (1999), Jennex and Olfman (2011), and Nunamaker et al. (1991). In concept formation, the study frames initial concepts coined from extant literature and performs the experimentation in this research context. Relaying on the theoretical concepts, the research provides the understanding of the design and implementation of the shared KMS during system development phase. Finally, the observation phase discusses the evaluation of the KMS success to probe the use and consequence of the agricultural KMS for supporting knowledge sharing and integration.

Knowledge management encompasses various processes and practices, which concerned with the creation, acquisition, storage, sharing, integration, and use of knowledge. In this regard, the study is conducted to develop the process conceptual framework for KMS development and use to support the knowledge sharing and integration KM activities. The KMS can be developed to support the knowledge integration through socialization among users and experts and combination through discovering interesting patterns in observation (Becerra-Fernandez & Sabherwal, 2010). This study addresses the KMS development in order to support users for knowledge integration and sharing through enhancing communication, interaction, and socialization of users from different social groups in agriculture.

1.9 Organization of the Study

This dissertation is organized as follows. The dissertation consists of eight chapters. Following this introductory chapter, the second chapter presents the review of relevant background literature including the concept of knowledge, KM, KMS, KMS tools, and KMS architecture. The chapter also provides the review of extant literature on agricultural knowledge types, treatment of knowledge in agriculture and challenges to integrate knowledge in agricultural KMS development.

In chapter three, the potential theories for understanding of the KMS development and use for supporting knowledge sharing and integration in agriculture are reviewed. The selected theories are further presented in detail. Then, the potential concepts for understanding of the KMS development for knowledge sharing and integration are presented. Furthermore, issues in KMS design, use, and evaluation are discussed.

Chapter four is devoted for presentation of the methodology of the research process including the research design, case study selection, data collection techniques, and analysis methods. The chapter starts with the discussion of the research paradigm. Following section discusses the research design followed by the selection and description of the case study. The chapter also presents data collection and analysis methods applied at the different analytical levels. Last section of this chapter outlines the trustworthiness of the study and the official and ethical procedures carried out in the research.

The fifth chapter explains the detailed account of the case study employed in the study to better understand knowledge types and their treatment and ways of knowledge sharing across the different CoPs in agricultural KMS development. Following sections discuss the concepts derived from the analysis of the data, including the roles and practices of knowledge brokering by extension agents, knowledge and skill required by the knowledge brokers, and identification of boundary objects.

In chapter six, the development of KMS is presented including the components of KMS, architecture of KMS, and prototype of the KMS. The chapter also explained the detail account of the use and consequence of a shared KMS in supporting the KM activities. The next chapter provides synthesize of the findings aligning with the extant literature. As such, concepts in the conceptual framework including knowledge types, the roles and practices of extension agents as knowledge brokers, a shared KMS boundary object, and the use and the consequence of the KMS are discussed in detail. The chapter also discusses the success of the KMS boundary object. Finally, the research process is evaluated using the principles of interpretive research.

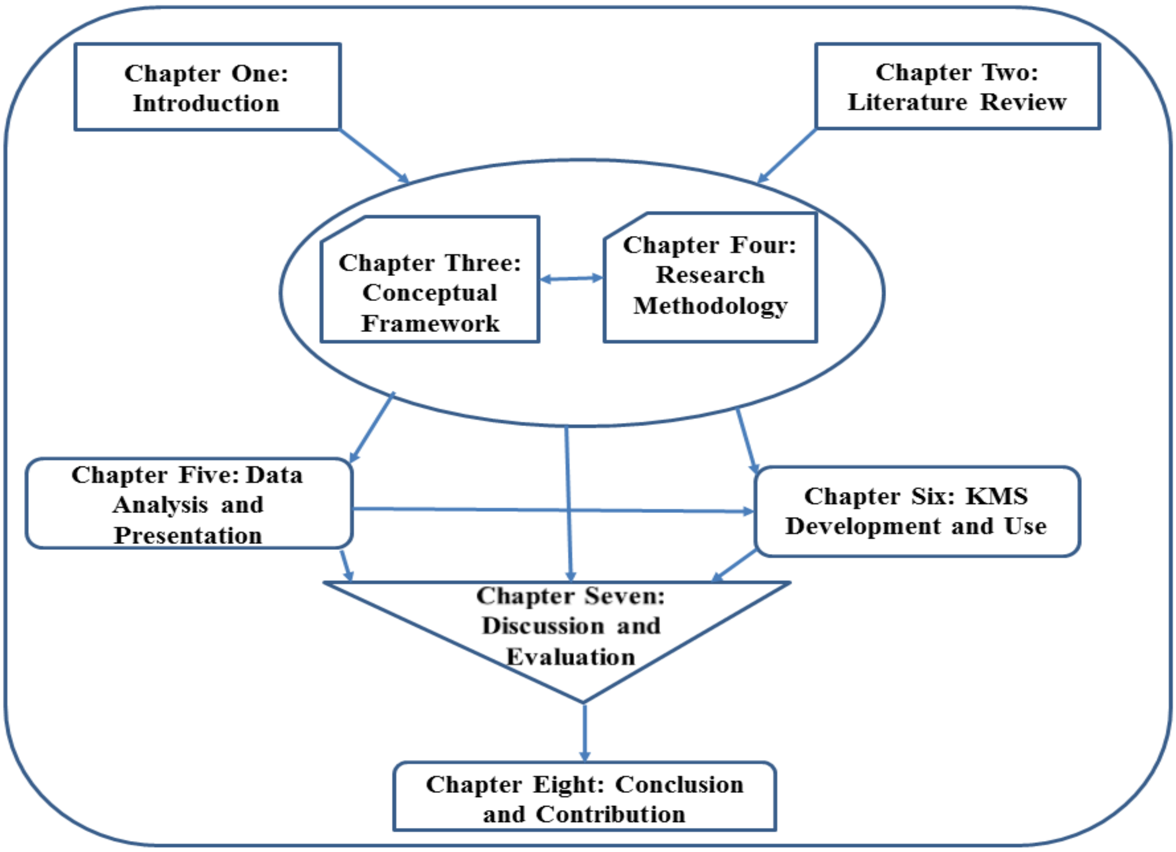

Figure 1-1. The Research Chapters Layout

In the last chapter, conclusion, implications, limitations, and future research directions are presented. The chapter first presented the conclusion through revisiting the research questions and objectives. Then, theoretical, methodological, and practical contributions of the research are explained. In the following section, the research limitations are discussed and consequently recommendations are highlighted for further investigations and improvements in agricultural KMS development and use. In closing, suitable concluding remarks are advanced. Figure 1-1 shows the general layout of the research chapters.

CHAPTER

2. LITERATURE REVIEW

2.1 Foundations

Knowledge is a fundamental asset for firms in the contemporary economy. It is distributed across individuals, groups, and organizations. The main challenge in all organizations is to efficiently discover knowledge, create new knowledge, capture, store, share, and apply it to gain competitive advantage. For this purpose, knowledge management is increasingly practiced in organization. Also, ICTs are supporting knowledge management activities in organization for different purposes. As a result, organizations are developing, implementing, and managing ICT-based KMS. The following sections present the background concepts in agricultural KMS development including knowledge and its type, KM and KM activities, KMS, KMS architecture and tools, and the relationship between them.

2.1.1 Knowledge

Knowledge is broadly used as a scientific notion for the most important and dynamic driver of the modern economy (Ibert, 2007). It is becoming the most critical resource of organizations, and can add value greatly to an organization's ability to bring competitive advantage (Alavi & Leidner, 2001). Knowledge is a crucial organizational asset but often it is a resource difficult to access that is challenging to share, imitate, buy, sell, store, or evaluate (Bragge & Kivijärvi, 2011, p. 213). This is due to organization's knowledge is mainly embedded in the minds of its members, working routines and processes, organizational rules, practices, and norms (Bragge & Kivijärvi, 2011; Jennex & Olfman, 2006). Therefore, the ability to create, acquire, share, integrate, and apply distributed knowledge has emerged as a critical organizational capability (Sambamurthy & Subramani, 2005).

Knowledge is the most valuable form of content in a continuum beginning at data, encompassing information, and reaching at knowledge according to the pragmatic definition of it (Davenport & Prusak, 1998; Grover & Davenport, 2001). Data are raw facts consisting of a set of discrete, objective facts about events (Davenport & Prusak, 1998, p. 4) such as who, where, what, when about something (Jennex & Bartczak, 2013). Data are classified, summarized, transferred, and corrected in order to add value and become information within a certain context (Grover & Davenport, 2001). Thus, data become information when creator adds meaning to them through the process of contextualizing, categorizing, calculating, correcting, and condensing (Davenport & Prusak, 1998; Grover & Davenport, 2001). The conversion can be facilitated by storing, classifying, capturing, processing, and communicating through technologies. These, in turn add place, time, and form utility to the data, whereby, information can serve to inform or reduce uncertainty within the context of problem. Information is, hence united with the context in which it has utility that provides a useful story (Grover & Davenport, 2001; Jennex & Bartczak, 2013).

Knowledge is a broad and abstract notion that has defined epistemological debates rooted from western philosophy since the classical Greek era (Alavi & Leidner, 1999; Newell, Robertson, Scarbrough, & Swan, 2009). Biloslavo and Zornada (2004) indicated that despite increasing in research of knowledge, KM and related subjects, no unified definition of knowledge can be found in business and academic literature. Some definitions of knowledge that can be found in the extant KM literatures are given in Table 2-1. This research has both an applied and theoretical or philosophical orientation, which seeks to address how multiplicity of knowledge is shared and integrated in agricultural KMS development and use. In building this research, it has been adopted the working definition of knowledge given by Davenport and Prusak (1998). Additionally, many of the KMS development researches adopt it, among others Alavi and Leidner (1999, 2001), Jennex (2014), and Jennex and Olfman (2006). Davenport and Prusak (1998) defined knowledge as:

> *An evolving mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knower's. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms.* (Davenport & Prusak, 1998, p. 5)

Knowledge is, therefore an experience and information processed in the mind of individuals and it is personalized and subjective information related to facts, procedures, concepts, interpretations, ideas, observations, and judgments (Alavi & Leidner, 2001; Davenport & Prusak, 1998). Knowledge is the most difficult organizational resource to manage due to its origination and it is applied in the minds of human beings (Grover & Davenport, 2001).

Therefore, from the definition we can understand that knowledge has various elements with the highest value, high human contribution, the highest relevance to decisions and actions, and dependence on a specific context (Davenport & Prusak, 1998; Grover & Davenport, 2001; Nonaka, 1994). In organization, knowledge often becomes embedded in artifacts such as documents, video, audio or repositories and in organizational routines, processes, procedures, practices, and norms (Davenport & Prusak, 1998; Jennex, 2014).

Table 2-1. Definition of Knowledge

Definition	**Reference**
Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information.	(Davenport & Prusak, 1998, P. 5)
Knowledge is the power to act and to make value producing decisions.	(Polanyi, 1967)
Knowledge as a form of capital, that is the transformation of information into knowledge is a critical step in value creation, which determines what kind of advantage an enterprise has in competition.	(Stewart, 1997)
Knowledge is things that are held to be true in a given context and that drive people to action.	(Bourdreau & Couillard, 1999)
Knowledge is a justified belief that increases an entity's capacity for effective action.	(Nonaka, 1994)
Knowledge is a dynamic human process of justifying personal belief toward the truth.	(Nonaka & Takeuchi, 1995, p. 58)

Cross and Parker (2004) and Dalkir (2005) indicated that people are the most crucial conduits of knowledge. However, individual's memory is limited, human then need to embed knowledge in a useful and more permanent forms of knowledge repositories or organizational memory, among others documents, intranets, portals, and e-mails (Dalkir, 2005). In order to make knowledge repository useful, it is a must to capture and store the data, information, context, and culture in which the knowledge generated, what knowledge means, and how it should be applied (Jennex, 2014). Moreover, Dalkir (2005) also suggested that it is vital to remember that a context of each item of knowledge and must also be captured and stored such as when it occurred; who is knowledgeable about it; and who provided it. Hence, knowledge without the context cannot be complete (Flor, 2013) and it is critical to understand the knowledge with its context to successfully apply it. Ultimately, the concept of knowledge helps to explain the problem of knowledge capturing and other KM activities from individuals who are relevant participant and artifacts in agricultural KMS development and making it available for reuse to the remaining members who are owners of problems.

2.1.1.1 Perspectives of Knowledge

Knowledge can be seen from different perspectives according to the review of Alavi and Leidner (2001). It is viewed as a state of mind, an object, a process, a condition of having access to information, or a capability. In general, those views emphasized that knowledge empowers individuals to develop their personal learning and use of it to meeting their needs and expectations.

- A state of mind: knowledge is the state of knowing and understanding, which can enhance individuals' personal knowledge, so that individuals can effectively apply knowledge to the organization's requirements.
- An object: knowledge is viewed as an object or a thing. Therefore, it can be stored and manipulated independent of human action.
- A process: knowledge as a process refers to knowing and acting, which is a process of applying expertise. This view suggests that knowledge does not exist independent of human action.
- Access to information: knowledge is a condition of having access to information, which is an extension to the object view. This view of knowledge suggests that knowledge in organization must be organized in such a way that to easily access and retrieve.
- A capability: knowledge can also be viewed as a capability so that it has the potential to influence action.

These different views of knowledge lead to different KM strategies and different type of tools and technologies to manage knowledge (Alavi & Leidner, 2001). For example, view of knowledge as an object contends that knowledge management initiatives should highlight the importance of building and managing knowledge stocks in organizations. This can also have implied on KMS tools to involve gathering, storing, and transferring of knowledge.

Knowledge as process implies KM should focus on how knowledge could be created, shared, and distributed among individuals in organization and the role of technologies in this regard is to link different knowledge sources and enhance communication, interaction, and collaboration among users coming from formal and informal groups.

2.1.1.2 Taxonomies of Knowledge

An understanding of the taxonomies of knowledge is significant for knowledge management theoretical framework development and design of KMS in order to incorporate different types of knowledge. There are various ways of knowledge classifications. Jennex and Croasdell (2005) and Jennex and Olfman (2003) indicated that the most commonly used classification is Polanyi's (1967) and Nonaka's (1994) dimensions of 'tacit' and 'explicit' knowledge based on its complexity as first undertaken by Polanyi (1967). Such an attribute is also articulated as the distinction between knowing and knowledge (Brown & Duguid, 1998; Ibert, 2007; Newell et al., 2009). Various researches have conducted to investigate the distinction between them (Nonaka, 1991, 1994).

The explicit knowledge is considered as formal and systematic, which can be transferred and shared (Nonaka, 1991), for example scientific knowledge that can be articulated through formal language. Whereas tacit knowledge exists in know-how, that is difficult to transfer. It is created and accumulated by individuals' experience over time in a specific context (Nonaka, 1991). For instance, the format of indigenous knowledge (IK) is highly tacit that is hard to articulate by formal language. The tacit knowledge resides in human brain and cannot be easily captured or codified (Krishnaveni & Sujatha, 2012). Despite difficulty and sometimes impossible to capture and diffuse the tacit knowledge compared to explicit knowledge, it adds more value to an organization (Krishnaveni & Sujatha, 2012).

Unlike explicit knowledge found in documents, tacit knowledge is difficult to articulate/codify and transfer directly from one person to another. Transferring tacit knowledge, which is non-verbalized, intuitive, and unarticulated, is much more complicated and requires informal transfer methods. An important feature of tacit knowledge is that we know more than we can articulate or attend to at any point in time (Polanyi, 1967). Tacit knowledge is largely linked to the culture and practice of individuals or local communities (Ocholla, 2007). The essential tacit knowledge transfer is a culture-based process, thereby, adaptive knowledge in organization is exchanged with others (Krishnaveni & Sujatha, 2012). The main research attention of knowledge management is how tacit knowledge is captured, converted to explicit, and communicated (Jasimuddin, Connell, & Klein, 2012; Nonaka, 1994; Sambamurthy & Subramani, 2005). Bragge and Kivijärvi (2011) indicated that organizations should, thus, have an explicit strategy for the management of their knowledge resources. Accordingly, in this research context there is a need to identify and investigate the two types of knowledge to share and integrate them in agricultural KMS development.

Knowledge can also be conceived as existing at multiple levels: at the individual, group, and organizational level (Nonaka, 1994; Sambamurthy & Subramani, 2005). Individual knowledge is personal knowledge, which is acquired and possessed by individual. It includes both tacit and explicit knowledge but largely tacit that resides in the minds of people according to Nonaka (1994). Knowledge is primarily created by individuals (Nonaka, 1994). Individual knowledge can be converted into group knowledge despite its conversion is not straight forward. Group knowledge creation needs interaction, coordination, and negotiation among individuals through developing shared meaning. It is created in collaborative activities and exists as a relationship among group members (Martins & Martins, 2011). Therefore, group knowledge is the collective tacit and explicit knowledge that is developed communally over time through group interactions. Storytelling, collaboration, and dialog are the main form of group knowledge creation (Brown & Duguid, 1991; Nonaka, 1994) and a community of practice is a good example of informal group that creates and possesses knowledge in formal and informal organizations (Brown & Duguid, 1991; Wenger, 1998, 2000).

Organizational knowledge is knowledge of individuals or groups, accumulated know-how, expertise and ways of working, that is institutionalized as organizational procedures, rules, and policies (Jennex, 2014; Martins & Martins, 2011; Nonaka, 1994). In general, it is greater than the sum of the currently employed individuals' and groups' expertise in organization since organizational knowledge creation is the integration and institutionalization of knowledge held by its members. Organizational knowledge is created through cycles of combination, internalization, socialization, and externalization that transform knowledge between tacit and explicit modes (Nonaka, 1994), which is discussed in section 2.1.2.1. In the dynamic process of knowledge creation, linkage between individual and group sharing similar tasks is critical, therefore communities of practice (Brown & Duguid, 1991; Wenger, 1998, 2000) play crucial role in communicating, sharing, and integrating organizational knowledge (Sambamurthy & Subramani, 2005). In sum, knowledge in organization originates, and is interpreted and used at the individual, group, and organizational levels. A community of practice is an important concept in sharing, communicating, and creating knowledge at group and organization level. Thus, this concept establishes the basis for further investigation of what the concept of knowledge entails in groups and organizations.

2.1.2 Knowledge Management

The growing significance of knowledge in organizations as an important resource has compelled managers to examine the knowledge underlying organizations' business, giving rise to knowledge management (KM) initiatives (Krishnaveni & Sujatha, 2012). KM is claimed to be an important strategy to increase innovativeness and responsiveness to help an organization competitiveness (Alavi & Leidner, 2001). However, organizational knowledge loss is a big challenge for organizations as the economy grows due to the loss of knowledge holders, failure to capture critical knowledge, failure of managing knowledge repositories, and knowledge forgetting (Jennex, 2014). Consequently, situations such as maintaining, locating, and application of knowledge have led to systematic endeavor to manage knowledge in an organization. According to Dalkir (2005), knowledge has to be applied for knowledge workers accordingly; what is of important to them, to their professional activities, and what the organization strives for gain, thereby KM to succeed.

KM is one that has come to be used to refer to explicit strategies, tools, and practices applied by management that seeks to make knowledge as a resource for organization (Newell et al., 2009). Jennex (2005) defined KM as the practice of selectively applying knowledge from previous experiences of decision making to current and future problem solving activities with the express purpose of improving an organization's effectiveness. King (2009) also describes it as the leveraging and improvement of an organizational knowledge asset to be accomplished for better knowledge practicing, improving organizational behaviors, making better decisions, and bringing improved organizational performance. The major challenges of KM are the process of knowledge capturing, integration, and sharing (Alavi & Leidner, 1999; Chantarasombat et al., 2010). The purpose KM is, hence to understand, focus on, and manage systematic, explicit, and deliberate knowledge building and application, that is manage effective knowledge processes and to renew knowledge constantly (Jasimuddin et al., 2012; Krishnaveni & Sujatha, 2012).

Knowledge management function in an organization operates KM processes (i.e., knowledge creation, storage, sharing, and application), develops methodologies and systems to support them, and motivates people to participate in them (King, 2009). It is clear that individuals perform each of the KM processes in organization. However, KM is largely an organizational activity that focuses on what managers can do in order to achieve KM's goals, how they can promote individuals to participate in achieving them and how they can create social processes that will facilitate KM success (King, 2009).

According to King (2009), social processes include communities of practice, self-organizing groups of people who share a common interest, and expert networks that are established to allow those with novice to contact those with expertise. This social process is very important since knowledge exists in the minds of individuals; therefore, for knowledge management initiative to be successful, knowledge must usually be transmitted by social groups, teams, and networks. KM processes are people intensive, and less technology intensive than most people might believe, although a modern knowledge-enabled enterprise must support knowledge management activities with ICTs. Despite the growing evidence of KM's contribution to organizational performance, there are several issues that still have not been fully addressed in the existing studies pertinent to the role of communities of practice in KM and KMS development and use. For instance, indigenous knowledge sharing and practice, how it is integrated to the scientific practices, and how to participate local communities in the development of KMS through understanding of the communities of practices is not yet clearly addressed except few attempts (Masinde, 2013; Puri, 2007).

2.1.2.1 Knowledge Management Process

Knowledge management is largely regarded as a process involving various activities (Alavi & Leidner, 2001). In most of the KM literatures, KM activity includes basic processes of knowledge creation, storing/retrieving, sharing/transferring, and use/application. KM process is viewed as cyclic process that encompasses activities and practices concerned with the creation, storing, sharing, and applying of knowledge and experience rather than as a linear process. As existing knowledge and experience are applied, they also lead to new knowledge creation, thus the process follows a circular flow and a nonstop process that continuously updates knowledge.

Knowledge creation refers to the development of new knowledge that does not exist before from the existing knowledge and experience by utilizing different sources (Alavi & Leidner, 2001; Nonaka, 1994). Ibert (2007) also discussed that, in most cases new knowledge creation is the result of interactive learning, which involves individual actors who are affiliated with a plethora of economic, non-economic, and intermediary organizations. An interactive learning refers to an exchange of critical knowledge and, thus essentially depends on information processing (Ibert, 2007). In organization, creation of knowledge involves the construction of new content or replacing knowledge within the organization's tacit and explicit knowledge. New knowledge can be created and amplified, when individuals interact for knowledge sharing through social and collaborative processes (Nonaka, 1994).

Nonaka's (1994) model of knowledge conversion is one of the most cited models for explaining organizational knowledge creation and a foundation for discussing knowledge management activities (Arisha & Ragab, 2013). The model of Nonaka (1994) organizational knowledge creation consists of two dimensions: explicit, declarative knowledge or codified knowledge and tacit or procedural knowledge. New knowledge can be created through the continual interaction of tacit and explicit knowledge and a growing spiral process, starting at the individual level moving up to the collective/group level, and then to organizational level (Nonaka, 1994). Organizational knowledge creation takes place when all four modes are organizationally managed to form a continual cycle: combination, internalization, socialization, and externalization (Nonaka, 1994) (see also Figure 2-1).

- Socialization (tacit-to-tacit): this mode refers to the conversion of tacit knowledge to new or other form of tacit knowledge by social interaction, face-to-face interaction, dialogue, and sharing experience among members of an organization. It promotes a mutual understanding by sharing of mental models, brainstorming to come up with new ideas, apprenticeship or mentoring interactions, and so on (Dalkir, 2005). In this mode, the process of acquiring tacit knowledge is not only strictly tied to the use of language but also consists of sharing experiences through observation, imitation, and practice (Dalkir, 2005). It is the easiest forms of exchanging knowledge because it is what people do instinctively when people meet each other. However, it is very challenging and time taking to share all knowledge type using only socialization mode (Dalkir, 2005).

- Combination (explicit-to-explicit): the combination mode is the process of recombining discrete pieces of explicit knowledge into a new form (Dalkir, 2005). The combination mode refers to the creation of new or other form of explicit knowledge from the existing explicit knowledge through manipulation such as merging, categorizing, sorting, reclassifying, modeling, and synthesizing (Nonaka, 1994). A synthesis in the form of a review report, a trend analysis, a brief executive summary, or a new database to organize content can be an example for the combination.

- Externalization (tacit-to-explicit): it refers to conversion of tacit knowledge into new explicit knowledge through narratives and analogies to convey an individual's conceptualization to others. In externalization, individuals are able to articulate the knowledge, know-how, and know-why (Dalkir, 2005). The existing tacit knowledge can be transcribed, written down, taped, drawn, or made tangible or concrete in some manner. Then, knowledge becomes tangible and permanent, and easy to disseminate among an organization's members.

- Internalization (explicit-to-tacit): this refers to the conversion of explicit knowledge into new tacit knowledge within an individual by learning and experience. It is highly linked to learning by doing (Dalkir, 2005). This process converts/integrates shared individual expertise (i.e., experiences and knowledge) into individual mental models. Then, new knowledge is applied by individuals who broaden, extend, and reframe it in their own previously existing tacit knowledge bases (Dalkir, 2005).

These four modes of knowledge creation are not pure and sequential; but one is highly interdependent and intertwined with others and involve continuous and dynamic interaction between tacit and explicit knowledge (Nonaka, 1994; Nonaka & Takeuchi, 1995).

Knowledge storage is the process of formal representation of knowledge to enhance knowledge reuse. After new knowledge is created, knowledge management initiatives should be there to prepare content to be stored into the organization's memory. Organizational memory includes knowledge residing in various component forms, among others written documentation, organizational procedures and processes, structured information stored in electronic databases, codified human knowledge stored in expert systems, and tacit knowledge acquired and stored in the minds of individuals and groups of individuals (Alavi

& Leidner, 2001; King, 2009). Knowledge capturing is the processes and mechanisms that is used to identify, select, filter, capture, purify, collect, and optimize relevant knowledge for inclusion in various storage media that supports business process in order to maximize the content impact and long term reusability (King, 2009). Krishnaveni and Sujatha (2012) indicated that the value of knowledge increases when it is preserved and reused.

Knowledge transfer/sharing is another important area of knowledge management to create methods to facilitate sharing of knowledge (Jasimuddin et al., 2012). Knowledge sharing is a process of the conveyance of knowledge from one place, person or ownership to another or potential knowledge seekers through communication channels (Alavi & Leidner, 2001; Krishnaveni & Sujatha, 2012). As cited in the work of Krishnaveni and Sujatha (2012), several knowledge management literatures argued that an organization that encourages knowledge transfer among its members is more productive and more likely to be competitive than an organization that does not. An example can be Toyota's knowledge sharing network, which appears to be greatly effective at facilitating knowledge sharing among suppliers and can be a model for others (Dyer & Nobeoka, 2000). Knowledge sharing includes communication of new knowledge to potential knowledge users, is often modified in the receiving unit. However, it does not necessary mean a full replication of knowledge in the receiving part (Krishnaveni & Sujatha, 2012). Alavi and Leidner (2001) indicated that knowledge transfer occurs at different levels including between individuals, to groups from individuals, within and across groups, and to the organization from the group. However, it is a complex process in organizations where there is weak system for locating and retrieving knowledge that resides in organizations.

Another important aspect of knowledge management is the application of knowledge. It is a process that promotes knowledge retrieval to use in problem solving, decision making, innovative activities, and source of competitive advantage for organizations. Consequently, it is important to understand the KM activities by different relevant social groups in agriculture which contributes to realize the architecture of KMS so as to support KM activities in the KMS. Previous researches such as Jennex (2014) and Jennex and Olfman (2001) suggested that KM activities need to be supported through KMS to foster an organization and individuals effectiveness.

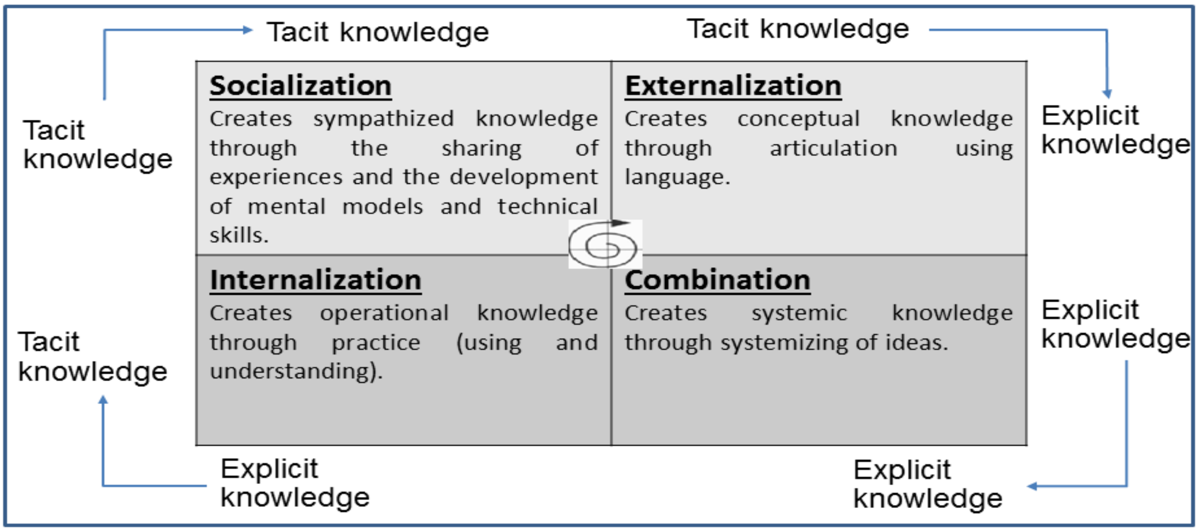

Figure 2-1. Four Modes of Knowledge Conversion

(Adapted from Nonaka (1994))

2.1.3 Knowledge Management System

Information systems are designed to assist managers and professionals by processing and disseminating vast amounts of data and information to organization-wide such as management information system (Alavi & Leidner, 1999). Despite the fact that these systems contributed to individuals and organizational improvements in varying degrees and an important components of an organization's IT investment, these systems were processing data and information. ISs in organizations are also targeting on professional and managerial activities by focusing on organization's knowledge creation, transferring, gathering, storage, and integration, which are referred as KMS (Alavi & Leidner, 1999). KMS, a class of IS, is a managerial, technical, social, and organizational system structured and implemented to support KM activities within an organization, thereby, enables to manage knowledge effectively and efficiently (Arisha & Ragab, 2013). As a consequence, KMSs have met with a significant success in business organization and spreading also to other sectors, like in education and instructional design (Edmonds & Pusch, 2002). In general, for an information system to be classified as KMS the main purpose of it must be to promote one or more of the four organizational KM processes including knowledge creation, storing/retrieving, transferring/sharing, and use/application.

Previously, KMS was viewed from the perspective of information systems, databases, and knowledge structures, and believed that knowledge is developed and managed following universal and standardized rules (Assegaff & Hussin, 2012). In this perspective, social or organizational culture and other social factors are ignored in the development of KMS. However, KMS can be seen as an activity system that involves people who make use of objects such as tools and technologies to create artifacts and products that represent knowledge to achieve a shared goal (Dalkir, 2005, p. 167). It is not, therefore, the technology that distinct KMS from other type of ISs; however, it is the highly involvement of human activity in its operation and designed to put organizational participants in contact with recognized experts in a variety of topic areas (King, 2009). KMS encompasses the entire activity system including human-use aspects rather than only focusing on technology aspects (Dalkir, 2005). The flow of knowledge among self-managing groups within an organization that considers a group to be the primary holder of knowledge and KM as the interaction between physical resources, conceptual resources, and social and organizational processes (Assegaff & Hussin, 2012) and these are significant social factors in designing of KMS. Besides, extant KM/KMS literature indicated that knowledge work involves communication among loosely structured networks and communities of people and, therefore development of KMS involves identifying social practices in a particular context (Saade, Nebebe, & Mak, 2011).

The social aspect of KMS is important in delivering tacit knowledge and promotes knowledge creation and sharing through social interaction. KM and KMS literature suggested that IT-based approach to KM needs to be complemented by social method endeavors (Assegaff & Hussin, 2012; Saade et al., 2011). KMS should have function for managing knowledge and facilitating people to stay in touch, thereby enables to share and work together among communities. It is, therefore recommnded to develop KMS by considering KMS as socio-technical system, which consists of technical aspect of the technology and social system (Assegaff & Hussin, 2012; Saade et al., 2011). Miah et al. (2012) also proposed an approach that combines technologies and human actors; as such the social reaction to the technology is of highly significant in KMS development. The review of Miah et al. (2012) indicated that the socio-technical approach in agricultural KMS is increasingly recognized with the understanding that the adoption rate of KMS was little across various developed agricultural KMS applications so far. In building this research, KMSs refer to the integration of information technologies, social factors, organizational culture, knowledge, and mechanisms that are developed intending to support the four KM activities (Becerra-Fernandez & Sabherwal, 2010).

2.1.3.1 Knowledge Management System Architecture

As indicated by Cristescu and Cristescu (2008), researchers are increasingly focusing on the development of collaborative problem solving technological artifact, which is an extension that promotes human intelligence by providing communication infrastructure, thereby enhances collaborative problem solving among workers in geographically distributed areas. KMS is a complex socio-technological solution in which it provides opportunities for participants to create, store, integrate, and share knowledge and enables them to interact and collaborate (Antonova, Gourova, & Roumen, 2009). KMS supports KM activities by providing specific functions such as communication (i.e., e-mail and discussion forums); coordination (i.e., shareable calendars and task lists); collaboration (i.e., shareable artifacts and workspaces); and control (i.e., internal audit trails and automatic version control) (Dalkir, 2005). The main challenge in KMS development remains in defining the architecture that supports different social groups for sharing and incorporation of multiplicity of knowledge from various sources.

Several researchers investigated the architectures of KMS (Alavi & Leidner, 2001; Antonova, Gourova, & Roumen, 2009; Biloslavo & Zornada, 2004; Cristescu & Cristescu, 2008; Edmonds & Pusch, 2002; Jung, Choi, & Song, 2007; Maier, 2007; Marshall & Rossett, 2000; Saade, Nebebe, & Mak, 2011). Marshall and Rossett (2000) indicated that KMS consists of two complimentary parts, namely technical and social. The technical part is used to capture, package, and distribute tangible and documented products, whereas the social component enables collaboration, connection, and reflection among users of the system (Marshall & Rossett, 2000). Cristescu and Cristescu (2008) also proposed architecture of KMS for problem solving environment, which consists of four basic parts:

i. People component which is responsible for producing and applying knowledge objects including administrator, knowledge author, knowledge reviewer, and technology designer;
ii. Knowledge object which consists of sub components: computational problems, algorithmic solutions, and implementations for sharing meaning of information derived from knowledge structure;
iii. Technical infrastructure part enables users to capture, store, and deliver knowledge content based on the user demand; and

iv. Knowledge management process component comprised of knowledge creation, storage, dissemination, and application.

Moreover, Alavi and Leidner (2001) also provided KMS architecture based on knowledge management process model to support the KM processes. The extant KMS literature in general indicated that KMS architecture consists of people, knowledge, and technology and their interaction to facilitate KM processes. Despite increasing research of KMS, unified components of KMS cannot be yet identified in literature. According to Maier (2007), the sources of KMS architecture include theory-driven, vendor-specific, and market driven architectures as described follow.

- **Theory-driven architecture:** components of KMS determined based on the theoretic investigations in which a theory-driven decomposition of an organizational memory can be derived for ideal groups of functions or components of KMS.
- **Vendor-specific architecture:** KMS may aim to integrate the existing IT systems within specific organization for KM activities through incorporation of large number of modules/functions among others text mining, search engine, tools for semantic integration of meta-data on data and documents, visualization, administration of users and privileges, and publishing and reporting.
- **Market-driven architecture:** it is driven from empirically proven important components of an organizational KM environment which is integrated with more traditional data and document management systems as well as communication systems and other integrated IT company.

KM focuses on the management of continued dynamic nature of knowledge, thereby allows members of an organization to share ideas, documents, and information and blends users into a community of shared knowledge through promoting reciprocity among users regardless of physical location or time constraints (Edmonds & Pusch, 2002). KMS extends in the perspective of employees as an important knowledge workers through promoting them with the means to create, store, and transfer knowledge, whereby to ultimately contribute to a shared and dynamic body of knowledge (Cristescu & Cristescu, 2008). The KMS function allows many workers to organize meaningful activities around shared and reusable artifacts to achieve specific goals (Edmonds & Pusch, 2002). Thus, KMS addresses different type of knowledge workers and expertise. KMS is developed for multiple users having different and changing requirements. KMS along with KM applications comes the creation of a culture that promotes people to view knowledge as dynamic in which it continually grows and changes, and that provides a means for processing knowledge and the development of KMS architecture to facilitate the process and to manage documents.

Despite literatures in KMS provide different components of it, many of the literatures lack theoretical background to develop KMS and give less emphasis to the human components and social factors of KMS. As indicated by Thomas, Kellogg, and Erickson (2001), knowledge is linked with human cognition, and it is actively created, applied, and transferred in ways that are indistinguishably entwined with the social settings. Dalkir (2005) also stated that knowledge as the decisive basis for intelligent and competent behavior at the individual, group, and organization level. The KMS architecture requires to be developed to support the stages of knowledge processing and transformation of knowledge at different level, thereby to ensure that the knowledge objects need to reach the intended potential users and are put to good use (Dalkir, 2005).

KMS can provide integrated services to deploy KM activities and instruments for networks of relevant participants (i.e. active knowledge workers), in knowledge-intensive business processes along the entire knowledge life cycle (Maier, 2007). Therefore, KMS must consider both human and social factors in the development (Thomas, Kellogg, & Erickson, 2001). KMS architecture is a complex environment that involves different knowledge workers and expertise. In building this research, there is a need to consider all important components and features of KM aspects for sharing and integration of agricultural knowledge systems in the architecture. The architecture will be derived relying on the roles and practices of relevant actors from different social groups based on theoretical background (Maier, 2007), thereby theory-driven architecture fits to the problem situation at hand.

2.1.3.2 Knowledge Management System Tools

ICTs are the most powerful enablers of organizational knowledge management processes. Many KM literatures argue that building appropriate ICT system is an essential part of successful KM process (Andreeva & Kianto, 2012). ICTs assist KM activities by providing knowledge repositories and methods for capturing and retrieving knowledge (Jennex & Olfman, 2006). KMS is an IT-based system developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, and transfer (Alavi &

Leidner, 1999, p. 114), despite not all KM initiatives involve an implementation of IT system. ICTs in KMS support the functions of knowledge creation, construction, identification, capturing, acquisition, selection, structuring, valuation, organization, linking, formalization, visualization, distribution, retention, maintenance, refinement, evolution, accessing, search, and application of knowledge (Jennex & Olfman, 2006). Andreeva and Kianto (2012) also indicated that KMS usage as a powerful tool for promoting the capturing, storing, and disseminating organization's knowledge assets and enables organization to manage its knowledge effectively and efficiently, whereby increase its competitiveness and financial performance, in turn is a key competitive asset. In-line with this, organizations are being implementing KMS particularly to facilitate the codification, collection, integration, and dissemination of organizational knowledge.

KMS tools can promote knowledge creation processes, despite the fact that new knowledge creation involves mainly individuals and group of individuals. KMS tools developed to enhance collaboration, coordination, and communication processes facilitate group work and promote interaction between individuals in a group. They can also serve as a brokerage function of bringing together those who seek a certain piece of knowledge with those who are able to provide that piece of knowledge. For example, groupware software and electronic mail in organization promote interaction between individuals and groups, whereby can accelerate growth of knowledge creation (Alavi & Leidner, 2001; Nonaka, 1994). Another example can be an intranet, which can increase an individual's information exposure, thereby new individual knowledge can be created through internalization mode of knowledge creation (Alavi & Leidner, 2001). Data mining tools can also promote users to create new knowledge by extracting hidden knowledge or pattern from the stored data or information.

Despite the fact that organizations can create and learn knowledge, they also forget or lose the acquired knowledge. The storage, capturing, organization, and retrieval of organizational knowledge or organizational memory are, thus an important aspect of KMS. KMS tools such as advanced computer system storage technology and retrieval techniques like query languages, multimedia databases, database management systems, content management systems, and data warehouse are used to store and update organizational memory for future use (Alavi & Leidner, 2001). For example, content management software represents the convergence of full-text retrieval, document management, and publishing application and promotes the unstructured data management requirements through capturing, storage, and document publication (Duffy, 2001).

Another application of KMS is transferring knowledge and best practice within an organization and across organizations. Technologies can extend the individual's reach beyond the formal communication line, thereby promote knowledge transfer (Alavi & Leidner, 2001). Therefore, organizations have implementing ICT-based KMS to promote their knowledge transfer activities (Alavi & Leidner, 2001; Jasimuddin, 2005). Advanced technologies such as group support systems, groupware software**,** and computer-assisted communications technologies, among others the Internet, intranets, Email, voice mail, video conferencing, and electronic bulletin boards are used for knowledge transfer in organizations. Groupware software is also promoting organizations to create intra-organizational knowledge in the form of structured and unstructured information and knowledge and to transfer memory across organizations (Duffy, 2001). An innovative advanced technology for transfer is also applying intelligent agent software to develop profiles of organizational memory (Alavi & Leidner, 2001).

KMS tools can also support application of knowledge by embedding knowledge into organizational routines (Alavi & Leidner, 2001). ICT-based KMS can promote knowledge integration and application by facilitating knowledge capturing, updating, and accessibility of organizational directives (Alavi & Leidner, 2001). KMS access software provides individual and team access to knowledge base (Duffy, 2001) and enables users to retrieve relevant knowledge. For example, intellectual capital management software enables users to transfer know-how into corporate policy and procedure, thereby leveraging expertise by making it available to support business practice as needed. Content retrieval technologies such as search engines are also promoting access and retrieval to unstructured information and knowledge from different sources, thereby facilitate knowledge application.

2.1.3.3 Web 2.0 Tools and Knowledge Management

The Web browsers are the universal interface to a wide range of new generation Web-based KMS applications (Jimoyiannis, Tsiotakis, Roussinos, & Siorenta, 2013). The Web has been transformed from Web 1.0 in which users passively retrieve information and knowledge and they were delivered by a small group of experts in one-directional communication to Web 2.0

in which learning environment is provided through participatory, interactive, and read/write platform (Madar & Abdikadir, 2015). Web 2.0 broadens users' communication and interaction capabilities, whereby enables knowledge distribution, sharing, creation, and combination through participatory practices (Jimoyiannis et al., 2013). Consequently, Web 2.0 applications are today widely used to develop online KMS so as to support KM activities (Gaál, Szabó, Obermayer-Kovács, & Csepregi, 2015; Jennex, 2007; Sivarajah, Irani, & Weerakkody, 2015). Web 2.0 refers to a set of Web-based technologies such as wiki, blogs, content aggregators, social networking sites, podcasting, and other emerging forms of participatory applications and social media (Gaál et al., 2015; Sivarajah et al., 2015; Wang, Xiong, & Sun, 2007). Web 2.0 tools are very familiar to us, they are commonly used for entertainment and personal communication such as YouTube, Linked-in, Skype, Facebook, Blogger, and Wikipedia. Extant literatures indicated that Web 2.0 tools have a huge potential for supporting knowledge management activities (Flor, 2013; Madar & Abdikadir, 2015).

Web 2.0 tools are characterized by being user-centered, enhance, active participation, social network formation, promote communication, interaction, and collaboration, and harness collective intelligence (Freeman, Schroeder, & Everton, 2017; Wang et al., 2007), which help to systematize the processes of knowledge sharing, creation, and integration (Antonova et al., 2009; Gairín, Rodríguez-Gómez, & Armengol, 2012). These tools are important for supporting KM processes including explicit knowledge publishing and tacit knowledge extraction, dissemination, integration, and utilization across various CoPs having common interest. In conclusion, Web 2.0 tools allow individuals to activity participate in knowledge sharing through communication and interaction receiving and transferring knowledge. As a consequence, this research and others such as Nicola-Rocca and Parrish (2013) believe that Web 2.0 tools have a capability to share indigenous knowledge having the tacit format in agriculture. However, freely available social media and Web 2.0 applications were not designed specifically for agricultural KM process purposes and need to redesign. Table 2-2 provides the summary of the description of Web 2.0 tools and corresponding KM activities.

Table 2-2. KM Activities and Web 2.0 Tools

Web 2.0 Tool	Description	KM Functions
Social Networking	Application for connecting people, expanding users' social or business contacts having similar practice or interest.	It is used for connecting people and locating each other with similar interest, enhancing communities of practice and community of interest, and facilitating communication and sharing of ideas among people.
Wiki	It is a collaborative and communication space which allows multiple users to add, edit, comment, or remove content.	Wiki tool is used for collaborative, mediated, content production and organization and allows the content to be shared, archived, and reviewed.
Blog	Blog is a user frequently updated content such as stories, news, thought, reviews, experience, and web link.	It is used for journaling, and users can subscribe to a blog and post comments in an interactive format.
Podcasting	Podcasts are audio recordings of talks that can be played computer and mobile devices.	It enables knowledge sharing through audio recordings, or format of talks.
Real time collaboratio n tools	They integrate disparate channels for voice and data communications, instant messaging (IM), email, and electronic conferencing into a single experience.	In KM, it is used to provide real time voice communication for interaction and knowledge sharing.
Tagging and Bookmarkin g	Capability for users to save their bookmarks and tag them with keywords to organize documents and share information with.	They can be used for storing, filtering, and sharing collections of web content and to rate it.
Mashup	Web application that combines data from multiple sources and mashes it up into a new use or tool.	It enables knowledge sharing and integration from different sources.
Aggregator (RSS)	Really Simple Syndication (RSS) feeds is a family of web feed formats used for syndicating content from blogs or web pages. It feeds and receives notifications of that Web page's updates.	RSS enables knowledge sharing and integration from different sources.

Sources*: Summarized from the works of Darwish and Lakhtaria (2011), Gaál et al. (2015), Jennex (2007), Jimoyiannis et al. (2013), Sivarajah et al. (2015), and Wang et al. (2007).*

2.2 Knowledge Types in Agriculture: Scientific and Indigenous

Corresponding to the two broad entities in the agricultural sector (modern and traditional), knowledge created and used in the sector falls into two: scientific and indigenous knowledge (Agrawal, 1995, 2002; Degaga & Angasu, 2017). These two types of knowledge can be differentiated based on substantive, methodical, and contextual subjects (Agrawal, 1995, 2002; Kanjo, 2012; Ruheza & Kilugwe, 2012; Tripathi & Bhattarya, 2004, UNDP, 2012) (see also Table 2-3). As such, scientific knowledge includes all methods and activities driven by theoretical models, governed by testing of hypotheses and not necessarily utilitarian, which is universal, contrary to the indigenous knowledge (IK). IK is seen as concrete and closely tied to solutions practiced by indigenous people, which is usually location specific (Lanzano, 2013). It is the knowledge and experience applied by local people and what they know and practice, that evolved through generations' trial and error and evidenced flexible enough to survive with environmental change, while western/modern knowledge is a science mainly characterized by experimentation (Eyong, 2007).

Table 2-3. Comparisons between Indigenous and Scientific Knowledge

Attributes	**Indigenous Knowledge**	**Scientific Knowledge**
Source	Local communities	Scientific researchers
Formats	Non-formal knowledge	Formal knowledge
Scope	Location specific; unique to specific area	Universal
Communication	Orally transmitted and generally not documented	Written document
Method	Solutions practiced by indigenous people	Driven by theoretical models and governed by testing of hypotheses
Acquisition	Trails and error	Scientific experimentation

Sources: *summarized from the works of Agrawal (1995, 2002), Kanjo (2012), Ruheza and Kilugwe (2012), and Tripathi and Bhattarya (2004).*

The concept IK is not a new phenomenon. The notion of IK is used interchangeably in many researches to either refer to one of the following: traditional knowledge, community knowledge, traditional ecological knowledge, local knowledge, cultural patrimony, folklore, and cultural heritage (Sillitoe, 1998). It refers to activities and practices of a group of people (community), applied, and passed over generations locally with long histories of close interaction with the natural environment across cultures and geographical spaces (Nicola-

Rocca & Parrish, 2013; Sillitoe, 1998). It helps people to organize folk knowledge of flora and fauna and being unique to a given community, for example farming practices (Nicola-Rocca & Parrish, 2013; Sillitoe, 1998; Warren, 1991; World Bank, 1998). It is informally communicated in local customs, experience, technology, and wisdom through actions, demonstrations, objects, and symbols (Ocholla, 2007; Puri, 2007). Most small-scale farmers in Ethiopia and in other developing countries are illiterate but they are rich in IK and have been experienced it over the ages (Masinde, 2013; Warren, 1991).

IK has long been used as the basis for local-level decision making in agriculture, forestry, art and craft, communication and entertainment, weather forecasting, traditional medicines and healing, soil treatment, education, food security, natural resource management and conservation, and other vital socio-economic activities in rural communities in many parts of the world (Agrawal, 1995, 2002; Kanjo, 2012; Masinde, 2013; Ruheza & Kilugwe, 2012; Tripathi & Bhattarya, 2004; Warren, 1991; World Bank, 1998, 2005). It includes knowledge about animals, people, places, land, plants, and other historical events associated with a particular community (Nicola-Rocca & Parrish, 2013). IK have been passed on to other generations and have enabled indigenous people to survive, manage their natural resources and the environment surrounding them (Eyong, 2007). IK also includes cultural heritage in the form of traditional stories, dances, songs, and ceremonies that reflect beliefs related spirituality, family, and social justice (Eyong, 2007; Nicola-Rocca & Parrish, 2013). Therefore, knowledge of these various elements form a set of interacting units named as indigenous knowledge systems (IKS). Eyong (2007, p. 121) described IKS as a set of interactions between the various economic, ecological, political, and social environments within a group or among groups with a solid identity, driving existence from local resources through patterned behaviors that are transmitted from generation to generations for long, thereby to survive with environmental change.

Local people throughout the world have various IK. For example, farmers in Ethiopia have their own IK of soil treatment (Fanta, 2006). They are using it for classifying, describing, and characterizing local soil types in their fields based on the soils' characteristics, problems, and their suitability for various crops (Fanta, 2006). Another example can be the Ethiopian pastoralists' rangeland management that is traditionally practiced to make use of the scattered rangeland resources on a large scale in a country (World Bank, 2005). However, much of the indigenous knowledge are yet not adequately explored and remain invisible, in turn there is a grave threat to the extinction of IK (Kanjo, 2012; Masinde, 2013; Rahman et al., 2011; Sarkhel, 2016; Tripathi & Bhattarya, 2004). The rapid change in the way of local indigenous communities has largely accounted for the loss of IK. Additionally, younger generations overlook the role of IK due to the influence of modern technology and education (Nicola-Rocca & Parrish, 2013). Thus, urgent actions are needed for documentation and management of IK and integration of it with the scientific knowledge in a systematic way like other knowledge systems before it disappears altogether as the gap or failure in the management of IK system may slow down the rural development (Sarkhel, 2016).

IK has an essential share for the lives of the poor farmers and enabled them to survive in harmony with nature (Agrawal, 1995, 2002). The importance of IK in climate change adaptation, food security, soil management and conservation, and sustainable ecosystem management is now increasingly recognized. It is, hence critical to understand rural communities and the use of IKS together with scientific knowledge and is also increasingly advocated for socio-economic development (Agarwal, 2001; Agrawal, 2002; Nicola-Rocca & Parrish, 2013; Sarkhel, 2016; World Bank, 2005). IK has become one of the top agendas in the discourse about how sustainable resources use and development can best be brought. The greater recognition of the benefits of it can lead to greater effort to further interest of the poor and marginalized farmers (Agrawal, 2002; UNDP, 2012).

It is good to note that IKS on their own is not enough to address all aspects in sustainable ecosystem management, but can be enhanced if integrated with scientific knowledge and techniques (Kipkorir et al., 2011; Shiferaw, Hurni, & Zeleke, 2013; Tripathi & Bhattarya, 2004). However, the significance of integrating IK with modern scientific ecosystem management is considered as a step to overcome problems of global environmental concerns such as weather forecasting, food production, climate change, natural resource management, and unsustainable ecosystem services (Kipkorir et al., 2011; Shiferaw et al., 2013). For example, through integrating scientific and IK in weather forecasting, IK can help farmers to get ready for timing and distribution, whereas a scientific prediction support farmers to prepare for amount (Kipkorir et al., 2011).

IK is mainly hosted in the minds and practice of people commonly by communities rather than individuals. IK remains intact among the group of people and it is practiced by certain regional, local communities and passed from generations to generations orally and often through imitation and demonstration, stories, songs, folklore, dances, myths, beliefs, and rituals (Masinde, 2013). The local communities indigenous ways of communications and organizations are very important for preservation, development, and the distribution of IK as it is stored and possessed in minds of individual's and is articulated in practices, stories, cultural values, dances, ritual community laws, songs, local languages, local agricultural activities, and materials (Jote, 2012). This point of discussion resonates with the concept of communities of practice (Brown & Duguid, 1991; Lave & Wenger, 1991; Wenger, 1998) discussed in organization context, which rejects the viewing of knowledge as an objective entity that can be easily moved from one place to another.

Knowledge is embedded in a particular context and practiced by communities, so that communities create their own distinctive languages, shared norms, values and practices over ages (Puri, 2007, p. 357). CoPs have common knowledge of what the community performs, of how to perform it, and of how it intertwined with other communities and their acts (Lave & Wenger, 1991; Wenger, 1998). Knowledge is, thus, socially distributed, since it is constructed and entrenched in the collective actions of different communities (Puri, 2007) and shared through interaction among them. In the present inquiry, multiple knowledge systems from the different CoPs needs to be incorporated in agricultural KMS to support the marginalized small-scale farmers and, therefore needs to understand the role of communities of practice for knowledge sharing and integration.

2.2.1 Agricultural Indigenous Knowledge in Ethiopia

Despite the fact that IK have been applied for decision making by local communities in different dimensions, the most important area in which this form of knowledge applied is the different aspects of agriculture. Ethiopia is very rich in IK on various areas such as architecture, conflict resolution, medicine, education, agriculture, cultural social governance, health, and cottage industry (Jote, 2012). In agriculture, various researchers have indicated that local rural people of Ethiopia have plenty of IK for different agricultural domains, which consists of an unseen resource for rural sustainable development (Fanta, 2006; Fenta, 2004; Guye, 2014; Jote, 2012). As such, components of IK of agriculture vary depending on the social and environmental situations of particular local setting as well as the life style of its practitioners. Common IK of agriculture in different part of the country, for example pest management, land use (i.e., forest gardening and shifting cultivation), soil fertility management, weed management, crop harvesting and storage, seedling preparation and planting, seed preparation and sowing (Fanta, 2006; Fenta, 2004; Guye, 2014; Jote, 2012). Table 2-4 summarizes some examples of IK in agriculture possessed by rural communities.

Table 2-4. Exemplary Indigenous Knowledge in Ethiopia

Domain	Indigenous knowledge	Areas	Reference
Soil classification	Classifying, describing, and characterizing local soil types in their fields based on the soils' characteristics, problems, and their suitability for various crops.	In districts of Dejen areas	(Fanta, 2006)
Soil fertility management	Soil classification for identifying soil fertility level based on its color.	Bore Woreda	(Guye, 2014)
Soil and water conservation	Building of check dams, lengthy step-like terraces called *daldal*	Irob Woreda	(Fenta, 2004)
Natural resource management	Soil and water conservation practices, traditional pest controlling practices like hand picking, using bait, bending of stalks, and hazing with smoke.	North Shoa	(Demissie, Merene, & Desta, 2005)
Rangeland management	It is traditionally practiced in order to make use of the scattered rangeland resources on a large scale in a country.	In districts of Borena	(World Bank, 2005).
General in agriculture	Soil conservation practices, ploughing, weeds controlling, climatic prediction knowledge, and ethno-veterinary.	Bale zone	(Jote, 2012)

As indicated in Table 2-4, farmers in different regions of Ethiopia are rich in various IK for agricultural sustainability in which the modern provision of knowledge and technology could not replace. Despite ample of IK in Ethiopia and other developing countries, there are still concerns on the contribution of it for sustainable development. Several researches such as Fanta (2006), Jote (2012), and Guye (2014) also pointed out that majority of the rural communities rely dominantly upon IK and traditional farming to sustain their livelihood but scientific communities overlooked its contribution.

Additionally, Guye (2014) indicated that rural people to whom development endeavors are directed have their own cumulative body of IK that enables them to arrive at decision for different aspects, in which it helps better to manage their livelihood. As such, literatures suggested that local community's IK need to be promoted and carefully integrated with modern scientific knowledge and technology. The best way out for Ethiopia and other developing countries for sustainable rural development is good to strongly link the modernization with the traditional values and beliefs of local people. However, as stated by Fanta (2006) in Ethiopia, the absence of effective linkage between IK and scientific communities has been identified as one of the major problems that hinder the effectiveness and sustainability of the rural development. In order to integrate IK with scientific knowledge and practice, there is a need to identify IK and practices in agriculture and understand how IK is shared and how different CoPs develop shared understanding to blend the different knowledge systems in agricultural development.

2.3 The Treatment of Knowledge in Agricultural Development

Research and development have gone through various efforts from the focus on economic development and growth on equity, and to participatory development and sustainability. Knowledge is recognized as a significant resource for sustainability of economic and social development process of any country (UNDP, 2012; World Bank, 1998, 2005). Previous researchers indicated that indigenous people in different part of the world possess various knowledge in their environment, based on long period of living handy to nature (Agrawal, 1995, 2002; Eyong, 2007; Kanjo, 2012; Ruheza & Kilugwe, 2012; Tripathi & Bhattarya, 2004; Warren, 1991). The issue of IK has been increasingly recognized as a crucial role for socio-economic development including at level of rural community; however its significance in this aspect has been neglected for long. IK along with culture-specific situations is seen as an important point in discussions on sustainable use of environmental resources and sustainable rural development (Boikhutso, 2012)

Today, for many local communities, IK is still highly alive and crucially important for their survival (Boikhutso, 2012; Jote, 2012), in turn undermining their IK is to deprive the local community of a crucial resource (Jote, 2012). Agrawal and Gibson (1999) and Agrawal (1995, 2002) also strengthen this by indicating that using IK in development enterprises supports local communities to actively participate in different aspects of decision-making process. Accordingly, the World Intellectual Property Organization, WIPO, has recognized the use of IK and acknowledged local systems of innovation and intellectual property (Barasa, 2007). It is a critical indication in the area of research and development to promote and utilize these local resources and empowering local communities for their sustained livelihood. As such, IK is a critical element of the social capital of local communities and constitutes their main asset in their endeavors to gain control of their own lives and sustainability (World Bank, 1998, 2005). Accordingly, the potential contribution of IK to locally managed, maintained, and cost-effective survival strategies should be encouraged in the development process. The African department of the World Bank in its 1998 report on '*Indigenous Knowledge for a Framework for Action'* (World Bank, 1998) has also launched '*Indigenous Knowledge for Development Program'*, thereby to promote the blending of IK into operations. The major premises indicated include (World Bank, 1998, p. 8):

- *Understanding the local community with its context promotes for better adaptation of global knowledge;*
- *Using local indigenous knowledge systems increases sense of ownership, whereby ultimately produces results on the ground with sustainability;*
- *Learning from and building on the indigenous knowledge systems embedded in local communities helps to empower these local communities and promote a sense of equity in their interactions with government and external development partners; and*
- *Building on indigenous knowledge systems could only be achieved in partnership with the local communities themselves.*

The need for a local community to safeguard its IK calls for the acceptance of IK by successive generations (Olaide & Omolere, 2012). The International Federation of Library Associations and Institutions (2008) in its statement on *'Indigenous Traditional Knowledge'* suggested that there is a need to implement program to collect, store, and share IK and involve and empower the local communities to transfer their knowledge to the next generation, publicize the values and significance of IK, and promote the recognition of principles of intellectual property to ensure the proper protection and application of IK, among others. According to Boikhutso (2012), if IK is properly integrated with scientific knowledge, it can be the foundation for bringing sustainable people-centered development. In concert with this, the World Bank (World Bank, 1998) recommended that local communities need to be empowered and participated in the development through harnessing, preserving, and promoting their IK by integrating it with scientific knowledge and practice using ICTs.

The growth of ICTs in developing countries offers new opportunities for providing relevant agricultural information and knowledge for smallholder farmers, which can help for sustainable natural resource use and conservation, and to improve productivity and brings higher returns so as to aid poverty reduction (UNDP, 2012; World Bank, 1998). As a result, there is growing recognition in IS literature for the potential of ICTs as enablers of socio-economic development in developing countries, and, hence the need for their effective diffusion (Aker, 2011; Puri, 2007; UNDP, 2012). Despite the availability of various ICT-based programs in Ethiopia and other developing countries, these initiatives are becoming non-sustainable, a fad, and with limited impact on knowledge, adoption, and wellbeing of poor small-scale farmers (Aker, 2011). This is because, such initiatives have been relying on scientific knowledge of agriculture that marginalized IK and associated local farmers (Kanjo, 2012; Masinde, 2013; Puri, 2007; Ruheza & Kilugwe, 2012). The current KMS technologies do not allow farmers to use their own IK within the context of their specific problem. However, such systems are supposed to be developed for betterment of local farmers. Hence, for Ethiopia and other developing countries to progress in the knowledge economy, besides to best practices and scientific knowledge adapted from other parts of the world (i.e., western countries), local IK must be incorporated in the technology.

Literature indicated that agricultural KMS development mainly consisting of four different forms of knowledge which play critical role:

- Application knowledge is scientific knowledge possessed by agricultural researchers arises from their educational background, findings of researches and their everyday institutional practices (ATA, 2014; Puri, 2007; UNDP, 2012). For example, the modern scientific method used for soil fertility management is the use of chemical fertilizer and in weather forecasting information system relevant spatial and non-spatial data are required to address the application domain; which are drawing on the accumulated experience of prior scientific work in similar applications.
- Indigenous knowledge relating to the application domain possessed by the rural local communities (ATA, 2014; Puri, 2007; UNDP, 2012). Local community specific, it is traditional knowledge, innovations and practices of local communities and is developed outside the formal education system. It is acquired by local communities through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture.
- Technology based knowledge is also scientific knowledge inscribed in agricultural KMS development. It is explicit, considered universally applicable, rational, analytical objective, codifiable, and hence transferable; extensive use of remotely

sensed data and mathematical modeling used in Geographic Information System (GIS), market IS, weather forecasting; implication of computer technology.

- Implementation knowledge includes resource managers' knowledge, drawn upon in field implementation of similar projects (Puri, 2007). Such knowledge is possessed by a champion, a sponsor, a facilitator, a practice leader, a knowledge service center or office, and members, which is more official community role (Dalkir, 2005).

However, IK and social context of local communities are not well considered in KMS development. The full potential of the KMS technologies had not been utilized due to the emphasis given to technical rather than socio-cultural factors (Sahay, 1998; Sahay & Robey, 1996). The main question in KMS development is how to make everyone a winner. Despite the fact that development in IT and the increase in the knowledge and experience of the users, the number of failures in KMSs development project is high (Miah et al., 2012; Mursu, 2002; Walker, 2002). As indicated by the review of Miah et al. (2012), the low adoption rate of agricultural KMS and DSS is due to the following three basic reasons:

- The rapidly changing situations that occur in many modern businesses meant that many applications were dated before they were used.
- Systems developed by researchers with the intention of discovering information relationships but not focused on the practical solutions required by end-users especially farmers.
- System developers used their own problem solving strategies involving usually theoretical scientific knowledge rather than IK of farmers that is the practical knowledge of them used for problem solving in agriculture.

Additionally, Walker (2002) indicated that application of agricultural ISs in rural resource management has been largely disappointing because such systems emphasize on technology rather than user-centered approach in designing and development of the systems. Therefore, IS may not be adopted by the users due to its irrelevance for decision making, inflexibility to use, inaccessible and users may lack confidence in the use of the application. Many of KMS technologies do not allow farmers to use their own knowledge within the context of their specific problem and do not support farmers to enhance the outcome. The indications lead to an appealing issue for addressing agricultural KMS development, use, and evaluation within the socio-technical nature of the development (Miah et al., 2012).

2.4 Gaps in KMS development and use for Knowledge Sharing and Integration

Indigenous and scientific knowledge in agriculture are not mutually exclusive but are mutually reinforcing, and there is an urgent need of understanding of the integration of them (Kipkorir et al., 2011; Tadios, 2012). Despite the recognition of the importance of IK, there are still problems to create appropriate instrument for the promotion, preservation, and integration of IK with scientific knowledge through maintaining the basic characteristics of IK (Boikhutso, 2012; Jote, 2012; World Bank, 1998). Many studies have been investigated to understand the various aspects of IK and to integrate it in the multiplicity of knowledge systems. However, they are descriptive particularly focus on the social or ethnological features of indigenous knowledge systems rather than on the technical aspects. Thus, they lack adequate information and impressionistic regarding the systematic transfer of IK across communities and cultures as indicated by the World Bank in its 1998 report on '*Indigenous Knowledge for a Framework for Action'* (World Bank, 1998).

Following this recommendation of the World Bank, the use of IK alongside scientific knowledge is increasingly advocated in knowledge management literature and, hence many attempts have been made to identify the benefits (Akinwale, 2013; Fanta, 2006) and the needs to incorporate the two broad knowledge systems (Kanjo, 2012; Mercer et al., 2009; Tripathi & Bhattarya, 2004) (see also Table 2-5). For instance, Ruheza & Kilugwe (2012) studied the significance of integrating IK and scientific knowledge for natural resource management. Their result indicated that survival, flourish, and integration of IK and scientific knowledge for sustainable management and use of biodiversity rest on recognition, enhancement and promotion of IK, and its accommodation into the scientific knowledge in its way of knowing and doing, while considering cultural, spiritual, and local political aspects of the knowledge system. Akinwale (2013) also examined the digitization of IK as a critical resource in order to effectively manage natural resources in Africa. Another example can be the work of Tripathi & Bhattarya (2004) investigated the role of GIS for the storage and sharing indigenous knowledge for natural resource management through the participation of local communities.

However, little has been done on the conceptual framework development for understanding how varieties of knowledge are integrated together. Among the few efforts, Mercer et al. (2009) have presented a process framework by employing a participatory approach for incorporating indigenous and scientific knowledge to reduce a community's vulnerability to environmental hazards. It is expected to facilitate a process knowledge identification and integration, thereby to bring successful integration of indigenous and scientific knowledge at the community level. Kanjo (2012) has also investigated for understanding of the link between IK and scientific knowledge for improving the quality of data in health information systems.

Despite the fact that the integration of scientific and IK systems can be expected to improve agricultural productivity and sustainable use of natural resources (Tadios, 2012), yet there is no clearly developed comprehensive framework demonstrating how the two can be integrated specifically in the development of agricultural KMS and use. One attempt is the work of Puri (2007), who develops the conceptual framework for understanding of the blending of the multiplicity of knowledge in agricultural KMS based on the concepts of participation and boundary objects. However, it is not compressive to address the integration of knowledge in KMS development, for example the roles and practices of knowledge brokering among the owners of the problem is not addressed. Additionally, previous studies conducted in agricultural KMS development framework did not address how concepts are implemented and evaluated in the technological artifact. However, KMS for knowledge integration is required to be implemented and understood the ongoing interactions of individuals coming from different social groups in the development and use of KMS.

In knowledge management systems applications, fragments of knowledge are contained in different stakeholders and, therefore knowledge sharing between them is an important precondition for effective KMSs development (Rosenkranz et al., 2014) for knowledge integration. The crucial to the concept of knowledge sharing is the notion of knowledge exchange among participants from different CoPs (Pee, Kankanhalli, & Kim, 2010). Knowledge sharing hence refers to the bidirectional knowledge exchange and differs from other concepts such as knowledge transfer, which refers to the unidirectional knowledge flow from one another (Pee et al., 2010). Knowledge sharing is a precursor to knowledge integration.

The integration of scientific and indigenous knowledge in agricultural KMS development is a complex process that involve several methods and encourages a shift in systematic science from the development of knowledge integration products to the development of processes problem focused integration (Raymond et al., 2010). KMS development for knowledge sharing and integration involves multiple views, multiple approaches, multiplicity of knowledge systems, consisting of the technology itself, methodologies for system development, knowledge relating to the application domain, and IK that has been previously neglected (Puri, 2007; Raymond et al., 2010). Pawlowski and Robey (2004) also indicated that IS development such as KMS should encompass relevant combination of knowledge by bringing all pertinent CoPs together, which consists of people with diverse knowledge and experience with various artifacts and objects; and, therefore knowledge exchange between them is a key aspect in the development process. Therefore, participation of relevant stakeholders and multiplicity of knowledge issues are widely acknowledged as important success factors for development of KMS and usage of it.

Table 2-5. Exemplary Researches on the Importance of Knowledge Integration

Research Areas	**References**
Soil fertility	(Buthelezi, Hughes, & Modi, 2010; Fanta, 2006; Gowing & Payton, 2004; Gray & Morant, 2003; Scott & Walter, 1993)
Intercropping practices	(Degaga & Angasu, 2017)
Climate change adaptation	(Kipkorir et al., 2011; Sova, Chaudhury, Helfgott, & Corner-Dolloff, 2012; Stigter, Zheng, Onyewotu, & Mei, 2005)
Land management	(Puri, 2007; Shiferaw et al., 2013)
Health	(Byrne & Sahay, 2007; Kanjo, 2012)
Disaster risk reduction	(Mercer et al., 2009)
Natural resource management	(Akinwale, 2012; Donovan & Puri, 2004; Rist & Dahdouh-Guebas, 2006; Tripathi & Bhattarya, 2004)

In agricultural KMSs development, knowledge is mostly captured from agricultural facilities with the use of modern and scientific methods, incentives and practices which emphasize the superiority of scientific knowledge (Masinde, 2013). Additionally, IS research and practice in the West have been largely confined to organization settings and shaped by their societal context (Puri, 2007). However, literatures in knowledge management are relatively silent outside the formal organization settings. The integration of the aforementioned diversified knowledge systems in agriculture and the interaction between the associated occupational groups or CoPs are an important area of research, by the fact that IK is historically marginalized from the modern scientific communities. Accordingly, there is a need to strengthen the link between IK contained in the local communities and scientific knowledge in agricultural KMS development and use. In closing, a comprehensive conceptual framework is required to understand knowledge integration in agricultural KMS development and use.

2.5 Summary

This chapter has reviewed background concepts such as knowledge, knowledge management, KMS, KMS architecture, and KMS tools. Knowledge is an important resource of an organization but difficult to access, share, and use. The growing significance of knowledge in organization as an importance resource has compelled managers to examine the knowledge underlying organizations' business, giving rise to KM initiatives. The role of KM initiatives in an organization is to support KM activities, develops systems to support them, and motivates people to participate in them. ICTs are the most powerful enablers of organizational knowledge management processes. ICTs assist KM by providing knowledge repositories and methods for capturing and retrieving knowledge. Many organizations are developing ISs designed specifically to facilitate the storage, sharing and integration of knowledge, which are referred to as KMS.

Understanding agricultural knowledge systems sharing and integration are the main challenges, but the most important issues in KMS development to support stakeholders. The two equally important broad knowledge systems in agricultural KMS are scientific and indigenous knowledge. However, IK has not been yet fully explored and largely remains invisible in turn might be lost; hence needs management and improvement for the rural development efforts. Accordingly, research and development initiatives increasingly advocate the significance of IK together with scientific knowledge for socio-economic development. The indications lead to an appealing issue for readdressing KMS design and use within a socio-technical nature of the development. The following chapter will present the potential theories, the detail of the selected theories, and the initial theoretical lens of the study.

CHAPTER

3. CONCEPTUAL FRAMEWORK

3.1 Theoretical Foundation

The main challenge of this research is to understand concepts in agricultural KMS development and use processes for interlinking and sharing knowledge from different sources to readdress the problems of local farmers. Thus, system developers, agricultural experts, and extension agents must be brought together to acknowledge the importance of IK contained by the local community. All relevant stakeholders who are owners of problems must also be participated in the framing of the problem and the solution throughout the development of KMS and the use of it. Several efforts have been made to involve all relevant participants in KMS development in organizational context. However, little have been done to involve users outside formal organization settings such as rural community members in agriculture and health systems (Byrne, 2004; Korpela et al., 1996; Puri & Sahay, 2003; Puri, 2007). Additionally, Puri (2007) has stated that despite few attempts in participation of rural communities and involvement of IK, little have been done on how the situations for users to express their knowledge and experience in the development of KMS particularly in developing countries. In the following sections, an attempt is made to review the place and the involvement of local communities who host IK through extant literature, thereby contribute for understanding of the integration of it with scientific knowledge in agricultural KMS development and use.

3.1.1 Development Theory and IS Design Approaches

Participation methodologies have been increasingly evolving and improving since first gaining an international recognition in the 1960s for various aspects of human and associated environment (Claridge, 2004). Participation represents a move from the standardized, top-down paradigm that dominated early development initiatives towards a diversified, bottom-up paradigm of people, and locally sensitive methodologies (Chambers, 1994; Claridge, 2004). The review of Claridge (2004) indicated that literatures on participation and associated participation methodologies rooted mainly from two major areas, namely political sciences and development theory; and it is highly dominated by theories of development. Different development theories appeared through time since the conceptualization of development depends on different theories in relation to economic, political, and social trends, namely modernization theory, social systems theory, and micro-theories of development (Chambers, 1994; Claridge, 2004; Jote, 2012).

The importance of participation has been increasingly recognized as the world's poor have actually suffered due to development, in turn everyone needs to be participated in development decision, implementation, and benefit (Claridge, 2004). Top-down approach to development was as a result of modernization theory in the 1960s. Literatures have come up with the weakness inherent in traditional approach (i.e., top-down), which focuses on single disciplines and reductionist paradigms, as it is matured (Agrawal & Gibson, 1999). This has been highly criticized and other emerged development theories have highlighted disparities as it fails to involve local communities, thereby led to the rise of more intensive participatory methodologies during the 1980s (Puri, 2007). As a result, it is shifted towards people-centered development, and the shift from top-down to bottom-up leads to acknowledgement of the value of local IK through the participation of rural communities in developing countries. Accordingly, several theoretical and empirical models have been emerged and used, which aimed at seeking and promoting community participation and drawing upon IKS to support and improve the development and implementation of various field programs (Chambers, 1994). For instance, Chambers (1994) has developed Participatory Rural Appraisal (PRA) model to enhance the participation of rural communities for rural development. The model is described as growing family of community participation methodologies to enable local community to share, enhance, and analyze their knowledge of life and conditions, to plan and act (Chambers, 1994).

The popularity of community participation is drawing from the diverse application and acceptance for the need of community participation. In concert with it, many researchers have found that it has become mandatory for development strategies to be participatory (Agrawal, 1995; Agarwal, 2001; Byrne & Sahay, 2007; Byrne, 2004; Chambers, 1994; Claridge, 2004; Kanjo, 2012; Puri & Sahay, 2003; Puri, 2007). Similarly, authors in IS community also strongly recommend that user participation is critical to the successful IT-system development (Byrne, 2004; Byrne & Sahay, 2007; Puri, 2007; Puri & Sahay, 2003) to involve the users' knowledge systems and enhance the usability of the system. Accordingly, participatory design (PD) approach is increasing advocated and used in information system development. Consequently, PD including its role in addressing issues of power has been seen as a topic of pivot debate above all in IS literature (Byrne & Sahay, 2007).

Many researchers in the socio-technical method proposed a user-centered approach is critical as a means of evaluating users' active participation in IS development process (Miah et al., 2012). User experience is important in developing KMS application and how design is created and how it adds value for target end-users. Users can add new knowledge and modify primary features to adapt the IS into the problem context (Fischer & Ostwald, 2003). Thus, KMS development involves different stakeholders from different disciplines who create and use the technological artifact. In KMS development, users participation can be distinguished as technological artifact design time when the artifact is being designed and use time when the artifact is being used (Fischer & Giaccardi, 2004; Fischer & Ostwald, 2003; Germonprez et al., 2011). IS researchers suggested different classification of IS design based on the roles of the user participation: professionally dominated, participatory, and meta-design approaches as indicated in Table 3-1. In building this research, there is a need to select the appropriate design approach in keeping this research objective.

PD traces its root to Scandinavian trade unions, but its ancestry also includes action research and socio-technical design (Byrne & Sahay, 2007; Mursu, 2002). Participatory Design (PD) approach is an assessment, design, and development of technological and organizational systems that places a premium on the active involvement of workplace potential users of the system in design process (Mursu, 2002; Muller & Druin, 2010) (see also Table 3-1). It seeks to involve all relevant users more deeply in the process of system development to propose and generate design alternatives (Fischer & Ostwald, 2003). However, much of the research and many debates have been confined to formal organization in the western context with only limited and peripheral issues addressed relevant to developing countries setting (Byrne & Sahay, 2007; Puri, 2007).

Several researches, for example Byrne and Sahay (2007) and Puri (2007) have suggested to address the issues of PD research specific to the developing countries context in IS development (ISD). For instance, the involvement of ICTs has not generally been discussed and analyzed in development theory specific to the developing countries settings (Puri, 2007). However, development theory provides insights into how community participation may be enabled, nurtured, and sustained (Puri, 2007). Accordingly, Puri (2007) insights the importance of structural changes to enhance the participation of rural communities, thereby contributes to the positive outcome of ISD in developing countries (Puri, 2007). However, the format of IK is tacit and unique to specific communities and difficult to document and codified during ISD (design time) through participatory design approach. This approach needs to be extended not only to actively involve users in the ongoing design process but also in the use of the system. Additionally, KMSs are not merely relaying on the existing knowledge but also new knowledge created during KMS application.

In PD approach, future use and problem are not also be completely anticipated at design time while developing the system (Fischer & Ostwald, 2003). Designed system needs to be evolvable at use time to fit new needs besides to the best effort while designing for changing tasks and incorporate new knowledge and technologies (Fischer & Ostwald, 2003; Germonprez et al., 2011). Design approaches such as PD have yet focused primarily on functions, processes, and contents taking place at design time. Additionally, design science research has also largely considered the design of an IS to be completed before putting system into effect and used by end-users (Germonprez et al., 2011). As such, the work of Germonprez, Hovorka, and Gal (2011) extends the design science (Hevner, March, Park, & Ram, 2004) research discourse on how to explicitly including end-users (i.e., people) as deep and active participants in an ongoing design time and in the ongoing use of system, they called it secondary design. Similarly, Fischer and Ostwald (2003, 2004) describe such design approach and named it as meta-design.

In meta-design approach, open system can be created so as to add new content and to modify the system by the end users as new need arises and supports complex interaction and collaboration, thereby involves users at use time. The approach enables to view the users as active participants and co-designers in the technological artifact development and use (Fischer & Ostwald, 2003). Hence, this approach can enable to create socio-technical environments in the development of KMS that allows end users to engage in sharing, integrating, and creating knowledge rather than being restricted to the consumption of existing knowledge (Fischer & Giaccardi, 2004; Fischer & Ostwald, 2003). This research seeks to understand important concepts in the development and use of agricultural KMS for knowledge integration and sharing through involving users coming from different social groups. As such, in addition to the KMS design approach the research needs further theory so as to understand the communication and interaction among users coming from different social groups in KMS development and use as discussed in the following sections.

Table 3-1. The Role of Users in Different Design Approaches

Design Approach	**Design Time**	**Use Time**
Professionally-dominated	Users have no voice.	Users have to live with artifact designed by others.
Participatory	Users are active participants; systems are designed as complete systems artifacts.	Users are consumers of artifacts designed with their input, but artifacts cannot be involved to serve unforeseen needs.
Meta-design or Secondary design	Users are active participants; systems are designed as seeds; design is focused on design for participation.	Users can act as designers and involves the artifact to fit new needs.

Sources*: Fischer and Giaccardi (2004), Fischer and Ostwald (2003), and Germonprez et al. (2011).*

3.1.2 The Concept of Communities of Practice

Different kinds of theories of learning exist (Saade et al., 2011; Wenger, 1998), and each emphasizes on different aspects of learning (Wenger, 1998). According to Saade et al. (2011), learning theories can be seen from the two perspectives. One of the viewpoints is cognitive processing, which focuses on processing and representing knowledge. Another viewpoint is cognitive constructivism, which focuses on how knowledge is constructed. Social learning theory is a combination of behavioral and cognitive theories (Bandura, 1977). According to Bandura (1977), social learning theory focuses on the learning that occurs within a social context. The theory considers that people learn from one another through observational learning, imitation, and modeling and form social groups and interaction. The social learning theory is conceptualized as a community of practice (Brown & Duguid, 1998; Lave & Wenger, 1991; Wenger, 1998) and used for understanding of the different aspects of KM in organizations and informal groups.

Anthropologists Jean Lave and Etienne Wenger coined the term '*communities of practice*' when they were studying situated learning in the context of five apprenticeships (i.e., Yucatec midwives, Vai and Gola tailors, naval quartermasters, meat cutters, and nondrinking alcoholics) as a learning model. Accordingly, they indicated that people (novices) initially join a community and gradually interact with others and learn from experts at the periphery through acquisition of knowledge and skills in the context of everyday activities. Through the process, they move from legitimate peripheral participation into full participation (Lave & Wenger, 1991, p. 37). As a result, they become more competent and involved in the main processes of the particular community. The point of this discussion indicates that learning is a social event. Accordingly, the term CoP was coined to refer to the community that acts as a living curriculum for the apprentice (Lave & Wenger, 1991). After the articulation of the concept, people started to see it everywhere, even when there is no formal apprenticeship system. Lave and Wenger (1991, p. 94) argued that the social relations of apprentices within a community change through their direct involvement and interaction in activities; in the process, the apprentices' understanding and knowledgeable skills developed. Accordingly, they define a community of practice as:

> *A system of relationships between people engaged in the same practice, communicating regularly with one another about their activities, and seeking to improve their competence in the given practice, through construction, exchange and sharing of a common repertoire of resources. It is an intrinsic condition of the existence of knowledge*. (Lave & Wenger, 1991, p. 98)

CoP can be seen as a group of people along with their shared resources like knowledge and dynamic ongoing interactions, who assemble to make use of shared knowledge to enhance learning and create a shared value for the group (Dalkir, 2005; Lave & Wenger, 1991; Wenger, 1998). The term *community in CoP* is to refer to these groups are formed through common tasks, contexts, situations, and interests rather than by typical geographic, business unit, department, or functional unities (Dalkir, 2005; Lave & Wenger, 1991). The word *practice* in CoP refers that knowledge in action- how individuals do their tasks on a day-to-day basis rather than the formal policies and procedures in an organization that dictate how work should be done (Dalkir, 2005; Lave & Wenger, 1991). CoP is, therefore about learning as social participation in a setting of shared practices (Karner, Rohracher, Bock, Hoekstra, & Moschitz, 2011; Wenger, McDermott, & Snyder, 2002).

Social scientists have used versions of the concept of CoP for a variety of analytical purposes (Wenger et al., 2002) and various disciplines are now attracted much with community of practice: information science, computer science, health services, psychology, sociology, education, natural resource management, among others (Blackmore, 2010). According to the review of Dalkir (2005), researches in knowledge sharing and dissemination point to one critical dimension, which is learning and it is mainly social event. As a result, the role of communities of practice in the process of learning, knowledge generation, organizational learning, KM practice has attracted much attention from academics and practitioners (Blackmore, 2010; Roberts, 2006). CoPs have been identified as a mechanism through which knowledge is captured, transferred, and created (Brown & Duguid, 2001; Wenger, 1998; Wenger et al., 2002) and have become increasingly recognized in KM literature and practice (Krishnaveni & Sujatha, 2012).

According to Desmarest (1997), KM has two orientations: information-based (codifying and storing content) and people or interaction-based (connecting knowers). The former focuses primarily on knowledge capturing, storing, and codification. This approach emphasizes highly on explicit knowledge rather than tacit and favors the externalization objective (Dalkir, 2005). However, the approach neglects the social aspects of knowledge such as context, background, history, and social resources (Dalkir, 2005). In concert with this, critics maintain that this oversimplifies knowledge specifically overlooking of the social context of knowledge (Dalkir, 2005). Whereas, the people/interaction-based approach places a great deal of emphasis on knowledge sharing through interactions of people (Desmarest, 1997), in which organizations today tend to be associated it with CoPs (Thomas et al., 2001). According to Dalkir (2005), this social constructivist approach to learning and knowledge transfer believed to be better suited to address KM activities.

Researchers suggested that KM needs to view knowledge as something that is ultimately constructed in a social setting. The generation of knowledge in CoPs occurs when group of people participate and interact and share the relevant knowledge necessary to solve the problem (Wenger, 1998). Through the process of problem solving, members of group produce knowledge through interactions and a group memory is also created (Dalkir, 2005). Thus, social constructivism views knowledge as a subjective, social artifact rather than an objective entity (Pawlowski & Robey, 2004). As such, knowledge is derived from shared understanding among members that emerge through social interactions (Dalkir, 2005; Lave & Wenger, 1991). Ardichvili, Page, and Wentling (2002) indicated that various researches have reported that creating and supporting CoPs is a strong alternative to building teams, such as in the new product development, knowledge management, and other aspects of an organization. Therefore, knowledge is understood as a socially constructed resource, in turn knowledge management activities should be emphasized on social relations through fostering communities of practice (Gairín et al., 2012)

Wenger (1998, 2000) discussed communities of practice in the perspective of knowledge management as it is vital for any organization operations especially for those recognize knowledge as a key asset. As a result, CoPs in IS literature are providing a useful conceptual framework, thereby, to analyze and understand the sharing and creation of knowledge over space and time (Roberts, 2006). In concert with this, managers are seeking to develop and support CoPs as part of their KM strategies in an organization (Wenger et al., 2002), whereby to create value and improve performance. As such, pieces of knowledge exist from different groups of people for specific domain of problem and needs to be integrated as a solution of problem through connecting people and fostering interaction among them. Theory of CoPs is providing concepts to create rich learning environment to develop shared understanding among participants, thereby enhances knowledge sharing and integration (Krishnaveni & Sujatha, 2012). In KMS development and application which involves different social groups who have pieces of knowledge, the concept of CoPs is very important to understand the ongoing interactions and knowledge sharing among participants.

3.2 Conceptualizing the KMS Development Process

The concept of knowledge in this research is very important which emerges from different communities of practice. As stated by Wenger (2000), knowledge is created, organized, shared, revised, and transferred within and across different CoPs. Different pieces of knowledge reside in different CoPs that need to be integrated to provide multiplicity of knowledge systems in large social setting having common interest. KMS development requires expertise in a variety of areas and involves different specialists, among others IS specialists (i.e., designers, programmers, human-computer interaction specialists), marketing people, subject specialist, and user participants (Fischer & Ostwald, 2003). The main challenge here is to bring all social groups and their knowledge through developing shared understanding among participants to enhance knowledge sharing and integration. This is partly because of stakeholders are usually unable to provide their requirements precisely. This is attributed to differing perspectives of users, subject specialist, and system developers or differences in internalized frames of experiences (Rosenkranz et al., 2014).

The complexity in KMS development derived from synthesizing the needs of stakeholders' having different perspectives for a problem. The management of large amounts of knowledge pertinent to a design task and understanding of the design decisions can determine the long-term evolution of a designed artifact (Fischer & Ostwald, 2003). Despite capturing and transferring of explicit knowledge is possible, tacit knowledge is yet a challenge for organization's experts to capture and transfer. According to Levina and Vaast (2005), integrating knowledge from various sources requires an understanding on how to overcome obstacles associated with the embeddedness and tacit-ness of knowledge. The concept of CoP in KM and KMS development is increasingly becoming significant to enhance social interactions, thereby supporting capturing, sharing, and integration of tacit knowledge (Krishnaveni & Sujatha, 2012; Brown & Duguid, 1998).

In order to understand knowledge sharing and integration in agriculture, the theory of situated learning within CoPs (Lave & Wenger, 1991; Wenger, 1998, 2000) was selected. The theory helps in creating a social infrastructure and views knowledge as socially constructed rather than viewing knowledge as an objective entity (Pawlowski & Robey, 2004; Rosenkranz et al., 2014). The concept of CoPs is originally developed by Lave and Wenger (1991) in a study of situated learning, the framework is currently being used to analyze and facilitate knowledge transfer in a wide range of diverse social environments. Situated learning is conceptualized as the social context of learning in CoPs and defined as an informal aggregation of individuals engaged in common enterprise and distinguished by the manner in which its members interact and share interpretations (Lave & Wenger, 1991; Wenger, 1998). This view stresses that knowledge is situated in people's heads and actions as a result of social interactions also in a CoP who share a common interest (Bechky, 2003; Lave & Wenger, 1991).

According to Karner et al. (2011), interaction and informal learning in CoP are critical for tacit knowledge capturing, sharing, and integrating with the codified knowledge. In agricultural KMS, IK having the tacit format possessed by the local communities needs to be captured and integrated in the system in the development and use of KMS. The theory of situated learning within CoPs (Lave & Wenger, 1991; Wenger, 1998, 2000) provides various concepts that can be applied to both inform and structure investigations about learning and act as analytical lenses. In particular, the theory helps to identify relevant social groups organized around a particular interest area, to understand the ongoing interactions of individuals having common interest in the design and use of the KMS, and how individuals develop shared understanding through participation and interaction to deepen their expertise, which are the precursors for knowledge sharing and integration (Brown & Duguid, 1998; Wenger, 1998, 2000; Wenger et al., 2002).

3.2.1 Community of Practice

Community of practice comprises of three elements: domain, community, and practice. It is through developing these three elements in conjunction that one cultivates such a community and characteristics that distinguish a CoP from other social groups (Wenger et al., 2002). Different CoPs may reside within an organization or members of a CoP may be from various organizations or in different distributed geographical location. They come in different forms: quite small/very large, local/cover the globe, formal/informal and structurally characterized by a domain of knowledge, a notion of community and a practice (Wenger, 1998). CoP defines competence and differentiated from other CoPs by combining the three basic elements (Wenger, 1998).

A domain of knowledge is topic or theme to be addressed and advanced. It creates common ground for the participation and interaction of individuals in a CoP which guides their learning so as to provide meaning to their actions. The second element is a community in which members motivated by it for mutual interest in the domain (Wenger, 2000). Then, members in community engage in joint activities and discussions, help each other and share knowledge for common interest in their domain. Through, they build relationships and interactions that enable them to learn from one another, thereby they produce different kinds of resources (capital) in their domain (Levina & Vaast, 2005). The third element is the practice, which is the specific focus around which a CoP develops, shares and sustains its core of expertise such as ideas, tools, language, routines, sensibilities, artifacts, experiences, knowledge, stories, ways of addressing recurring problems, and shared repertoire of resources that serve to move the field of inquiry forward (Wenger, 2000; Wenger et al., 2002).

A convergent interplay of competence and experience is drawn from the three basic elements through time that involves mutual engagement. As a result, they offer an opportunity to negotiate competence through an experience of direct participation (Wenger, 1998). As such, they remain vital social units of learning even in the context of much larger systems. These larger systems are constellations or communities of interrelated CoPs (Wenger, 2000). Thus, terms: domain, community, and practice may clarify the difference between the concept of CoP as a social structure with other types (Wenger et al., 2002).

In the case of agricultural KMS development, there are diversified knowledge systems and associated occupational groups or CoPs. Broadly, the sources of knowledge for agricultural KMS include: scientific research and local rural communities (Puri, 2007; UNDP, 2012). The informal local communities consist of groups of farmers distributed in the rural areas of the country who possess IK and practices. Scientific research comprised of groups of agricultural researchers and system developers located in formal organizations such as universities and agricultural research institutes, who process scientific knowledge and practices. In addition, there are group of workers located in formal organizations and rural districts, who are responsible for knowledge transfer and introduction of new technologies from technologist and agricultural researchers to rural communities (Aker, 2011). In Ethiopia, these workers are called extension agents (Davis et al., 2010). Thus, this research is primarily interested in identifying each relevant social group through examining the structural social properties of them: the domain of knowledge, community, and practices.

Within a CoP, learning is seen as a process of social participation (Lave & Wenger, 1991) in which members with different level of experience and knowledge interact each other, thereby convey both tacit and explicit knowledge (Lave and Wenger 1991). According to Lave and Wenger (1991, p. 35), learning within a CoP takes the form of "*legitimate peripheral participation (LPP)"*. As discussed in the previous sections, newcomers enter into a CoP from the periphery and move toward the center over time through participating in a CoP as they gradually become knowledgeable (Lave & Wenger, 1991). Accordingly, each CoPs develops its own world view local to that particular CoP which reflects its shared knowledge, values, assumptions, beliefs, meanings, and practices (Brown & Duguid, 1991; Lave & Wenger, 1991; Pawlowski & Robey, 2004). This research is also interested in the inquiry to understand the learning processes and forms in each relevant social group in agricultural KMS development and use.

Despite the fact that knowledge is vital for an innovative problem solving within and across functions in an organization, it may also hinder problem solving and knowledge creation across functions due to its tacit-ness and sticky nature (Carlile, 2002, 2004). According to Carlile (2002, 2004), knowledge is localized, embedded, and invested in practice, in turn knowledge from one function or practice may not properly fit into another. Additionally, the differences in the frames of references between participants belonging to different occupation groups with specialized, domain-specific knowledge result in knowledge boundaries that separate organizational subunits and CoPs (Brown & Duguid, 2001; Rosenkranz et al., 2014). Wenger (1998) also stated that shared practice by its very nature creates boundaries among CoPs. Specialization of knowledge in practice and function makes it difficult the collaboration from different disciplines and the accommodation of knowledge developed in another practice (Carlile, 2002, 2004).

Similarly, in this research setting outside an organization context, there are knowledge boundaries that separate participants, for example members of local rural communities with other CoPs from scientific communities. According to Wenger (2000), such knowledge boundaries can create separations, fragmentations, disconnections and misunderstanding, but they can also be opportunities of unusual learning, places in which different perspectives meet and new possibilities can arise. In KMS development, knowledge boundaries can create opportunities for developers to build a knowledge-based competitive advantage (Levina & Vaast, 2005). Additionally, spanning across different CoPs can develop competencies through integrating expertise from different sources (Levina & Vaast, 2005; Puri, 2007). Collaboration across different CoPs and leveraging knowledge systems from them are critical for innovation design to share and integrate knowledge systems. The CoP theory emphasizes relationships, interactions and learning among individuals within a community, it also addresses relationships, interactions, and learning across different communities. The cross-boundary sharing of these CoPs is a critical success factor for the reorganization across CoPs (Snyder & Wenger, 2010). Brown and Duguid (2001) also stated that interaction across boundaries can provide an opportunity for learning, whereby allowing an organization to create coherent, synergistic, and integrated knowledge.

In an organization, members from different CoPs contribute their own knowledge and experience through participation in cross-functional project and create multiplicity of knowledge systems by combining different pieces of knowledge to get job done (Wenger, 2000). Wenger (2000, p. 234) stated that:

> *In social learning systems, the value of communities and their boundaries are complementary. Deep expertise depends on a convergence between experience and competence, but innovative learning requires their divergence.*

Fischer and Ostwald (2003) stated that community of interest (CoI), which is similar to conceptualization of it as community of communities or a community of representatives of communities by Brown and Duguid (1991, 1998). Wenger (1998) also describes it as constellation of communities which brings together participants from different CoPs and is defined by their collective concern with the resolution of a particular problem for the purpose of sharing knowledge, learning, and creating new knowledge. Examples of CoI are:

i. A team interested in electronic-commerce development that includes software designers, end-users, marketing specialists, psychologists, and software developers;
ii. A group of citizens and experts interested in urban planning (Fischer & Ostwald, 2003);
iii. In GIS application, different groups are typically responsible for the component technologies of a GIS, namely digitizers, analysts, programmers, remote sensing technologists, system administrators, GIS technicians, users, and policy makers (Sahay & Robey, 1996).

A CoI brings participants from different CoPs having common interest in a single organization or different organizations in distributed environment together. The distinctions between CoP and CoI are summarized in Table 3-2. For example, learning through informed participation within CoI is more complex and multifaceted (Fischer & Ostwald, 2003) than legitimate peripheral participation (Lave & Wenger, 1991) within CoP that assumes a single domain of knowledge system (Fischer & Ostwald, 2003). The CoI has multiplicity of knowledge in which each members considered to be knowledgeable in a particular area of the problem and may not knowledgeable in others (Fischer & Ostwald, 2003). Development of knowledge in a CoP involves the refinement of one domain of knowledge system; new ideas coming from the practice within CoP; whereas in a CoI, knowledge is developed through synthesizing, mutual learning, and the integration of multiplicity of knowledge systems. As such, in this research perspective, there are different CoPs such as local communities, agricultural researchers, system developers, and extension agents working together in the development of agricultural KMS and the use of it. Therefore, in CoI, members from different CoPs need to contribute their knowledge and experience to achieve a common goal. The main challenge in this regard is to understand how members coming from different CoPs participate, interact, and contribute knowledge for their common interest in the development and use of agricultural KMS.

Table 3-2. Distinctions between Community of Practice and Community of Interest

Dimensions	Communities of Practice	Communities of Interest
Major objectives	To create, expand and exchange knowledge, and to develop individual capabilities; domain coverage.	To be informed; shared understanding, making all voices heard.
Members	Self-selection: novice and experts, apprentice and masters.	Whoever is interested: relevant owners of problems from different domains.
What holds them together?	Passion, commitment, expertise, and identification within CoP.	Access to knowledge, shared understanding, and common interest.
Learning	Legitimate peripheral participation	Informed participation
Nature of problems	Different tasks in the same domain	Common task across multiple domains.
Development of Knowledge	Refinement of one domain of knowledge system; new ideas coming from the practice within CoP	Synthesis and mutual learning through the integration of multiplicity of knowledge systems.

***Sources**: summarized from the works of Fischer and Ostwald (2003) and Wenger et al. (2002).*

The creation of networks and community of communities fosters collaboration among different CoPs and enhances shared understanding among participants which is critical for knowledge sharing and integration (Fischer & Ostwald, 2003; Snyder & Wenger, 2010; Wenger, 1998). According to Wenger (1998, p. 129), when a social configuration is viewed as a constellation or community of communities of practice rather than a CoP, there is a need to understand the continuity of the constellation in terms of ongoing interactions among practices. KM literatures (Davenport & Prusak, 1998; Jennex, 2005; Nonaka, 1994; Nonaka & Takeuchi, 1995) in particular the theory of situated learning in communities of practice (Lave & Wenger, 1991; Wenger, 1998, 2000) provides the source of concepts for the investigation of knowledge sharing and integration across different CoPs: communities of practice, knowledge brokers, and boundary objects to bridge knowledge boundaries across relevant CoPs in a community of interest.

3.2.2 Knowledge Brokering

Brokering is an important concept used to enhance knowledge sharing among CoPs within the agriculture sector of KMS development, specifically between scientific and local communities. It denotes activities of individuals that involves the facilitation of the connections, bringing new ideas in and from the outside, and exchange of knowledge between CoPs across knowledge boundaries (Levina & Vaast, 2005; Pawlowski & Robey, 2004; Rosenkranz et al., 2014). Individuals as knowledge brokers facilitate exchange of knowledge and experience through linking two or more groups of people separated by space, hierarchy, or function (Gasson, 2005; Lave & Wenger, 1991; Levina & Vaast, 2005). Wenger (1998, p. 109) described the roles of knowledge brokering as complex activities as:

> *It involves the process of translation, coordination, exchange, and alignment between perspectives and it promotes interaction between two or more CoPs.*

Individuals act as brokers across two or more CoPs, while they are weakly linked to several communities at once and full members of none (Pawlowski & Robey, 2004; Rosenkranz et al., 2014). They perform their activities as third parties, rather than as members of the source or recipient of knowledge (Pawlowski & Robey, 2004). They participate in the work of multiple communities and facilitate knowledge exchange across CoPs' knowledge boundaries (Brown & Duguid, 1991; Pawlowski & Robey, 2004). Knowledge brokers are, therefore individuals bridging gaps in social organization and foster knowledge exchange across the knowledge boundaries through enhancing participation, translation, coordination, alignment, and negotiation among members from different formal and informal groups (Wenger, 1998), thereby facilitate and promote transaction between previously separated practices (Kislov, Wilson, & Boaden, 2016). In building this research, there are extension agents in the Ethiopian agricultural extension system, who are responsible for knowledge transfer and introduction of new technology to local communities from research. They are playing an important role as knowledge brokers through transferring knowledge. Spectacular successes in knowledge transfer from research to local farmers aside, they are also ill-studied in their roles of knowledge exchange as indicated by previous literature.

As stated by Pawlowski & Robey (2004), IS professionals played a significant role in knowledge management programs and became popular during the 1990s. However, their roles and practices have been restricted to developing and operating tools for organizational knowledge capturing and contribution of knowledge to the system. Consequently, many studies have been investigated the roles of system developers as knowledge brokers in the context of formal organization in which information system developers can directly communicate and gather requirements from end-users and domain experts (Levina & Vaast, 2005; Pawlowski & Robey, 2004; Rosenkranz et al., 2014). Other professionals such as managers, human resource specialists, and sales representatives are also examples of brokers since they are expected to span inter and intra organizational knowledge boundaries (Levina & Vaast, 2005). In this study context, agricultural professionals such as development agents and extension workers are playing as knowledge brokers between technologist and agricultural researchers, and the local farmers. These people mediate the practices of the research and technologists with the local farmers to transfer knowledge and technology to local farmers from research. In this investigation, the use of the term brokering is similar to Pawlowski and Robeys' (2004) and Rosenkranz and his colleagus' (2014) conceptualization, but this research applies it across both formal work units (i.e., practices in agricultural institutions and universities) and informal communities of practice (i.e., local rural farmers practice), thereby, investigates the roles and the practices of knowledge brokering to strengthening the weak link between the two broad CoPs (i.e., local and scientific).

The aspect of participatory design and notion of boundary objects have been investigated by few researches to involve local communities (Byrne & Sahay, 2007; Puri, 2007; Puri & Sahay, 2003; Zewge, Dittrich, & Bekele, 2014). However, the roles and practices of agricultural professionals as knowledge brokers to bring all CoPs together has been largely ignored in this paper context, for example to the involvement of rural community members who will be served by health and agricultural information system in developing countries. Previous works on knowledge brokering suggested the importance of designing knowledge brokers' roles and practices in order to deal with the challenges in the knowledge boundaries (Levina & Vaast, 2005; Pawlowski & Robey, 2004; Rosenkranz et al., 2014). Hence, it is important to probe the roles and practices of extension agents as knowledge brokers in order to understand how agents mediate the interaction among participants coming from different CoPs and foster the incorporation of diverse knowledge in agricultural KMS development.

Several researches indicated that knowledge brokers are responsible for mediating the practices among several CoPs and an amalgamation of diverse knowledge systems (Gasson, 2005; Levina & Vaast, 2005; Pawlowski & Robey, 2004; Rosenkranz et al., 2014). For this purpose, the study of knowledge brokering has led to the recognition of the skill needed for professionals as brokers and to the identification of role-specific brokering activities such as knowledge sharing (Pawlowski & Robey, 2004). Wenger (1998, p. 109) described the skill required by knowledge brokers:

Brokering requires the ability to link practices by facilitating transactions between communities of practice and to cause learning by introducing into a practice elements of another.

Knowledge brokering, hence requires multidimensional skills to support different social groups having their own domain of knowledge and experience and to maintain their roles over time (Kislov et al., 2016). Previous literatures suggested the requirements of skills and knowledge for knowledge brokering by the agents to coordinate the communication and interaction of individuals coming from different CoPs (Karner et al., 2011; Kislov et al., 2016; Pawlowski & Robey, 2004; Robeson, Dobbins, & DeCorby, 2008). However, researches are not only silent in the roles of agricultural professional as knowledge broker but also the skill and knowledge requirements. Therefore, this research also investigates the skill and knowledge requirements by agents for their roles of knowledge brokering in the development and use of agricultural KMS.

3.2.3 Boundary Objects

The term boundary object is coined to define objects that serve to coordinate and mediate the perspectives of various collaborative CoPs for some practice (Star & Griesemer, 1989). Boundary objects can be expected to address the limitations of knowledge brokers in social networking and collaboration among members from different social groups distributed in geographical location, hierarchy, or function (Levina & Vaast, 2005; Star & Griesemer, 1989). Wenger (1998) defined boundary objects in the perspective of CoPs as:

any artifacts, documents, terms, concepts, and other forms of reification around which communities of practice can organize their interconnections. They enable coordination, but they can do so without actually creating a bridge between the perspectives and the meanings of various constituencies. (Wenger, 1998, p. 107)

Communities develop their own practices, routines, documents, rituals, artifacts, symbols, tools, conventions, websites, and stories through time (Wenger, 1998). They are any objects that are relevant to the practices of multiple communities, but they may be used and viewed differently by each of CoPs (Brown & Duguid, 1998; Rosenkranz et al., 2014), and support collaboration, interaction, and knowledge sharing across CoPs (Puri, 2007). Boundary objects mediate and coordinate productive breakdowns in collaboration across different social perspectives, distributed organizational workgroups, and geographical boundaries (Gasson, 2005; Puri, 2007). Previous researches are resulted in the identification of wide range of boundary objects in different context, for example prototypes, diagrams, database (system) documentations, user training materials, standards, policies, technical extraction, transformation, and loading (ETL) mappings, report printouts in data warehouse application (Rosenkranz et al., 2014). Other examples can be shared systems and related artifacts like information system with its documentation and user training materials served as boundary objects in bridging users in organization (Pawlowski & Robey, 2004); physical prototypes, standardized reporting forms in IS implementation and use (Levina & Vaast, 2005); and e-collaboration system as boundary object (Gasson, 2005).

There are also several examples of researches which investigated the role of information systems or IT as boundary objects in order to understand its role in bridging the knowledge boundaries across CoPs (Gasson, 2005; Levina & Vaast, 2005; Pawlowski & Robey, 2004). Knowledge workers use IT-based technological artifact to connect and transfer knowledge among individuals distributed in different organizational functions and geographical location (Gasson, 2005; Levina & Vaast, 2005). Information systems allow the interaction and collaboration of individuals from different social groups, share their own knowledge, and coordinate their activities (Levina & Vaast, 2005; Pawlowski & Robey, 2004; Rosenkranz et al., 2014). Diverse meanings and interoperations are attached to the common technological object by participants from different CoPs and shared understanding can be developed through collaboration and negotiation among them (Wenger, 1998). As a consequence, IS as a boundary object provides powerful potential for sharing and integration of distributed knowledge through crossing knowledge boundaries among CoPs (Gasson, 2005; Star & Griesemer, 1989).

In the context of knowledge sharing and integration in KMS development that involves local rural communities, little have been worked on the identification and roles of boundary objects. In previous researches such as the works of Al-Kodmany (2001) and Puri (2007), maps (e.g., paper maps and scale models) are served as boundary objects as visualization tools to draw out community expertise and local knowledge, thereby contribute to the integration of IK with scientific knowledge. Another example of boundary objects comes from the work of Byrne and Sahay (2007), but not declared as such by the authors. However, they displayed pie charts and histograms, which can be served as boundary objects to share knowledge of local communities in the development of a child health community-based information system in South Africa. The findings of the previous researches have indicated that IK is embedded in the practice by local communities, among them, handicrafts, artwork, folk music, traditional stories, songs, words, dances, and ceremonies during agricultural practice.

Local rural communities and agricultural domain experts possess different knowledge types. Additionally, members from different social groups also use shared boundary objects for their interactions. However, the development of agricultural KMS for knowledge sharing in developing countries did not involve objects possessed by local communities (Puri, 2007; Zewge et al., 2014). As a result, the KMS does not allow local communities to use knowledge from the system and to contribute and share their knowledge through it. For example, ECX and ATA are running KMSs in Ethiopia for knowledge sharing across relevant social groups but the system is very difficult for local farmers to interact with other social groups. Regardless of differing perspectives, KMS as a boundary object provides an effective communication medium through which users are able to express their requirements and needs (Puri, 2007). Information system professionals who develop and support the agricultural KMSs are, therefore to learn the work practices and boundary objects possessed by each user community. Thus, in the development of agricultural KMS, system developers should involve objects possessed by relevant CoPs in particular local communities, whereby a shared KMS as a boundary object can enable all relevant participants coming from different CoPs to interact and collaborate for their common practice. As stated by Carlile (2002, p. 453), a shared system as boundary object provides "*an infrastructure or process where current and more novel forms of knowledge can be jointly transformed, producing more shared knowledge*". As such, this research seeks to investigate boundary objects possessed by different relevant social groups and integrate them in the development of the KMS.

The use of boundary objects supported by participants practice is important for dissemination of agricultural knowledge among relevant communities. Consequently, consideration of boundary objects together with the concepts of knowledge brokering can play an important role in this investigation. Moreover, it is important to design technological artifact as boundary object within knowledge brokering roles intended to enable multiple practices to negotiate their relationships and connect their perspectives (Wenger, 1998). Several researches further suggested to investigate dynamics of the interplay between technological artifact as boundary object and knowledge brokering through designing and using the technological artifact for knowledge sharing and integration (Gasson, 2005; Levina & Vaast, 2005; Pawlowski & Robey, 2004; Rosenkranz et al., 2014).

3.2.4 The Design and Use of KMS

Information systems research have been perceived by some authors as purely a social science, thus ignoring the technology side of it (Burstein & Gregor, 1999; Nunamaker et al., 1991). However, this view is changing as more researchers recognize that IS involves an unavoidable technical component (Jennex & Olfman, 2011). Information systems such as DSS and KMS are essentially considered as social systems, having IT as one aspect. Information system development is a critical practice in an understanding of the diffusion and the implementation of information system through analysis, design, implementation, and use of it (Mursu, Olufokunbi, Soriyan, & Korpela, 2000). The developed technological artifact can be used as a proof of concepts investigated empirically (Burstein & Gregor, 1999), thereby system development process can align the theory (i.e., basic research) with practice (i.e., applied research) (Jennex & Olfman, 2001). Therefore, this research is further interested in the development and the use of technological artifact (i.e., KMS) as a boundary object to understand the concepts in a conceptual framework within socio-technical design science (Miah et al., 2012), whereby to further build a process conceptual framework for the KMS development and use for knowledge sharing and integration.

KMS development for knowledge sharing and integration requires an active participation of users not only in the design of KMS but also in the use of it after development (Germonprez et al., 2011). Additionally, KMS development research can assure its relevance to the problem domain through understanding of the design, the use, and the consequence of the KMS to represent the views of problem owners within the social or organizational context. A structurational model of technology by Orlikowski (1992, 2000) modified from Giddens's theory of structuration (Giddens, 1984) is widely cited in IS literature for the analysis of IS development, use, and organizational or social system impact (Jones & Karsten, 2008; Rose & Scheepers, 2001). Orlikowski and Robey (1991) also suggested that the use of structuration framework of technology allows researchers to probe the system development process, the use, and the consequence of the IS use together.

The theory of structuration is primarily coined by Giddens (1984) during early 1980's. According to the extant literatures, the aim of structuration theory is to blend structure and agency together through interaction as a social process (Giddens, 1984; Jones & Karsten, 2008; Orlikowski, 1992, 2000; Orlikowski & Baroudi, 1991). The theory of structuration consists of structural properties of social systems that enabled and constrained the users action and it is also the result of previous actions (Jones & Karsten, 2008; Orlikowski, 1992). The structural properties of social systems consist of the rules and resources, which are both the medium and the consequence of users' practices as they interact with the technology across time and space (Orlikowski, 1992). Social structure facilitates and constraints the social system through providing rules and resources that enable human agents to make sense of their practices in the social context (Orlikowski & Robey, 1991).

Technological artifact is not only created and changed in the design of it as a result of human action, but also in the use of it to perform some activity (Orlikowski, 1992). Orlikowski (1992) described it as duality of technology consisting of the design and use time of the technological artifact. A structurational model of technology is composed of three basic components: human agents, technology, and structural properties of social systems (Orlikowski, 1992), which are critical for understanding of the duality of technology. Structures such as knowledge and procedures are found in organization in which system developers incorporate into the technological artifact (Orlikowski, 2000). Users can also add and redefine content and modify properties, functions, and applications of the technological artifact in the use time of it after development (Germonprez, Hovorka, & Collopy, 2007; Germonprez et al., 2011; Orlikowski, 2000). For example, relevant social groups in KMS and DSS add their knowledge and experience, modify contents, and customize the functions and applications when they use the system for their practices. When relevant groups regularly interact with the technology, they make use of the existing or planned contents, functions, and applications of the technology (Germonprez et al., 2011; Orlikowski, 1992, 2000). As a consequence of ongoing interaction, certain properties of the technology are implicated and reconstructed in the community's structure (Rosenbaum & Shachaf, 2010).

The social interaction among members coming from different social groups is mediated through three dimensions including facilities, norms, and interpretative scheme (Giddens, 1984). Orlikowski (1992, p. 410) described these dimensions in the perspectives of social interaction with the technology as:

Human agents build into technology certain interpretive schemes (rules reflecting knowledge of the work being automated), certain facilities (resources to accomplish that work), and certain norms (rules that define an organizationally sanctioned way of executing that work).

Relevant social groups in this regard interact relaying on their tacit and explicit knowledge of their prior action through the facilities (i.e., technological artifact as a boundary object) following the norms that govern their ongoing interaction (Orlikowski, 1992, 2000). Interpretive flexibility in this context of study refers to the capacity of the technological artifact to maintain the divergent interpretations of different relevant social groups (Sahay & Robey, 1996) for knowledge sharing and integration. Consequently, they recursively instantiate and reconstitute the rules and resources that structure their social action (Orlikowski, 2000) drawing upon the rules and resources of the community's structure (Rosenbaum & Shachaf, 2010). The model consists of the following components which distinguish between four types of influences (Orlikowski, 1992, p. 409-412):

I. ***Technology as a Product of Human Action****: Technology is an outcome of human actions such as design, development, appropriation, and modification.*

II. ***Technology as a Medium of Human Action****: Technology facilitates and constraints human action through the provision of interpretive schemes, facilities, and norms.*

III. ***Institutional Conditions of Interaction with Technology****: Institutional properties influence humans in their interaction with technology.*

IV. ***Institutional Consequences of Interaction with Technology****: Interaction with technology influences the institutional properties of organizations.*

Accordingly, this research primarily seeks to understand the design of the technological artifact as a boundary object relying on the roles and practices of participants, domain knowledge, and boundary objects of different relevant formal and informal social groups in agricultural KMS in-line with the first components of Orlikowski's (1992, p. 409) model (i.e., "*technology as a product of human action*"). However, there is no clear understanding of how a shared KMS boundary object is developed. Accordingly, system development (SD) including the design of concepts, construction of architecture and prototyping need to be carried out. SD provides the explanation and synthesis of available boundary objects and the roles and practices of relevant social groups that produces the technological artifact or system

(Nunamaker et al., 1991). Then, the developed technology artifact as a boundary object will serve as a medium for the communication and interaction of members coming from different CoPs (Orlikowski, 1992, p. 410). The technological artifact as a boundary object should be able to adapt the needs and expectations of all relevant users so that it needs to robust enough to maintain common identity (Star & Griesemer, 1989, p. 393). Additionally, the resulted artifact serves as a link between the concept formation stage or social research with the technological development research (Nunamaker et al., 1991). The developed artifact will be used to proof concepts and further provides concepts in addressing its use. Subsequently, this research is interested in probing the usage of a technological artifact for understanding whether or not it is being utilized by the relevant participants from different social groups as expected (Jennex & Olfman, 2006, 2011).

Structural properties of the social systems such as rules and resources and the technological artifact conditions such as interpretive flexibility are important to sustain the divergent interpretations of members from different formal and informal social groups (Orlikowski, 1992, 2000; Sahay & Robey, 1996). They are both the medium and emergent properties while users interact with the technology (Orlikowski, 1992, 2000; Sahay & Robey, 1996) in accordance with the third and fourth components of Orlikowski's (1992, p. 411-412) model. Formal organizational structure and conditions of the technological artifact may not coincide with actual human action that involves diverse interests and in which users practice have unexpected consequences (Orlikowski, 2000; Wenger, 1998). As stated by Orlikowski (2000), it is the ongoing use of a technological artifact by human agents within a particular social context that creates the technological artifact's social characteristics and gives it meaning. Hence, this research examines the conditions and emergent properties of the structural properties of the social systems as users interact through the interplay of technological artifact as a boundary object and extension agents as knowledge brokers through observation. Finally, the research is further interested in examining the consequence of institutional conditions and the interplay of technological artifact as a boundary object and extension agents as knowledge brokers in practice for knowledge sharing and integration. The consequence is described as the effect in which the KMS boundary object, institutional conditions, and knowledge brokering have on the effectiveness of the participants coming from different CoPs for knowledge sharing and integration (Jennex & Olfman, 2001, 2006).

The Orlikowski's (1992, 2000) structuration model of technology provides a structuration perspective and practice lens that has been employed for understanding of the design, the use, and the consequences of the interplay of KMS boundary object and knowledge brokers for knowledge sharing and integration. This model of technology was selected because it gives high emphasis to the complex social interaction among people and with technological artifact while it is designed and used in an organizational or social context (Orlikowski, 1992, 2000; Orlikowski & Baroudi, 1991; Orlikowski & Robey, 1991) so as to understand the interaction between members coming from different social groups in a community of interest and the technological artifact as a boundary object. Additionally, the model of technology allows for understanding of the consequence that emerge on the structural properties of the social systems as members in the social groups interact with the technology employing the current structural properties (Orlikowski, 2000). By using this theoretical model, this research is to investigate the design of a technological artifact as a boundary object, to understand the significance of a shared technological artifact by relevant CoPs for their action, and to understand the consequences of the interaction between the various social groups with a technological artifact for knowledge sharing and integration. In sum, the initial process conceptual framework of the study consists of the relevant social groups, the roles and practices of knowledge brokers, boundary object, designing of a shared KMS boundary object, the use of brokering and KMS, condition of structural properties of the social system, and the consequences for knowledge integration.

3.2.5 Evaluation of the KMS Boundary Object

There have been many technology developments, changes, and innovations as well as further research on KM/KMS success in different context of use (Jennex, 2017), which need to be investigated. Accordingly, the KMS/KM needs to be evaluated in the organization to understand the value, its importance, and how it is used thereby, help managers/practitioners to understand how KMS for KM activities should be designed, implemented, and justify the KM/KMS investments (Jennex, 2017; Jennex & Olfman, 2011; Jennex, Smolnik, & Croasdell, 2016). As indicated in Jennex (2017), the Jennex and Olfmans' KM/KMS Success Model (2006) modified from DeLone and McLean (1992, 2003) IS Success Model is the most widely employed and useful model in predicting success when applied to understand the design and implementation of a KM/KMS initiative and to assess the KM/KMS in different knowledge areas such as Velasquez, Durcikova, and Sabherwal (2009) and Jennex (2008).

The model is also being used mostly with the new use to determine the organizational readiness to adopt and use the KM/KMS initiatives (Jennex, 2017). In order to understand the success of the use and consequence of the KMS, the study evaluated the KMS/KM conditions and the organizational social properties by employing a model of Jennex and Olfmans' (2006) KM/KMS success.

Jennex and Olfman (2006, p. 54) described KM/KMS success as reusing of knowledge to improve individuals performance and organizational effectiveness by providing the right knowledge to the right person at right time. Hence, this paper is interested in addressing the success of KM/KMS in agriculture using the Ethiopian extension system for knowledge systems sharing and integration for understanding of the concepts in the use of the KMS after its development. KM/KMS is expected to have a positive impact on individuals performance and the overall organizational performance that improves organizational effectiveness using the dimensions of KM activities: KMS search, storage, and retrieval functions, KMS/KM strategy, knowledge content, capability of the KMS to support users, and organizational culture (Jennex & Olfman, 2001, 2006). Accordingly, the following critical success factors were used to evaluate the KMS boundary object's success in this study defined in Jennex and Olfman (2006), and Jennex (2017).

System quality. Jennex and Olfman (2001) described the system quality factor as how good the KMS/KM is in its operational characteristics in order to perform the KM activities such as knowledge creation, storage, transfer, and application. It also addresses how much extent the knowledge system is represented in the knowledge repository of the KMS and the KM/KMS infrastructure integration (Jennex & Olfman, 2006). Jennex and Olfman (2006, 2001) defined the system quality factor with three constructs: technological resources of the organization, KM/KMS form, and KM/KMS level. Technological resources refer to the capability of an organization through the integration of KM/KMS infrastructures to develop, operate, and maintain the KM/KMS (Jennex & Olfman, 2006, p. 56). Integrating the technological infrastructures and organizational capabilities enables the KM/KMS form and KM/KMS level constructs (Jennex & Olfman, 2006). Jennex and Olfman (2001) defined the KM/KMS form as the extent to which the knowledge resources and KM activities are computerized and integrated. They further described the KM/KMS level construct as the ability to provide knowledge from different sources to support current activities through

KM/KMS mnemonic functions of knowledge searching, visualization, retrieval, assessment, and manipulation.

Knowledge quality. Jennex and Olfman (2006, 2011) described the knowledge quality dimension as the incorporation of the knowledge and KM activities to capture the right knowledge with its context and to provide it to the right users at the right time. It consists of three constructs: KMS/KM strategy and process, linkages to knowledge, and richness of knowledge (Jennex & Olfman, 2001, 2006). The KMS/KM strategy and process construct refers to the organizational processes for identifying knowledge users, sources, processes, and knowledge capturing, storage, sharing, and integration in the KMS/KM (Jennex & Olfman, 2006, p. 57). It is crucial for ensuring the contents and effectiveness of the constructs of linkages and richness of the knowledge systems (Jennex & Olfman, 2001, 2006). The construct knowledge richness refers to the accuracy and timeliness of the stored knowledge in the KMS with its context to make the knowledge useful for decision making (Jennex & Olfman, 2006). Additionally, they defined knowledge linkages as crucial to assess the knowledge and experts' maps in the KMS/KM to locate the sources of knowledge to the participants.

Service quality. Jennex and Olfman (2006) defined this dimension as the adequacy of the KMS/KM to support users to utilize KMS/KM effectively. This dimension consists of three constructs: management support, user KM/KMS service quality, and KMS/KM service quality (Jennex & Olfman, 2011). The management support construct reflects the organizational capability such as organizational or social properties and structure to provide resources to create and maintain KM/KMS, enhance knowledge sharing culture, and avail encouragement, incentives, and control structure for knowledge exchange (Jennex & Olfman, 2006). They described the user KMS/KM service quality as the support provided by the organization to help their employees and users to utilize KMS/KM (Jennex & Olfman, 2001, 2006). Jennex and Olfman (2006) described the KMS/KM service quality as the support provided by the KMS developers to KMS/KM users and to sustaining the KMS including developing and maintaining KMS, maintaining the database and knowledge repository, and ensuring the reliability, privacy, security, and availability of the KMS.

The KMS use. It is measured via the intent to use and the overall user satisfaction. The intent to use/perceived benefits is a construct that measures perceptions of the benefits of KMS/KM by users on meeting current and future users' needs and expectations (Jennex & Olfman, 2006). The user satisfaction construct measures satisfaction with KM/KMS by relevant users from different social groups. It is considered a good complementary measure of KM/KMS use as desire to use KM/KMS depends on users being satisfied with KM/KMS (Jennex, 2017). Moreover, user satisfaction is a critical factor for the continued use and success of technological artifacts such as the KMS (Chen, Chen, & Chen, 2009; Tong, 2009). Hence, the study will measure the intent of use and the overall satisfaction by relevant individuals from different social groups in Ethiopian agricultural extension systems.

Finally, the ***performance impact/consequence*** is determined by the ability of these critical success factors to affect use of the KMS and overall user satisfaction and then to the individuals' performance and organizational effectiveness. Jennex and Olfman (2001) derived two constructs to understand the impact of using KMS/KM: individual impact and organizational impact. An individual's use of the KM/KMS will produce an impact on that person's performance in the workplace for his/her roles and practices (Jennex, 2017). Increase in the individuals' performance can be fostered when the KMS/KM has given the user a better understanding of the decision context, the users perform their roles and practices quicker or make better decisions (Jennex & Olfman, 2001, 2006). Organizational impact relates to the performance of the organization as a whole in which each individual impact contributes (Jennex & Olfman, 2006). Accordingly, this study will assess the impact of the KMS on individuals and the organization (i.e., the Ethiopian extension system) in KMS use for knowledge sharing and integration to seek for concepts so as to further develop the process conceptual framework.

Figure 3-1 depicts the process conceptual framework of the study using the theory of situated learning in communities of practice (Lave & Wenger, 1991; Wenger, 1998), a structurational model of technology by Orlikowski (1992, 2000), and the KM/KMS success model (Jennex & Olfman, 2006; Jennex, 2017; Jennex, Smolnik, & Croasdell, 2016) for understanding of the agricultural KMS development and use for knowledge sharing and integration. Wenger's (1998) and Lave and Wengers' (1991) theory of situated learning in communities of practice provides a systematic and sociotechnical-oriented framework that can be used for understanding of the relevant social groups or CoPs, the roles and practices of knowledge brokers, and boundary objects so as to foster knowledge sharing and integration among formal and informal groups having common interest. Following the concepts formation, a structurational model of technology by Orlikowski (1992, 2000) is used to develop and understand the use of the KMS boundary object. Finally, the success of the KMS/KM is assessed using a model of KM/KMS success of Jennex and Olfman (2006) and Jennex (2017).

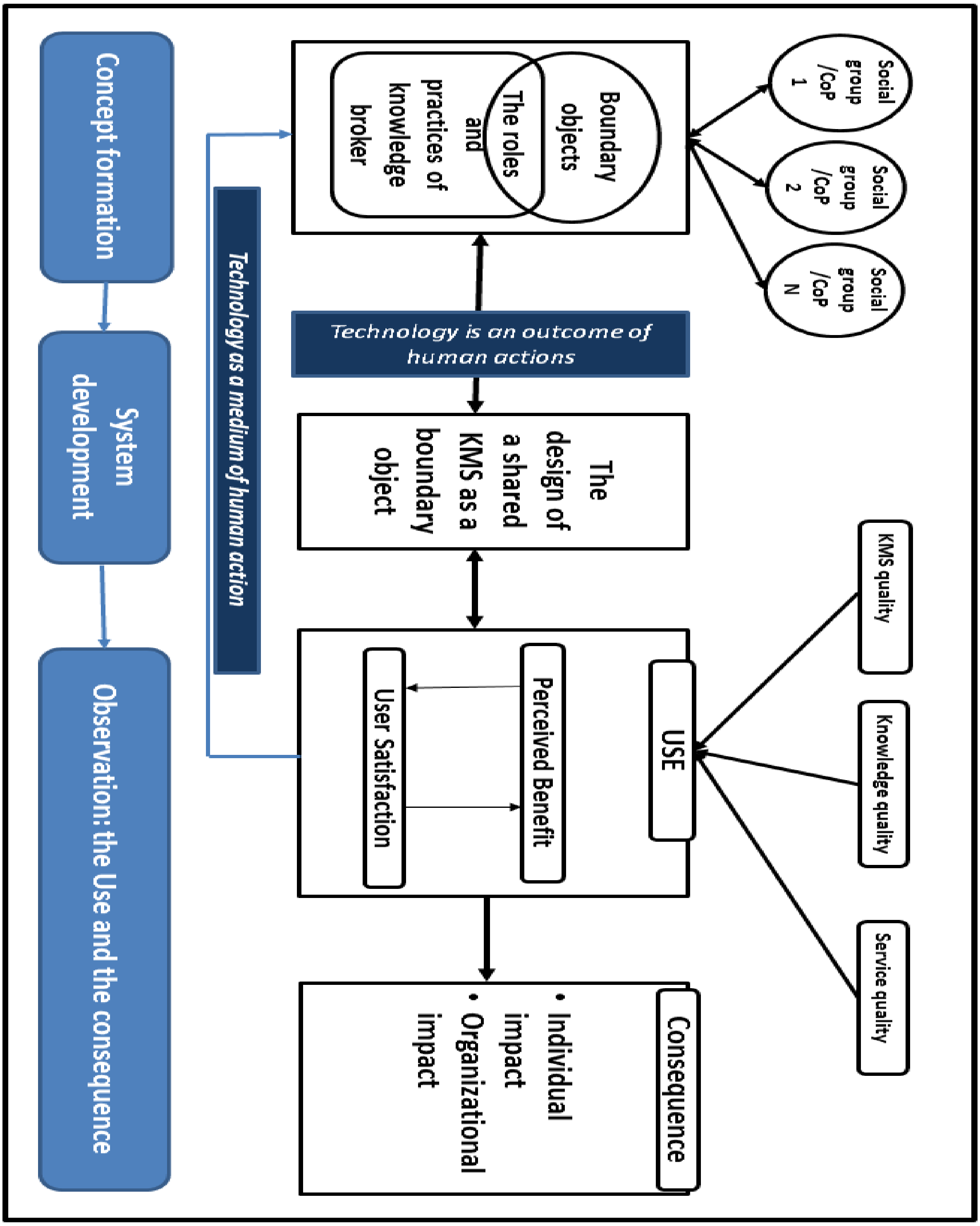

Figure 3-1. An Initial Process Conceptual Framework of the Research

(Adapted from Lave and Wenger (1991), Orlikowski (1992), and Jennex and Olfman (2006))

Finally, concepts anchored from the different theories discussed above are interlinked to construct the initial research conceptual framework for examining the pre-identified constructs and further investigating the emergent concepts that arise from the data. Consequently, the initial conceptual framework contributes to the development of the process conceptual framework in agricultural knowledge management systems for knowledge sharing and integration. Specifically, this initial conceptual framework helps to understand concepts in different stages of agricultural KMS development including the concept formation, system development, and evaluation. Moreover, the study's initial conceptual framework is an important factor leading to a choice of an appropriate research methodology (Rowlands, 2005) to understand knowledge related issues in KMS development and use in agriculture.

3.3 Summary

The initial conceptual framework for the study has been discussed in this chapter, which is derived from the extant literatures. As such, relevant theories for understanding of the knowledge systems integration such as development theories, theory of communities of practice, and a structurational model of technology are presented. The theory of situated learning in communities of practice and a structurational model of technology selected are justified for understanding of the KMS development and use for the knowledge systems sharing and incorporation.

The theory of situated learning in communities of practice provides two important broad concepts: communities of practice, knowledge brokering and boundary objects for understanding of the KMS development and use. The theoretical conceptual framework is not enough to understand the agricultural KMS development. Previous KMS development literature suggested that IT-based approach to KM needs to be complemented by system development. Therefore, system must be developed and evaluated to understand the designing and implementation of the KMS for sharing and integration of knowledge, to measure the critical success factors for the KMS use and to further refine the conceptual framework in social context. For this purpose, the study is interested in the design, use and consequence of a shared KMS. In order to understand the design and the use of the technological artifact as a boundary object for knowledge sharing; the Orlikowski's structuration model of technology has been employed. It provides a structuration perspective and practice lens for the interaction of members coming from different CoPs having common interest with the technological artifact in the development and use of the KMS. Finally, the chapter discussed the Jennex and Olfmans' (2006, 2011) success model of KMS/KM for understanding of the system use and impact through the functional dimensions of system quality, knowledge quality, and service quality.

The next chapter discusses the appropriate research methodology to the development of the conceptual framework for understanding of the agricultural KMS development and use in agriculture.

CHAPTER

4. RESEARCH METHODOLOGY

This chapter covers the study paradigm, design, and methods used in this research to conduct systematic investigation in order to establish concepts and grasp the conclusions.

4.1 Research Paradigm

Social scientists achieve their position by virtue of their knowledge of what the field has to offer in terms of its theoretical ideas based on ontological, methodological, and epistemological assumptions (Henning et al., 2004, p. 12). A paradigm is used to guide the research about the basic belief system or world view (Godfrey-Smith, 2003; Henning et al., 2004). A paradigm is, thus, a comprehensive belief system, world view, or framework that guides research and practice in a field. Various taxonomies are made in literatures to distinguish between paradigms, but they share three fundamental assumptions, namely, ontological, epistemological, and methodological. Ontology is the art of philosophy, which deals with general questions of reality, and the nature and form of reality (Godfrey-Smith, 2003; Guba & Lincoln, 1994). Epistemological assumption refers to the philosophy of knowledge or how we come to know (Henning et al., 2004). According to Godfrey-Smith (2003, p. 5), it is "*concerned with questions about knowledge, evidence, and rationality*". Methodology is the procedures that the researcher uses to know and much more practical in nature that we come to know by inquiring in certain way (Henning et al., 2004). It is concerned with the methods that researcher can use to try and understand the world better (Henning et al., 2004).

Authors suggested different classification of underlying framework for understanding of the philosophies of knowledge or epistemologies. Each of these conceptual paradigms informs a specific methodological framework in a logical and coherent way. For example, Guba and Lincoln (1994) suggested four underlying frameworks for research: positivist, post-positivist, constructivist, and critical. Henning and her colleagus (2004, p. 16) also suggested three research paradigms: positivist, post-positivist, and critical having different philosophies of knowledge. Furthermore, Orlikowski and Baroudi (1991) provided three research frameworks: positivist, interpretive, and critical. According to Myers and Klein (2011), in information systems research, the three research paradigms of Orlikowski and Baroudi (1991) are the most cited and commonly used (Klein & Myers, 1999; Myers, 2009). These are not also too different from Guba and Lincoln's (1994) paradigms. Table 4-1 summarizes the differences between the three paradigms in terms of ontological, epistemological, and methodological assumptions.

The knowledge goal of a positivist framework is to describe, explain, and predict the phenomena of human experience (Henning et al., 2004, p.17). It is promised on existence of a priori fixed relationships within phenomena which are typically investigated with structured instrumentation (Orlikowski & Baroudi, 1991, p. 5). Research followed this kind of philosophy is primarily to test theory through observation and measurement (Orlikowski & Baroudi, 1991). According to the review of Orlikowski and Baroudi (1991), a positivist study paradigm is dominant in IS research that reflects the precepts informing the study of natural phenomena. According to Henning et al. (2004), knowledge in this paradigm is stem from experience and observation. Methodologies in this paradigm include: survey studies, quantifiable measures of variables, hypotheses testing, and the drawing of inferences about a phenomenon from the sample to a stated population, measurement and scaling, and statistical analysis (Guba & Lincoln, 1994; Henning et al., 2004; Orlikowski & Baroudi, 1991). Descriptive researches in this paradigm can also be a case study, with/without simple descriptive statistics (Orlikowski & Baroudi, 1991).

The interpretive paradigm aimed at to capture the lives of participants in order to understand and to interpret the meaning (Henning et al., 2004). In this paradigm, a reality is "*assumed to exist but to imperfectly grasp because of basically flawed humans with their biases or the theoretical standpoints that underpin their work*" (Henning et al., 2004, p. 19). Knowledge in this paradigm is constructed not merely through observable phenomena, but also by description of people's intentions, beliefs, values and reasons, meaning making and self-understanding. The methodology in this paradigm includes: unstructured observation, open interviewing, idiographic descriptions, modified experiment, and qualitative data analysis in this philosophy, which are all ways to capture informant's knowledge and experience (Henning et al., 2004).

Table 4-1. Differences of Positivism, Interpretive, and Critical Assumptions

Assumptions	Positivism	Interpretive	Critical
Ontology	**A single reality:** it is real and apprehensible.	**Multiple realities**: multiple local and socially constructed realities.	Reality is 'real' but only imperfectly and probabilistically apprehensible.
Epistemology	**Objectivist:** findings are true, dispassionate, detached observer of truth.	**Subjectivist:** findings, values and knowledge emerged from the interaction.	***Modified objectivist:*** findings are probably true.
Methodology	**Experiment, Survey, observation:** quantitative, statistical, testing of theory and hypotheses.	**Participation:** qualitative, hermeneutical or dialectical.	Participation, involvement, collaboration, and engagement.

Sources: *Summarized from Guba and Lincoln (1994), Henning et al. (2004), and Orlikowski and Baroudi (1991).*

A critical framework is a process of "*deconstruction*" of the world (Henning et al., 2004, p. 22). It is aimed at *"to critique the status quo, through the exposure of what are believed to be deep-seated, structural contradictions within social systems; and thereby to transform these alienating and restrictive social conditions*" (Orlikowski & Baroudi, 1991, p. 6). Critical research is seen as being one of social critiques, whereby aims to transform these alienating and restrictive social conditions (Klein & Myers, 1999). Knowledge in this paradigm is assumed on "*lived experiences and the social relations that structure experiences"* (Henning et al., 2004, p. 23). The methodology in this paradigm includes: participation, involvement, collaboration, and engagement (Guba & Lincoln, 1994; Henning et al., 2004).

4.1.1 Interpretive Research Approach

This research follows interpretive paradigm based on several reasons discussed as follows. Primarily, this study is for understanding of the KMS development for knowledge sharing and integration through involving participants coming from different CoPs possessing indigenous and scientific knowledge in agricultural KMS design and use. In interpretive studies, the phenomena of knowledge transfer are construed as on that is formed both socially and historically within local social context in contrast to the view of knowledge as an absolute (Pawlowski & Robey, 2004; Puri, 2007). Accordingly, knowledge can be transferred by sharing experience and ongoing interactions across members coming from different CoPs with different perspectives irrespective of its type. Such view of knowledge enables the researcher to understand how to move IK from one CoP to another and integrate with scientific knowledge in agricultural KMS development. The format of IK is highly tacit, subjective, and local to different groups of local communities. Interpretive research assumes that people create and associate their own subjective and intersubjective meanings as they interact with the world around them (Orlikowski & Baroudi, 1991). Consequently, this paradigm can be best fit to this research in question. Puri (2007) in agricultural KMS development, Kanjo (2012) in community based health KMS development research, and Johannessen, Gammon, and Ellingsen (2012) in the design of a system for electronic orders of laboratory analyses and referrals followed qualitative interpretive paradigm.

Secondly, this research is to develop a conceptual framework based on prior literatures and empirical evidence to understand phenomena for knowledge sharing and integration. Thus, despite pre-concepts were identified, the interpretive paradigm yet allows to explore emerging findings and explanations from the data (Klein & Myers, 1999; Walsham, 1995). This paradigm does not assume predefined dependent and independent variables. However, it focuses on exploring phenomena on the complexity of human sense making as the situation emerges within cultural and contextual situations (Henning et al., 2004; Orlikowski & Baroudi, 1991). According to Walsham (1993), theory based interpretive research can be used as part of the iterative process of both data collection and data analysis. Accordingly, the interpretive paradigm is believed suitable for the research undertaking.

Thirdly, the study is carried out to understand the knowledge integration through system development. Interpretive research perspective can help researchers to observe the users and understand human thought and action in social and organizational contexts (Klein & Myers, 1999; Rowlands, 2005). Therefore, it has the potential to produce deep insights into KMS development phenomena. Interpretive approach in IS development like KMS can enable the researcher to understand the context and the process, thereby, IS influences and is influenced by the context (Walsham, 1993). Therefore, interpretive paradigm in this research is expected to provide subjective understandings of the conditions, practices, processes, and consequences of social action as expressed by participants in their particular social context in the development and use of KMS.

Additionally, seven principles of interpretive research suggested by Klein and Myers (1999, p. 72) clarify the appropriateness of this approach in analyzing the conceptual framework investigation in KMS development and use. Klein and Myers (1999) proposed a set of principles for conducting and evaluating or justifying of interpretive field research of a hermeneutic nature: the fundamental principle of the hermeneutic circle; principle of contextualization; principle of interaction between the researchers and the subjects; principle of abstraction and generalization; principle of dialogical reasoning; principle of multiple interpretations; and principle of suspicion. At the end, a conceptual framework development is evaluated through employing the principle of Klein and Myers (1999) (see also section 7.4.2). The evaluation and justification of the process conceptual framework by the seven principles of interpretive research is further considered as the suitability of the interpretive paradigm for understanding of the KMS development for knowledge sharing and integration.

4.2 Research Approach

This research applied systems development action research approach (Burstein & Gregor, 1999; Nunamaker et al., 1991). As stated by Burstein and Gregor (1999, p. 123), when a method or system in system development (SD) work is developed and evaluated by the researcher in close collaboration with practitioners in a social context then such work can be regarded as a form of action research. In this kind of research in which action research is used in a SD methodology, the researcher interventions generally comprised of defining user requirements and designing the new system with the collaboration of relevant participants as the intended users. One of the most comprehensive definitions of action research is provided by Hult and Lennung (1978, cited in Lau (1997)). They put it that:

> *Action research simultaneously assists in practical problem-solving and expands scientific knowledge, as well as enhances the competencies of the respective actors, being performed collaboratively in an immediate situation using data feedback in a cyclical process aiming at an increased understanding of a given social situation, primarily applicable for the understanding of change processes in social systems and undertaken within a mutually acceptable ethical framework.*

As such, the most unique aspect of action research as a strategy of inquiry is in its iterative process consists of problem diagnosis, action intervention, planning and taking, evaluation, and change implementation influenced by the researcher and participants (Baskerville, 1997). This research is conducted to readdress the problem of users through integrating knowledge in KMS design and use. Interpretive researcher, thus, attempts to understand phenomena through accessing the meanings by participating owners of the problem and scrutinized and/or endorsed by others that participants assign to them (Henning et al., 2004; Orlikowski & Baroudi, 1991) throughout KMS development process and use iteratively. The review of Lau (1997) on the use of action research in IS research over a twenty-five years period indicated that several researches in action research followed interpretive paradigm. For example, Byrne and Sahay (2007) followed action research in interpretive assumption for IS development in developing countries context.

The theory of situated learning in CoPs, from which the study conceptual framework concepts are drawn, provides a social container for understanding of the knowledge systems integration and the associated social groups. Nevertheless, understanding of the concepts merely are not enough in KMS development research, but system must also be developed to test and measure the underlying concepts, thereby, to guarantee its sustainability (Nunamaker et al., 1991). System development is an important practice and research area in understanding of the development of the technological artifact through bridging the gap between the technological and the social sides of it. In keeping this, a structuration model of technology is used as a structuration perspective and practice framework to probe system development process and the consequence of the IS use together as suggested by Orlikowski and Robey (1991). According to Nunamaker et al. (1991, p. 92) and Burstein and Gregor (1999), the crucial role of SD is the result of the fact that the developed system can serves both as a proof-of-concept for the fundamental research and provides technological artifact that becomes the focus of expanded and continuing research.

This research employed the multi-methodological approach to IS research proposed by Nunamaker et al. (1991) and then further developed by Burstein and Gregor (1999) in action research perspective. The approach consists of four strategies: theory building, experimentation, prototyping, and observation as depicted in Figure 4-1. Nunamaker et al. (1991) and Burstein and Gregor (1999) indicated that to gain a complete understanding of a complex research area such as DSS and KMS development (e.g., Jennex, 2014), a multi-methodological approach to research is the most effective strategy.

The extended methodological framework of Burstein and Gregor (1999) draws the places of ISD phases into multi-methodological approach of Nunamaker et al. (1991) based on Avison and Fitzgeralds' (1995) IS definition (Figure 4-2). They defined it as the effective design, delivery, use, and consequence of IT-based system in organizations and social system (Avison & Fitzgerald, 1995, p. xi). Accordingly, the areas of IS research concerns (see Figure

4-2) can be mapped onto the multi-methodological framework depicted in Figure 4-1. This mapping can be viewed as a guide to a variety of methods that can be used when approaching a study of one or more phenomena of IS research, which is followed in this research.

As stated by Nunamaker et al. (1991, p. 94), theory building includes development of new ideas and concepts, and construction of conceptual frameworks, new methods, or models, which may be used to suggest research hypothesis, guide the design of experiments, and conduct systematic observations. In this regard, the initial conceptual framework is coined from extant literatures to understand concepts for the general requirement of the SD. The first iteration of this task is done before which is linked to the first phase of phenomena of interest in SD (i.e. design and development of underlying models, tools, languages, and system components) shown in Figure 4-2 (Area I) (Burstein & Gregor, 1999).

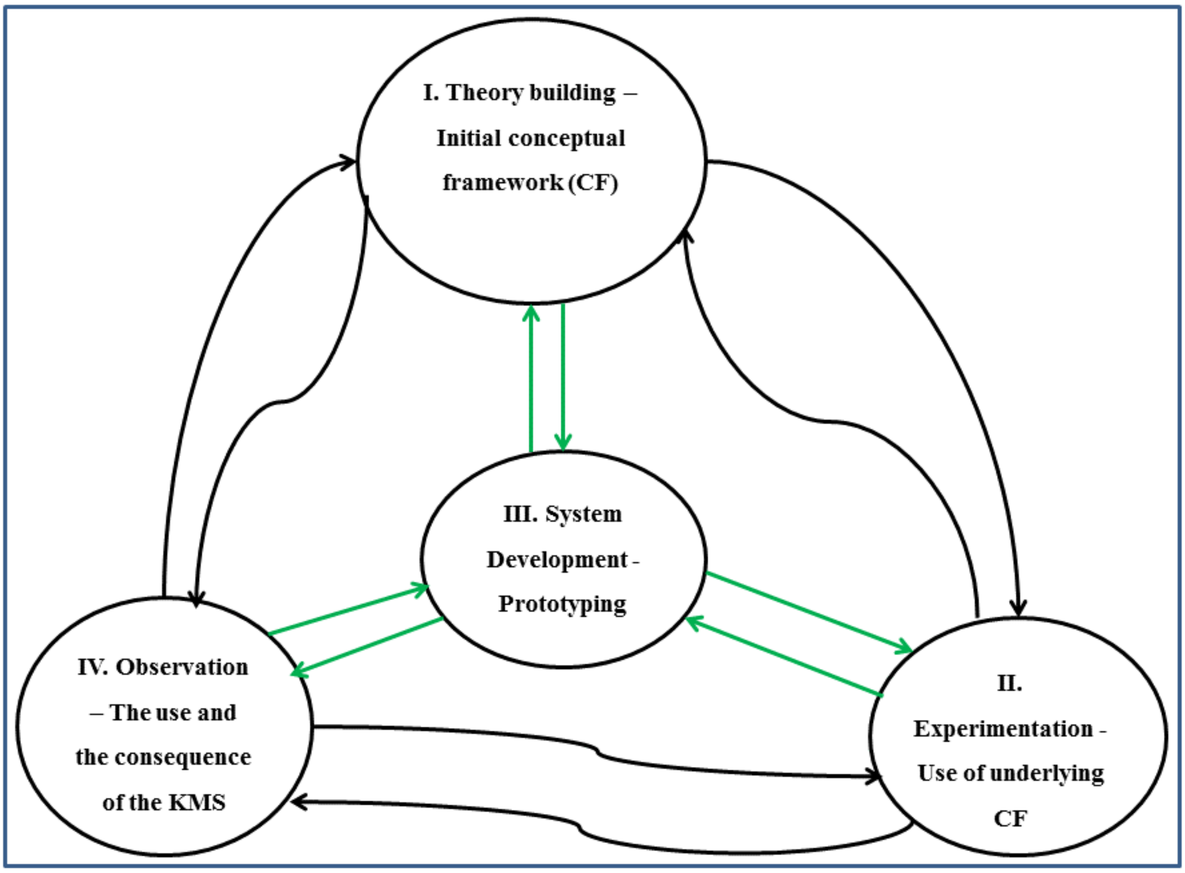

Figure 4-1. A Multi-Methodological Approach to Information Systems Research

(Adapted from Burstein and Gregor (1999) and Nunamaker et al. (1991))

Following step is experimentation, which includes research strategies such as laboratory and field experimentations, as well as computer and experimental simulations (Nunamaker et al., 1991). This step is guided by the initial conceptual framework and facilitated by SD (Area II) in Figure 4-2. In this research, the initial conceptual framework coined from extant literatures is further investigated empirically in order to understand concepts for the general requirement of the KMS development. Results from experimentation are used to refine conceptual framework and improve the existing system (Nunamaker et al., 1991). Moreover, the proposed experimented conceptual framework leads to the development of a system with the intention of illustrating the conceptual framework (Burstein & Gregor, 1999). Then, the technological artifact was designed relying on the concepts from the conceptual framework, which can serve as boundary object mediating collaboration across different CoPs (Area III).

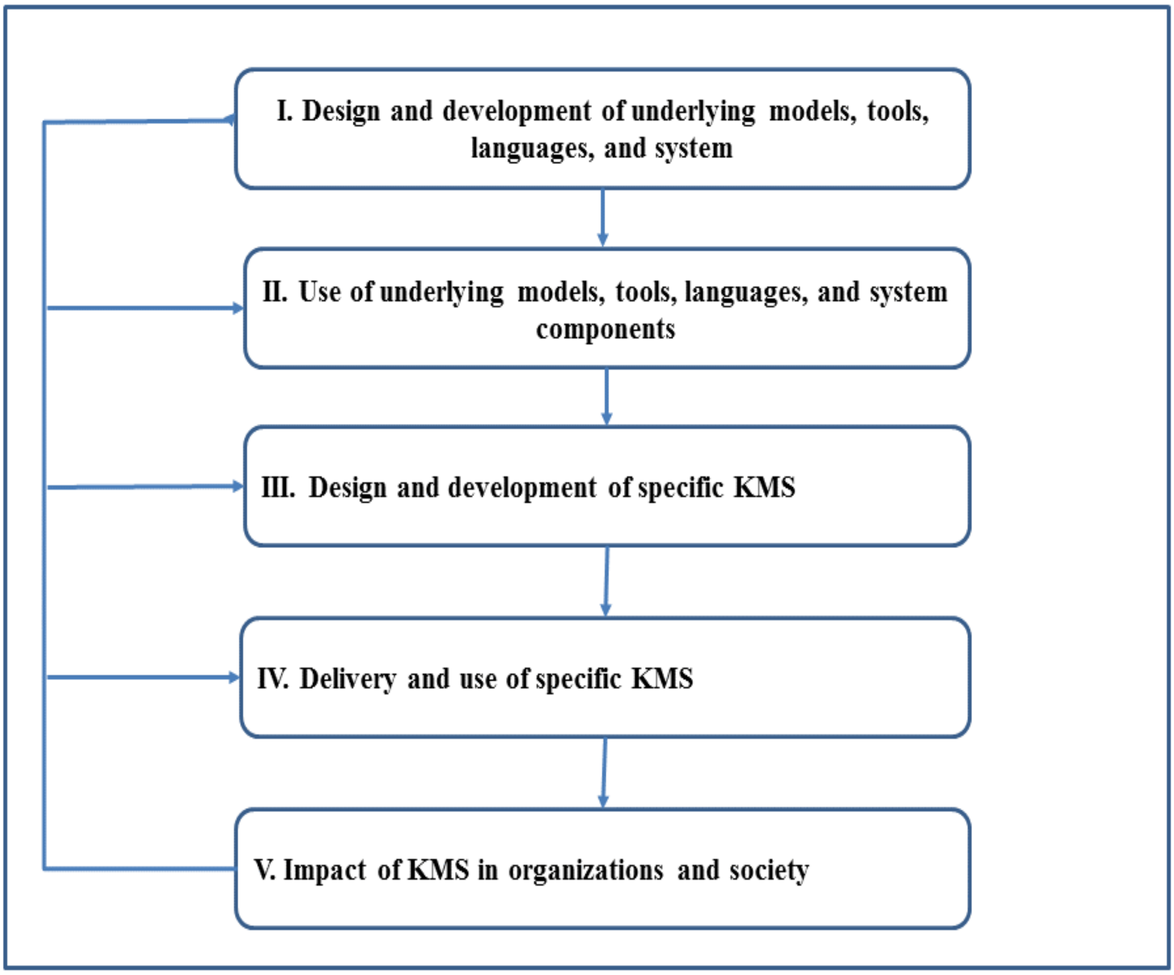

Figure 4-2. Phenomena of Interest in Information System Research

(Adapted from Burstein and Gregor (1999))

Thereafter, Nunamaker et al. (1991) indicated that observation is conducted which includes research methodologies such as case study, field studies, and sample survey that are unobtrusive research operation. In order to make the KMS relevant for the problem domain, the system should be observed as being useful, development should represent the views of decision makers within the social and organizational context (Miah et al., 2012). Accordingly, a prototype developed in this study was observed by using case study through examining the project of KMS development of ATA in Ethiopia as a case to investigate the use and consequences of KMS in the social systems (Areas IV and V of Figure 4-2). As a result of the feedback, a process conceptual framework proposed was further strengthening.

4.3 Research Method: The Case Study Research Design

According to the review of Lau (1997) on the use of action research in IS, the case study is the preferred method of presentation. Most of the interpretive researches reviewed in the work of Lau (1997) and Brocki and Wearden (2014) were employed single case analysis through concentrating on relevant individuals and contexts, for example Pawlowski and Robey (2004), Puri (2007), and Johannessen et al. (2012). In this investigation, agricultural KMSs development are found to be an adequate setting since such systems are developed to support local smallholder farmers who possess IK and agricultural domain experts who process scientific knowledge. The main agricultural KMS in Ethiopia is KMS of Agricultural Transformation Agency (ATA), which provides theoretically relevant organizational context for studying knowledge sharing and integration. This organization was selected due to the presence of multiple project groups of participants who possess their own knowledge and its decentralized structure established to create a network effect among stakeholders. There are participants from different communities with differing expertise and domain-specific knowledge: local farmers, domain experts, extension agents, and system developers and important subjects considered in this study. The case study is subject to multiple interpretations by many users from different CoPs (Sahay & Robey, 1996), in turn important to understand the details of the KMS development and use for knowledge sharing.

4.3.1 Historical Roots of the Initiative under Study

Despite the agricultural sector significance in its economy, Ethiopia has experienced food security problems over the ages. In response to this, the government has implemented various strategies to transform the sector, among others, taking different policy measures, development interventions, agricultural projects, and extension approaches (Nigussie, 2013). The agricultural extension and advisory services play a significant role in agricultural development and can contribute for improving the livelihood of farmers (Davis et al., 2010; Nigussie, 2013). Agricultural extension service was first introduced in a country in 1953 by Haramaya University (Nigussie, 2013). In the 1960s, extension services were provided to a larger number of small-scale farmers under the Comprehensive Integrated Package Projects (CIPP). The extension system later changed into a Training and Visit (T and V) style system in the 1980s that was supported by the international donor organizations at the time. In the T and V model, specialists provide relevant technical information and knowledge and village visits to the selected communities (Aker, 2011). By 1995, the government introduced the Participatory Demonstration and Training Extension System (PADETES) worked with this T and V approach to specifically promote improved seed and chemical fertilizer succeeded in convincing the government to expand its coverage under the National Agricultural Extension Intervention Program (NAEIP) (Davis et al., 2010; Nigussie, 2013). However, there have been great strides in agriculture, productivity yet remains low in a country (Davis et al., 2010; Environmental Protection Authority, 2012).

The agricultural sector and other complementary institutions that support it such as extensions are keys to poverty reduction in Ethiopia (Davis et al., 2010). In 1992, the government of Ethiopia instituted a policy of Agricultural Development Led Industrialization Strategy (ADLI). The ADLI provided a long-term development framework for economic transformation since 1992 (Environmental Protection Authority, 2012). In 2005/2006, the government of Ethiopia has developed a five-year (2005/06-2009/10) Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) under the umbrella of ADLI to accelerate the transformation of agriculture from subsistence to a more market-oriented sector (Davis et al., 2010; Environmental Protection Authority, 2012). The Ministry of Agriculture and Rural Development (MoARD) has produced a document outlining rural development policies, strategies, and instruments to the plan into effect (MoARD, 2001). The MoARD has also aligned with donor support with plans to scale activities in the sector and to meet the resource gaps identified and to contribute for sustainable economic development in a country as a whole (Davis et al., 2010). Accordingly, a core part of the government's investment in agriculture is the public agricultural extension system.

The government invested in agricultural technical and vocational education and training colleges to train extension agents in agricultural sciences charged with carrying out agricultural extension activities with farm households (UNDP, 2012). As a result, the program had trained 62,764 extension agents at the diploma level by the end of 2008 (Davis et al., 2010). This rapid expansion has been followed by the construction of Farmer Training Centers (FTCs) in each rural district or *kebele* (the lowest administrative division level in Ethiopia). Since 2002, more than 8,489 FTCs have been built at *kebele* level (Davis et al., 2010). FTCs are staffed by extension agents to provide demand-responsive extension and short-term training services in rural areas (Davis et al., 2010; Nigussie, 2013). Most of the FTCs have at least three extension agents with a range of technical skills to facilitate agricultural knowledge transfer from researchers to farmers (UNDP, 2012). The Ethiopian Institute of Agricultural Research (EIAR) and Regional Agricultural Research centers (RARCs) in a country are delivering agricultural research findings to farmers (UNDP, 2012). However, the linkage among relevant stakeholders (i.e., research centers, universities, and agricultural extension systems) is yet weak and need to be improved in order to use them as a vehicle for creating, exchanging, and updating agricultural knowledge, technology, and practices of smallholder farmers (Aker, 2011; Davis et al., 2010; Nigussie, 2013).

In spite of the significant role that FTCs and extension agents can play in knowledge exchange, the program is still not successful due to various issues. Some of the major problems are inadequate infrastructure and localized technical information, lack of finance and other input to run FTCs, agriculture office enforcement of extension agents to serve as a general practitioners, most FTCs have no access to electricity and do not have electronic equipment such as telephone, post office, TVs, and computers and weak link among stakeholders (Davis et al., 2010; Nigussie, 2013; UNDP, 2012). Besides to these, only few FTCs have advanced teaching equipment such as computers and access to the Internet. In these FTCs, there is also a need to provide soft-skill trainings to extension agents to upgrade their skills particularly in the areas of ICTs to optimally utilize them in their daily agricultural extension work with smallholder farmers (Davis et al., 2010; Nigussie, 2013).

The rapid spread of ICTs in Ethiopia and other developing countries offers a unique opportunity to transfer agricultural knowledge and technology through private and public ISs (Aker, 2011). In this regard, there are complementary organizations and projects that work closely with the public agricultural extension system to enhance knowledge exchange. For example, the International Livestock Research Institute (ILRI) had a countrywide project called Improving Productivity and Market Success (IPMS) (Jama et al., 2004). The goal of IPMS was to increase the uptake and impact of technologies for smallholder farmers and pastoralists in Ethiopia to accelerate market-oriented agricultural development through the modern types of ICT-based KMS (Environmental Protection Authority, 2012; Jama et al., 2004). IPMS project had been running KMS to support smallholder farmers in a country via Internet based web portal to avail easier access to agricultural knowledge countrywide (Jama et al., 2004). However, the KMS of IPMS project was ended in April 2013 with limited impact on knowledge and wellbeing of poor small-scale farmers (International Livestock Research Institute, 2013). Another complementary program to the public extension system is the Ethiopian Commodity Exchange (ECX) (ECX, 2008). The ECX is designed particularly to tackle problems that had been identified as the major deficiencies to a fair and efficient agricultural market system in a country such as the lack of transparency, competition, market information, bargaining power of small-scale producers, poor quality standards, and inadequate volumes of production (ECX, 2008; UNDP, 2012). The ECX is now running mobile-based website, SMS, and Integrated Voice Recording (IVR) to provide relevant agricultural market information for smallholder farmers.

The ATA is another initiative of the Federal Government of Ethiopia that works closely with the public extension system in various agendas in agriculture. It was established in 2011 to transform the agriculture sector and realize the interconnection goals of food security, poverty reduction, and human and economic development (ATA, 2014) in-line with the country Growth and Transformation Program (GTP). During 2010/11-2014/15 period also called GTP I, ATA has contributed for the growth in production of traditional crops by promoting the adoption of improved technologies by smallholder farmers, and by increasing investment in rural infrastructure, particularly for irrigation and improved watershed management (ATA, 2015).

During the current five-year plan (2015/16-2019/20) also called GTP II, ATA continues to focus on accelerating growth in production of traditional crops complemented by the establishment of a market system that benefits farmers and non-farm rural actors and natural resources development (ATA, 2015). However, it has been still a number of challenges to provide up-to-date knowledge timely to local communities efficiently from research (ATA, 2014). In response to these issues, ATA has been developing various IT systems in collaboration with numerous private, public, and governmental organizations. For example, the ATA and the MoARD in partnership with the Africa Soil Information Service (AfSIS) were first developed the Ethiopian Soil Information System (EthioSIS) (ATA, 2012). The system aims to address key soil fertility bottlenecks and transform the agriculture sector by incorporating soil health (ATA, 2012). In addition, the ATA, National Meteorological Agency (NMA), and MoARD have undertaken efforts to provide local, user-tailored forecasts to 28 woredas using IT-systems and expanding the initiative to other woredas in a country. With the growth of mobile phone coverage in a country, these initiatives have moved away from traditional ICTs (Radio and TV) to mobile telephony including voice, SMS, and Internet-based services. Accordingly, the ATA and the MoARD are now running an IVR, SMS, and 8028 agricultural hotline based system for leveraging mobile technologies to disseminate relevant agricultural information and knowledge to smallholder farmers (ATA, 2012, 2014).

To sum up, as a result of the aforementioned efforts, much improvement has been registered in the livelihoods of smallholder farmers by increasing their productivity and production levels in Ethiopia over the past decades (ATA, 2014; Nigussie, 2013; UNDP, 2012). In spite of these achievements, there is still more work to be done particularly in the areas of agricultural KMS development. For instance, the IK is a critical component of an innovation system, but not appreciated enough. It is disappearing, in part due to the focus on the promotion of scientific packages, which tend to be preferred by extension and research at the expense of IK (Davis et al., 2010; Warner et al., 2015). Therefore, there is a need to fit extension approaches to various agro-ecological zones through integrating scientific and IK and provide up-to-date knowledge to local farmers timely. In building this research, to understand the integration of IK and scientific knowledge in agricultural KMS development, the EthioSIS developed for soil fertility management is considered as a case study.

4.3.2 The Research Site

In order to enhance crop production and productivity, healthy and fertile soils have become a major issue in Ethiopia. However, land degradation in the form of soil erosion and severe run-off, nutrient depletion, soil compaction, and increased salinization and acidity create a serious threat to sustainable intensification and diversification of agricultural production systems the country (ATA, 2015). The agriculture sector has been adversely affected by the degradation of soil fertility and health partly because of improper soil management and conservation techniques compounded by a lack of up-to-date and comprehensive information on the country's soil conditions. Chemical fertilizers are applied to increase the fertility of the soil and used throughout the country independent of the soil type and without identifying the deficiency of the soil (ATA, 2015). Furthermore, the lack of detailed and localized soil fertility information was hindering the ability of extension agents to guide smallholder farmers in making the most effective recommendations for soil nutrient applications.

As such, a detailed woreda-level soil fertility status atlas tailored to fertilizer recommendations specific to soil fertility conditions is highly required. In addition, examination of land features such as vegetation, climate factors, and erosion risk, and physical and chemical properties of soil is vital for acquiring knowledge on soil health and fertility. As a result, the EthioSIS project was launched in 2012 for digital soil fertility mapping to support the smallholder farmers and other relevant stakeholders. The system is developed to sample the fertility status of agricultural soils across the country and to analyze the specific nutrient needs of soils in all rural locations throughout the country, thereby, providing access to an expanded range of blended soil nutrients (ATA, 2014, 2015). The system has the potential to change fertilizer use around the country in which the development of the EthioSIS was initiated by means of a business plan.

Ethiopia is a country in which politically divided into 14 Regional States (Ayitenew, 2014). The different projects of ATA are functioning in the selected regions of the country (i.e., Amhara, Oromia, Harari, SNNP, and Tigray) (ATA, 2012, 2014). The ATA selection of these regions is based on their contribution to national production in the prioritized commodities and a prioritization of the regions in which the multi-donor supported Agricultural Growth Program (AGP) was active (ATA, 2015). The densely settled areas of Northern Ethiopia (i.e., Amhara and Tigray) are among those with the highest rate of soil loss since the environment is highly degraded as compared to the Southern part of the country which includes Oromia and SNNP regions (Mulat, 2013).

The Amhara Regional State is located in northwestern of Ethiopia. The region has an estimated land area of about 170,000 square kilometers. The region borders with Tigray in the North, Afar in the East, Oromia in the South, Benishangul-Gumiz in the Southwest and the country of Sudan to the West. The Amhara national regional state is the second densely populated regions and has a population of above 24 million (Ayitenew, 2014). The high plateaus of the region have been adversely affected by the rapid growing of population over the years. Increase in population and inappropriate existence of farming practices contribute to problem of natural resource depletion, among others, land degradation, soil impoverishment and erosion, proliferating deforestation, overgrazing of common lands, ocean acidification, and misuse of agrochemicals (Gessesse, Klik, & Hurni, 2009). The region is divided into 11 Zones, 140 woredas, and close to 3429 kebeles.

North Gondar is one of the eleven Zones in Amhara Regional State, which is located in the North Western part of the country. The study was conducted in two districts (i.e., Ambachira and Debresalam) of Gondar Zuria woreda (see also Figure 4-3) of North Gondar Zone as case study areas, where ATA's EthioSIS and mobile-based 8028 hotline is functioning. Districts are selected in consultation with district, Zonal, and Regional Agricultural and Rural Development offices. The case study areas experienced high natural environmental degradation over the ages. However, communities in the areas are rich in IK (Gessesse et al., 2009). This interpretive research in these case areas concentrates on individuals roles pertinent to indigenous knowledge, practices, and contexts, and to make greater endeavors in involving the voice of end-users in particular local farmers in KMS development and use rather than broad generalizations of human behavior (Brocki & Wearden, 2014).

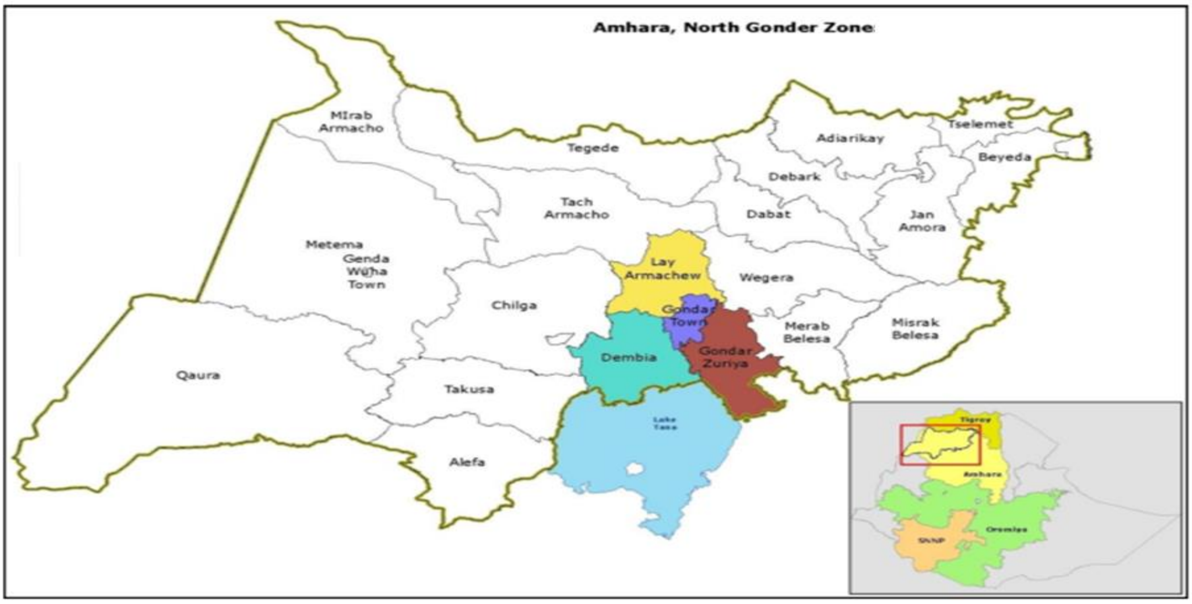

Figure 4-3. Map of the Study Area: Districts in North Gondar

4.4 Subjects of the Study

The study unit of analysis consists of the roles and practices of relevant social groups in particular the roles and practices of extension agents as knowledge brokers and boundary objects possessed by those social groups. Additionally, the research analyses the design, the use, and the consequences of the KMS boundary object.

Local farmers, domain experts, system developers, and extension agents are occupation groups in agricultural KMS development (i.e., the EthioSIS). Hence, they are important subjects for this study context. Local farmers are the source of IK about agriculture such as soil fertility management and conservation, natural resource management (NRM), who have been practiced and observed such phenomenon for long period of time. The domain experts (subject matter specialists) are knowledge workers or researchers of NRM, soil fertility management and other agricultural scientific practices, who are the source of scientific knowledge from universities, agricultural research institutes, and Regional and Zonal agriculture bureaus. Extension agents are experts in agricultural science, who are responsible for the facilitation of agricultural knowledge and technology transfer from researchers to farmers. These groups of workers are located in Zonal, woreda or district level agricultural offices. System developers are experts of IS development and management, who develop, operate, manage, and maintain agricultural KMS for knowledge sharing. These groups of informants are located at ATA and other partner organizations such as MoARD. This multiplicity of participants is important to find all-inclusive appreciation of the totality of their experiences. It also assists to create a broad and comprehensive variety of opinions, views, and issues in agricultural KMS development.

4.5 Data Collection Techniques

One of the characteristics of qualitative research is the use of multiple data sources such as observations, interviews, and review of documents (Creswell, 2009). In this investigation, primary as well as secondary data sources are obtained from relevant sources. Secondary data were obtained from published and unpublished materials that are relevant to the study. Documentary materials like magazine articles, official reports, procedures, presentation materials, guidelines, and official website are culled from the MoARD, agricultural research institutes, and the ATA. Secondary sources are vital to get insight for the case area, the country's agricultural policy, soil fertility management and conservation, and other issues germane to agriculture development and KMS development procedures. Additionally, literature survey was conducted to identify the existing key characteristics and conceptual models of KMS development for knowledge sharing and integration. For this purpose, both academic and general search engines were used. In addition, primary data gathering techniques: in-depth semi-structured interviews and participant observations were employed.

4.5.1 In-depth Semi-Structured Interviews

Interview is an important data collection tool to gather rich data from relevant subjects in various situations (Myers, 2009) aimed at finding what participants think, know, and feel (Henning et al., 2004). Problems concerning agricultural KMS development, use and users' coping mechanisms can be best understood by the interaction between the researcher and other diversified group of participants. According to Myers (2009), there are three type of interview techniques, namely structured, unstructured, and semi-structured. In structured interviews, all questions are prepared in advance and informants have limited choices in answering. Whereas in unstructured interviews, few set of predefined questions are developed and more open-ended questions that intend to explore informants' opinions in depth (Myers, 2009). Semi-structured interviews reside between the structured and unstructured type of interviews. In semi-structured interviews, despite predefined questions prepared a prior; the answers to the questions are not limited and other questions can be also asked during the interviews (Myers, 2009). A key feature of it is in the partial pre-planning of the interview questions. Individual in-depth semi-structured interviews were carried out in this research. A review of Brocki and Wearden (2014) indicated that semi-structured interview is commonly used for data gathering technique in an interpretive research.

In designing the interview questions, the researcher is guided by the research objectives and the initial conceptual framework (Brocki & Wearden, 2014). The interview questions consisted of eight parts as shown in Table 4-2. The first sets of questions established the research participant's perspectives on relevant knowledge systems in agriculture. The following categories of questions examine agricultural knowledge sharing and integration practices and challenges. The third and the fourth sets of questions consist of questions for understanding of the knowledge systems integration: the roles of knowledge brokering and the skill and knowledge required for knowledge brokering. Then, the next sets of questions provide identification of boundary objects for knowledge sharing and integration by relevant social groups. Interviews on these sets of questions were carried out in phase I. An interview in phase I took an average of 45-50 minutes.

In phase II, interviews were made on the last three sets of questions. The last three sets of questions comprised of questions related to agricultural KMS development process, the use and the consequence of a shared KMS boundary object. Additionally, one open-ended question was included at the end of the interviews to allow the research informants to add comments that they might consider pertinent to the study both in phase I and II. An interview in phase II took an average of 20-30 minutes. All interview questions both in phase I and II were open-ended. Table 4-2 summarized the categories of questions, objectives, and sample questions and relying on the table, separate checklists were developed for interviews with different subjects based on their roles in agricultural KMS development and use.

These interviews involved the four occupation groups: local rural farmers, extension agents, agricultural researchers, and system developers. The four groups of informants were expected to answer questions pertinent to their roles. Interview guide for farmers (refer Appendix I.A) has been prepared to examine the knowledge they use for soil fertility management and conservation and their feeling in agricultural KMS development and use. Interview guide for extension agents (refer Appendix I.B) has prepared to understand IK and scientific knowledge sharing, the roles and practices of extension agents as knowledge brokers, and the design, the significance, and the consequence of KMS for their roles and practices. Interview guide for agricultural researchers (refer Appendix I.C) was prepared to understand the role of IK and scientific knowledge and their integration in agricultural KMS development and the use and the consequence of KMS for knowledge sharing and integration. The last interview guide for agricultural KMS developers (refer Appendix I.D) has been developed to gather data concerning how they treat IK and scientific knowledge in the development of KMS, architecture of KMS, and procedures followed to KMS development.

Table 4-2 Interview Objective and Sample Questions

	Question Categories	Objectives	Example Questions *[Not all participants might be able to answer these questions]*
1	Knowledge types	• Establish types and characteristics knowledge	What knowledge sources do you use for task accomplishment?
2	Knowledge management issues	• Examine agricultural knowledge sharing • explore the challenges of knowledge integration	How do you share knowledge among members of your communities and other communities about the agricultural practices?
3	The roles and practices of knowledge brokering	• Identify of the role of extension agent as knowledge broker	In your current position, do you find yourself providing connections between members coming from different CoPs for knowledge sharing and integration?
4	Skills and knowledge required for knowledge brokering	• Determine the skills and knowledge required by extension agents for their brokering practice and role	Do feel that you have adequate skill for your role of brokering? What are the skills and competencies that might enable you to transfer knowledge and introduce technology?
5	Boundary objects	• Identify boundary objects employed by different CoPs	What are the boundary objects such as documents, procedures or processes which help you to transfer knowledge to farmers from research and among yourself?
6	KMS development	• Propose new architecture • Design KMS as a boundary object	How do KM activities characteristics contribute to the architecture of KMS? What are specific procedures you adhere to KMS development?
7	The use of KMS	• Point-out the significance of the KMS	Does the KMS support you to carry out your practices?
8	The KMS impact	• Point-out the consequence of the KMS	What do you feel about the impact of using the KMS?

Source: *Author own compilation based on the initial conceptual framework, Figure 3-1.*

4.5.2 Participant Observations

Observation is another data collection method used to gather data which may be difficult to gather through interviews (Cassell & Symon, 2004). Data collected through observation can also be used to cross-check and complement the data collected through interviews. Observation in research can be either direct or participant (Guest, Namey, & Mitchell, 2013). Direct observation refers to a quantitative technique in which the data collector is interested in observable behavior and ordinal data about how often, how many, how intensely, who was there, and others (Guest et al., 2013). It is, hence, normally a structured or standardized form of data collection. Data collected by it are often observed and do not essentially require any form of interaction between researcher and the research subject. However, participant observation is a qualitative method that requires interaction with human. It is relatively unstructured, which is interested with why and how questions in a particular context (Guest et al., 2013). Data collected through participant observation are usually free flowing and the analysis is much interpretive (Cassell & Symon, 2004; Guest et al., 2013). Hence, participant observation is appropriate qualitative data collection method in this research.

Participant observation involves the researcher social interaction with respondents to examine first-hand day-to-day experience and behavior of informants in particular situation and to understand their feelings and interpretations (Cassell & Symon, 2004). Accordingly, the researcher looks deep into the KM situation in the local rural communities and SD at ATA by participant observations. Through on-site participant observations, first-hand information about IK of agricultural practices and traditions and KMS development practice at ATA can be best undertaken in a natural setting. Therefore, participant observations were used to collect data about practices of the local farmers such as the way farmers manage and use IK, the role of ICTs in IK management, and the procedures how extension agents, domain experts, and system developers communicate and interact each other and with local farmers. In addition, the researcher is also needed to gather very rich, detailed organizational information at ATA such as how KMSs are developed and in the selected districts where KMS of ATA is functioning to understand the KMS usage. Appendix III provides field observation checklists. During the visits, notes were taken through informal conversations with relevant actors. Pictures and movies were also taken when permissions obtained.

4.5.3 Review of Documents

Organizational documents provide a ready to use information for understanding of the case under investigation. According to Yin (2003), such documents can provide additional information over interviews about historical records and events and also be used to triangulate data collected through interviews and observations. Table 4-3 shows sample documents referred from relevant organizations MoARD and ATA. These documents include official reports, training manuals, presentation materials, maps, magazines, project reports, and websites.

Table 4-3 List of Sample Organizational Documents Reviewed

No.	Subject	Organization	Type	Reference
1	Transforming agriculture in Ethiopia	ATA	Annual report	(ATA, 2012)
2	Transforming agriculture in Ethiopia	ATA	Annual report	(ATA, 2014)
3	Agricultural transformation agenda	ATA	Annual report	(ATA, 2015)
4	Community-based participatory watershed development: Part I and II	MoARD	A guideline	(Desta, Carucci, Wendem-Ageňehu, & Abebe, 2005a, 2005b)

Source: *Author own compilation*

4.5.4 Participant Selection

In building this qualitative research, the sampling plan was flexible and evolved with the research needs. Primarily, the case study areas are purposively selected as mentioned in the above sections based on administrative structure of agricultural extension services in a country where ATA's EthioSIS is operating. Two district case areas were selected based on the discussions held with domain experts at regional and zonal levels. Potential research participants were selected based on their area of expertise and the knowledge work that they are performing relevant to this research context.

One group of the subjects is local farmers from the selected districts. These subjects are believed to possess rich IK of agriculture because of their close attachment to such traditional technology on one hand, and on the other, they are among the social groups who directly or indirectly benefit from the current ATA's KMS. The selection of this group of respondents was mainly made using snowball sampling. In this sampling technique, a researcher identifies a small number of informants who identify others who qualify for inclusion and these, in turn identify others until enough data were obtained. In our case, the first small number of informants was selected from the two district case areas based on their experience in agricultural practice, which were carried out in consultation with the agricultural experts and extension agents. Then after, other informants were selected by referral from those interviewed earlier. Additionally, discussions with these people provided a deeper understanding of their informal social networks. Jote (2012) indicated that this technique is found to be effective as farmers are not readily available because of the nature of their scattered work place and lifestyle.

Another group of the research subjects is extension agents who assist local farmers and located in regional and zonal agricultural offices, and all rural woredas of the country. Informants from this group have been selected based on their familiarity about knowledge and experience in knowledge brokering between local farmers with technologist and domain experts. Similarly, informants from domain experts in agriculture were also purposefully selected based on their familiarity in knowledge and experience in agricultural research and practice. This group is located in ATA headquarter, national, regional and zonal level agricultural research centers in a country. The last group of the research subjects is system developers. Again respondents from this group were also purposefully selected based on their familiarity and experience in development and support operation of agricultural KMS.

Table 4-4 shown below presented the summary of the respondents' background information and their organizations. Additionally, details of respondents' profile are also presented in Appendix IV. An interpretive research review of Brocki and Wearden (2014) revealed that sample size of an interpretive research depends on a number of factors, for example, the roles of participants as discussed above, in turn there is no right sample size in such type of research. In general, interpretive research concentrates on specific cases and individuals and small sample sizes are the norm (Brocki & Wearden, 2014). In total, 54 informants were participated in the two phases of the research process. Even though the size of the sample is not that big, it is the depth that matters because a researcher was keep asking until no new data were emerged. Interviews were first carried out by researcher at ATA headquarters. Entry was negotiated with the human resource manager, who authorizes interviews to begin at the highest level and to proceed down the chain of command. Interviews were conducted iteratively with individuals from all subjects until there is nothing new; that is when the incremental insights provided by additional interviewing are judged to be insignificant.

Of the total 54 informants, 43 of them, one human resource manager and 10, 8, 12, and 12 were selected from domain experts, system developers, extension agents, and farmers, respectively in the first phase of the research. The first phase of the research sought for understanding of concepts germane to knowledge types, the roles and practices of extension agents, and boundary objects. Informants from the domain experts, extension agents, and local farmers were further iteratively interviewed and observed in the second phase of the research. This phase aimed at for understanding of the KMS design, the use, and consequences of it. For this purpose, 39 informants from a total of 54 including 10 domain experts (i.e., 8 previously interviewed and 2 informants only in phase II), 13 extension agents (i.e., 9 previously interviewed and 4 informants only in phase II), 11 local farmers (i.e., 6 previously interviewed and 5 informants only in phase II), and 5 system developers who were participated in phase I are again participated in phase II (April 2017 to September 2017). In the second phase, farmers were selected on a voluntary basis and based on their educational background and their awareness and skill with mobile, computer, and the Internet. In particular, farmers in this phase were selected on a basis of their reading and writing skill and access to desktop computers at FTCs in their rural district and mobile devices.

4.6 Procedures of Data Management and Data Analysis

The action research method presented above serves as an analytical tool for the process that took place in this study using KMS development at ATA as a case area (Figure 4-2). Each stage presented is not linearly conducted nor is each step distinct. In this investigation, data collections and analyses were carried out side-by-side in accordance with the recommendation of Klein and Myers (1999) and Walsham (1995) in an interpretive study. Through an iterative process of data collection and analysis following the multi-methodological approach to IS research, the initial concepts established were expanded and revised through analyzing data collected for recurring patterns, ideas, and concepts. The research objective was to extend the theoretical lenses in useful ways rather than to remain true to all aspects of the concepts in the initial conceptual framework preconceptions. As such, the research process was neither entirely deductive nor entirely inductive like the works of Pawlowski and Robey (2004) and Levina and Vaast (2005).

Table 4-4 Summary of the Study Informants

Number of Respondents, their Job Title, and Organization				
Job Title	**Organization**	**Total No. in Phase I**	**Total No. in Phase II**	**Total No. in Phase I & II**
Human resource manager	ATA	1	0	0
Agricultural researcher	ATA	5	4	4
	MoARD	1	3	1
	Amhara's RARCs	2	1	1
	North Gondar agricultural office	2	2	2
Sub-Total		**10**	**10**	**8**
System developer	ATA	6	4	4
	MoARD	2	1	1
Sub-Total		**8**	**5**	**5**
Extension agent	Amhara Regional agricultural office	1	1	0
	North Gondar agricultural office	5	4	4
	Gondar zuria woreda/kebele	6	8	5
Sub-Total		**12**	**13**	**9**
Farmer	Ambachira Kebele or district level	6	4	2
	Debreselam Kebele or district level	6	7	4
Sub-Total		**12**	**11**	**6**
Total respondents participated in each phase		**43**	**39**	**28**
Total respondents in the two phases of the study		**54**		

***Note**: 28 of the informants participated in phase I and II of the research.*

***Source**: Author own compilation*

Data obtained in KMS development process in phase I and II were processed into information and knowledge through interpretation, meaning people attached to them, and the context (Rowlands, 2005; Walsham, 1995) through highlighting words or sentences from the transcribed data. Such processes influence the use and interpretation of the KM and subsequently affect the design and refining of the KMS development because data are socially constructed in the community. Therefore, in this community-based KMS and integration of agricultural knowledge in KMS development investigation, it is required to understand people, social and cultural contexts. During the analysis, the specific actions were taken on the data for reduction, categorization, and identification of an overall structure including coding and splitting, integrating the split data to form themes, and aligning themes with relevant social groups from the case study conducted iteratively (Ritchie & Lewis, 2003).

4.6.1 Interview Transcription

During the interviews, detail notes were taken and immediately transcribed using respondents' own words as fast as possible. Voluntary informants were also tape-recorded when permissions obtained and immediately transcribed using the informants' own words. Conversations and interviews with farmers were done with their respective native language with the help of local translator professionally. Therefore, interviews with local farmers were carried out in Amharic (see also Appendix II, the Amharic version of interview checklist). For this purpose, the interview guide was translated to Amharic with the help of language professional and an agricultural researcher to understand jargons used in agriculture. Interviews with other informants were conducted in a mix of languages (English and Amharic) which were translated into English. One example of transcribed interview data from the extension agent's subject is attached at Appendix V.

4.6.2 Data Coding and Splitting

In interpretive research, all relevant human actions and understanding are achieved by iterating between considering the interdependent meaning of the parts (open codes) and the whole that they form (thematic codes) (Klein & Myers, 1999; Rowlands, 2005). Lawrence and Tar (2013) indicated that analysis in interpretive IS studies involves coding the assignment of themes and concepts to a selected unit such as sentences taken from interviews transcript. Concepts are combined into related categories; links between categories are identified and verified against the data, and selective coding attempts to integrate the categories into a conceptual framework, which accounts for the phenomena being investigated (Ritchie & Lewis, 2003), for example, the work of Pawlowski and Robey (2004) and Rosenkranz et al. (2014). Before starting the coding of the transcribed data, the general research questions in-line with the initial conceptual framework and research objectives have been examined to determine the best possible way to code the data (see also Table 4-2). Open coding approach was followed to identify the categories from the data (Strauss & Corbin, 1998). Then, the thematic coding approach was followed for unifying data and structuring.

4.6.2.1 Open Coding

An open coding was primarily conducted for breaking down, comparing, conceptualizing, organization, and categorizing data (Strauss & Corbin, 1998). According to Strauss and Corbin (1998), this process is commonly employed in qualitative data analysis, thereby, the researcher identifies and naming the conceptual categories where the phenomena observed are organized. During this phase, the researcher started with a simple coding scheme that included broad categories from the case (i.e., the EthioSIS) describing knowledge systems types and their treatment, knowledge sharing practice, KMS development, challenges of integrating knowledge in KMS development, the role of extension agents as knowledge broker and boundary objects, and the design, the use and the consequence of KMS.

Table 4-5 Snapshot of Open Code – Identification of Concepts

Sample Interview Logs (Quotes)	Informant	Open Code
I have been using this land for more than 26 years. Thus, I know the characteristics of the soil than anyone else. I have my own knowledge and practice to preserve its fertility through manure and fallowing. I frequently use animal dung for its fertility health. I also use chemical fertilizer recommended by the extension agents.	Farmer-Respondent #10	• Knowledge and practice • Characteristics of soil • Manure • Fallowing

Source*: Author own compilation*

Using this scheme, all data from interviews, participant observations, and organizational documents were split or categorized into broad coded segment. The researcher reads the data several times to categorize the data to each broad segment. Following the categorization of sentences from each informant into the above broad categories, the researcher divided the sentence into meaningful phrase with appropriate level to represent the concept. In order to group similar ideas and identify concepts and differentiate concepts, the researcher assigned different colors to phrases through highlighting words or sentences from the transcribed interview (see Table 4-5). Then after, the initial coding scheme was carried out based on the initial conceptual framework, then the researcher continually changed and refined during the analysis as new categories emerged iteratively.

4.6.2.2 Thematic Coding

In order to understand the conceptual framework through the roles and practices of knowledge brokering and the design, the use and the consequence of a shared KMS as a boundary object for knowledge systems sharing and integration, thematic coding was used. Thematic analysis is one of the predominant techniques used for qualitative data analysis and is a method for identifying, searching, analyzing, exploring, and reporting patterns or themes within data (Braun & Clarke, 2006). Hence, this method of analysis best fits to this research.

The research defined themes or patterns by integrating the split data under each broad category on the basis of similarity in the meaning of concepts by going through the data. Through this process, new themes were emerged and added to the initial framework. Then, labeled segments were combined and assigned new labels that reflected common theme of combined statements, in turn the generation of conceptual framework. Statements describe the relationships between relevant social groups, the structural properties of social systems, the roles and practices of extension agent as knowledge broker, the design, the use, and the consequence of a shared KMS as a boundary object for knowledge integration and sharing. The works of Sahay and Robey (1996) and Tajul (2013) are examples of researches that employed thematic analysis. Finally, the process conceptual framework in KMS development and use for knowledge sharing and integration was developed. Final coding scheme of the research is presented at Appendix VI.

4.7 Prototyping and Evaluation of the KMS for Knowledge Integration

On the basis of the concepts and assumptions in the conceptual framework, agricultural KMS is developed and applied in order to understand the use and the consequence of KMS as a boundary object, in turn the conceptual framework was further developed. Meta design (Fischer & Ostwald, 2003) or secondary design (Germonprez et al., 2011) suggested that in order to understand the KMS development for knowledge sharing and integration, there is a need to understand the users interaction in the design and use of the system. Therefore, following structuration model of technology of Orlikowski's (1992), the research designed and prototype the new system and understood the use and consequence of it. Thus, a highly interactive and integrative KMS was developed through participating relevant users in designing of a system and in use of it. In order to create the KMS, Web 2.0 tools such as wiki, blogs, social networking, and voice communication were employed.

Relevant users were engaged in the system design and use time to observe the functions and contents emerged during the use time. The KMS was developed relying on the roles and practices of relevant social groups and boundary objects possessed by them in agricultural development. As indicated in the work of Miah et al. (2012), the developed KMS should be valued by the relevant users. Feedback from the users through evolutionary prototyping has been examined. Additionally, the success of the effectiveness of the KM/KMS needs to be measured using the critical success factors from the individuals' and organization's performance metrics. The most cited Jennex and Olfmans' (2006) KMS/KM success model modified from DeLone and McLean (1992, 2003) IS Success Model was used to measure the success of the KMS boundary object. Finally, the process conceptual framework was improved through understanding of the use and consequence of the technological artifact as a boundary object for knowledge sharing and integration.

4.8 Establishing Trustworthiness of the Study

The trustworthiness of the study procedures, quality, and findings in both qualitative and quantitative researches are critical. However, assessing the accuracy of qualitative research findings is not an easy task. There are several strategies in qualitative research which ensure the trustworthiness of the study. The most important elements to judge the trustworthiness of qualitative research are validity, reliability, and generalizability (Kohlbacher, 2006; Ritchie & Lewis, 2003). They are in general concerned with the robustness and credibility of the original research evidence in different ways (Ritchie & Lewis, 2003). According to Ritchie and Lewis (2003, p. 270), "*reliability meaning 'sustainable' and validity meaning 'well grounded' will have relevance for qualitative research since they help to define the strength of the data*" and validity takes priority and a precondition for reliability (Kohlbacher, 2006).

4.8.1 Validity

The validity of findings or data is understood to refer to the accuracy and precision of a research reading (Ritchie & Lewis, 2003; Yin, 2003) explained with two distinct dimensions: internal validity and external validity (Ritchie & Lewis, 2003). Internal validity analogous to credibility is concerned with a demonstration that the research instrument measures what it is claimed to measure and external validity is concerned with the degree to which the research findings such as abstract constructs or postulates generated, refined or tested are applicable to other groups (Ritchie & Lewis, 2003). Creswell (2009, p. 191-192) suggests eight strategies by which validity in qualitative research is established. These include triangulating different data sources of information; using member checking to determine the accuracy of the research findings; using rich description to convey the findings; clarifying the bias the researcher brings to the study; presenting negative information that runs counter to the themes; spending prolonged time in the field; using peer debriefing; and using external auditor to review the entire project.

In building this research, various mechanisms were used to maintain internal validity of the research procedures taking mainly Creswell's (2009) suggestions into consideration. The researcher in interpretive is encouraged to employ verities of data and information from different sources and different analysis methods (Henning et al., 2004) to understand the situation. As such, this research employed various data sources including interviews, participant observations, and organizational document analysis which can increase the validity of the research by way of triangulating different sets of data. Moreover, different analysis methods were used in order to strive for the validity of the research including framing of the initial theoretical lens through literature analysis, the research further investigated empirically from the data collected from various groups of social groups in order to develop concepts, and analysis has been also made through designing and assessing the use of the KMS in a given social setting. Furthermore, after writing the dissertation, the researcher gave to agricultural experts for reviewing the document and their feedbacks contributed to the research validity in particular the domain area. Also, five articles were presented and published in different peer reviewed conference proceedings, which increase the validity of the research findings (see also Appendix IX).

The research generalizability or transferable analogues to external validity refers to the degree to which the research findings can be generalized. However, generalizability is used in a limited way in such type of interpretive qualitative research, since the aim of this kind of study is not to generalize research findings to individuals, sites, places, or settings outside of those directly studied (Creswell, 2009). The value of qualitative research in this regard is to provide a detail description of phenomena and themes or concepts development in a particular social context (Creswell, 2009). Orlikowski and Baroudi (1991) and Sahay and Robey (1996) also discussed that the aim of an interpretive research is to increase understanding of the phenomena within a specific social context rather than generalizing to other settings or to a population. However, the detailed research data collection and analysis methods, the interpretive evaluation guidelines, the applied systems development action research approach, the case study selection procedures and context, and assumptions made in this research can foster the transferability or generalizability of the underlying research.

4.8.2 Reliability

Reliability also called dependability in qualitative researcher which refers to the consistency of the researcher's approach across different researchers, methods and different projects (Creswell, 2009). Yin (2003) suggests that qualitative researcher/s can be achieved through documenting the procedures of the case study and the research instrument in detail as possible. For this purpose, this study clearly explained the research question, assumptions and theories employed in the research. Additionally, the study explained in detail how data were collected.

Moreover, the research applied multiple methods of data collection and analysis (triangulation). The combination of the various data collection methods including interviews, participant observations, and organizational document analysis allows to maximize the treatment effect and to better observe the research questions. In-depth semi-structured interview followed in this research consists of some partial pre-planning interview questions (refer also Table 4-2). As such, standardization of at least some of the interview questions increases data reliability. Interviews were also conducted in the native languages of the informants and translation was conducted properly with the support of language professionals. Additionally, subject matter experts also support the translations to understand especially the indigenous terms from local communities in agriculture. Moreover, the interviews with the respondents were tape recorded to better support the trustworthiness of the research. In order to avoid mistakes, the transcripts of the interview were read and reread several times. Also, constructs identified in the process conceptual framework are clearly specified and discussed in consultation with extent literature.

4.9 Official and Ethical Procedures

Researcher has to consider the official and ethical principles under which the research is conducted, in particular in terms of request for permission, respect for respondents, and confidentiality of information gathered from subjects and documents. Different research institutions and associations outline guidelines of issues in conducting research that indicate researcher's responsibilities to the research profession, the research collaborators, the public and the funding agencies. In this research, one of the ethical considerations is to seek for official permission from responsible bodies in hierarchical offices. Prior to traveling to the research sites chosen for the study, it is an ethical requirement to hold official letters to make rapport with the administration bodies of the research sites. Accordingly, researcher received official letter from the coordinator of Information Systems track, IT Doctoral Program, Addis Ababa University (Appendix XII). Through this letter, the researcher applied to the human resource manager at ATA and got permission for the entire work.

The respondents particularly the local farmers might prefer to protect their data from other colleagues, merchants, and brokers; hence they might be reluctant to provide information. So there could be a challenge to get accurate information from local farmers about their indigenous knowledge and practice in question. For this, the other important ethical principle is informed consent that considers the voluntary participation of the respondents in the research activities (see also Appendix X and XI for English and Amharic version, respectively). The consent begins with the explanation of the purpose and the aim of the research by the researcher so that the respondents would have full authority over their participation on the research. This was followed by informing them to respond freely in the way they like and as much as they can without missing the aim of the research. This also required lengthy observation of farmers' practice and production sites as well as developing a close work relationship.

Confidentiality of the information collected from respondents is also ethically a must. So, participant privacy was protected by the study. In order to maintain the confidentiality of data and protection of the respondents' privacy, various techniques were used during and after the interviews, participant observations, and organizational document analysis. One means can be stating before every session that the researcher would not reveal anything that learnt from the participants to other participants or member of the community or to some other bodies. Additionally, instead of using the exact name of the participants, the researcher used codes to preserve participants' anonymity in data reporting.

4.10 Summary

This chapter begins with the description of the research paradigms and justification of the selected perspective. The philosophy which underpinned this research is interpretive philosophy. In this research, the multi-methodological approach to KMS research in action research perspective consisting four strategies: theory building, experimentation, observation, and system development was employed to understand KMS development in knowledge integration and sharing.

The KMS development practice of ATA is used as case study. The ATA is an organization that is developing agricultural KMS in the country, which are operating in all regions of the country. In-line with this, two districts are selected from the North Gondar Zone of Amhara Regional State of Ethiopia. Subjects for this research are local farmers, extension agents, agricultural experts, and KMS developers from the case study. Data were gathered by employing semi-structured interviews, participant observations, and organizational document analysis. The data were analyzed using an interpretive analysis in accordance with the principle of dialogic reasoning. Concepts framed in the conceptual framework have been implemented in order to refine the conceptual framework. Web 2.0 tools have been employed to develop the KMS. Finally, the procedures held to maintain trustworthiness of the research and ethical considerations followed in this research have been explained.

Up to this point, this study has presented the research problems, the literature review, the initial conceptual framework, and the research methodology. The following chapter presents the case study findings and concepts in conceptual framework development that emerges from the analysis of the empirical data.

CHAPTER

5. PRESENTATION OF THE RESULT

This chapter is devoted to the presentation of the research findings. Data analysis proceeded iteratively between examinations of data and development of concepts through interpretations based on the extensive reflections of participants' views, assumptions, and attitudes. The chapter begins through presenting the current status of the case: the Ethiopian Soil Information Systems (EthioSIS) within the scope and the context of the study, thereby identified the relevant social groups and their roles of participation in system development. Following the description of the case, this chapter has presented the type of knowledge possessed by relevant social groups or communities of practice in agricultural KMS development and use. Then, it discussed the knowledge sharing and challenges to share and integrate the scientific and indigenous knowledge in system development. Next, themes identified under the roles and practices of agricultural extension agents as knowledge brokers have been presented in detail, which is critical to understand the social interaction and knowledge sharing and integration in system development. The following section discussed the skill and knowledge requirement by extension agents for their roles of knowledge brokering. The chapter lastly presented the roles of boundary objects possessed by relevant social groups since knowledge brokering alone is not enough to understand the knowledge sharing and integration in system development.

5.1 The EthioSIS as a Case Study

The goal of the EthioSIS project is to design and develop a central depository database to house accurate soil information of the rural areas of the country to be available for all potential users. Analysis from the informants' interviews and participant observation indicated that the three main objectives of the system are: (1) to capture soil conditions in all rural districts or kebeles of the country, (2) to generate up-to-date soil fertility information, and (3) to suggest fertilizer based on the characteristics of the soil so as to transform the fertilizer recommendation service to farmers. ArcGIS tool was selected for the development of the system in ATA and other collaborative organizations: AfSIS, MoARD, and

Wageningen University over two competing packages based on its technical and functional superiority. ArcGIS in the EthioSIS is used for geo-statistical analysis and map making. There is also one powerful satellite image processing server to enhance the processing capacity of the geo-statistical model. The EthioSIS uses Server Area Network (SAN) storage with a capacity of 20 terabytes to hold the master database and geo-statistical modeling data.

The field data were collected using mobile and sensor technologies and directly uploaded to the central database as revealed from the document analysis and participants' observations at ATA. Developers are also used mobile devices to navigate to sample points and track soil sample processing. The EthioSIS uses remote sensing satellite technology and extensive soil sampling to provide high-resolution fertility soil mapping for each region. Human resource manager at ATA reported that until June 2016, 65,500 soil samples were collected from 585 woredas and the system predicts the fertility status of districts in these woredas of the country and recommend fertilizer accordingly. The EthioSIS in general helps different stakeholders in Ethiopia to make informed land use decisions and to better manage soil resources.

The EthioSIS is positioned as a modern scientific approach to development planning involving the use of both satellite remote sensing data, mobile applications, and GIS technology ultimately to support local farmers. In building this research, the social context was analyzed in terms of the project structure as revealed from the data through interviews and participants' observations. Structure in accordance with the work of Sahay and Robey (1996) refers to the configuration of an organization with respect to departmental responsibilities, relations with other organizations, and relevant potential groups of users in the formal and informal organizations. The research has identified four different social groups relevant to the process of the EthioSIS development including agricultural researchers, technologists, extension agents, and local farmers.

Agricultural researchers are staffs from the soil research unit in ATA and other related organizations such as EIAR, RARCs, MoARD, and Universities. Agricultural researchers group conduct various researches pertinent to soil fertility management and conservation, including soil surveyors, laboratory experts, and provide project supports. Domain knowledge for the agricultural information systems is extracted from those experts and data collection through mobile and sensor technologies are also carried out with the support of them. The technologist groups include system analyst, programmers, database developers, system administrators, geographers, and GIS experts from various departments in ATA and

MoARD responsible for the development of the system, administration and running of the system, and management of the system resources: the EthioSIS. Local farmers are end users of the agricultural knowledge and technology distributed geographically throughout the local areas of the country. There are also a group of people called extension agents, who are responsible for transfer of knowledge and technology from researchers and technologists to local farmers. In addition, this group provides advisory service to farmers through the support of the EthioSIS.

The findings of the research described the participation of social groups and the major problems in the development of the agricultural KMS development: the EthioSIS resulted from the informants' interviews and participants' observations. Figure 5-1 is the picture illustrating the feeling of all stakeholders who are involved either as active participants or as someone able to exert control over the situation and, therefore bring their viewpoints and opinions into how the agricultural KMS is developed and managed in all situations. During the initiation stage of the project, agricultural researchers and technologists are actively participated, for example, in selecting the software tool and formulation of the action plan and later in the design and implementation stages. The system supports the research groups through facilitating their research works by providing data and spatial analysis. However, extension agents who transfer knowledge and technology to the farmers using such system were not participated in the development process.

Data analysis from the data gathered through respondents' interviews and participants' observations indicated that the system development methodology used in this case is top-down. During the data collection phase, technologists and agricultural researchers have gone to each woredas in different regions of the country and collect relevant data. The participation of extension agents in an agricultural KMS development is critical since they are transferring knowledge and technology from research to local farmers through the support of such system, the EthioSIS. Their participation is not only important to provide their requirements but also to reflect the local farmers' needs and expectations because they work closely with them. However, in the current system development practice, extension agents are only given training about the system to support their technology and knowledge transfer and advisory service to the farmers. Additionally, despite the system is supposed to be developed to support the local farmers; there is no involvement of local farmers during the development process. As such, the requirements of the main users (i.e., extension agents and farmers) and their socio-economic features are not considered in the system development.

Despite researchers actively participated in the development of the system, the system does not allow them and other end users to contribute and share their knowledge during the use of the system. Even though the EthioSIS is in the fifth year of its implementation program, the project encounters several problems: sustainability and poor in performance in general, and poor in user's involvement, lack of continuity in project management activities, high resistance by end users, no collaborative working environment, inappropriate co-ordination among stakeholders, and problems in administrative and communication issues, to name a few. Therefore, the impact of the system is not yet successful as of the expectation during the initiation phase of the development process.

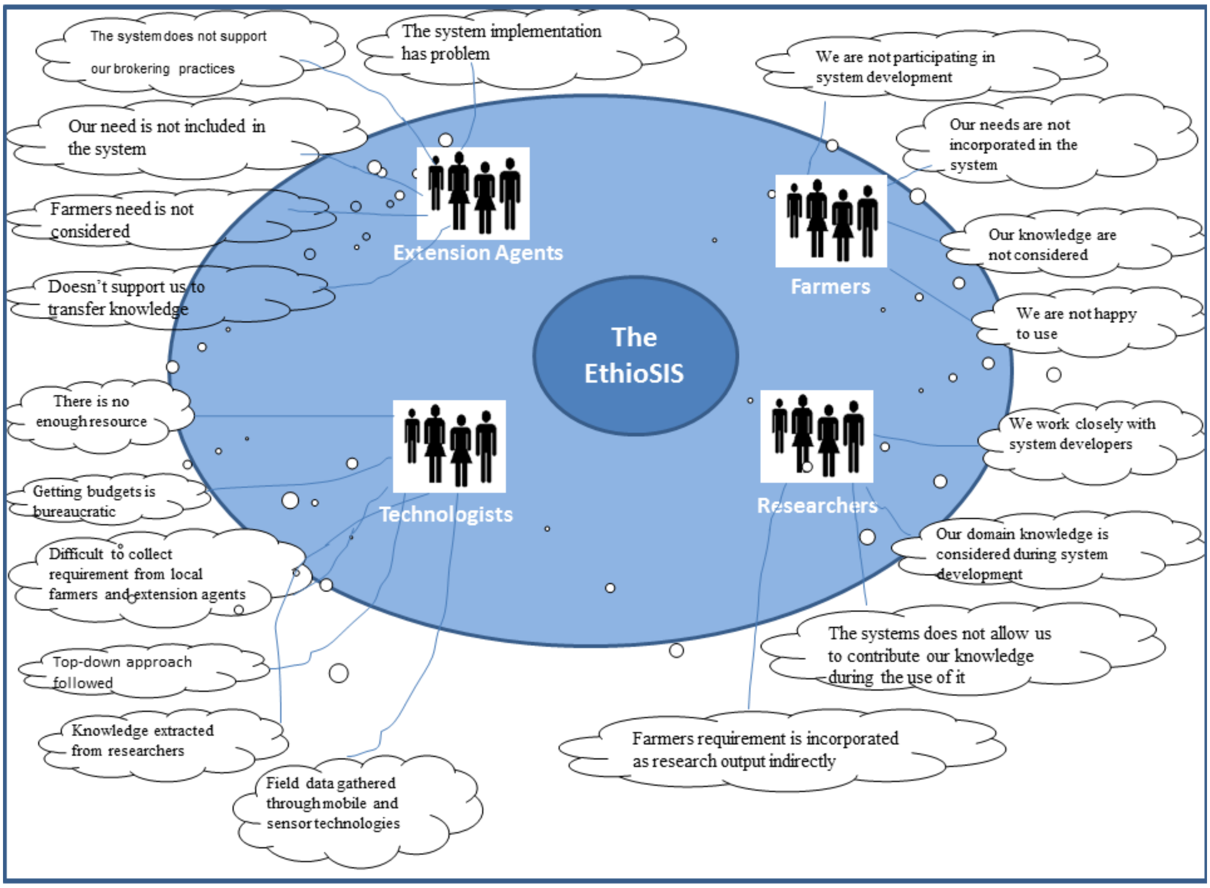

Figure 5-1. The Picture Depicting for Participants' Views

Source: *Author own compilation based on the analysis of the data.*

In sum, the system relies on data extracted from domain experts and data generated on the basis of recognized scientific principles, draw upon spatial inputs derived mainly from the interpretation of remotely sensed satellite data. However, the social aspects of local communities and their IK are totally ignored. The EthioSIS development methodology purely emphasizes on a normative approach based on scientific methods and computer-based modeling almost without the involvement of local farmers and extension agents in the action plan, design and implementation processes. The research identified four relevant social groups: agricultural researchers, technologists, extension agents, and local farmers. The participation of members from all relevant social groups is important not only in the development of the system but also in the use of the system to contribute and share their knowledge. In order to involve all relevant social groups in the KMS development, there is a need to understand the knowledge systems they possess and how they share their knowledge in their every day practices.

5.2 Types of Domain Specific Knowledge in Agricultural KMS

Having identifying the relevant social groups, in-depth interviews and participants' observations were carried out to discuss the knowledge possesses by each CoPs. According to the respondents, both scientific knowledge which is provided by the EthioSIS and IK hosted and applied by local farmers are important for soil fertility management and conservation. However, interviews and participants' observations at ATA indicated that KMS development for soil fertility analysis and recommendation relies fully on scientific knowledge from agricultural researchers and technologists. The research has resulted in to two categories of scientific knowledge in the development of agricultural KMS for knowledge integration specifically for soil fertility management and conservation. These are application domain and technology-based knowledge. In addition, the research identified indigenous knowledge and practices possessed by local communities as discussed below.

5.2.1 Application Domain Knowledge

Application domain knowledge is scientific knowledge possessed by agricultural researchers arises from their educational background, findings of researches and their everyday institutional practices. As indicated by one of the agricultural expert respondents:

> *I have been serving in the agricultural institution for 21 years. The sources of knowledge for agricultural decision making are research institutions and universities in the country, which are results of scientific experimentation, research results, observations, and policies. For example, to maintain the soil fertility, we use different chemical fertilizers depending on the type of the local soil type and deficiencies in it.* (Agricultural-Researcher-Respondent #4)

The modern application scientific knowledge related to soil fertility management includes soil experimentation, soil resource surveying and processing, mapping and interpretations of the result, the use of different chemical fertilizers based on the result of experimentation through identifying the soil type and its nutrition deficiency. Such knowledge is documented in scientific journals, organizational reports and incorporated in the database of agricultural KMS. IS developers said that:

> *During the development of the EthioSIS, we have been extracted and collected domain knowledge about the issues of soil fertility management from agricultural researchers. We have also consulted various documents and procedures from agricultural research centers and Universities.* (IS-Developer-Respondent #4 and #8)

In the development of agricultural KMS, for example, the EthioSIS, domain scientific knowledge of agriculture represented in the database is required. As per the respondents and participants' observations, such knowledge is gathered from domain experts or agricultural researchers, field survey, and organizational documents from universities and research institutions.

As indicated by the majorities of researchers and system developers' interviews and observations, in order to develop the database of the EthioSIS for incorporating the application domain knowledge about soil fertility management, primarily soil samples were gathered from each rural kebeles or districts from different regions of Ethiopia. Soil samples were gathered based on a gridded approach and conducts various types of field analysis. Sampling design adopts stratified grid sampling skewed to agricultural land (80% cultivated and 20% on potential agricultural land). Accordingly, data related to top soil: (0-20 cm) vs (0-50cm), relevant geo-referenced field data, soil samples, slop/topography, land management history, land use/ cover, crop growing, local soil naming, soil color, and crop residue management for each rural kebeles or districts in Ethiopia have been collected. Then, soil processing based on logs, dries and grinds soil samples were conducted and distributed to laboratories for analysis to understand the physical characteristics and nutrient levels within the soil through spectral analysis and wet chemistry as appropriate. In turn, appropriate blending fertilizers are recommended for each kebeles as shown in Table 5-1.

Table 5-1 Blended Fertilizer Recommendations from Kebeles in North Gondar

S. No	Zone	Woreda	Kebele	Type of Fertilizer
1	North Gondar	Gondar Zuriya	Ambachira	NPSB
2	North Gondar	Gondar Zuriya	Ayibayesus	NPSB
3	North Gondar	Gondar Zuriya	Birbowakis	NPSB
4	North Gondar	Gondar Zuriya	Abunesemra	NPSZnB
5	North Gondar	Gondar Zuriya	Debresalam	NPSB

***Source**: Database of the EthioSIS*

5.2.2 Technology-based Knowledge

Technology-based knowledge is scientific technical knowledge possessed by application developers identified in agricultural KMS development. It consists of knowledge engineering for knowledge extraction from different social groups, KM activities, and KMS development and operations. Field data are gathered through interviews, field observations, and support of technologies such as remote sensing, mobile applications, and GPS in each agricultural rural woredas in the selected regions of the country. As indicated by one of the IS developer respondents:

> *I have been participating in the development of agricultural KMS and management for 3 years at ATA and for 4 years in another organization as a programmer. The sources of knowledge for system development are the domain experts and end users like extension agents. To extract knowledge from those people there is a need of knowledge and skill of knowledge extraction or engineering.* (IS-Developer-Respondent #2)

One of the most important tasks in KMS development is to extract knowledge from different users. Knowledge and skill in knowledge engineering is critical to effectively discover knowledge from the users in particular in the requirement elicitation stage of the system development. Knowledge in agriculture is contained by researchers, practitioners, and local communities. Agricultural KMS developers need to gather knowledge from those participants; in turn they require to have communication and knowledge extraction knowledge and skill. Knowledge captured from different sources further requires KM activities for storing and application. As reported by one of system developers:

> *In agriculture, there are several stakeholders who have power in KMS development who have their own knowledge. Knowledge extracted from them needs processing so as to store, integrate and apply. Particularly, for the same topic different views and knowledge are sometimes gathered. Despite its challenges to integrate the different views, all knowledge and perspectives are critical in agricultural development.* (IS-Developer-Respondent #5)

Thus, knowledge should be managed and processed in order to incorporate in the knowledge repositories of the KMS. For this purpose, knowledge of KM activities is required for the synthesis of knowledge from different sources storage, sharing, and integration of knowledge in KMS development and use. Consequently, new category of scientific knowledge in such system development was also emerged, namely technological scientific knowledge including knowledge of KM activities. Knowledge of KM activities is important for system developers to extract knowledge and understand the users KM practice.

The technological knowledge is also required for the development and operations of agricultural KMS. Other informants from the technologist group reported several skill and knowledge required in system development and running of the system, among other, communication skills, requirement gathering, data analysis, system designing, programming, system testing, database development, and system administration are required as a technologist. Specifically, in agricultural KMS development, knowledge of GIS is required since many of the system development and data analysis are supported through GIS tools. A GIS expert also added up that:

> *In agricultural KMS development, knowledge of system development, GIS, and remote sensing are required. GIS is an important tool for agricultural system development because it is the tool used for different land resources management and spatial data analysis like land, water, soil information. In addition, the rules of cartography and map, map production and analysis, GPS knowledge and skills are also critical.* (IS-Developer-Respondent #3)

For spatial analysis, the geo-statistical prediction model is used for analysis purpose from large sampling areas. GIS experts and geographers at ATA which host the EthioSIS project are responsible for analysis and maintenance of spatial data. Majority of the IS developer informants reported that in addition to knowledge of KMS development and administration, knowledge of GIS like different participatory mapping such as ground, sketch, 3-D, transect and scale mapping and compass and distance measuring devices such as GPS are required. Thus, in addition to the domain scientific knowledge, technological knowledge of system developers for knowledge extraction, KM functions and KMS development and GIS are important in agricultural KMS development.

5.2.3 Indigenous Knowledge of Local Farmers

Local people are important source of IK. Local people in the selected case areas were asked about IK of soil fertility management and conservation. Interviews with local farmers are conducted with the support of extension agents. This helps researchers in translating and interpreting their local language and expression. Extension agents and agricultural researchers are also asked about their perspectives regarding IK of local communities for soil fertility management and conservation.

Interviews with farmers revealed that indigenous practices have been applied by farmers for long period of time to keep and increase the soil fertility and conservation, thereby, to increase productivity in their local areas. Local farmers are owners of pool of IK parameters that enable them to assess the fertility loss in their farm land that they have been practiced for long. Farmers’ respondents indicated that they have their own knowledge and practice for soil type identification and requirement for it to maintain its fertility. For instance, they use different indigenous techniques, technologies, and parameters of identifying characteristics of soil fertility on farm land. Informants reported various IK and practices applied in their farming land: identifying soil type, indigenous naming of soil type and describing the characteristics of soil types. They have also their own indigenous technologies and practices for preserving soil fertility such as manuring, crop rotation, fallowing, intercropping, and multi cropping, and different ways of soil conservation.

5.2.3.1 Soil Type and Naming

Farmers have their own traditional ways of classifying, describing and characterizing local soil types in their fields. The classifications include soil characteristics, soil problems and their suitability to various crops and pest control mechanisms.

According to the interviews of farmer informants:

> *We have our own knowledge and experience for identifying soil type and describing the characteristics of soil, namely soil color change; productivity declines; appearance of sand in the field; poor seedling germination immediately after sawing; yellowing and other coloration of crop leaves during crop growth.* (Farmer-Respondent #3, #4, #6, #8, and #12)

Farmers have their own local naming of soil type based on its characteristics in their farming land. They usually classify the soil in various ways through the soil characteristics such as color of the soil, the problem of the soil, and its suitability to crops. In the study areas, in general farmers classified the soil into three and have their own local naming as follows and summarized in Table 5-2:

> *i. 'Keyatie' a soil which is found from farmland at the top of sloppy areas to the very plain areas with nearly zero slopes. Farmers grouped this type of soil as medium fertile soil. It has a color of red and in some place, it is white.' Teff' crops are mostly cultivated in this type of soil.*
>
> *ii. 'Nechatie' a sandy soil type which is found in mountains and nearby areas in which it is characterized as very poor soil fertility. It is stony, sandy, cement and gray type. It is suitable for maize production due to its high humus, water and moisture retaining capacity.*
>
> *iii. 'Walka' is a black soil, which highly dominates the flat catchments including the banks of river. It is characterized as the most fertile soil. It is suitable for maize and 'teff' cultivation in the case study areas.*
>
> (Farmer-Respondent #3, #4, #6, #7, and #11)

Table 5-2 Local Farmers Soil Classification

Soil Characteristics	**Local Naming of Soils by Farmers**		
	Keyatie	***Nechatie***	***Walka***
Color	Red and white	Gray	Black
Stoniness	Slight	Moderate	Very slight
Crops suited	Teff	Maize	Teff and maize
Fertility	Fertile	Less fertile	Most fertile
Moisture	Medium	High	High

Source: *In-depth Interviews with farmers and participants' observations*

5.2.3.2 Soil Fertility Management

One of the farmer respondents stated that:

> *I have been using this land for more than 26 years. Thus, I know the characteristics of the soil than anyone else. I have my own knowledge and practice to preserve its fertility. I frequently use animal dung for the soil health at my farm land.* (Farmer-Respondent #10)

Data analysis from the majority of the farmers and participants' observations revealed that for maintaining the soil fertility, they have been applying various IK and practice at their farming field such as crop rotation, mixed cropping, manure, compost and fallowing along with the application of scientific fertilizer as described in Table 5-3.

5.2.3.3 Soil Conservation

Soil erosion is one of the major problems in these case areas due to high rain fall, deforestation, and wind storm. It is affecting the soil fertility through degrading. In response, local farmers have the various indigenous ways of soil fertility conservation, which are highly practiced in case areas to maintain the soil fertility as revealed from the analysis of farmers' informant interviews and participants' observations at the two local districts in North Gondar: Ambachira and Debreselam. For example,

Table 5-3 Indigenous Knowledge and Practice for Soil Fertility

Practice	Description	Informants
Manure	*The manure is prepared from household waste like crop residues and animal residues to increase the productivity of soil. It is usually collected when cattle's go out for grazing. The collected and processed manure is then added to the farm land to maintain the soil fertility for growing crops such as maize, teff, potatoes, cabbages and onion.*	Farmer-Respondent #1, #2, and #5
Compost	*Compost is made through mixing vegetation decay, broad green leaves, leguminous plant that fixes nitrogen and manure. Then, the mixtures put together in a ditch and are fermented for around 21 days. This way preparation is much similar with the preparation of the traditional manure except the latter is made without using ditch and waits years for fermentation.*	Farmer-Respondent #2, and #5
Crop rotation	*It is a process of cultivating different crops through shifting at the same farm land in different cultivating seasons. Farmers believed that such indigenous practices can maintain the soil fertility and conserve its fertility as well.*	Farmer-Respondent #11, #2, and #7
Mixed cropping	*It is a process of growing of two or more different crops simultaneously at the same farm land. It is an indigenous practice primarily to increase productivity as farm land size decrease. Farmers also believed that such multi cropping can provide favorite condition for the soil and water so as to conserve and maintain the soil fertility.*	Farmer-Respondent #1, #2, #4, and #8
Fallowing	*Fallowing refers to leaving of a farm land idle or left uncultivated and without crops for a number of periods ranging from one season to several years. It is an indigenous practice conducted in these case areas to restore the soil fertility. Researcher respondents indicated that this practice can increase the organic matter content of the soil, improve the soil structure, and protect the soil from erosion. However, only few farmers practice such method because of the shortage of farm land.*	Farmer-Respondent #1, #2, and #5 Agricultural-Researcher-Respondent #7

Source*: Author own compilation based on the analysis of in-depth interviews and participant observations*

Traditional ditches ('feses'), traditional waterways ('boi'), stone terraces ('yedengay erken'), traditional cut off drain ('tekebkeb'), vegetative barriers ('Geta'), plant trees on the edges of their plots, plough across the slop of the farm land, and contour ploughing. (Farmer-Respondent #1, #2, #3, #5, #7, #9, and #10)

Such traditional ways of soil fertility conservation are largely practice in these study local districts case areas and other parts of the country as per the majorities of the respondents. For instance, traditional ditches are indigenous practices widely used for erosion control. Local farmers named it as '*feses*'. It is micro-channel built on cultivated fields to direct excess water from cultivated fields.

Despite farmers have various IK, practices, techniques and parameters of identifying and maintaining the quality of fertility of their local soil, they don't understand the amount of loss of nutrient contents in the soil type as soil scientists do scientifically, as agricultural researchers indicated. Thus, as one of the agricultural expert informants responded:

The two-broad knowledge of agriculture: scientific application domain and indigenous knowledge complement each other. (Agricultural-Researcher-Respondent #5)

There are farmers in the two local districts who are using both the scientific and the indigenous knowledge for soil fertility management and conservation and for other farming practices. (Observation)

Moreover, a number of informants from farmers and extension agents, and field participants' observations assured that both scientific and indigenous methods of soil fertility management and conservation are widely used in the visited farming areas and it is when both knowledge systems integrated that sustainable agriculture development can be realized. However, participants in the agricultural system development processes are agricultural researchers and technologists and the key motive for participating them was to engage in research and development of KMS involving the latest technologies. However, the involvement of the main users (i.e., local farmers) and extension agents who are responsible for agricultural knowledge transfer, and IK possessed by the local farmers were totally ignored in the development of the KMS.

Despite the fact that IK from local resources in KMS application for soil fertility management and conservation are critical for the community decision making process, IK and associated local communities are not involved in the development of the EthioSIS. Informants reported that the current KMS development and use for soil fertility management and conservation can negate, destroy, and corrupt the sacred IK. The development of KMS for agricultural KM activities needs to exploit the indigenous peoples' knowledge systems. As such, this research understood the potential of IK to bring the full potential of the KMS in agriculture and the development needs to involve and blend both scientific and IK together. Table 5-4 presents knowledge types, sample interview logs, and key indicators of concepts related to knowledge types identified in agricultural KMS development process. In conclusion, there are three different categories of domain-specific knowledge, which are relevant in agricultural KMS development:

i. Farmers' indigenous knowledge
ii. Technological knowledge of technologists
iii. Application domain knowledge of agricultural experts.

5.3 Scientific and Indigenous Knowledge Sharing

Results of the study indicated that, there are different ways of transferring scientific and IK. With regard to scientific application knowledge, there are agricultural extension services in a country, who are responsible for transferring scientific knowledge and technologies to rural farmers from research. For this purpose, there are people responsible for disseminating knowledge and technologies, providing training and support to Ethiopia's farmers, making them a critical component in the effort to increase agricultural production and transform the sector, who are named as extension agents (ATA, 2014). Whenever there is new agricultural knowledge and technologies, training is given to extension agents hierarchically. Then, they train and support farmers, accordingly. Agricultural extension services in Ethiopia follow top-down approach for knowledge and technology sharing. As one of the extension agent respondents reported:

> *We do make use of various ways to transfer scientific knowledge and technologies to local farmers: trainings, field visits, exhibitions, demonstration, publications, and using traditional forms of ICTs (i.e., TV and radio), and modern forms of ICTs.* (Extension-Agent-Respondent #7)

Table 5-4 Knowledge Types in Agricultural KMS Development

Knowledge Type	Informant	Sample Interview Logs	Indicators
Scientific application domain knowledge	Agricultural-Researcher-Respondent #4 and participants observations	*The sources of knowledge for agricultural decision making are research institutions and universities in the country, which are results of experimentation, research results, observation, and policies. For example, to maintain the soil fertility, we use different chemical fertilizers depending on the type of the local soil type and deficiencies in it.*	• Results of experimentation • Research results • Soil sampling • Soil testing • Policies • Chemical fertilizers
Scientific technological knowledge	IS-Developer-Respondent #2 and observation	*… Knowledge of system development including communication skills, requirement gathering, data analysis, system designing, programming, system testing, database development, and system administration are required as an IS expert. Specifically, in agricultural KMS development, knowledge of GIS is required since many of the system development and data analysis are supported through GIS tools.*	• Communication skills • KM activities • Requirement gathering • System designing • Programming • System testing • Database development • System administration • Mapping • Spatial analysis
IK	Farmer-Respondent #3, #4, #6, and #8	*… We have our own knowledge and experience for identifying soil type through its characteristics…* *… Maintaining the soil fertility, they have been applying various IK…* *… traditional ways of soil fertility conservation are highly practiced in case areas …*	• Soil type identification • Soil characteristics • Local soil type naming • Soil fertility management • Soil conservation

Source: *Author own compilation based on the analysis of gathered data.*

Agricultural knowledge created from agricultural research centers and Universities are stored and disseminated to the end users (i.e., farmers) for use in various forms. The main repositories of such scientific knowledge are publications, audio visuals, and websites. Then, such knowledge is transferred to end users (i.e., local farmers) through intermediaries (i.e., extension agents) notably through trainings, field visits, exhibitions, demonstration, publications, and using traditional forms of ICTs (i.e., TV and radio), modern forms of ICTs such as Internet, mobile phone, E-mail, Interactive Voice Response (IVR), and websites. such as mobile-based SMS and Interactive Voice Response (IVR) service, E-mail, and Websites.

In the perspective of IK sharing, informants have been suggested on the importance and ways of preserving and transferring IK practices of agriculture to the areas of similar context as well as to the young generation. The study revealed that, transfer of indigenous knowledge within and across local communities of practice can be seen in two dimensions: horizontal and vertical. The horizontal refers to the transfer of knowledge among different local CoPs, whereas the vertical one is concerned with transferring knowledge and practices over generation within a CoP. With relation to the vertical knowledge sharing, almost all the respondents indicated that, IK are transferred from generation to generation and from one individual to another orally. They communicate orally about their everyday agricultural practices, elders in the communities also tell story to others like youngsters in their kebele and their relatives in their home (i.e., storytelling). They also use imitation, demonstration, and observation of practical activities. One of the farmers said that:

> *Generation in general learns from each other through observation (i.e., what is practically happening in our village) and children listen their parents what they advise; for example, I learn from what my father and neighbors' practices and advices, and I also work with my father and with others and learn from them. Now I am showing to my son, my relatives, and youngsters in our kebele what I learn and observe from my father and other elders. I also tell different stories about different traditional aspects of agriculture.* (Farmer-Respondent #11)

Another farmer informant also explained as follows:

> *Whenever I go to my farm land for different activities, I go with my sons starting from their childhood (when they reach to around five years). Then, they observe me, they also ask me how and I respond. Through, they learn different agricultural practices. Then, they will start practicing themselves. This is how we learn and transfer the agricultural knowledge and practices.* (Farmer-Respondent #4)

Therefore, IK and practices are mainly transferred to others through oral expression and by acquiring their parents' or elders' practices through observations what and how their parents, elders, and others in their local district are doing things. Newcomers acquire knowledge from others in his/her local communities through observations, oral expressions, imitation, and practicing, and become knowledgeable. Then, they start practicing in the local community.

With regard to the horizontal, indigenous knowledge and best practices of one local CoP transferred or shared to the other local CoPs. In rural part of Ethiopia, there are different types of informal groups in which people gathered together at the community level, for example funeral and other social aspects groups ('*Idir*' or '*Senbete*'), work or labor sharing groups ('*Jigie*'), and savings and loan–type groups ('*Iquob*') are identified in the study case areas through informants' interviews and participants' observations. Besides to these primary purposes, people share knowledge and experience when they meet together. Best indigenous practices are also studied, documented, and shared to the communities in the country scientifically. For this purpose, today there is an attempt to support such type of knowledge sharing using different traditional Medias such as TV and Radio, and modern ICTs such as ICT kiosks, website, and IVR. Moreover, today role model farmers, who have best agricultural practice for high productivity, share their experience to other local CoPs.

Table 5-5 Sharing Mechanisms of Knowledge Types in Agriculture

Knowledge Type	Informant	Sample Interview Logs	Indicators
IK sharing	Farmer-Respondent #3 Farmer-Respondent #8 Observation	*... Others observe me ... they will start practicing themselves ...* *... I will tell different stories ...*	• Oral expression • Practicing • Storytelling • Observation • Trial and error • Informal groups
Scientific knowledge sharing	Extension-Agent-Respondent #7 and observation	*... We do make use of various ways to transfer scientific knowledge to local farmers: trainings, field visits, exhibitions, demonstration, Publications, and using traditional modern forms of ICTs ...*	• Training • Guidelines • Advisory services • Intermediaries/brokers • Publications • Traditional technologies • Modern ICTs

Source: *Author own compilation based on the analysis of the gathered data.*

In sum, analysis of the data revealed that IK is transmitted, shared, and communicated orally and through practice, observation, and demonstration. Thus, indigenous ways of communication and organization are critical for the preservation, development, and the transfer of IK as it is stored in people's memories and is expressed in activities, stories, technologies, cultural values, ritual community laws, local languages, traditional agricultural activities, and materials. Moreover, this is useful to participating the local farmers CoPs, thereby to share and integrate IK and practice with scientific endeavor to empower the local farmers and having multiplicity of knowledge in the development of agricultural KMS. Table 5-5 provides the summary of IK and scientific knowledge sharing mechanisms.

5.4 Challenges of Knowledge Sharing and Integration

Agricultural research and development are brought up to analyze agricultural development problems and to offer solutions using scientific methods without involving the knowledge and skills of local communities. Knowledge and technologies from research are implemented in different local rural areas without understanding of the local context. Scientific view of knowledge treats indigenous knowledge as outdated and primitive, according to the informants from different subjects. As a result, scientific point of view of researchers and technologists overlooked the farmers' point of view in terms of agricultural productivity and sustainability. As one of the agricultural researcher informants reported:

> *The education system in Ethiopia emphases on the western scientific methods and technology, which overlooked the role of IK and practice of local farmers in different aspects.* (Agricultural-Researcher-Respondent #7)

The country's education system and Medias are advocating scientific knowledge, technology, and practices. In particular, young people exposed to such western education are underestimating and losing IK and practice. This is attributed to young people spent more time at academic institutions than with elders in the community. As a result, IK possessed by local farmers has been overlooked in the development effort for long. In response, various efforts have been made by research and development to involve IK through the participation of local communities in the development endeavors. For instance, planning the development of watersheds[1] for the country started in the 1980's (Desta et al., 2005a, 2005b) for implementing natural resource conservation and development programs in large-scale

[1] A watershed is defined as any surface area from which runoff resulting from rainfall is collected and drained through a common confluence point.

composed of 30-40 thousand hectares. However, this program is yet unsatisfactory because of limited participation of local communities.

A planning approach shifted into bottom-up, using smaller units (Desta et al., 2005a) for participating the community at smaller sub-watershed. As such, MoARD and World Food Program, WFP, technical staff developed simple participatory and community-based watershed planning guideline called the Local Level Participatory Planning Approach, LLPPA. Several NGO and bilateral organizations have been using the approach in different part of the country for participatory land use efforts. The lesson learnt from these efforts shown that one common standardized guideline in a country is required and then, Community-based Participatory Watershed Development, CPWD guideline was prepared in 2005. Consequently, today research and development in the country are using this guideline to participate and support rural community in a country in smaller watershed.

Despite having CPWD to participating rural communities, yet in practice non-participatory top-down is being carried out. In the Ethiopian extension system, top-down approach is employed for knowledge and technology transfer. Technological packages are also prepared based on the available improved technologies and attempts are made to transfer them to farmers without involving farmers' needs and expectations. However, informants believed that the wealth of IK of farmers can be used as source of improved technology option if it is properly investigated and integrated with the scientific knowledge in KM practices.

This is also the main concern in technology-related endeavors like agricultural KMS development the one under investigation. According to one of the extension agents:

> *The current KM practice in the Ethiopian agricultural extension systems emphases is given more on scientific knowledge and technology transfer from research to local farmers.* (Extension-Agent-Respondent #3)

Analysis of data shown that, the western scientific knowledge has been the dominant knowledge in the current agricultural KM practices and KMS development due to several reasons. The education system and traditional technologies such as TV, radio and the modern ICT-based agricultural KMS development and applications provided by different organizations are fully relaying on scientific knowledge. As a result, use of IK and practices is declining especially young farmers are not interested to use IK during their farming activities like in soil fertility management and conservation.

There have been great efforts to participate the rural community in agricultural development endeavors, but still difficult to incorporate their need at community level in KMS development due to various reasons. One of the agricultural researcher respondents said:

> *Even though, there are guidelines on how to involve the local community in the agricultural development efforts, it is difficult to incorporate the local community IK in the KM activities and KMS development endeavors.* (Agricultural-Researcher-Respondent #6)

This is due to the document like CPWD in which it does not explicitly guide on how to involve the rural communities and consider their IK in agricultural KM practice and KMS development. As a result, agricultural KMSs are not effectively used by extension agents and local farmers as expected. Thus, today this is the main concern in the development of KMS for improving social development through involving local farmers. However, as one of the system developers put it:

> *We are not aware about IK hosted by local farmers and how such knowledge is going to be incorporated in the KMS development. In addition, there is no guidelines who participate, how and why to participate the local communities in the development of agricultural KMS.* (IS-Developer-Respondent #5)

IS developer informants also reported that the guideline mentioned above does not address who participate, how to participate, why participation in the development of agricultural KMS. As such, a comprehensive guideline is required in this issue since what is included in the KMS depends on who participated, why and how to participate in the development of KMS. In particular, there is a need to understand how farmers are sharing knowledge and experience with others.

The EthioSIS is a large-scale IS project with significant and complex software components in Ethiopia. It further involves various communities of practices. Analysis of the data indicated that the development of the EthioSIS incurred huge capital and consuming a good deal of development time, has a very high possibility of failure since it fails to participate the end-users: local farmers. As the result reveals the acquisition and integration of different knowledge do not involve the end-users (i.e., farmers) however, the system is supposed to be developed to support them. Additionally, resources are required to involve end users and their knowledge in the system development. As one of the IS developer informants reported:

> *The development of the EthioSIS is purely relaying on scientific knowledge of soil fertility management. This is due to the difficulty in incorporating IK from different local communities at kebele level throughout the country. Moreover, the ATA does not have enough budgets to incorporate IK in the development of the system.* (IS-Developer-Respondent #1)

Another important set of reasons for failure of knowledge integration is system developers and agricultural experts feel that contributing knowledge is associated with self-based considerations. Such experts felt the need to establish themselves as experts and neglect the knowledge from the end-users (i.e., local farmers). Thus, this complexity creates a gap between the research and farmers where there is no consideration of IK practices. One of the community representatives in study areas stated as follows about his participation in system development:

> *I have observed extension programs sponsored by the government and NGOs for long period of time. No one consulted us earlier while in planning and implementing extension programs and didn't consider our knowledge and experience as well. They usually did what they wanted without our participation. However, we need full participation of programs implemented for us since we know what we want through the development process and activities and monitor them accordingly.* (Farmer-Respondent #6)

Another farmer respondent also commented that:

> *... We are passive observers of what is happening to our farm land ...* (Farmer-Respondent #7)

The agricultural researchers, extension agents, and concerned offices are not controlled by the local communities. They did not ask local farmers anything while they are developing computer or mobile based applications. However, they asked and forced them to use such applications and different agricultural knowledge and technology. In general, such structure in development initiatives needs to be revised in order to participating farmers in the development efforts. Their participations are critical to provide recommendations according to their context of problems. As one of the extension agents reported:

> *Farmers usually lack trust for various development efforts conducted on their farm land since they are not actively participating in the planning of such endeavors.* (Extension-Agent-Respondent #6)

The participation of local communities in decision making is not yet well developed in various efforts done in agriculture. Additionally, researchers from top policy makers down to the extension workers and to farmers at the end, who are suggesting scientific knowledge and technology, whereby they did not fully recognize IK and practice of local farmers. As a result, farmers lack trust to implement the new knowledge and technology on their farm land. Therefore, the integration of IK with the scientific knowledge in the development of KMS is yet the top concern of research and development efforts in order to re-address problems of local farmers in a country. Despite the fact that the EthioSIS is relying purely on scientific knowledge, IK hosted by local farmers are also critical for soil fertility management and conservation and other agricultural activities.

Table 5-6 Challenges of Knowledge Integration

Knowledge Integration	**Informant**	**Sample Interview Logs**	**Indicators**
Challenges to share and integrate knowledge systems	IS-Developer-Respondent #5 Agricultural-Researcher-Respondent #4	*… we are not aware about IK hosted by local farmers …* *Scientific point of view of researchers overlooked the farmers' point of view in terms of agricultural productivity and sustainability.*	• The result of ignorance • No comprehensive guideline • Lack of trust • Lack of resources • Lack of awareness • Knowledge and skill gap • Technological limitations

Source: *Author own compilation based on the analysis of the data.*

In sum, the main challenges for the integration of IK and scientific knowledge in agricultural development such as KMS development is ignorance of IK. As such, a scientific point of view in maintaining, for example soil fertility management and conservation can only partially reflect the farmers' point of view in terms of agricultural sustainability. Consequently, knowledge boundary between various participants of CoPs: agricultural experts, extension agents, rural communities, and KMS developers is the main challenge for sharing and integration of knowledge in KMS development. This knowledge boundary across different CoPs can be seen as a challenge and a solution for integration of the two broad knowledge types: IK and scientific knowledge in concert with case background (i.e., the EthioSIS). Raising awareness and knowledge and skill development on how to participate the local farmers and incorporation of local farmers' IK are critical to close knowledge boundary, thereby integrate scientific and IK in agricultural KMS development (see also Table 5-6).

5.5 Extension Agent as a Knowledge Broker

The EthioSIS services are aligned with the country agricultural extension system. The agricultural extension system in Ethiopia follows Farmers Training Center (FTC)-based extension approach. FTCs are positioned to transfer improved agricultural technologies and knowledge, skill development, and for the provision of other institutional services to local farmers in order to support smallholder farmers in taking vital decisions for increasing production. Each FTC is staffed with three extension personnel with a range of different knowledge and technical skills (i.e., natural resource management, animal science, and plant science). According to the data analysis findings from informants' interviews, participants' observations, and document analysis from ATA and MoARD, the FTC provides a wide range services, among others:

- Farmer training and extension services on improved farming techniques by various ways such as training, exhibits, demonstration farms, and farmer-to-farmer extension;
- Transferring agricultural knowledge and technologies to local farmers from research;
- Market-oriented information and advisory services for farmers;
- Meeting and communication facilities;
- Developing and maintaining relationships; and
- Conducting assessments of agricultural knowledge and technologies.

FTC at each rural kebele is linked to zonal and regional level agricultural research centers in Ethiopia. Extension agents are located in each rural kebele and at zonal and regional level agricultural offices to facilitate agricultural knowledge and technology exchange. These extension agents operate at two different levels. There are extension agents at rural district/kebele level called development agents, who are directly work with farmers at their respective areas and responsible for managing the function of FTC. These agents work with the support of agricultural bureaus at zonal and regional level and are key agents in the administrative structure for applying agricultural extension services throughout the country. The second type of extension agents are extension workers in each woredas, zonal, and regional agriculture bureaus, who are responsible for providing technical support and training to respective development agents. In general, extension workers and development agents are facilitating and improving the agricultural knowledge and technology transfer to local farmers from research. This study is aimed at understanding of the roles and practices of these extension agents as knowledge brokers in agricultural system development and use for knowledge sharing and integration in agriculture. Accordingly, this study is resulted with five themes or concepts of the roles and practices of extension agents as knowledge brokers for bidirectional knowledge exchanging between the scientific communities and local farmers' communities as discussed in the following sections.

5.5.1 In-betweenness of Extension Agents

Analysis of the data from the informants' interviews and participants' observations indicated that extension agents are positioned between agricultural researchers and technologists with local farmers. This enables them to facilitate the knowledge exchange between agricultural researchers and technologists with local farmers. One of the extension agents described the knowledge sharing process as follows:

> *Agricultural researchers and experts from research centers and Universities are the source of new knowledge and technology of agriculture. Guidelines and training documents are prepared and sent to extension workers, who work together with agricultural researchers. Then, extension workers at woreda or zonal or regional levels give training to the development agents. Then, development agents train, consult, demonstrate, and work with local farmers in their respective areas.* (Extension-Agent-Respondent #3)

Extension agent in the Ethiopian agricultural extension system as a knowledge broker positioned exactly in-between different social groups to transfer knowledge and technology. Development agents at kebele level with other extension workers at woreda and zonal level are positioned to transfer technology and knowledge from research and participate in the practice of local community. Extension agents are learning about knowledge and technology from research and technologists through training, demonstration, and documents. Then, they teach and demonstrate local farmers on how the new knowledge and technology is implemented and work with them at their duty district area. Additionally, agents also guide and supervise local farmers when they apply the new knowledge and technology in their agricultural practices. Another extension agent explains his role as:

> *I work closely with farmers and observe the practices of local farmers for assessing the new knowledge and technology.* (Extension-Agent-Respondent #3)

One of the agricultural researcher informants also added up that:

> *Extension agents transfer scientific knowledge and technology to the farmers and they also provide the farmers' traditional knowledge in their woreda for research purpose to researchers. They learn the work practice of farmers in the farming area through observing and discussing with local farmers.* (Agricultural-Researcher-Respondent #7)

> *There are experts trained in agricultural extension and rural development at regional, zonal and woreda level offices who are responsible to train and demonstrate knowledge and technologies from research institutes to development agents. Development agents at the rural districts train farmers to transfer this new knowledge and collect feedback from the farmers and transfer back to extension workers at woreda and zonal levels.* (Participants' observations)

Extension agents positioned centrally not only to transfer knowledge to farmers but also to assess the ongoing implementation of new knowledge and technology. For this purpose, agents collect feedback from farmers and reflect the feedback to the research. Additionally, agents collect IK and practices of farmers for research purpose and system development both to the agricultural researcher and technologists. Extension agents are, therefore positioned in-between or intermediary position to bridge gaps between farmers and research through exchanging knowledge. Additionally, agents are go-between technologists and farmers for various activities in agricultural KMS development process and use. When the system developers collect requirements and expectations from farmers for the system development, they reach to the end users via extension agents. An agricultural researcher informant also added up that:

> *We usually sitting together and discuss with extension agents and sometimes with rural farmer community representatives, when we want to plan and implement*

different community development programs at local level. (Agricultural-Researcher-Respondent #6)

Extension agents provide information for technologists about the different aspects in their district including: resources, social settings, economic features, knowledge and practices of farmers in their mandate areas since they closely work with farmers in various aspects. Furthermore, provision of technology and training are given to relevant stakeholders through following the top-down structure of the extension system until it reaches to local farmers. One of the IS developer informants commented that:

> *Extension agents need to be aligned with the IS units in relevant organizations such as the ATA and the MoARD to transfer knowledge related to agricultural KMS to farmers.* (IS-Developer-Respondent #8)

Despite agents are positioned in-between research and local farmers, they transfer mainly knowledge and technology from research to farmers following the top-down hierarchical structure of the extension program. Agricultural extension service in Ethiopia is based on scientific principles of education and communication methodology. Thus, the hierarchical (top-down) of the extension system in Ethiopia does little to encourage and exploit the inherent resourcefulness of extension agents as knowledge brokers who work closely with local farmers to transfer indigenous knowledge and practices. One of the farmer informants commented that:

> *… Extension agents sit with us and teach us but they do not want to lessen us …* (Farmer-Respondent #3).

Local farmers need to be able to get involved in action plan, choice, implementation, and decision making in community development extension programs implement in their respective areas. However, the roles of extension agents in this regard are silent. As a result, local farmers in Ethiopia are currently in need of voice demand and want to play in developing extension's priorities and evaluating its outcome. As a result, they need empowerment in general for agricultural productivity. Finally, one of the IS developers suggested that:

> *Extension agents should place themselves by listening the voice of all relevant stakeholders in agricultural KM activities and KMS development. As a result, they can*

understand different perspectives held by relevant stakeholders. (IS-Developer-Respondent #3)

Table 5-7 The In-betweenness Role of Extension Agents

Role of Agents	Informant	Sample Interview Logs	Indicators
In-betweenness	Extension-Agent-Respondent #3	*… Extension workers at regional and zonal level work together with agricultural researchers. … Extension agents are also there to collect feedback and assess the implementation of new knowledge and technology by the farmers …*	• Working closely • Sitting together • Learn work practice • Listening the voice of all • Understand different perspectives • Feedback • Impact assessment • Uncover needs of relevant CoPs • Align their position with the IS units
	Agricultural-Researcher-Respondent #7	*… Extension agents learn the work practice of farmers in the area …*	
	Farmer-Respondent #3	*… The role of extension agent is to teach us but they do not want to listen us and we wonder if they closely work with us …*	
	IS-Developer-Respondent #8	*Extension agents need to be align with the IS units in relevant organizations to transfer knowledge related to agricultural KMS to farmers.*	
	IS-Developer-Respondent #3	*Extension agents should place themselves to lessen the voice of all relevant stakeholders in agricultural KMS development. Accordingly, they can understand different perspectives held by relevant stakeholders.*	

Source: *Author own compilation based on the analysis of in-depth interviews and observations*

Extension agents need to go-between participants from all relevant CoPs and take intermediary position to bridge gaps and connect previously separated different communities of practice through exchanging knowledge. In sum, extension agents in the Ethiopian agricultural extension system are not only positioned as knowledge brokers to provide agricultural knowledge and technology transfer to local farmer from researcher top-down manner in which the current system is operating but also to exchange knowledge and technology among participants including system developers. Additionally, extension agents as knowledge brokers positioned themselves in ways that enabled them not only for sharing knowledge and technology from research to local farmers but also to work closely with local farmers to participate them in KMS development. Simultaneously, the indigenous knowledge and practices of local farmers can be shared and integrated in KMS development process. It is, therefore vital for extension agents as knowledge brokers to work closely with different knowledge source of CoPs to understand the perspectives held by different CoPs working for common interest (i.e., agricultural productivity) to share and integrate different knowledge in agricultural KMS development. Table 5-7 provides sample interview logs and key indicators regarding to the in-betweenness role of extension agents.

5.5.2 Enhance Participation

An extension agent as a knowledge broker is vital in blending different separate CoPs in agriculture through crossing the knowledge boundaries among them, thereby enhances the participation of local farmers and other stakeholders in various agricultural development including the KMS. One of the extension agents reported that:

> *Whenever, there is new agricultural knowledge and technological improvement, first we create awareness to them about the problems and opportunities on their farming land in order to transfer knowledge and technology to farmers.* (Extension-Agent-Respondent #11)

The awareness creation on new agricultural technology and knowledge strengthens the participation of local community in agricultural development. Additionally, as one of the extension agents stated:

> *When we transfer knowledge and technology to local context we tried to understand farmers' ideas and work with them through participating them.* (Extension-Agent-Respondent #12)

Agents further assist farmers through providing and facilitating technical skills, providing available resources, consulting, working closely with local farmers in their respective rural kebele, translating knowledge and technology to their context, and assessing the ongoing implementation of new knowledge and technology. The task requires understanding of their practices through participating them in various development efforts. Through all these activities, interaction between extension agents with local farmers has been seen. Extension agents as knowledge brokers need to cross the boundaries of the local farmers to encourage them in order to participate and interact with them. Moreover, ability to listen farmers, giving value to farmers' insights, and encouraging their decision making are critical to strengthen the participation of local farmers. One of the local farmers stated that:

> *Whenever we face any problem regarding our soil fertility treatment practices, we contact extension agents at FTC located at our own kebele and get appropriate advice from them.* (Farmer-Respondent #10)

Local farmers who frequently contact with extension agents were able to get agricultural knowledge and technology timely and being able to appraise their knowledge and skill through demonstration.

Agricultural researchers and system developers provide training and guidelines to extension agents to share new knowledge and technology to local farmers. But extension agents are not frequently communicating and working closely with researchers or system developers. As a result, in the Ethiopian agricultural extension systems, different units or groups of people such as agricultural system developers, researchers, and local farmers worked as independent organization or function. Moreover, as per the researcher observation:

> *Relevant CoPs are located in different organization like agricultural system developers at ATA and agricultural researchers at ATA, MoARD and extension agents at kebele and woreda.* (participants' observations)

As such, there is knowledge boundary among relevant CoPs having common interest and crossing the knowledge boundary by extension agents between different local CoPs, researchers, and system developers is very limited. However, extension agents have a great potential to encourage members from different CoPs if they are allowed to crosses different units or CoPs.

In the past, extension system in the country was focus on agricultural technology transfer. However, the current extension approach gives emphasis to the human resource development (organization, mobilization, and empowerment) besides to the technological transfer to enhance the interaction between relevant stakeholders. The human resource development involves the rural communities and their social system aiming at improving leadership capacity, institution, and mobilization and organization of local farmers for the empowerment of farmers. The extension system currently gives equal emphasis to human resource development and promotion of agricultural technologies through integration of different units by crossing various units. Thus, as one of the agricultural researchers put it:

> *Extension agents as knowledge brokers need to work with different CoPs such as local farmers, agricultural researchers, and agricultural KMS developers through crossing various units or functions in different organizations such as MoARD and ATA and the informal local communities.* (Agricultural-Researcher-Respondent #3)

IS developers and agricultural researchers indicated that when they want to contact local farmers for different activities, they make use of extension agents as intermediaries. The researcher asked "*why*?" and many of the informants revealed that:

> *Extension agents frequently contact and work closely with local farmers in their district, therefore extension agents know about different aspects of the local farmers such as how to communicate, their language, culture, and other issues than others.*

Consequently, extension agents can easily interact with local farmers. Additionally, system developers and agricultural researchers also contact extension agents in the development of agricultural KMS to gather the system requirement. For example, during the development of the EthioSIS, system developers and agricultural researchers work closely with the extension agents during the data collection phase of the process. These extension agents should work closely not only with the local farmers but also with the technologists and researchers in order to understand the knowledge and technology they transfer to local farmers. As discussed in the previous sections, farmers have ample indigenous knowledge and experience about their farm land and its different features and stayed in the area for long period of time. In concert with this, IS developers and agricultural researchers have been asked about why you fail to ask directly local farmers rather than extension agents and incorporate their indigenous knowledge in system. Majority of the informants reported that it is easy to access extension agents at farmers training centers in each kebele throughout the country and we can easily communicate with extension agents during data collection, so we prefer extension agents than local farmers.

Farmers are also asked about their interaction in particular about their participation in KM practice and the development of agricultural KMSs like the EthioSIS directly or through intermediaries. Many of the respondents stated that no one asked us about our requirements. One of the farmers said that:

> *Many times they bring us different technologies but we afraid to use them. Why? This is because they never participate us in our village in the development of systems.* (Farmer-Respondent #2)

One of the extension agent informants strengthen the saying of this farmer as:

> *When we tried to transfer technologies like mobile-based system, many of the farmers usually resist attending the training and demonstration. Few who may attend in the training, again will not use it for decision making.* (Extension-Agent-Respondent #5)

Extension agents usually cross the boundary of the local community to transfer knowledge and technology to them from research. However, this role of extension agents is very limited in involving the local farmers in KMS development. One the agricultural researchers commented that:

> *… Extension agents need to develop the ability to establish credibility and trust with different CoPs for knowledge sharing and integration.* (Agricultural-Researcher-Respondent #2)

Extension agents as knowledge brokers should facilitate participation and communication among relevant participants or CoPs. For this purpose, they need to have special qualities to enable them to bypass several CoPs and should understand the culture and perspectives of different CoPs in order to enhance knowledge sharing and integration. Extension agents are also required to develop credibility and trust by different CoPs in order to foster their role of crossing the knowledge boundary.

Participation of local farmers and involvement of their indigenous knowledge in research and development endeavor is very limited, almost none. Extension agents as knowledge brokers can support the interaction of local farmers and scientific CoPs in different agricultural efforts through crossing different units. Extension agents need to work with researchers and technologist not only to transfer knowledge from research to local farmers but also to reflect the farmers' views to them to incorporate their need in the system. As a result, the sharing and integration of indigenous and scientific knowledge can be enhanced in the development of agricultural KMS (see also Table 5-8).

Table 5-8 The Enhancing Participation Roles of Extension Agents

The Role of Extension Agents	**Informant**	**Sample Interview Logs**	**Indicators**
Enhance participation	Extension-Agent-Respondent #9 Extension-Agent-Respondent #4 Agricultural-Researcher-Respondent #3	*… Through various activities for knowledge and technology transfer high interaction between extension agents with local farmers have seen …* *… Local farmers are encouraged to participate in the training and demonstration for effective knowledge and technology transfer …* *Extension agents need to work with different CoPs crossing various units.*	• Crossing boundaries • Encourage interaction • Crossing various units • Mobilize across all participants • Involve the interests of all stakeholders • Understanding of the culture of different CoPs • Ability to establish credibility.

Source: *Author own compilation based on the analysis of in-depth interviews*

5.5.3 Network Formation

Extension agents assist local farmers through face-to-face contact and communicate on average 4-5 days in a month during training and demonstration at FTC and farming site visits which limit the exchange of knowledge among them and with other CoPs. In this regard, information from in-depth interviews indicated the role of extension agents in developing and maintaining relationships among farmers and with other CoPs as a community of interest through building of a network. It is a crucial role in the agricultural knowledge and technology development and exchange. The interviewed agricultural researchers and experts indicated that extension agents identify and bring people together when some agricultural development is planned and implemented. As one of the agricultural researchers described:

> *Extension agents notify and bring participants from different social groups in the Ethiopian extension system for agricultural development.* (Agricultural-Researcher-Respondent #4)

During the planning and implementation of agricultural development, different stakeholders meet together following the hierarchical structure of the country extension system. The process of interaction among relevant stakeholders is facilitated by extension agents. As such, extension agents foster the formal networks of stakeholders and among themselves. As indicated by one of the extension agents:

> *In most cases, the role of extension agents in extension services is viewed solely as a provider of input delivery service and knowledge and technology transfer, but the extension agents have a knowledge broker role to facilitate the informal networks of local farmers and other formal communities.* (Extension-Agent-Respondent #3)

Thus, extension agents as knowledge brokers have a critical role in developing and maintaining strong relationships within local CoPs and different CoPs having common interest. Extension agents can also align the formal and the informal groups having common interest such as KMS development.

The extension agents in the extension program have focused on individuals in connecting the research with the practice of local farmers. Thus, agents are expected to deal with all aspects of knowledge and technology transfer and connecting all relevant stakeholders. However, as indicated by majority of the respondents, brokering involves collective process unfolding at team level. As such, the network of the extension agents is also highly required for their activities of knowledge brokering. As one of the extension agent informants reported:

> *We usually discuss about different agricultural practices conducted in our respective kebele where we work when we meet at zonal, regional or national level during training. Then, we communicate and share knowledge and experience at our work place with other colleagues through phone.* (Extension-Agent-Respondent #7)

However, in the Ethiopian extension system, networking as a role of knowledge brokering is not emphasized and supported, as majority of respondents reported. As one of the extension agent respondents commented:

> *The link among different participants is important to enhance knowledge and technology transfer. This role can be strengthening if there is modern technology supporting communication and collaboration available for establishing networking among extension agents and other relevant participants.* (Extension-Agent-Respondent #2)

As such, analysis of the interviews revealed that absence of an extension team is one of major problems of the extension program in Ethiopia, which hinders effective transfer of knowledge and technologies. Due to this, respondents suggested that in order to maximize the impact of knowledge and technology transfer from research to the practice of farming in the country, extension agents should be deployed in the system as a team. The analysis also suggested the importance of supporting the extension agents as knowledge brokers' communities of practice and creating zonal, regional, or national forums for agents occupying intermediary roles can help alleviate their sense of isolation and enhance knowledge sharing among them. For this purpose, they need communication technologies for their networking since agents are geographical distributed in different locations throughout the country. Such technologies also enable them to foster networks with other social groups.

Enhancing informal networking of farmers at community level is vital for knowledge and technology sharing among themselves and from research and development institutes. In Ethiopia, there are several types of informal groups in which people gathered together at the community level, for example funeral groups ('*Idir*' or '*Senbete'*), work or labor sharing groups ('J*igie*'), and savings and loan–type groups ('*Iquob*'). These groups create important entry point for and promote linkages to outside actors and serve as a mechanism for transferring knowledge and technology. Extension agents often closely work with such informal networks to strengthen the link between individuals in a CoP and foster link between different CoPs (i.e., researchers and system developers) with local communities.

Table 5-9 The Networking Role of Extension Agents as Knowledge Brokers

The Role of Extension Agents	**Informant**	**Sample Interview Logs**	**Indicators**
Network formation	Agricultural-Researcher-Respondent #7 Extension-Agent-Respondent #7	*… They identify and bring people together when some development endeavor is planned and implemented.* *… We share knowledge and experience and form network through exchanging phone number …*	• Bring people together • Form network • Connect people • Foster informal groups • Align the formal and the informal groups

***Source**: Author own compilation based on the analysis of in-depth interviews*

In conclusion, the role of extension agents as knowledge brokers is critical to create network among different groups of participants and strengthen the link within each CoPs. Networking among participants from heterogeneous CoPs can enable to incorporate collective actions. Trainings, field observation, and demonstration given to local farmers at FTCs involve in the extension program need to be organized in better planned and coordinated way with informal organizations, thereby, promote their network and foster knowledge and technology sharing. Examples of sample interview logs and key indicators for the networking role of extension agents are presented in Table 5-9.

5.5.4 Knowledge and Technology Translation

There is a need of translating agricultural knowledge and technology from its original form into a form that is more suitable for the users' roles and practices (Tubigi, Alshawi, & Alalwany, 2013). It is crucial to simplify the knowledge and technology in order to suit them to the users' requirements and their own knowledge and experience base. One of the extension agents described his roles and practices as a knowledge broker as follows:

> *I gather relevant knowledge and information from various sources in particular from research communities. Then, I will assess the quality, relevance, significance, and applicability of the knowledge and information to the context of the problem or situation of the farming land in which I am working on. I then transfer the meaning the knowledge and information to the local farmers so as to solve their problem situation.* (Extension-Agent-Respondent #12)

As such, one of the roles and practices of extension agents is to gather evidences from research to advice and solve the farmers' problems. Agents assess the evidence gathered for its quality, significance, and relevance to the farmers' context of problem and transfer the meanings of the information, knowledge, and technology to a given situation to solve the farmers' problems. Knowledge in scientific communities (i.e., agricultural researchers and system developers) and local communities (i.e., local farmers) are based on different frames. Thus, extension agents as knowledge brokers translate knowledge and technology from research into different local contexts and vice versa. There are also cases in which stakeholders with different background requires explanation from another, for example, in this research context where there are different stakeholders with different specializations having their own knowledge and experience. Then, an extension agent as a broker can translate, interpret, and explain from one to another. One of the extension agents explained the role of brokering as a translator as:

> *We explain and translate knowledge from research to farmers with their own language and ways of expression and continuously advise them during the implementation. In addition, when agricultural researchers and system developers want to gather data from local farmers we assist them through translating and explaining the farmers' views.* (Extension-Agent-Respondent #10, participants' observations)

Extension agents in the extension system as knowledge brokers act as translators, in particular framing elements of the world view of scientific research in terms of the perspective of local communities. Primarily, they translate the knowledge and technology from research and development experts into another language and useable formats for local communities in which the local farmers are using. For example, researchers produce the knowledge and technology employing English language. Additionally, training manuals, guidelines and other documents are usually prepared using English language. Then, agents translate it into the local language (i.e., Amharic language in this research case area) of farmers. Additionally, agents support the local farmers to transform the knowledge and technology into action. They make use of the farmers' own terms to explain the procedure of transforming agricultural knowledge and technology into practice. One of the agricultural experts described this role as:

> *In Ethiopia, there are about 80 different languages. Even within the same community having the same language, there are different local ways of expression, jargon, and terminology. Primarily, extension agents must be able to communicate with the local farmers in their local language and understand the local context. Additionally, it is very important to translate appropriately when knowledge and technology is transferred to local farmers. The same is true, when different agricultural requirements gathered from local communities to technologists and agricultural researchers.* (Agricultural-Researcher-Respondent #3)

For this purpose, communication skill with multilingual (i.e., being able to communicate with multiple CoPs having different language and ways of communication) is highly required for extension agent as a broker to understand and transfer knowledge across different communities of practices. Agents also explain how new knowledge and technology are adopted and implemented in local farming practices. For this purpose, they understand the local farming context to interpret and apply new knowledge and technology into the local context. This role of agents is not only to translate knowledge from research to farmers but also the vice versa. Since agents work closely with the local farmers, researchers and technologist collect data from farmers via agents. Agents translate and interpret the farmers' indigenous knowledge and practices to the research.

This role is especially critical in sharing and integrating knowledge from local rural with scientific communities where there are different knowledge and languages between them but all having common interest working for agricultural productivity. However, one of the extension agents stated that:

> *We face sometimes to understand the needs of farmers since we fail to communicate smoothly due to difference in language, even in the same language there are differences in ways of expression in local communities.* (Extension-Agent-Respondent #6)

Additionally, training manual, guidelines and other documents are usually prepared using English language. This is difficult for extension agents to understand, translate, interpret, explain, and transfer to local communities. Extension agents collect information from local communities for research purpose, and researchers analyze in terms of the local context. Then, extension agents translate and interpret these findings into locally relevant action messages through advices and assist the local farmers in decision making. IS respondents also indicated that whenever they gather requirements from local farmers (in fact it is not common to gather requirement directly from local farmers in system development as discussed in the previous sections), extension agents greatly help them in translating, interpreting, and explaining what farmers said. One of the IS developer informants added up that:

> *When we gather requirement from local farmers throughout the country in the development of agricultural KMS, extension agents positioned in kebele can help us in translating, interpreting, and explaining what farmers meant for.* (IS-Developer-Respondent #5)

IS informants also reported that this role of knowledge brokering is not only important requirement gathering from local farmers but also from agricultural experts. As one of the IS developer informants indicated:

> *We face of problem in understanding even when we gather requirement from agricultural experts. This is because these experts use a lot of agricultural acronyms, jargons, and terminologies and explain things from an agricultural perspective.* (IS-Developer-Respondent #8)

Table 5-10 The Knowledge and Technology Translation Roles

Role of Extension Agents	Informant	Sample Interview Logs	Indicators
Knowledge and technology translation	Extension-Agent-Respondent #10	*When we give advisory service to the local farmers through knowledge and technology transfer, farmers usually request us explanation. … We interpret and explain to them.*	• Be able to communicate • Explain • Translate • Advise • Interpret • Applying knowledge • Transform
	Extension-Agent-Respondent #1	*… We translate the knowledge and technology from research to farmers based on their context of problem ...*	
	Agricultural-Researcher-Respondent #3	*… Extension agents must be able to communicate with the local farmers in their local language and understand the local context …*	
	Extension-Agent-Respondent #4	*We are not only there to translate and interpret knowledge to farmers but also, we ensure whether they make sense it or not through observing and helping while they apply the knowledge and technology.*	

Source*: Author own compilation based on the analysis of in-depth interviews.*

Agricultural experts have their own acronyms, jargons, and terminologies in different fields of specializations in agriculture. As such, extension agents can also enhance communication between agricultural researchers and IS developers in translating, interpreting, and explaining as knowledge brokers. Consequently, extension agents should support farmers while local farmers apply the knowledge and technology from research. As one of the extension agent informants reported:

> *We are not only there to translate knowledge to farmers but also, we ensure whether they make sense it or not through observing and helping while they apply the knowledge and technology.* (Extension-Agent-Respondent #4)

In closing, translation and interpretation of knowledge and technology roles by extension agents are not only important to effectively communicate and exchange knowledge with local farmers for knowledge and technology transfer but also with agricultural experts and IS developers. Consequently, knowledge translation occurs between groups having different knowledge and social context. Table 5-10 presents sample interview logs and key indicators for the knowledge and technology translation roles of extension agents.

5.5.5 Coordinate Collaboration and Negotiation

Extension agents as knowledge brokers are representationally referred to as a bridge between relevant social groups. Agents coordinate the collaboration and negotiation among researchers and systems developers with local farmers through exchanging knowledge and technology. One of the interviewed agricultural researchers reported that:

> *For any agricultural development, all relevant participants from different CoPs should meet together and discuss with the problem and the solution. In this regard, extension agents are responsible for coordinating the collaboration and negotiation among participants.* (Agricultural-Researcher-Respondent #7)

Another agricultural researcher informant said that:

> *Extension agents can facilitate two-way communication and create room for multiple voices.* (Agricultural-Researcher-Respondent #8)

Agricultural development is complex problem that requires collaboration and negotiation among various dynamic social groups for developing solutions. Extension agents provide an environment conducive for learning and coordinate the collaboration and negotiation among relevant participants from researchers, technologists, and local farmers' groups. They facilitate who and how people work together and negotiate for problem solving, encourage people to contribute knowledge and reflect on others idea, and assist individuals and groups to engage them in a dialogue during problem solving process. In particular, extension agent roles and practices of collaboration and negotiation can eliminate farmer group problem of participation through enhancing a two-way communication with other scientific CoPs.

An agricultural researcher commented that:

> *Extension agents can greatly contribute for effective collaboration and negotiation so as to reach an agreement for development effort among relevant stakeholders especially with the local farmers to bring consensual problem solving.* (Agricultural-Researcher-Respondent #3)

In order to perform any community level development effort, there is a need to create a community having common interest focused understanding through collaborating and negotiating with all relevant owners of the problem. There are several social groups in agriculture who closely work together on collaborative tasks and extension agents mediate interaction among them. Extension agents first need to focus on problems of local communities and clearly discuss on problems as well as the solutions.

In the current extension system, technological packages are prepared and transferred to farmers without the consent of them rather relying on the available new improved technologies. Thus, development effort is not based on the needs and expectations of the end users, farmers. This is due to top-down structure of the Ethiopian extension system. Extension agents usually enhance one-way communication from research to local farmers. An agricultural researcher commented that:

> *All owners of the problem should communicate and collaborate for different agricultural activities implemented in a country. If they communicate each other they can bring shared understanding especially with local farmers. As a result, all relevant stakeholders can reach an agreement for development effort.* (Agricultural-Researcher-Respondent #3)

Relevant social groups with common interest may collaborate on various agricultural activities through the extension agents' brokering role thereby develop a repertoire of shared meaning or understanding, common language and practices. Through these processes of interaction, knowledge can be shared among relevant social groups and new knowledge can also be created through integration of pieces of knowledge from participants. Analysis of interviews indicated that researchers provide research findings and technology, then agents train and demonstrate accordingly to local farmers. One of the farmers also point out that:

> *… Agents come to us only to tell us about new technologies and knowledge and forced us to use and implement …* (Farmer-Respondent #4)

However, extension agents need to work closely work with local farmers, encourage them to reflect their view, discuss and negotiate on the various endeavors on agriculture. Then extension agents provide the local farmers' views and requirements to the researchers so as to incorporate their need in the development efforts. One of the farmers put it as:

> *Development agents brought us new knowledge and technology on different agricultural aspects from government and NGOs. They directly forced us to put it into effect without our interest during our farming practice. Many of them may be important for our agricultural productivity. However, since they never discuss about the program in advance particularly on what is being addressed, many of us refrain to implement. That is why many of extension programs implemented so far fed up quickly.* (Farmer-Respondent #8)

Failure to involve local farmers in development efforts, lead usually unsustainability of the endeavors as one of the extension agents put it:

> *… The whole thing ends as a fashion if farmers are not participated …* (Extension-Agent-Respondent #8)

Extension agent roles and practices of collaboration and negotiation can eliminate the farmer group problem of participation through enhancing two-way communication with scientific social groups. The current structure of an agricultural extension system, that emphases one-way communication, is not appropriate to participating local communities and involves their indigenous knowledge in the development effort. Thus, there is a need to create a learning environment to provide open dialogue between researchers, technologists, and local farmers by extension agents instead of unidirectional knowledge and technology transfer. As one of the extension agent informants commented:

We are told from research about new technologies and supply to directly transfer to farmers. As a result, they indicated that farmers usually resist for accepting them. We usually report the problem to the top-level officials and we suggest we need to first communicate, discuss, and negotiate with local farmers for the implementation of solutions to their problems. (Extension-Agent-Respondent #5)

As indicated by researchers in order to frequently collaborate, discuss and negotiate with local farmers when development initiatives are planned, extension agents need to closely work and communicate with farmers and understand their agricultural or farming practice in deep. Development efforts should always begin with the problem of communities and their consent is also important for the solution. IS developers are also asked about whether they develop the system based on the users, farmers need or not. Majority of the informants responded that "*no*". This is attributed to various reasons, among others there is enough budgets and human experts to incorporate the need of the farmers throughout the country, difficult to gather and negotiate with them, and we can get summarized information about kebele from extension agents who work there with local farmers.

Table 5-11 The Negotiation Role of Extension Agents as Knowledge Brokers

The Role of Extension Agents	Informant	Sample Interview Logs	Indicators
Collaboration and negotiation	Agricultural-Researcher-Respondent #8	*… Extension agents can facilitate two-way communication and create room for multiple voices…*	• Two-way communication • Common understanding • Collaboration • Agreement • Discussion • Informal groups • Negotiation
	Agricultural-Researcher-Respondent #4	*… there is a need to create common community focused understanding through negotiating with all relevant owners of the problem …*	
	Agricultural-Researcher-Respondent #7	*… participants should sit together and discuss with it and they need to reach an agreement …*	

Source*: Author own compilation based on the analysis of in-depth interviews*

Another IS developer respondent added that:

> *In order to participating the local farmers and incorporate their knowledge in KMS development process, negotiation with local farmers through intermediaries is critical in all phases of system development. For this purpose, procedures on how to deal with the local farmers are important in advance.* (IS-Developer-Respondent #2)

Extension agents as knowledge brokers need to discuss, enhance two-way communication between research communities and local farmers, and reach consensus with all relevant participant especially local farmers to reflect the voices of farmers. In particular, it is important to develop a detail understanding of the rural context among relevant social groups having common interest. Extension agents need to work, collaborate, and negotiate with all relevant CoPs in order to bring common understanding for their practice so as to integrate pieces of knowledge. As a result, local farmers can be empowered to participate and negotiate as of their interest in the development efforts; thereby they can share and integrate their indigenous knowledge with scientific knowledge and practice (refer also Table 5-11). In closing, Table 5-12 depicts the summary of the sub-themes or concepts emerged as the roles and practices of extension agents as knowledge brokers in systems development. In order to carry out these roles and the practices of knowledge brokering by the extension agents, concepts for the requirements of knowledge and skill are emerged from the data analysis as discussed in the following sections.

5.6 Skill and Knowledge Required by Extension Agents

Skill and knowledge are critically important for the roles and practices of knowledge brokering by extension agents to exchange agricultural knowledge and technology among relevant social groups in agriculture. According to the informants, so far many of the extension agents are certificate holders with 6-9 months training in agriculture. However, currently these extension agents are upgrading their education level to diploma, degree and masters, since many agricultural colleges and Universities are opened in the country. One of the extension agents said that:

> *We are expected to provide advisory service for all types of farmers (i.e., independent of their income, type of crop they produced, and other factors) in the kebele that we are assigned to work. We are trained as a specialist in one of the areas either natural resource management or plant science or animal science from the agricultural*

colleges and universities. However, we are expected to work as generalist to serve as natural resource management, plant science and animal science expert. As a result, we usually face difficulties in consulting farmers. (Extension-Agent-Respondent #4)

Table 5-12 The Generated Sub-Categories of the Roles of Knowledge Brokers

Unique Codes	**Sub-category**
• Closely working with IS professionals, researchers, and local farmers • Learning the work practices of all participants • Involve all voice demand especially the local farmers • Sitting together with relevant CoPs • Uncover needs of relevant CoPs • Align their position with the IS units • Understand the perspectives held by different CoPs	In-betweenness of extension agents
• Encourage participation • Encourage interaction • Mobilize across local farmers, researchers, and KMS developers • Involve the interests of all stakeholder considered in the process	Enhance participation
• Communicating knowledge and technology • Translation of knowledge and technology into practice • Interpretation of knowledge and technology into the local context of use • Explanation • Advise • Help people to make sense • Help people to apply knowledge into practice	Knowledge and technology translation
• Link local farmers with research • Align the formal and the informal groups of common interest • Connect people from different CoPs • Bridging people together • To help them to build relationship • Forming partnerships with other brokers • Encourage informal groups	Network formation
• Discuss • Dialog • Consensus • Persuade • Two-way interactions • Debate • Mutual appreciation • Efforts to understand each other • Shared understanding	Coordinate collaboration and negotiation

Source: *Author own compilation based on the analysis of the data gathered from the informants' interviews and participants' observations.*

In order to promote the roles and the practices of extension agents as knowledge brokers, they need to work on their specialty or intensive training is required for their tasks in other disciplines. In addition to their knowledge and skill gained from the college and Universities, extension agents are also provided different training when new knowledge and technology emerge on a regular basis from research and technologist group. As one the extension agents indicated:

> *We have been given various trainings and demonstration from different research and development organizations.* (Extension-Agent-Respondent #6)

Additionally, extension manuals and guidelines are also given to extension agents as an important knowledge sources for enhancing their advisory tasks. Moreover, as one of the extension agent informants commented:

> *Farmers need knowledge about marketing and management to sell their products in fair price and use the money appropriately for their lives.* (Extension-Agent-Respondent #8)

Therefore, agents also need to have knowledge of business and marketing to support smallholder farmers in this regard. In sum, extension agents need to have domain knowledge they transfer between research and local farmers. Extension agents are acquiring such knowledge and skill while they attend their formal education and when progressive trainings are given. In addition to such domain knowledge, extension agents further require knowledge and skill about brokering and KM for their roles and practices of knowledge brokering.

5.6.1 Brokering Skill and Knowledge

The research identified various skill and knowledge required by extension agents. Primarily, researcher rose that "do you have the skill to communicate with stakeholders especially the local farmers?" to the extension agents. Many of them responded "*yes*" and stated that since we grew up in the rural area we know how to communicate with the local farmers. We can easily communicate and understand their problem. One of the extension agent informants said that:

> *I tried to contact the local farmers frequently as possible and talking with them about their farming practice with their own language. Through, we share agricultural and*

market knowledge and provide appropriate agricultural technology. (Extension-Agent-Respondent #2)

I further asked extension agents that "*do you use their indigenous way of communication and terms*?". Many of them responded as "No", why? Even if we have rural background, we do not know communication style and indigenous terms used by the rural communities in each kebele especially the elders. But through time we tried to learn, understand and use them. A related problem with this is the high turnover of experienced extension agents. The analysis in general indicated that there is a gap in understanding or learning the practice of the local farmers by extension agents.

Local farmers have their own communication skill and IK of agricultural practice exercised for many years. One of the agricultural researchers also commented that:

... Extension agents need to have skill on how teach adults and communicate ... (Agricultural-Researcher-Respondent #5)

Moreover, extension agents need to develop excellent skill of oral and interpersonal communication to foster their role of knowledge transfer. Additionally, IS informants also commented that in the development of agricultural KMS, IS developers make use of extension agents as intermediaries to collect the requirement from local farmers and to train and transfer technology and knowledge. One of the IS developer respondents stated that:

We collect requirements from farmers through extension agents since these people work closely with local farmers. For this purpose, excellent skill of writing and oral communication skills is required by them to gather requirement and need from farmers and researchers for building rapport with target users and developing strong network link with them and among themselves. (IS-Developer-Respondent #4)

As such, extension agents as knowledge brokers need to have oral communication skill to effectively communicate with relevant stakeholders to transfer knowledge to local farmers from research and demonstrate and teach them. Since agents collect feedback from farmers about their practices and gather requirement when information system is developed, agents need writing skill to transfer such data to researcher and technologists. Additionally, agents need to develop strong interpersonal skills to transfer knowledge to users with wide range of ages including youngsters and elders.

One of the agricultural researchers commented that:

> *Extension agents are connecting members from various communities, mediate and coordinate the interactions among communities. Hence, they need to have skill to build network among participants and coordinate the communication and collaboration through considerable diplomacy among them since participants are from different social groups having their own experience and goals.* (Agricultural-Researcher-Respondent #8)

Another extension agent reported that:

> *... We translate and interpret technology from research into local context to support and solve local community problems ...* (Extension-Agent-Respondent #2)

In addition to the aforementioned skills of oral communication, writing, and interpersonal skill and knowledge about networking, coordinating, and negotiation are critical so as to foster knowledge sharing and integration. Knowledge brokers are also responsible for facilitating interaction between various groups or CoPs, crossing the boundary of different functions or groups, creating relationship within and among CoPs and translate and interpret knowledge and technology into different rural context. Thus, to effectively perform those roles, they need to have skill of mediation, leadership, negotiation, networking, interpersonal, and participants' management and influencing skills. Almost all informants firmly believe that these brokering skill and knowledge are crucial and need to be improved for knowledge and technology transfer and integration by extension agents. Finally, agricultural experts reported that now research and development are giving emphasis to this situation and need to be further strengthen.

5.6.2 Knowledge Management Skill and Knowledge

Extension agents as brokers are required to share and integrate multiplicity of knowledge among different participants. The volume of knowledge received and shared between different sources (i.e., agricultural researchers, KMS developers, and local communities) by extension agents are large. They also need to search and refer different materials such as literatures, guidelines, websites, and manuals for their carrier. One of the IS developers commented that:

> *Large volume of information and knowledge are received by extension agents from different sources; then they need to have knowledge about knowledge management activities such as storing, retrieving, searching, and sharing.* (IS-Developer-Respondent #3)

As such, primarily an ability to find relevant information and knowledge from different sources is critical. Too much volume of knowledge is received, integrated, and shared by knowledge brokers. As one of the extension agents commented:

> *We face difficulty to handle documents received from various sources so as to apply to the context in which we are working on.* (Extension-Agent-Respondent #7)

Once information and knowledge are gathered, knowledge brokers require knowledge and skill to access, select, assess, and apply the knowledge to a given context. For this purpose, brokers need to acquire and develop skill of knowledge management activities including knowledge capturing, storing/retrieving, sharing, and application to solve a problem. Moreover, as reported by one of the extension agents:

> *There are various ICT tools from different organizations deployed to support us and local farmers. However, they are difficult for us to use them for managing documents and knowledge.* (Extension-Agent-Respondent #4)

Another IS developer informant mentioned that:

> *Extension agents need to be aware and have knowledge about ICT tools for supporting their KM activities.* (IS-Developer-Respondent #4)

In order to support extension agents through ICT tools, intensive training and awareness on how to apply technologies for KM activities are required not only for extension agents but also to researchers and local farmers. Thus, extension agents need to know about knowledge management activities and ICT tools, which are vital for effective and efficient knowledge brokering role. Knowledge about document and content management is further required by agents. Additionally, they need to develop the ability to synthesize knowledge from different sources and translate and interpret into the local context of use.

Table 5-13 Skill and Knowledge required by Knowledge Broker

Skill and Knowledge	Informant	Sample Interview Logs	Indicators
Knowledge Brokering	Agricultural-Researcher-Respondent #7	*Extension agents facilitate communication and collaboration among relevant participants or CoPs.*	• Teaching skills • Interpersonal skill • Facilitation skills • Communication skills • Mediation skills • Negotiation skills • Networking skills • Writing skills • Participants management • Leadership skills • Influencing skills • Mentoring skills
	IS-Developer-Respondent #4	*… Excellent skill of writing, oral communication skills, and strong interpersonal skills are required by them to gather requirement and need from farmers and researchers for building rapport with target users.*	
	Agricultural-Researcher-Respondent #2	*… help to build network among relevant social groups.*	
	Extension-Agent-Respondent #5	*… be able to negotiate with different stakeholders…*	
Knowledge Management	IS-Developer-Respondent #3	*… They need to have knowledge about knowledge management activities such as storing, retrieving, searching, and sharing.*	• Information and knowledge gathering • Searching knowledge • Storing knowledge • Retrieving knowledge • Synthesizing knowledge • Document and content management • ICT tools skills
	IS-Developer-Respondent #4	*… They need to have knowledge about ICT tools for KM activities.*	

Source*: Author own compilation based on the analysis of the data.*

In closing, extension agents should possess knowledge from different sources: researchers, local farmers, and IS developers translate into different local context to assist local farmers.

For this purpose, extension agents as brokers require interdisciplinary skill and knowledge broadly brokering and knowledge management. Table 5-13 indicates the summary of knowledge and skill required by extension agents for their successful realization of knowledge brokering as per the respondents' response from different subjects.

5.7 Boundary Objects for Knowledge Sharing and Integration

Respondents from all subjects reported a wide range of boundary objects related to agricultural KM activities and KMS development process among others the EthioSIS, mapping, prototype, audio visual, GIS, GPS, guidelines, diagram, procedures, system documentation, telephone line, e-mail, team meeting, farming material, report printout, publication, newsletter, bulletin, user training manuals, websites, oral mapping, and ICT Kiosks. Members in each CoPs have their own boundary objects for their interaction as shown in Figure 5-2. It (Figures A, B, C, and D) is the picture illustrating boundary objects possessed by all relevant social groups. Some of the boundary objects are shared and used by participants coming from different CoPs such as guidelines, websites, and the EthioSIS.

System developer informants reported different boundary objects:

> *We are implementing various modern technologies to support farmers in sharing knowledge including the EthioSIS and the Agro-Meteorology Project.* (IS-Developer-Respondent #2 and #5)

Another informant added up that:

> *There are Input Tracking System and e-Voucher System for connecting smallholders to resources and information that can help them to increase their productivity and household income.* (IS-Developer-Respondent #1)

Others also stated that:

> *Mobile-based services such as IVR, SMS, 8028 hotline and digital tagging technology as part of the Teff International Market Access (TIMA) project are employed to disseminate information and knowledge to extension agents and local farmers.* (IS-Developer-Respondent #6, #7, and #8)

System developers in agriculture are developing various information systems to collect, processes, disseminate, and store agricultural knowledge and connect relevant stakeholders. For instance, the EthioSIS is developed to collect and process soil information of woredas in a country and recommend appropriate fertilizer. The system supports extension agents while they provide advisory service to local farmers. In the current extension system, agricultural knowledge created from different sources (i.e., research institutions and Universities) is stored in various forms including publications, audio visuals, databases, and websites. There are also online KMS for the storage and dissemination of agricultural knowledge and technologies such as http://slmethiopia.info.et, http://www.ecx.gov.et/index.html, and http://www.ata.gov.et/wp-content. The stored knowledge and information are then disseminated to end users such as rural farmers through extension agents notably during trainings, field visits, exhibitions, publications, and using traditional forms of ICTs such as TV, FM, and radio and modern forms of ICTs such as mobile-based IVR, SMS, and mobile hotline such as 808 of MoARD, 8028 and the EthioSIS of ATA, websites, ICT kiosks, and the EthioSIS. One of the IS developer informants commented that:

> *These applications are developed, maintained and used by different organizations in Ethiopia like ATA in collaboration with the MoARD, EIAR, and Ethio-Telecom.* (IS-Developer-Respondent #7)

These applications are developed mainly to transfer knowledge and technology to local farmers with the support of extension agents from research. As such, they are shared across multiple individuals coming from different social groups and connecting them for common interest, in turn they can serve as boundary objects.

Agricultural researchers and IS developers also suggested that mobile-based KMS can help more to share knowledge and bring collaboration among stakeholders in particular to support smallholder farmers. This is because many of the local farmers have the ubiquitous mobile devices and knowledge sharing can be promoted through such devices. Extension agents also stated that ICT-based KMSs are very vital for them to get connected with other colleagues, researchers, and local farmers, whereby share knowledge and technology, and bridge the boundaries. Additionally, extension agents reported that, they are supported with ICT tools such as the EthioSIS, IVR, SMS, and 8028 hotlines. ICT tools support the brokering roles of extension agents through supporting searching, storing, and processing the large volume of information. Therefore, electronic KMS tools are essential for extension agents for various

KM activities in particular to share and integrate knowledge systems efficiently and effectively. KMS tools are important for participants to enhance communication and collaboration among them and with other relevant stakeholders and for quick response from the request of different stakeholders, whereby facilitate knowledge sharing and integration.

As one of the agricultural researchers stated:

> *There were several guidelines and procedures prepared by the agricultural researchers for agricultural development inquiries. CPWD guideline is the main guideline; it is a practical and effective tool for utilizing at best the different disciplines related to agriculture and food security in which it supports collaboration and interaction among the relevant owners of the problems.* (Agricultural-Researcher-Respondent #4)

Extension agents are facilitating their role of knowledge brokering by using guidelines and procedures such as Local Level Participatory Planning Approach (LLPPA), Participatory Rural Appraisal (PRA), Participatory Land Use-Planning (PLUP), and Community-based Participatory Watershed Development (CPWD). These documents as guidelines are prepared by research to guide interaction of individuals from different stakeholders in agricultural multiple work practices and to ensure the involvement and collaboration of all relevant communities, which serve as boundary objects. CPWD guideline is prepared as possible as simple and practical to all relevant participants including rural community to enhance collaboration. As a result, today research and development efforts in agriculture are using this guideline for different agricultural developments to support rural community.

CPWD guideline provides interaction between and within communities depends on what happens at different levels of watershed. However, as indicated by extension agents who work closely with local farmers, the guideline has some limitations that could hinder knowledge sharing and integration. For instance, it is prepared in English language. As a result, it is difficult for extension agents and others to translate into different local languages to support rural communities. Local rural communities have their own local language. So it is difficult to use to bring common understanding among stakeholders. Accordingly, respondents suggested that the guideline should be prepared in different local language, at least to languages in which majorities of the local population are using such as “Afan Oromo”, “Amharic”, and “Tigrigna”. The CPWD guideline is developed to address all aspects of agriculture, as indicated by agricultural researchers. The guideline itself also stated that “*watershed communities need to be involved in all stages of planning, implementation and management of watershed development activities”* (Desta et al., 2005a, p. 20). However, system developers are not using it while they develop agricultural KMS. Interviews with IS developers also indicated that the guideline is not prepared to address issues related to KM activities and KMS development in agriculture.

Informants have been asked about boundary objects in the development of KMS, in particular to the case, the EthioSIS. According to the informants’ report, information and knowledge are gathered from different sources by employing telephone, GPS, e-mail, team meetings, and organizational documents through intermediaries (i.e., extension agents) in the development of agricultural KMS development. During requirement gathering, data collectors have been used kebele level surveys using GPS, remote sensing, and geo-statistical predictions. Then, the EthioSIS was developed, which consists of a soil resource database for serving as a base for the country’s soil resource mapping.

Local farmers make use of traditional forms of ICTs and modern forms of ICTs. These technologies help farmers to get agricultural knowledge and technology from research and technology group through the support of extension agents. As indicated by agricultural researcher and extension agent informants, farmers have their own ways of looking at and relating to their natural environment and to each other. As such, one of the agricultural researchers commented that:

> *The rural communities’ traditional education processes need to be carefully studied and constructed around observing natural processes, adapting modes of survival, obtaining sustenance from the plant and animal world, and using natural materials to make their tools and implements. These social aspects need to be represented in KMSs to preserve and share knowledge among relevant stakeholders.* (Agricultural-Researcher-Respondent #7)

Farmers are also asked about the boundary objects used for sharing their own IK with others. One of the farmer respondents said that:

> *We usually use our own language and expression, and storytelling to describe about our land and its features. We know about the border of our farming land, where water is found, and the characteristics of soil. And tell all these points to our kids and*

others, and communicate each other using our language and ways of expressions. We also use different symbols to represent the border of our land and different icons which looks like human in our farming land to protect uncollected seeds from birds during last season of the product. (Farmer-Respondent #9)

Farmer respondents reported various boundary objects such as observation, traditional music and ceremonies, symbols, farming materials, storytelling, and oral mapping. The role of storytelling and oral expression for IK sharing is discussed at section 5.3.3. For instance, one of the farmers stated that:

We use our own ways to represent the spatial dimension of important geographic features on the landscape and seascape. (Farmer-Respondent #3)

For many years, farmers have been used hand-drawn, mental map, and oral maps for defining of their land, homes, road, and water as well as depicting the location of important resource zones and sacred sites. These objects are used by farmers to represent and transfer their indigenous knowledge and practices to interact with others. As indicated by one of the agricultural researchers:

Participatory mapping can greatly help to participate farmers and incorporate their knowledge in the development effort through farmers' oral or mental maps. These make easy to indicate resource availability, to assess infrastructures and access, and even to identify wealth/social groups and relationships. (Agricultural-Researcher-Respondent #3)

Participatory mapping can stimulate discussion and debate among relevant participants Oral mapping is, therefore, an essential boundary object by farmers for knowledge sharing and integration among themselves and other stakeholders. They express about their natural environment through oral maps. As one of the extension agents reported:

Many of elders in this kebele know different aspects of their environment and they express different aspects of their environment orally. They describe boundary of their farming land, the characteristics of the soil including its deficiency, the location of water and other things using their own language and expression. They have strong attachment with their natural environment. (Extension-Agent-Respondent #5)

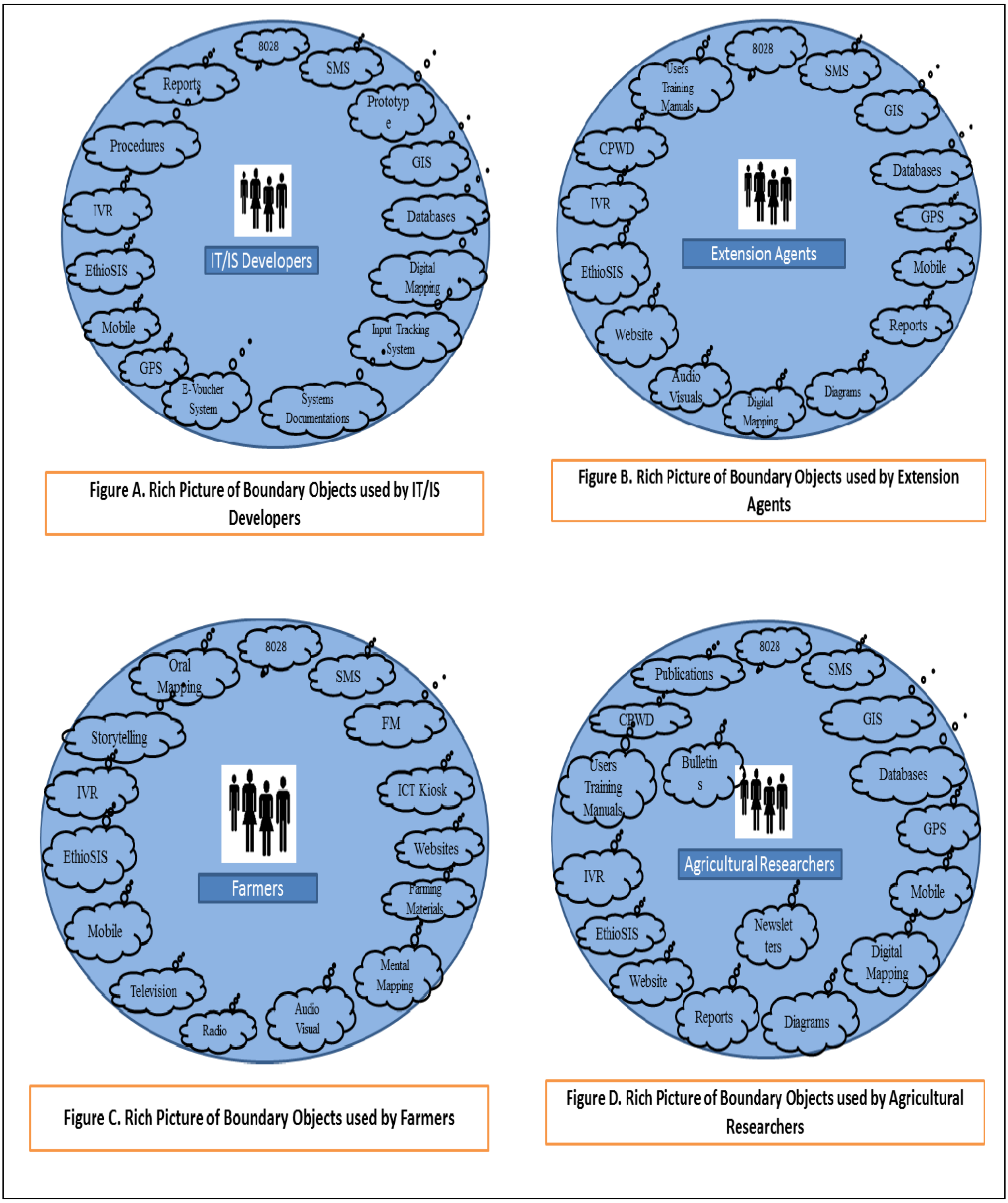

Figure A. Rich Picture of Boundary Objects used by IT/IS Developers

Figure B. Rich Picture of Boundary Objects used by Extension Agents

Figure C. Rich Picture of Boundary Objects used by Farmers

Figure D. Rich Picture of Boundary Objects used by Agricultural Researchers

Figure 5-2. The Pictures for Boundary Objects of Different Participants

Source*: Author own compilation based on the analysis of data gathered.*

Another agriculture expert also added up that:

> *Local farmers have strong relation with their natural environment and the land in which their subsistence needs relay on. They present different aspects of their land orally.* (Agricultural-Researcher-Respondent #3)

As such, oral map presented by traditional local communities may be seen as an indigenous ethnographic model of cultural code. Their oral mapping can reflect social behaviors, values, and different aspects of their natural resource use and conservation practices. As a result, in order to adapt to local community needs and share and integrate local farmers' IK in multiplicity of knowledge systems, boundary objects possessed by local farmers need to be incorporated in the KMS development, for example oral mapping.

Boundary objects need to interface between members from different social groups. Besides to the roles and practices of extension agent as a knowledge broker, boundary objects are also critical to knowledge share and integration in KMS development and use. However, boundary objects for sharing and understanding of IK are not considered in the development of agricultural KMS. Consequently, development efforts do not fully enable farmers to participate and collaborate in the use of such systems. Additionally, there are various boundary objects which are managed and used by different social groups and organizations. These objects are not properly used, integrated, and managed to support communication and collaboration among relevant CoPs in a community of interest. Thus, KMS development and use in agriculture are of little help and not properly addressing the problems of local farmers and extension agents. Guidelines prepared to enhance the participation of local communities such as the CPWD guideline also needs to explicitly address how local farmers participate in agricultural KMS development and use.

In sum, relying on concepts investigated such as the roles and practices of extension agents as knowledge brokers and boundary objects identified, a shared KMS as a boundary object is redesigned and developed and also investigated the use of it to further strengthen the conceptual framework thereby to share and incorporate diverse knowledge in the system. Table 5-14 shown below provides a summary of boundary objects used by relevant groups of participants for knowledge sharing and integration.

Table 5-14 Boundary Objects for Knowledge Sharing and Integration

Boundary Object	Informant	Sample Interview Logs	Indicators
Boundary object	Agricultural-Researcher-Respondent #2 Extension-Agent-Respondent #6 IS-Developer-Respondent #2 and #5 IS-Developer-Respondent #1 IS-Developer-Respondent #6, #7, and #8 Farmer-Respondent #9	*… One standard guideline is prepared: CPWD guideline …* *We are also using mobile-based 8028 automated hotline and website for free and receive information on high-value crops and a wide range of agricultural activities.* *We are implementing various modern technologies to support farmer in sharing knowledge: GIS, including the EthioSIS and the Agro-Meteorology Project.* *There are an Input Tracking System and e-Voucher System for connecting smallholders to resources and information …* *Mobile-based services such as IVR, SMS, 8028 hotline and digital tagging technology as part of the Teff International Market Access (TIMA) project.* *We usually use our own language and expression, and storytelling to describe about our land and its features. Sometimes we use different symbols to represent the border of our land and different icons.*	• EthioSIS • Mapping • Storytelling • Symbols • Prototypes • Mobile hotline • IVR • SMS • Audio visuals • GIS • GPS • Guidelines • Diagrams • Procedures • System documentations • Training manual • Farming materials • Report printouts • Publications • Bulletins • Newsletters • Websites • Observation • Oral mapping • ICT Kiosks

***Source**: Author own compilation based on the analysis of in-depth interviews and participant observations.*

5.8 Summary

This chapter has presented the findings of study based on data collected through interviews, field observations, and documents analysis. In order to examine the research in question, the EthioSIS as a case has been studied in detail. Primarily, knowledge type and associated participants and knowledge treatment have been identified through understanding of the KMS development of the case. As a result, three basic knowledge types have been identified namely farmers' IK, IS/IT experts' technological knowledge, and application domain knowledge of agricultural experts. Additionally, how such knowledge types are shared among relevant participants have been also investigated.

The main objective of this research is to probe how different knowledge types in agricultural KMS developments process are shared and integrated. Thus, relying on the initial conceptual framework, the role of extension agent as a knowledge broker, skill and knowledge required by extension agents for brokering role, and boundary objects have been investigated. As a result, five themes have been identified for the role of extension agent as a knowledge broker (i.e., in-betweenness of extension agent, enhance participation, knowledge and technology translation, coordinate collaboration and negotiation, and network formation), two themes for the skill and knowledge required by extension agent as knowledge broker (i.e., KM and brokering) and boundary objects possessed by relevant social groups for knowledge integration and sharing in agricultural KMS development have been discussed.

Finally, the findings of the research implied the development of a shared KMS boundary object to further understand the conceptual framework through understanding of the design and the use of the KMS. Thus, the next chapter explains the design and the use of a shared KMS boundary object.

CHAPTER

6. KNOWLEDGE MANAGEMENT SYSTEM DEVELOPMENT AND USE

KMS for knowledge sharing and integration needs to be designed to meet challenges raised by knowledge management researchers and practitioners. Hence, there is a need to design and probe the use the KMS in accordance with the theoretical understanding discussed in the previous chapter to propose the KMS architecture and further understand how the KMS boundary object supports the seamlessly flow of knowledge from different sources.

6.1 Issues in Building KMS for Knowledge Sharing and Integration

The research in KMS development is being conducted to develop a system that supports KM activities. It is designed to meet challenges raised by KM researchers and practitioners: technical, human, and social factors. Knowledge is bound up with human cognition, and it is created, applied, and transferred in ways that are inextricably entwined with the social context (Saade et al., 2011). In building this research, it is important to consider knowledge as socially constructed arising from the various CoPs and KMS development should consider both human and social factors in the design. Concepts drawn for knowledge sharing and integration in KMS development are critical parts of a system within the agricultural perspectives, namely social groups, boundary objects, and knowledge brokering roles and practices.

Knowledge management system design process involves stakeholders coming from different disciplines who create and influence artifacts. In this research perspective, there are various members from different CoPs who possess their own knowledge of multiple practices which need to be combined in system development. Additionally, the problem of knowledge sharing and integration is ill-defined especially IK since its format is highly tacit. However, KMS development in agriculture in the existing system assumed that problems can be clearly identified a priori and the system is developed accordingly. Informants from local farmers and extension agents indicated that their requirements are not considered in the development of the system especially the needs of local communities. As a result, the system does not allow farmers and other users to incorporate the emergent contents and functions in KMS. The system development methodology followed in developing countries is top-down fully relying on scientific knowledge from research and scientific principles in which the spatial data is drawn from interpretation of remotely sensed satellite data. Thus, in the development of agricultural KMS in Ethiopia, problems in each community are not clearly defined. However, in problem solving methodologies, in addition to clearly framing the problem a priori, the integration of problem framing and problem solving are needed in the usage progress of the system. Accordingly, this research further developed to understand the role of situated actions and emergent opportunities in the creative evolution of socio-technical environments through understanding of the KMS development and use.

Moreover, the design and use discontinuities have been observed in agricultural KMS development. As one of the technologists remarked:

> *We develop systems at the head office of ATA in Addis Ababa and evaluate the system by agricultural researchers. Then, extension agents and local farmers make use of the systems in different rural part of the country. As a result, social contextual information is not incorporated into the system.* (IS-Developer-Respondent #1)

However, the development and use of KMSs need to be conducted in the same social context to understand the different condition at different stages. ICT-based systems development and use in developing countries provides as an example of technology transfer of problem due to the involvement of technical systems developed in Western context and applied in developing countries. IK hosted by local farmers is critical for development efforts in agriculture. However, results discussed in the previous chapter indicated that local communities are not participated in the development process and their IK are not incorporated. Therefore, KMS technologies can negate, destroy, and corrupt sacred IK. As a result, such systems are alien to the end users such as local farmers and fed up as a fashion. The situation leads to the development and use of a shared KMS which involves the need and expectation of all relevant social groups in particular the local farmers. Several researches also suggested that integration of IK with scientific knowledge in the development and the use of KMS as a solution for different problems of local communities (Agrawal, 1995; Akinwale, 2013; Boikhutso, 2012; Kanjo, 2012; Mercer et al., 2009; Puri, 2007). Thus, relying on concepts investigated such as the roles and practices of extension agents as knowledge brokers, local farmers, and agricultural experts and boundary objects identified, a shared KMS's component is proposed, designed and its use and impact are discussed.

6.2 Components of KMS

In building this research, the architecture of the KMS is theory driven, which is derived from the conceptual framework developed by empirical investigation. The KMS architecture involves distributed or human oriented KMS architecture to engage relevant users to utilize both tacit and explicit personal knowledge. KMS needs to support the different participants including extension agent as a knowledge broker, local rural communities, and agricultural researchers. To this effect, critical components of an agricultural KMS for knowledge sharing and integration and relevant issues are identified. Following terminologies presented by Saade et al. (2011), three basic components of KMS for effective KM process were identified: people subsystem, resource subsystem, and technological subsystem.

6.2.1 People Subsystem

Technological artifacts and people are inseparable components of information systems such as in KMS and DSS. People component in KMS is responsible for producing, sharing, and applying knowledge. The component includes knowledge creators, knowledge users, knowledge brokers, knowledge reviewers, and technology designers. In building this research, the human subsystem includes local farmers, agricultural researchers, extension agents, and technologists, who are the core of the agricultural KMS development and use. Table 6-1 indicated human agents and their roles in agricultural KMS development.

- Agricultural researchers provide scientific knowledge which is the result of research and experimentation.
- Local farmers possess indigenous knowledge and use scientific knowledge provided by researchers.
- Extension agents exchange knowledge and technology between farmers, researchers, and technologists and coordinate the interaction and collaboration among users from different social groups.
- Technologists are responsible for the development of agricultural KMS. After KMS implementation, they also ensure its execution and administration by ensuring the

functioning of it and supporting participants, following up, providing technical maintenance of it, and ensure further the reliability and security of the KMS.

Several researchers suggested that technology needs to be designed based on the capability of relevant human agents (Orlikowski, 1992; Orlikowski & Robey, 1991). Additionally, in order to exchange and integrate knowledge, active participation and collaboration among participants from different CoPs are highly critical in KMS development and use process. However, as one of the farmer respondents reported:

> *No one was participated us while agricultural KMS was developed. In addition, the systems don't allow us to share our own knowledge to others. It is also difficult for us to use since it is presented in another language (i.e., English language). Hence, our participation is important in the development of the KMS.* (Farmer-Respondent #8)

In the current agricultural KMS development, managers, KMS developers, and agricultural researchers are involved and shaped an agricultural KMS development. However, end users such as extension agents and local farmers are powerless but their action can shape the technology. Additionally, there is no active participation and knowledge contribution from local farmers, which is considered as a warning sign for KM activities and system development in question is failing. Hence, development of this technological artifact (i.e., a shared KMS) as a boundary object is carried out for knowledge sharing and integration by paying attention to those people in particular the local communities and extension agents and their roles and practices who act as knowledge brokers and knowledge contributors and users.

6.2.2 Resource Subsystem

This subsystem consists of knowledge resources of the KMS. Relying on the roles and practices of relevant social groups as discussed above, knowledge resource is divided into two, declarative or actual knowledge and procedural or methodological knowledge. The former refers to knowledge expressed in the form of propositions whereas the latter is used to refer activities or guides as remembering how to perform an activity. In building this research, knowledge resource includes knowledge from local and scientific communities, rules including guidelines and procedures for social interaction in KM processes, system development and use and knowledge and skill required by extension agents.

Table 6-1. Human Agents and their Roles

Human Agents	**Roles**
Agricultural Researchers	• Scientific knowledge creation, recreation, and presentation • Use IK from local farmers for further research • Interact with extension agents and technologists • Evaluate the ongoing implementation of knowledge and technology.
Extension agents as knowledge brokers	• In-betweenness of extension agents • Enhance participation • Knowledge and technology translation • Network formation • Coordinate collaboration and negotiation
Local farmers	• Indigenous knowledge creation, recreation, and presentation • Use scientific knowledge from research • Interact with extension agents and researchers.
KMS developers	• Capture the needs and expectations of end-users • Capture and process knowledge and specification of the system • Design and implement KMS • Administer and maintain KMS • Ensure the reliability and security of the KMS.

***Source**: Author own compilation based on the analysis of the data.*

6.2.2.1 Knowledge Resource

There are two different categories of domain-specific knowledge relevant in agricultural KMS development including farmers' indigenous knowledge and scientific knowledge from research. Scientific knowledge includes scientifically collected, processed or analyzed data from relevant organizations such as the ATA, MoARD, and Universities which were collected from researchers through interviews, field survey by the support of technologies such as remote sensing, mobile applications, and GPS. These are documents such as publications, reports, newsletter and bulletins on soil fertility management and conservation. In the existing agricultural KMS (e.g., the EthioSIS), only these explicit scientific knowledge and procedures are considered and managed statically. However, IK from local communities which is tacit and embedded in the minds of human being and practice is ignored. Few attempts have been made by research and development to document IK through lesson learned, best practices, and storytelling. However, IK is mostly tacit and collected through ongoing interaction with local farmers in KMS development and use. In building the KMS, the application scientific and IK identified at section 5.2.1 and 5.2.2 were represented in the knowledge repositories of the KMS.

In order to integrate and share knowledge and support interaction between participants through KMS, knowledge repository and maps/taxonomy are required. Explicit knowledge from different participants (researchers and local farmers) is primarily stored in the KMS's knowledge repository. Knowledge resources in the existing agricultural KMS (i.e., the EthioSIS) are also integrated with the knowledge repository of the new KMS. Knowledge map includes searchable indexes or catalogues of expertise held by individual participants, since it is difficult or impossible to capture and store tacit knowledge. Therefore, it is the best way to map the knowers in an organized manner. In addition to storing explicit knowledge, the KMS needs to process tacit knowledge which is difficult to capture and store it in the repository. One of the strategies to capture such type of knowledge is to locate experts or knowers for tacit knowledge sharing and foster interaction with others as shown in Figure 10-2 at the Appendix VIII. In particular, the format of the IK is highly tacit and very difficult to capture and store in the knowledge repository. Therefore, knowledge map is developed for the directory of the knowers or communities as one component of the KMS.

Participants from different communities having common interest interact, collaborate, and negotiate relying on the existing explicit knowledge in the repository and knowledge map, thereby diverse knowledge is integrated and new knowledge is also created. The existing explicit knowledge in the KMS is a precursor to the development and sharing of tacit knowledge. Therefore, the integrated knowledge base or repository provides a means to integrate and build on their own collective knowledge from their process of interaction, collaboration, and negotiation. Process knowledge, usually tacit format, includes knowledge of scientific and local communities generated while using the existing knowledge and also knowledge emerged while practicing. Such knowledge can be integrated with the existing knowledge through editing, adding, and maintaining by several users on the web space as shown in Figure 10-1 at the Appendix VIII.

6.2.2.2 Procedures

The procedural rules or guidelines are also important resources that govern the design and use processes of technological artifact. They emphasize the development and use of the KMS that couples the human actions to provide the output (Germonprez et al., 2011). In building this research, CPWD guidelines (Desta et al., 2005a, 2005b) and KM processes (Nonaka, 1994) are taken into consideration in KMS development and use. CPWD guidelines are a comprehensive guideline employed in Ethiopia for any endeavors conducted in the area of agriculture for participating rural communities. In keeping this, this study used these guidelines to involve local communities and other stakeholders in the design of a shared KMS. However, the CPWD guidelines do not explicitly document the participation of relevant users in agricultural KM activities and KMS development. Additionally, in the community of interest, different groups of people share common practice or purpose and need guidelines or procedures for their interactions, communications, collaborations and negotiations through a shared KMS to share and integrate knowledge.

There are a number of constraints and procedures integrated in the KMS design, which affect KM activities and issues while using a shared KMS. These includes, who can access the KMS, what is the right knowledge and the right source, knowledge contribution (who, how, and what contribute), knowledge sharing and integration. As one of the extension agent informants explained:

> *We communicate with different people at different places or organizations such as researchers, technologists and local farmers to transfer knowledge and technology. Therefore, policies and procedures are critical to enhance knowledge sharing and integration when we are supported through such type of technologies.* (Extension-Agent-Respondent #4)

Therefore, the existing knowledge resources and procedures and guidelines from relevant social systems are taken into consideration in the KMS development, since such organizational or social systems properties influence relevant actors action in their interaction with the technology (Orlikowski, 1992).

6.2.3 Technological Subsystem

The KMS also consists of technological artifact used by users from different social groups to support KM activities. The implementation subsystem entails the use of concepts derived from the theoretical investigation such as the roles and practices of relevant social groups having common interest for knowledge sharing and integration. To this effect, the implementation subsystem is primarily concerned with the identification and development of applications for supporting KM activities in particular knowledge sharing and integration. When investigating the concepts for knowledge sharing and integration, it was discovered that such processes are built on previous knowledge systems. For this purpose, a shared KMS can support human communication, interaction, collaboration, and negotiation for knowledge sharing and integration from the existing knowledge repositories and knowledge map.

Knowledge transfer in formal and informal organizations occurs when members coming from different social groups create and transfer knowledge through exchanging between tacit and explicit knowledge. Process-oriented KM views knowledge as process, which enables participants to filter valuable knowledge and use, share, and integrate or combine knowledge systems to repositories (Maier, 2007). This procedure is consistent with the knowledge creation and transfer modes of Nonaka (1994). These modes are employed in this research to identify the technological sub-components in-line with KM processes in the KMS in particular for knowledge sharing and integration.

In the course of this research, there are different social groups identified who have a common interest. These groups need to form a network or team for interaction, thereby facilitates experiences and perspectives sharing. This socialization process enables users to sharing experiences by observation, interaction, imitation, and practice to create new tacit knowledge (i.e., tacit-to-tacit). This activity can be enhanced through the roles and practices of extension agents as knowledge brokers. For instance, the network formation and enhancing participation roles of agents can foster the socialization process. Socialization can, therefore, promote a mutual understanding by sharing of mental models of participants, which is an important precondition for sharing tacit knowledge. Then, the externalization mode can be triggered by successive dialogues (Nonaka, 1994).

Tacit knowledge from different members in particular from local communities with IK highly tacit can be transcribed and articulated through dialogues and storytelling. Consequently, tacit knowledge from different members can be converted into explicit knowledge in turn; pieces of knowledge from members coming from different social groups can be shared and combined. Additionally, the articulated knowledge can be combined with existing data and explicit knowledge in the KMS's knowledge repository. This mode of combination can be facilitated by extension agents as knowledge brokers between members from local and scientific communities and other explicit organizational knowledge. This mode in this research context can enable to combine indigenous and scientific knowledge; thereby knowledge integration can be achieved. Finally, users from different social groups access the existing explicit knowledge from different members and knowledge repositories and perform their tasks. Through such processes users can learn new knowledge, expand their existing knowledge and experience. This internalization process, therefore, converts explicit knowledge to tacit knowledge. Additionally, knowledge users' content communication can occur either via acquiring knowledge directly from knowledge repositories and maps or by constructing meaning from interaction, dialog, and reflection (Nonaka, 1994).

Web 2.0 technologies offer different tools for facilitating different modes of knowledge conversion between tacit and explicit. An application developed with Web tools does not require to be installed on any device, and functions through a Web browser and an Internet connection. Relying on the aforementioned modes of knowledge creation and transfer, specific Web 2.0 tools have been selected as depicted in Figure 6-1 and integrated in the design of KMS as shown in Figure 6-2. For instance, in order to enhance communication and interaction, Social Networking (SN) Web 2.0 tools have been utilized. Web 2.0 tools can enhance communication and interaction among participants, and develop and strengthen social groups, thereby support communities of practice and interest. Blogs, forum, Instant Messaging (IM), and wiki tools provide users to publish their knowledge and experience, and reflect on others perspectives and collaborate. At the end, pieces of knowledge from users and organizational knowledge repositories can be combined through social bookmarking, tagging, folksonomy, mashup, and aggregator (RSS). Finally, through the application of knowledge existed on Wiki (Docs), blogs, podcast, and forum of the KMS, participants can learn and develop new knowledge.

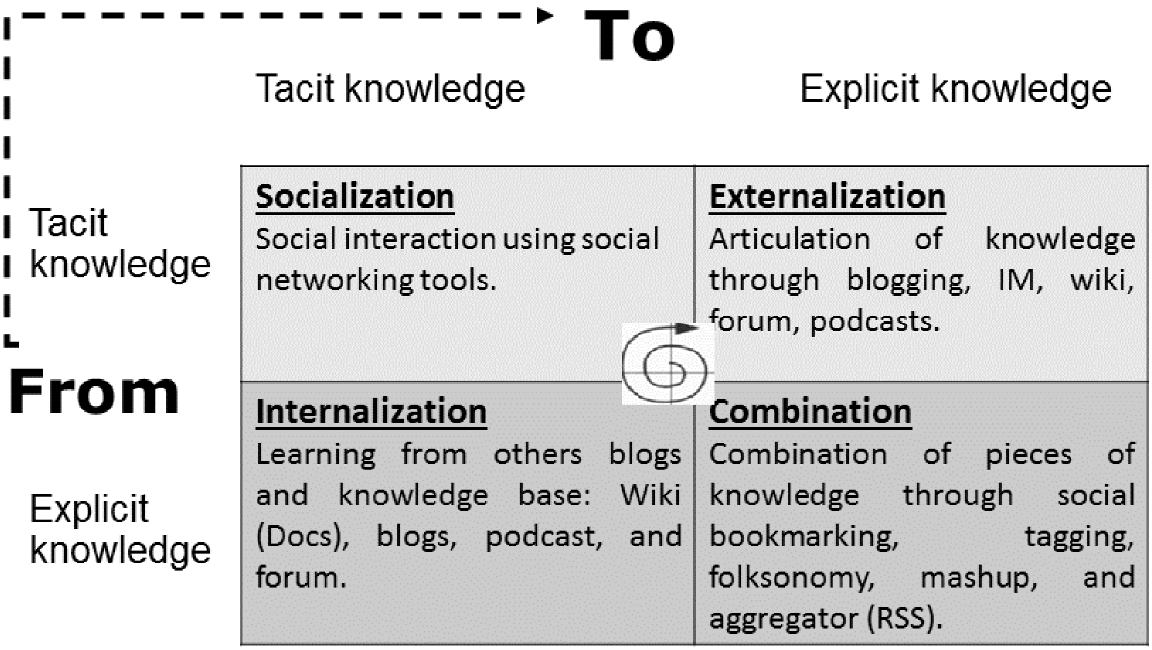

Figure 6-1. Web 2.0 Tools for Knowledge Sharing and Integration

Source*: Author own constructs of Figure 2-1.*

Architecture of a shared KMS employed both integrative and interactive applications to support the above mode of knowledge transfer and social interaction. Interactive applications are developed intending to enhance interaction among participants, thereby exchange tacit knowledge, whereas integrative applications are developed for facilitating explicit knowledge exchange. Integrative application exhibits a sequential flow of explicit knowledge into and out of a knowledge repository (Zack, 1999). Participants start interact each other through the existing knowledge in the repositories and knowledge maps. Therefore, knowledge repositories and maps become the primary medium for knowledge exchange, sharing, and integration; thereby provide virtual meeting space for members of different CoPs for contributing their knowledge and experience. Integrative application should support or provide knowledge repositories and maps for managing explicit knowledge, at the same time enabling interaction to share and integrate tacit knowledge such as IK. Interactive and integrative applications in a shared KMS support each other for knowledge sharing and integration and integrated in the design of the KMS as shown in Figure 6-2.

6.3 Prototyping of the KMS

The KMS prototype is developed to demonstrate the feasibility of a proposed KMS architecture. It is almost impossible to represent and store all relevant knowledge systems during the implementation of the system. This is due to the difficulty to extract and capture tacit knowledge, for example indigenous knowledge and such knowledge can be extracted, extended or new knowledge can be created as people communicate and interact with other participants during the use of the KMS. Thus, the process of design and incorporation of knowledge don't end when the KMS is developed. Therefore, initial design of KMS is primarily developed through involving users to incorporate their emergent functions and contents in use of the system in their local context.

Web 2.0 tools provide various ways of interaction among people to share users contributed content, develop content collection by user community, and to create and modify artifacts for content contribution and interaction. A prototype is developed by integrating freely available Web 2.0 tools from the Internet relying on tools proposed in Figure 6-1. A detail description of the utilized Web 2.0 applications in a web-based KMS is presented at Appendix VII. Web 2.0 tools were selectively employed in various ways with the corresponding KM activities in particular for knowledge sharing and integration. Additionally, the selection process involved the needs, expectations, and skills of relevant CoPs members in agricultural KMS. During the concept formation stages, farmers indicated that they expect their knowledge to be represented in the system. For this purpose, the indigenous knowledge identified are represented in the KMS. Many of the farmers in the country are not trained in formal education and cannot read and write. Hence, there is need to integrate Web 2.0 tools which can enhance visualizations, audio, and video.

Figure 6-3 shows the tailorable technological environment for the KMS having Web based platforms for supporting knowledge sharing and integration through networking, interaction, collaboration, and negotiation among members to store, access, share, and integrate knowledge. For this purpose, the developed KMS is highly integrated with various services and interactive composed of community development, forums, questioning and answering, visualization, locating and following experts, Wikipedia (for content integration, editing and commenting), and events management. The KMS consists of different applications in three layers: interface, interaction, and integrative (Figure 6-2). Users make use of the interface layer of KMS through the knowledge portal. Primarily, indigenous and scientific knowledge from different sources are presented on the knowledge portal in an understandable form. The interface layer consists of language translator (i.e., Amharic and English). Local farmers and development agents in this research study areas use Amharic language, whereas scientific researchers produce the research result in English language. Hence, the translator can translate the contents of the KMS Website from English to Amharic and vice versa.

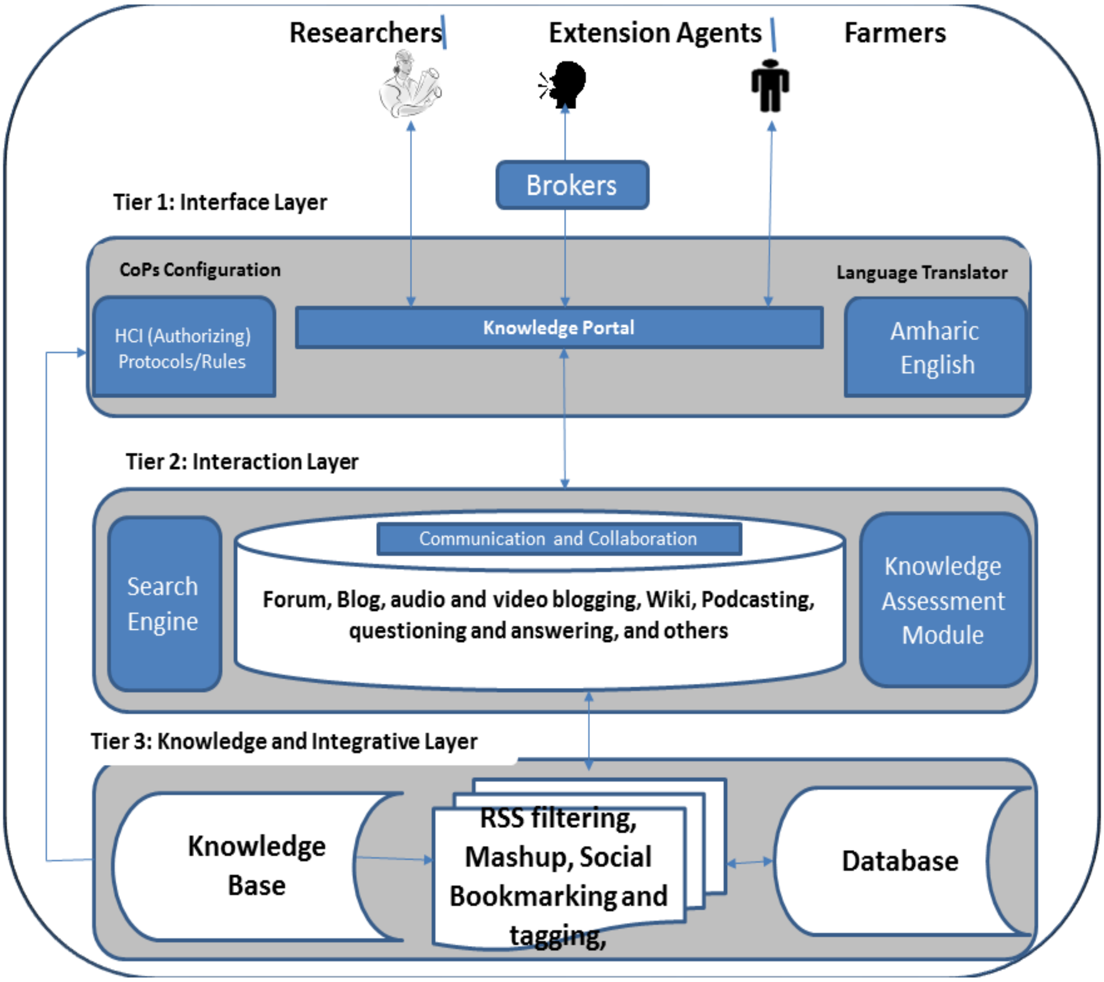

Figure 6-2. Architecture of a shared KMS using Web 2.0 Tools

Source: *Author own constructs.*

Interaction layer of the KMS consists of interactive, knowledge assessment, search engine, and content management applications. This application supports users learning from the existing knowledge sources. Interactive application provides communication and collaboration on the KMS. It is developed using Web 2.0 tools such as Wiki, exchange knowledge through blog, and group formation and discussion among members through forum. This application enables users to exchange their views and practices. This application can enhance exchanging of tacit knowledge. In addition, knowledge assessment application can enable users to identify, rate, and rank the knowledge important for them. It is very important to record knowledge contribution of every user, thereby to encourage people to share their knowledge. There is also search engine application, which supports users to find information they need through keyword searches. Keyword searches are the most popular way of finding relevant information.

Integrative layer of a shared KMS consists of applications for documenting or presenting and integrating contents from different sources. This layer comprised of integrative and knowledge storage applications. Knowledge storage application is consisting of database (i.e., the database of the EthioSIS) and knowledge base and serving as memory of KMS's data and knowledge. Integrative layer also contains tools for filtering and integrating contents from different sources such as RSS and collaborative filtering, mashup, tagging, and bookmarking.

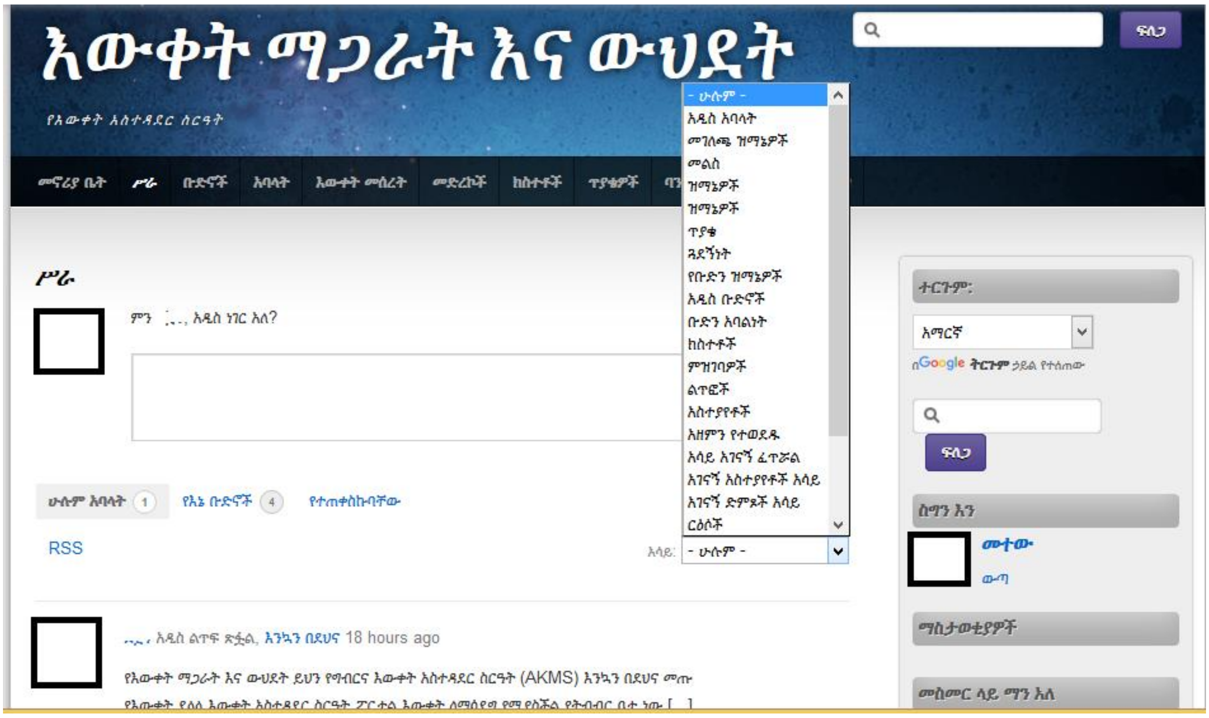

Figure 6-3. Knowledge Portal of a shared KMS

6.4 KMS Usage and Consequence

The newly developed KMS for knowledge sharing and integration is observed for understanding of the significance of it. In a community of interest, voluntary and open involvements of different social groups (CoPs) are required to understand knowledge sharing and integration through a shared KMS. The research provided access to a total of 39 informants, 28 of the informants were previously interviewed in phase I and 11 of them were new more informants joined the KMS use following its development. All informants were voluntary to participate in the research as respondents and informed in advance. Other users were also joining from different social groups. Finally, participants are observed while using the system and further interviewed them for understanding of the significance and consequence of a shared KMS boundary object. The interviews protocol for phase II, the number of respondents from each social group, and the details of the informants participated in phase II are presented in chapter four under sections 4.5.1, 4.5.4, and Appendix IV respectively.

The KMS developer noted that:

> *It is essential to develop the KMS through integrating the existing technological infrastructures and by using Web 2.0 tools to provide open learning environment for enhancing communication, interaction, and collaboration among users. It is also good to store electronically the explicit and tacit knowledge in different formats in the knowledge repository.* (IS-Developer-Respondent #8)

Integration of technological infrastructures including the hardware, networking, wireless connectivity, and software in particular the Web 2.0 tools in the KMS/KM initiative is critical in order to use the KMS/KM for knowledge sharing and integration in agriculture. This can also foster the participation of users in the system through knowledge access and contribution, thereby, knowledge and information in different formats from different sources can be available through the KMS. The accessibility and availability of ICT infrastructures were very limited in Ethiopia and other developing countries in Africa which affect the access to information and knowledge for development agents and farmers in rural districts. However, the emergences of new ICT's tools such as the ubiquitous mobile and universal wireless connectivity are today providing developing countries like Ethiopia with an opportunity to access agricultural information and knowledge. Nowadays, Ethiopian government acknowledges the importance of ICTs in agricultural and rural community development. Particularly, the use of mobile technology and Internet kiosks in rural districts have been prioritized in Ethiopian agricultural extension system and research to transfer scientific knowledge to extension agents and local farmers as reported by many agricultural researcher and document analysis such as ATA (2015).

ATA in collaboration with MOARD, and Ethiopian telecommunication are providing information to extension agents and farmers using mobile-based interactive voice response (IVR), short message service (SMS), and 8028 agricultural hotline. As reported by one of the

IS developer respondents at ATA, "*through 8028 agricultural hotline we have received 17 million calls from 2.2 million registered farmers and extension agents from every corner of the country to date*". This is an indication for the growth of mobile usage by farmers in the country to access up-to-date agricultural information timely. Therefore, to make this agricultural KMS accessible to extension agents and farmers, there is a need to make the system device compatible so as to allow users to access it with different devices from mobile devices to desktop computers. For this purpose, the WPtouch Web 2.0 tool was integrated with the KMS to provide multi-channel distribution feature.

6.4.1 The Use of KMS

The KMS usage is probed to describe whether or not the KMS is being utilized by the relevant participants from different social groups to enhancing their roles and practices for knowledge sharing and integration. The research presented how the KMS usage supports the extension agents to carry out their roles and practices of knowledge brokering as shown in the Table 6-2. Additionally, the KMS supports the participants from farmers' and researchers' groups to use and reuse the existing knowledge from the knowledge repositories of the KMS and helps them to contribute their knowledge.

6.4.1.1 The Use of the KMS by Extension Agents

Extension agents indicated various uses of KMS in order to enhance their roles so as to exchange knowledge. As one of the extension agents commented:

> *An online shared KMS enables us to get connected with farmers, researchers and extension workers and fosters communication and interaction with different social groups distributed geographically.* (Extension-Agent-Respondent #9)

An IS developer at ATA reported that:

> *Interactive voice response system is used to connect farmers and extension agents with experts through posting questions. I think this system is a good interface between farmers, extension agents, researchers, and other relevant stakeholders.* (IS-Developer-Respondent #1)

The system supports the roles of in-betweenness of extension among participants from the different CoPs as it is revealed from the analysis of the informant interview and participant observation. Extension agents can also easily communicate and interact with different CoPs: local farmers, researchers, and technologists through a shared online KMS, thereby, encourage users to participate and exchange knowledge. Accordingly, extension agents can cross different CoPs by a shared KMS. Also, the KMS enables users to connect with others informally in their CoPs and with other users from different CoPs, who are geographically distributed. The social network tools in a shared KMS enable users to identify the knowledgeable and novice, and interact on one-to-one, one-to-many, and many-to-many among users from different CoPs independent of the existing hierarchical structure. Such networking is important for exposing users to different knowledge and perspectives.

One of the extension agents reported that:

> *… Accessing contents in different formats such as audio, textual, document, images, and video and in different languages in which farmers and researchers utilized. This highly helped them to translate knowledge from research to local farmers and vice versa.* (Extension-Agent-Respondent #15)

Another extension agent noted that:

> *The KMS is easy for us and even for farmers in our kebele to use and to perform our roles of knowledge exchanging and use knowledge from different sources through it. This is because the system is accessible in our local language, has a user-friendly interface, and it provides different contents in different formats and functionalities relevant for our roles of coordinating the collaboration and interaction among participants through the knowledge exchanging.* (Extension-Agent-Respondent #4)

The KMS allows extension agents to access knowledge contents and perspectives. It enables them to understand knowledge with its application context. Subsequently, agents can translate and interpret knowledge and perspectives from one CoP to another. Moreover, Web 2.0 tools in a shared KMS such as Wiki support discussion and collaboration among participants. It allows an agent as moderator to add users and trace what is being shared. An extension agent as a moderator starts discussion in the forum, guides the process, helps users particularly the farmers, motivates users for participation, facilitates the negotiation of meaning among users, to name a few. As a result, a shared KMS enables extension agents to facilitate their roles of knowledge brokering.

Table 6-2. The Use of KMS by Extension Agents and Other Participants

Social Groups	**Construct**	**The KMS Usage**
Extension agents	In-between position of agents	It enhances the in-betweenness of extension agents through it they can reach to different CoPs who are distributed in geographical space so as to exchange knowledge.
	Enhance participation	Despite participants are located in different geographical space, agents can frequently communicate, interact and virtually work together with them in particular local farmers through an online KMS. The system, therefore, enables to foster the participation of users from relevant social groups.
	Knowledge and technology translation	It allows to store and access information in different forms including image, video, audio, text, and numeric data. Also, the KMS enables to translate contents from one language to another. As a result, agents can understand knowledge and its context from different CoPs so as to translate and interpret knowledge and perspectives from one CoP to another.
	Network formation	Supports building of community of interest through forming effective networking and building a sense of community bonds among participants within a CoP and among CoPs having a common interest.
	Coordinate collaboration and negotiation	Fosters the roles of agents through supporting mentoring and facilitating more effective collaboration and negotiation through cross-fertilizing ideas, knowledge, and perspectives.
Users from farmer and researcher groups	Knowledge access	• Helps users to access information from the repositories in different forms: image, video, audio, and textual data. • Supports users to access knowledge in their own language. • Helps users to keep up-to-date.
	Knowledge contribution	• Helps users to store information and knowledge. • Supports user to dynamically update information.

Source: *Author own compilation based on the analysis of gathered data*

6.4.1.2 The Use of the KMS by Local Farmers and Agricultural Researchers

The educated participants from rural communities and agricultural researchers form and join different CoPs based on their interest. As one of the educated farmer respondents in formal education stated:

> *The system is now easy for me to use. I can join extension agents and agricultural researchers' groups who can help me through providing information. I also received updates frequently through the system.* (Farmer-Respondent #14)

However, this farmer respondent commented on the easiness of this system for other farmers in his rural district that:

> *I do not think because there are many farmers in our district who cannot read and write and they do not have also access to mobile phone and computer.* (Farmer-Respondent #14)

Through the social networking features of the KMS, farmers who attended formal modern education and traditional education at Orthodox churches have been linked with specialists from extension agents and researchers' groups with the help of development agents. Accordingly, they locate experts to get relevant information for their practices through posting questions. They further access the existing knowledge from the knowledge repositories of the KMS and updates from blogs and E-newsletters, for example, about farmers' success stories. In addition, the system provides information for participants in different formats. However, there are several challenges raised by informants and observed by the researcher in utilizing the KMS by farmers at the rural districts.

One of the main challenges in the use of the KMS for agriculture by farmers is that the limited accessibility of mobile and computer devices particularly to the poor small-scale farmers. Additionally, despite there are attempts made in Ethiopian extension system in providing awareness and training to farmers about ICTs in farmers training center, many of the farmers reported the limitation in the skill of using such system to access agricultural information. Hence, this is an indication to provide more information, training, and awareness to farmers and extension agents about ICTs and Web 2.0 tools to foster knowledge exchanging among relevant stakeholders in agricultural extension system. ICT kiosks in the rural districts should provide Internet access, thereby encourages the use of such system for knowledge sharing. This can be strengthened by using affordable mobile technologies. Additionally, the extension agents need to closely work with farmers not only in transferring knowledge to farmers but also encourage, teach, and support farmers to use ICTs for knowledge exchanging.

An extension agent informant indicated that:

> *Many of the farmers have a difficulty to read textual contents from the website from different organizations. However, this website provides information in different forms especially audio and visual formats. As a consequence, farmers can listen audio contents and see images and videos, thereby, they interact each other and with other social groups.* (Extension-Agent-Respondent #8)

A farmer informant also added that:

> *I can access information in different forms such as textual, audio, and video in my own language (i.e., Amharic language). I can also share my own to others.* (Farmer-Respondent #7)

Therefore, contents presented in different languages and presentation of content in different forms enable farmers to access rich information and knowledge and be able them to interact. Participants in this open collaborative environment are not only passive information and knowledge resources receivers but also generate and contribute their knowledge. Farmers share and preserve their own knowledge (i.e., IK) using oral mapping, hands-on experience such as ceremonies and practice, observation, and storytelling. Hence, audio blogging, podcasting, video blogging, and instant message like Skype utilized in this KMS help farmers to access knowledge from others and share their own through posting audio and video with the help of extension agents. In particular, the interplay of the system and extension agents helps farmers those who can't read and write to access and contribute knowledge through visualization and audio.

An informant from researcher groups reported that:

> *Farmers and extension agents can communicate and interact with us by using the KMS. It is very important for us to reach too many extension agents and farmers. Consequently, the usage of it can avoid the existing hierarchical structure, thereby to*

> *exchange knowledge between farmers and research.* (Agricultural-Researcher-Respondent #5)

During the use time of an online KMS, it has been observed the communication and participation of participants from local communities those who can read and write and research groups who are located at distant. Their communication and interaction employed several forms such as text-based (chat), voice, and video communication through instant messaging, audio and video conferencing, and podcasting. As such, the attractiveness of these Web 2.0 tools lies in a direct contact between participants, whereby highly decrease the feeling of distance. Moreover, audio and video communication, visualization and mapping in the KMS foster the externalization of indigenous tacit knowledge from local farmers. In sum, a shared KMS boundary object provides access to knowledge from different sources in different forms for a large variety of users, allows users to add and update information and knowledge in the knowledge repository, customizes the interface and function of the KMS, and more. As a result, users from different groups communicate, interact and collaborate for their common interest, whereby, knowledge sharing and integration are enhanced.

6.4.2 The Consequence of the KMS usage

The consequence describes the effect of the KMS/KM on the effectiveness of usage by participants coming from different CoPs and by the overall organization for knowledge sharing and integration. The impact of the KMS usage includes knowledge sharing, knowledge integration, and new knowledge creation as shown in Table 6-3. As discussed above, the usage of the KMS/KM brought an increase in the users' performance for knowledge sharing through fostering the communication, interaction, and coordination. As one of the soil experts stated:

> *I used to collect data from the farm land some sample data through the support of technologies, then perform the analysis usually in the laboratories, and finally communicate the result. As a result, the acceptance level of the result by farmers was low. We believe that this is due to: we could not go over to the farmers and ask them what experience and knowledge they have and the difference in experience, perspective, and language between the researchers and local farmers. However, through a system of this kind the communication and interaction among researchers,*

farmers, and extension agents can be developed and we can understand each other so as to exchange knowledge. (Agricultural-Researcher-Respondent #9)

An extension agent also commented that:

> *… The KMS supports us to foster the communication and interaction among the local and scientific communities. Consequently, all relevant communities exchange knowledge and experience and remix their knowledge for agricultural productivity. In particular, model farmers in our district frequently communicate with us to get scientific advices and also share their IK and develop a competency to integrate knowledge from different sources. For instance, as a result of knowledge exchange among participants both local and scientific communities believed that, the indigenous manure and scientific chemical can be mixed together and the integration reduces vulnerability of crops to rainfall variations, leads crops to growth and drought tolerance, and raises yield crop growth.* (Extension-Agent-Respondent #7)

The key ingredient of a community of interest in agriculture is a network of relevant communities of practice working for agricultural productivity. In the KMS, it has been demonstrated the proliferation of community of interest (CoI) through fostering the informal and formal involvement of participants from farmers' and researchers' social groups. Building of CoI is a sine qua non condition for communication and interaction among participants, thereby, common language can be developed. Effective knowledge exchange can be achieved through a common language in KMS. Knowledge as an asset is, hence, shared across participants within a CoP and among CoPs through the system.

The KMS creates an open learning environment through providing reciprocity among users from different social groups. Knowledge exchanging for problem solving through a shared KMS brought knowledge systems richness including indigenous and scientific knowledge from different sources in different formats, context, and map of knowledge owners. Also, users can develop competencies to efficiently and effectively handle, link, and synergize knowledge and best practices. The KMS further provides different perspectives, knowledge and experience from different social groups, which create a complete insight to apply knowledge and create new knowledge. The system helps to build organizational memory through capturing, sharing, integration, and creation of knowledge. Consequently, the use of the KMS has an impact on individuals' decision making performance and knowledge acquisition from farmers and extension agents, researchers to research and solve problems.

Finally, increasing the users' performance through the use of the KMS and knowledge brokering is essential to bring an organization's overall performance.

Table 6-3. Consequences of KMS Usage

Construct	The Impact of the KMS Usage
Knowledge sharing	• Fosters communication and interaction. • Enables users to reflect on others thought. • Enables users to recognize the others' knowledge domains. • Enhances knowledge exchange. • Develops a common knowledge and language.
Knowledge integration	• Helps to develop elements of specialized knowledge that are common across individuals. • Helps to develop richness of knowledge systems. • Develops competencies to synergize knowledge.
Knowledge creation	• Develops competency to apply knowledge for decision making. • Provides different perspectives and experience to create new knowledge. • Helps to build organizational memory.

Source: *Author own compilation based on the analysis of the data.*

6.5 Summary

KMS development was conducted to extend the understanding of the conceptual framework for KMS development and use. This research follows theory-driven architecture to identify the components of the KMS relaying on concepts investigated empirically. The research has identified three subsystems of the KMS: people, resource, and technological subsystems. Then, KMS architecture is derived accordingly to supporting knowledge sharing and integration. The KMS, then, is developed based on the proposed architecture.

The KMS incorporated integrative and interactive applications for knowledge systems integration and sharing to enhancing communication, collaboration, and interaction among relevant participants. In order to implement these applications, Web 2.0 tools have been utilized. Then, through in-depth interviews and participant observations, the use and consequence of a shared KMS as boundary object by relevant users are further investigated.

As a result, a shared KMS boundary object allows extension agents to support their roles and practices of knowledge brokering and enables users from different CoPs to access knowledge in different forms, to add their knowledge and experience into the knowledge repositories of a shared KMS. Consequently, the KMS development and use can greatly contribute for sharing of users' knowledge, experience, and practice and integrate and produce new knowledge from the existing knowledge systems. The next chapter discusses the main findings of the research in accordance with the extant literature.

CHAPTER

7. DISCUSSION AND EVALUATION OF THE FINDINGS

7.1 Knowledge in Agricultural KMS Development

Knowledge intensive organization requires knowledge integration and sharing having highly distributed knowledge from various participants to bring effective performance and growth (Zack, 1999). The development and use of KMS involve different occupation groups who have their own knowledge and practices (Sahay & Robey, 1996). In this case, the research identified social groups who possess different knowledge systems, who are capable of influencing the implementation and use of technology: local farmers, agricultural researchers, technologists, and extension agents. Knowledge systems are the most important components in the development of agricultural KMS and usage. In this research, there are three different categories of domain-specific knowledge relevant in agricultural KMS development and use: farmers' IK, IS/IT experts' technological knowledge, and application domain knowledge of agricultural experts. In order to integrate and share knowledge systems, it is critical to identify relevant social groups, information needs and knowledge systems they possess (Karner et al., 2011).

7.2 Challenges of Knowledge Sharing and Integration in Agricultural KMS

The findings of this research indicated that, knowledge systems in agriculture have been applied in an isolated and fragmented manner historically in agricultural incentives. Despite many challenges in knowledge sharing and sharing in KMS development, their amalgamation can be expected to bring agricultural productivity (Puri, 2007; Tadios, 2012). IK is highly tacit which makes it challenging in sharing and integration (Karner et al., 2011). Another challenge for the integration of IK and scientific knowledge in agricultural KMS development is ignorance of IK hosted in local farmers by scientific communities. This is in-line with the work of Fischer and Ostwald (2003), which revealed that failure to include knowledge systems is the result of ignorance in technological artifact development in support of knowledge communication. Also, the research revealed that, guidelines for agricultural development produced by scientific community are not addressing the issues of knowledge management in particular IK. As a result, local farmers who possess IK lack trust from scientific communities since development endeavors do not participating them.

This research identified that ignorance of IK is attributed to lack of awareness about IK, and knowledge and skill gap on how to share and integrate IK. Previous researchers also support the findings through indicating that failure to consider IK held by local communities attributed to the gap in understanding of the way they share and preserve knowledge (Guye, 2014; Puri, 2007). The ways of IK sharing needs to be understood to transfer and integrate IK into the multiplicity of knowledge systems. Analysis of the data in this research revealed that, indigenous knowledge is basically transmitted, shared, and communicated orally, and through practice, observation, and demonstration. Therefore, scientific community needs to understand farmers' indigenous knowledge and practice, and KM activities so as to enhance IK sharing and integration with scientific knowledge and practice.

This research indicated that agricultural KMS is treated as different configurations of computer applications rather than a specific system or technology having social context, in turn it is limited in reflecting the local communities' knowledge and perspective. Sahay (1998) also reported that, this is due to IS application is treated as a set of technologies and tools in which a particular social context of the technology can itself be regarded as a non-human actor. As a result, applications usually incorporate the motivations and actions of systems designers, and they develop systems on behalf of their interests (Sahay, 1998). Moreover, the findings of this research indicated that agricultural knowledge and technology transfer involve the introduction of modern scientific knowledge and technology developed in the western context for developing countries. This result is also consistent with findings of Puri (2007) and Sahay (1998) in which technology transfer in developing countries developed in the western context. Consequently, IK and perspective held by local farmers are not incorporated in system development; simultaneously local farmers are not actively participated in KMS development.

Ignorance of IK and knowledge gap of how it is shared and integrated create knowledge boundaries between local communities and scientific communities in agricultural systems development. This boundary between researchers, KMS developers, and local communities constructed socially which creates separation among these groups of participants. This separation makes the knowledge systems exchange and integration very challenging.

Knowledge especially having the tacit format can be shared and integrated between people when social participation or interaction exists (Wenger, 1998). Interaction between different CoPs enhances tacit knowledge sharing and integration (Karner et al., 2011). Despite the fact that knowledge boundaries are source of division, fragmentation, disconnection, and misunderstanding among participants of the project, they have also a potential for knowledge systems sharing, integration, and creation of new knowledge (Blackmore, 2010; Fischer & Giaccardi, 2004; Wenger, 1998). As such, understanding of the role of IK is critical for agricultural productivity efforts in which knowledge and skill on how to participate the local farmers and incorporation of local farmers' IK are required by scientific communities.

Involving local people and their IK in the development process improves the chances of successful agricultural development (Puri, 2007). As the finding of this research indicated development of the KMS must include IK of local farmers from the local perspective using participatory approaches both in the development and use of the KMS. As a consequence, pieces of disparate knowledge systems from different CoPs can be integrated together in a more holistic entity. In closing, addressing the sharing and integration of agricultural knowledge system can be expected to bring opportunities including enhancing user participation, preservation of IK, sharing IK, develop local community confidence, creation of multiplicity of knowledge systems, foster the usability of the system and reusability of knowledge from different sources.

7.3 Conceptual Framework for KMS Development and Use

Figure 7-1 provides the findings of the study in the form of a process conceptual framework. The framework consists of concepts or themes identified following phases in IS (i.e., KMS) development suggested by Burstein and Gregor (1999) and Jennex and Olfman (2011) in understanding of the KMS development, use, and impact. The phases in system development action research consist of concept formation, system development, and observation as indicated at the bottom of Figure 7-1. Concept formation phase involves the formulation and experimentation of the theoretical concepts. Relaying on the theoretical concepts, the system development phase provides the design and implementation of the KMS. Finally, the observation phase discusses the evaluation of the KMS success to probe the technological and institutional conditions so as to understand the use and consequence of the KMS/KM.

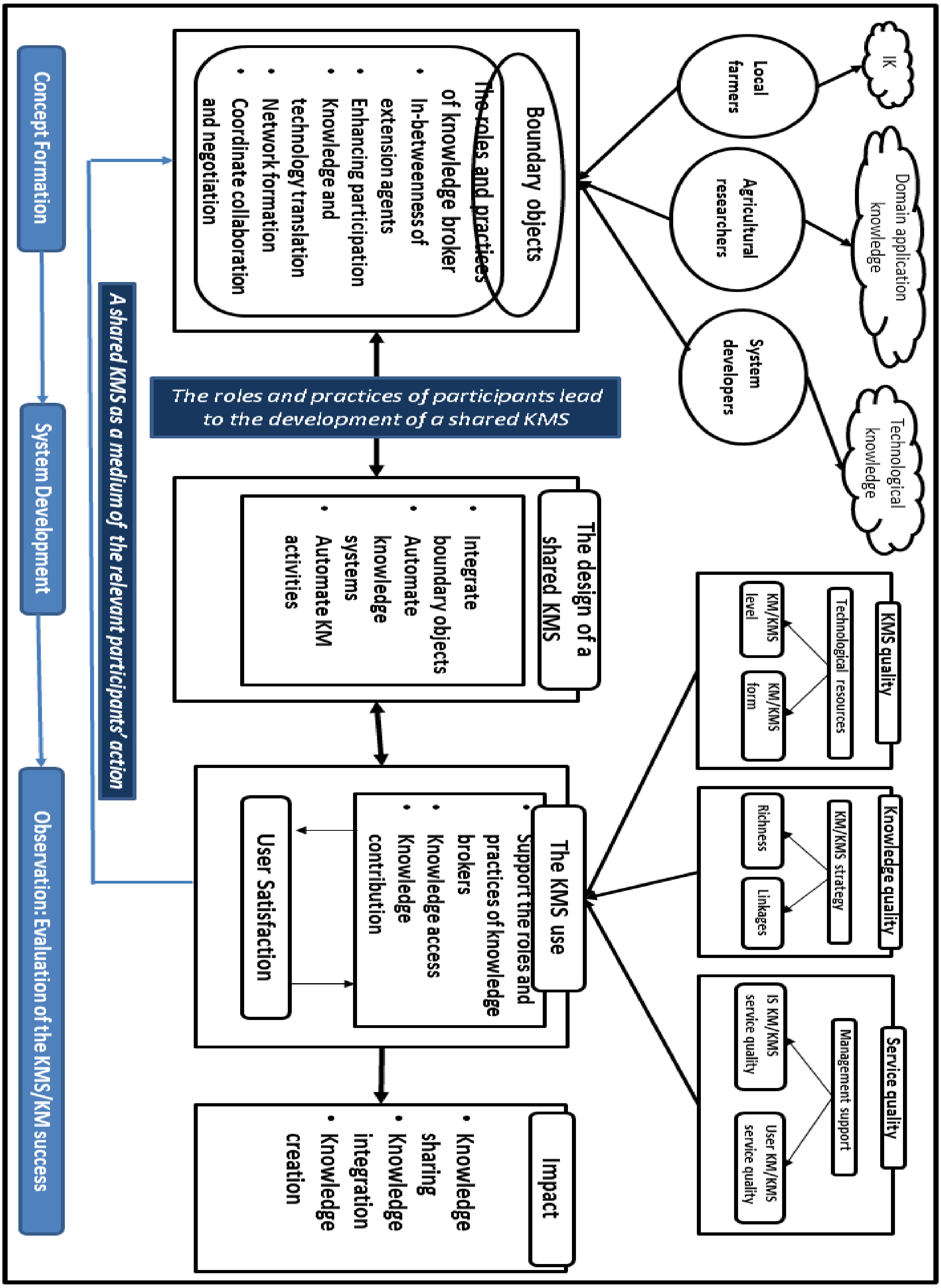

Figure 7-1. The Process Conceptual Framework for Agricultural KMS Development

Source: *Author own construct of Figure 3-1.*

7.3.1 Concept Formation

An agricultural KMS development involves the participation of multiple interdependent relevant social groups, typically representing specialized perspectives (Sahay & Robey, 1996). The process conceptual framework of this study consists of individuals from different social groups who are responsible for the component of agricultural KMS and having power in the agricultural system development and use: local farmers, research groups, extension agents, and technologists. These groups of participants have their own knowledge systems and roles, in turn each group has their own interpretation of a shared KMS and they can shape the technology. Therefore, identifying relevant social groups and involving their active participation and knowledge systems are critical in KMS development and use.

The findings of this research indicated that one of the challenges of knowledge integration in agricultural KMS development is to bring all relevant participants together and enhances the interaction between them to share and integrate their knowledge. For this purpose, some degree of shared understanding across the different relevant communities is required through effective communication (Rosenkranz et al., 2014). Wenger (1998) suggested that knowledge brokering and boundary object through situated interaction taking place in communities of practice can bridge knowledge boundaries.

Additionally, situated learning through interaction is highly relevant to the complex problems in agricultural KMS development due to the IK type of knowledge is embedded in practice, objects, and in the minds of human being. Accordingly, the roles and practices of extension agents as knowledge brokers with boundary objects can have a potential to bridge the knowledge boundaries, thereby contribute to knowledge sharing and integration across several social groups (Lave & Wenger, 1991; Levina & Vaast, 2005). To this effect, extension agents in the Ethiopian extension program can play great roles as knowledge brokers between research and local communities for knowledge sharing and integration in agricultural KMS development and use. Knowledge brokering is a multidimensional intermediary activity designed to build relationship and enhances interaction among participants for knowledge exchange.

7.3.1.1 Extension Agents as Knowledge Brokers

Several researches have been conducted to understand the roles of human agents as knowledge brokers in agricultural and health extension systems, new product development, and system development (Kanjo, 2012; Levina & Vaast, 2005; Pawlowski & Robey, 2004; Rosenkranz et al., 2014). However, there is a gap in agriculture about the roles and practices of extension agents as knowledge brokers for knowledge sharing and integration in KMS development and use. Moreover, extension agents in the current agricultural extension system are assumed to play merely roles in knowledge and technology transfer from research to local communities. However, extension agents are important human actors for knowledge brokering in agricultural sector for knowledge and technology exchange in two directions and providing extension consultancy services to local farmers. The findings of this research provide a detailed account of the roles and practices of extension agents as knowledge brokers for knowledge sharing and integration in KMS development and use. In order to share and integrate the broad knowledge systems in agricultural KMS development, this research is resulted in the following roles and practices of extension agents as knowledge brokers: in-betweenness of agents, enhance participation, knowledge and technology translation, network formation, and coordinate collaboration and negotiation.

7.3.1.1.1 In-betweenness of Extension Agents

The findings of this research revealed that extension agents are positioned to transfer knowledge and technology from research to local communities. Despite extension agents' in-betweenness foster interaction among relevant social groups; they are facilitating only one-way communication or activities in the current extension system. One-directional knowledge sharing from researchers and technologists to local communities by knowledge brokers is not very likely enough to share and integrate knowledge (Karner et al., 2011). However, in-betweenness of extension agents has a potential to transfer knowledge and technologies from local farmers to research and technologies groups. Previous works also reported that in-betweenness of knowledge broker needs to be positioned to enhance two-way communication and interaction between participants coming from different social groups for knowledge and technology exchange (Karner et al., 2011; Kislov et al., 2016). Knowledge brokers should be positioned to provide opportunities to participate users from different units of organization that is to incorporate users' domain knowledge in the system and enhance interaction.

In-betweenness of extension agents as knowledge brokers is critical to enhance two-way communication and interaction between research and system developers with local communities. For this purpose, they need to work closely with all relevant CoPs such as local farmers, system developers, and agricultural researchers to share and integrate knowledge among relevant CoPs. In particular, extension agents need to be well positioned to sustain an open and two-way communication with farmers and researchers through participating and interacting with them in all levels of agricultural development and KMS development (Hellin, 2012; Klerkx, Hall, & Leeuwis, 2009). As such, they can learn from local communities, educate them and engaging with them at the requirement elicitation or need assessment, planning, designing of KMS, implementation, usage, and evaluation levels.

7.3.1.1.2 Enhance Participation

Agricultural KMS development is cross-disciplinary in which contributions from multiple disciplines are highly required. It demands collective action of relevant social groups possessing different kinds of knowledge for their common interest in all stages of the development process in-line with the suggestion of Hellin (2012). Accordingly, extension agents as knowledge brokers can facilitate the interaction of members coming from different CoPs and motivate them to participate by crossing knowledge boundaries and engaging to educate and learn from them, in turn to exchange knowledge and technology. A learning community of practice must push its knowledge boundary and interact with other CoPs (Wenger, 1998). For this purpose, extension agents need to keep the different CoPs in touch, share resources such as knowledge and work closely with all relevant CoPs. In particular, to participate local communities and involve their highly tacit IK, it is important to focus on informal networks of local communities through crossing their boundaries and participating in their work practices. Choi, Huang, Palmer, and Lenore (2014) also suggested that crossing informal groups and creating relationship can significantly enhance active participations.

Participation is a complex social process that involves talking, working, feeling and belonging, which combines both personal and social relations (Wenger, 1998, p. 56). Thus, personal and social participation and active involvement of agents with different social groups are critical through crossing informal local communities and formal groups in relevant organizations, thereby supports the participation of all social groups and enables knowledge and technology exchange. However, extension agents need to get permission to cross different relevant CoPs both informal local groups at their farming land and formal social groups of agricultural researchers and technologists in organizations such as EIAR, RARCs, MoARD, and ATA. This role of knowledge brokering, therefore, requires special qualities of credibility and legitimacy of extension agents in order to cross and interact with different social groups (Hellin, 2012; Kislov et al., 2016; Koutsouris, 2014) and should take independent and an impartial position (Klerkx et al., 2009). However, maintaining neutrality in knowledge and technology exchange is still challenging due to the top-down structure of the extension system, which directs only the transfer of scientific knowledge from research to local farmers.

7.3.1.1.3 Network Formation

Collective action of informal groups of farmers and formal groups of researchers in organizations have a significant role for agricultural development (Hellin, 2012). According to Kislov et al. (2016) and Robeson et al. (2008), one of the strategies used to develop and maintain relationship and interaction among different CoPs is strengthening and building of a network. A community of CoPs or community of interest is a network of people from different CoPs engaged in a process of collective learning in a shared domain of interest (Wenger et al., 2002). In order to enhance participation and interaction among members from diverse social groups, the network formation role of extension agent is crucial in strengthening the bond within the CoP, creating a network between different CoPs, and engaging them for their common activities. An agent can bring different separated CoPs together, strengthen the link within a CoP and enhances idea and perspective exchanging (Kislov et al., 2016; Robeson et al., 2008). Pawlowski and Robey (2004) also suggested that one way that knowledge broker promotes knowledge sharing is through connecting users from different unit of an organization who are dealing with similar issues.

In this research, local farmers form informal network based on their social or personal relationships (Choi et al., 2014) and they self-organize and work together on an informal basis (Hellin, 2012). There are also formal and informal groups of research and technology in different formal organizations. Networking is especially important for this research context which consists of both formal and informal working groups in distributed environment having a common interest (Choi et al., 2014; Wenger, 1998). Fostering networks of informal groups and formal groups as a social, institutional, and technical process is crucial for interactive learning through brokering (Koutsouris, 2014). An interactive learning among members encourages knowledge sharing especially the indigenous knowledge having tacit format by exposing farmers through participation and interaction with formal groups, in turn knowledge from different sources can be integrated for their collective action.

7.3.1.1.4 Knowledge and Technology Translation

Knowledge translation occurs between two different CoPs having different knowledge systems, perspectives, and social contexts (Carlile, 2004). Accordingly, knowledge and technology translation are required through transforming their form from one CoP into another (Tubigi et al., 2013). The research is resulted in the role and practice of knowledge and technology translation by extension agents as knowledge brokers to local farmers from researchers and technologists and the vice versa. The finding is consistent with the work of Wenger (1998) as knowledge translation is the role of a broker in which framing elements of the world view of scientific research in terms of the perspective of local farmers and the vice versa. However, this role is carried out following the current hierarchical structure of agricultural extension system, which is top-down knowledge transferring from research to local farmer but not the vice versa. Knowledge exchange is an interactive process, which involves a series of interactions between social groups and it needs knowledge translation from one another.

This research revealed that the role of extension agents as knowledge brokers can translate and interpret IK and perspective of local farmers to research and system developers' communities of practice. Agents also support the transformation of knowledge and technology into action through explaining and interpreting the procedures into the specific context of use. Several researchers such as Kislov et al. (2016), Pawlowski and Robey (2004), and Tubigi et al. (2013) also reported the translation, transformation, and interpretation as the roles of knowledge brokers for knowledge exchanging facilitation. This is in-line with the argumentation that bi-directional knowledge and technology translation between research and local communities are critical for knowledge sharing and integration (Kislov et al., 2016).

7.3.1.1.5 Coordinate Collaboration and Negotiation

In agricultural development, there are different groups of people having different roles. Consequently, collaboration and negotiation among relevant social groups are important in agricultural collective action (Hellin, 2012; Klerkx et al., 2009; Koutsouris, 2014; Puri, 2007). Knowledge sharing and integration between different CoPs is a two-way collaboration and negotiation and a mutual adjustment of both source and recipient of knowledge and technology is critical (Karner et al., 2011; Kislov et al., 2016). Accordingly, one of the roles of extension agents as knowledge brokers is coordinating and facilitating negotiation between different stakeholders, thereby they participate and interact relevant stakeholders and develop a common understanding. The research revealed that the powerful potential of extension agents as knowledge brokers is in assembling individuals from different social groups and enhance collaboration in particular local communities who were neglected in different development efforts in agriculture. Knowledge brokers must also work together with other CoPs, while different social groups in a community of interest contribute their expertise (Karner et al., 2011). Collaboration needs not only promote contribution of knowledge and experience by participant but also reflects on how their expertise can productively and usefully be exposed and juxtaposed with others' expertise (Karner et al., 2011).

The process of agricultural development needs an open dialogue and negotiation among different social groups in developing solutions for complex and dynamic problems (Koutsouris, 2014). Extension agents assist participants to engage in a communicative dialogue and in the development of consensus about the action to be taken so as to negotiate on the scope of the problem to be addressed and consensual solution. Coordination role of agents allows participants to be confronted with different kinds of participations (Koutsouris, 2014; Wenger, 1998), consequently all users mutually reflect their expertise and knowledge from different sources can be integrated. However, during the interaction among members of CoPs, farmers may expect that scientific research overlooks their knowledge and experience. Thus, knowledge brokering activities require maintaining a certain degree of equanimity (Kislov et al., 2016; Robeson et al., 2008) while facilitating the coordination and negotiation roles. In sum, knowledge building and a deep shared understanding are best promoted when collaboration and negotiation are facilitated through brokers in a dialogic nature in an open community of interest.

7.3.1.2 Boundary Objects

Knowledge is not only embedded in the minds of human being, but also in working routines and processes, organizational rules, practices, norms and in different forms of objects (Bragge & Kivijärvi, 2011; Davenport & Prusak, 1998; Jennex, 2014). As such, the research were also interested in the roles of boundary objects for the externalization of tacit knowledge. This research has identified several boundary objects employed within CoPs and shared among members from different CoPs. Extension agents as knowledge brokers also use and produce boundary objects for their roles of brokering and use boundary objects possessed by participants from different CoPs for their roles and practices of knowledge brokering. Boundary objects have several roles for knowledge sharing and integration among members coming from different CoPs (Levina & Vaast, 2005; Pawlowski & Robey, 2004; Puri, 2007; Rosenkranz et al., 2014). For instance, they foster communication and interaction, and facilitate shared understanding across spatial, conceptual, temporal, geographical, or technological gaps (Fischer & Ostwald, 2003; Star & Griesemer, 1989).

Despite this research identified several boundary objects from different CoPs, they were performing in disparate manner, in turn did not brought common understanding among participants from different CoPs having common interest. This is due to: many of the boundary objects are in use and practiced only within a CoP and few shared boundary objects are not flexible enough to incorporate the needs and expectations of all relevant social groups, in particular local farmers. However, boundary object resides as an interface between various groups of people having common interest (Zaitsev, Gal, & Tan, 2014) and needs to be flexible enough to support them. In order to facilitate KM activities, software packages shared among communities should support the participation, communication, interaction, and collaboration. Previous researches also discussed the roles of shared technological artifacts as boundary objects to enhance participation and collaboration of relevant participants in formal organizations, thereby, to incorporate multiplicity of knowledge in KMS development and use (Levina & Vaast, 2005; Pawlowski & Robey, 2004; Puri, 2007; Rosenkranz et al., 2014). Corollary to this, the findings of this study suggested the requirement of one shared IT-based boundary object to share and integrate knowledge from different distributed CoPs having common interest. As such, a shared ICT-based technological artifact as a boundary object is expected to enable all relevant communities to participate and exchange knowledge in building heterogeneous relationships (Sahay, 1998).

7.3.2 System Development

Concepts and idea formation as a theoretical conceptual framework through the interplay of knowledge brokering and boundary object is the first and critical step in this action system development research (refer also Figure 7-1). Concepts in the conceptual framework further guide the system development including the design and prototyping of the technological artifact in accordance with the suggestions of Burstein and Gregor (1999), Jennex and Olfman (2001, 2011) and Nunamaker et al. (1991) so as to prove concepts and further link the theory (basic research) with practice (applied research). Technological artifact as a boundary object must be extended and reframed the way communities are organized in significant ways (Karner et al., 2011). Accordingly, a shared online KMS has been developed based on the research findings to support the roles and practices of extension agents and other social groups such as local communities and researchers for knowledge sharing and integration.

In order to identify the KMS architecture, the research employed human-centered approach (Antonova et al., 2009; Maier, 2007), which emphases the people and their activities in the system. People are the heart of KMS development and use (Marshall & Rossett, 2000). A general purpose of the development of the KMS is to solve problem of diverse group of people having common interest and enables participants to reflect on and engaged with their practices in the local context (Germonprez et al., 2007, 2011). Technological artifact used by multiple relevant groups needs to be flexible for their multiple interpretations (Sahay & Robey, 1996). Flexibility in the KMS can be brought when boundary objects possessed by participants from different social groups are integrated. As a consequence, relaying on the concepts drawn from the empirical investigation, the KMS has been developed based on the roles and practices of extension agents as knowledge brokers and social groups of local farmers and agricultural researchers and boundary objects possessed by them.

It is also essential to develop a knowledge structure to acquire relevant knowledge resources from individuals in the KMS (McCall, Arnold, & Sutton, 2008). Accordingly, knowledge resources in particular the explicit knowledge are represented in the knowledge repositories of the KMS; in turn it is required to foster the exchange and development of tacit knowledge. The KMS should be tailorable to incorporate users' need of information and knowledge and enable them to redesign the system in use time through modifying and adding functions. A tailorable system is an interactive, customizable, and modifiable technological artifact to incorporate emergent properties (Germonprez et al., 2007) through engaging users in recognizable environment. Accordingly, various integrative and interactive applications were employed to implement the proposed architecture in order to support the KM activities in-line with the suggestion of Zack (1999). Several researches suggested that Web 2.0 tools are appropriate for the implementation of integrative, interactive, and tailorable applications to promote knowledge sharing and integration among diverse groups of users in a distributed environment (Gaál et al., 2015; Jimoyiannis et al., 2013; Sivarajah et al., 2015). They further indicated that Web 2.0 tools provide a learning and participative environment for knowledge sharing, for example the works of Germonprez et al. (2011). Accordingly, a shared KMS having the above facilities was implemented in this research by utilizing Web 2.0 tools. Then, the significance of using a shared KMS boundary object and extension agent as knowledge broker for knowledge sharing and integration has been further investigated.

7.3.3 Observation- Evaluation of KMS/KM Success

Literatures suggested that IS research needs to be investigated not only in the development process but also in use of the technological artifact in the social context (Orlikowski & Robey, 1991). The last phase in this system development action research is to assess the success of the interplay of the developed technological artifact and the roles and practices of knowledge brokers in the study's social context to understand the technological and institutional conditions, the use of the KMS and the consequence of the usage. The success of the interplay of extension agents as knowledge brokers and KMS boundary object was assessed using Jennex and Olfmans' (2006, 2011) model of KM/KMS success dimensions. The interplay of the roles of brokering and a shared KMS boundary object is enabled through the structural properties of social systems and these may be sustained or changed when being used by human agents. The organizational structural properties and the condition of the technological artifact are essential to understand the success of the KMS/KM in the agricultural extension system. Accordingly, the study assesses and discusses the critical success factors pertinent to the structural properties of social systems or relevant organizations and technological conditions through the dimensions including the system quality, knowledge quality, and service quality as functional drivers to understand the system use and impact (Jennex & Olfman, 2006, 2011; Jennex et al., 2016).

7.3.3.1 KMS Quality

The system quality factor is measured through the three constructs, namely, technological resources of the organization, KM/KMS form, and KM/KMS level. Consistent with Jennex and Olfman (2006, 2011), technological resources available in the Ethiopian extenstion system and relevant organizations have the capability to integrate and operate the KM/KMS infrastructures through developing, operating, and maintaining the KM/KMS infrastructures for knowledge integration. This research found that the existing technological infrastructure in the organization and a common infrastructure (i.e., the Internet) have the capability to process both the scientific and indigenous knowledge. In building this research, integrated technological infrastructures in a shared KMS consists of networks, search engine, groupware tools, databases and knowledge repositories, clients, web server, database server, web server software, and client and server scripting languages. Additionally, the KMS integrated users' requirements and expectations, relevant social groups' competency in KM activities, knowledge brokering roles and practices by extension agents, and boundary objects possessed by relevant CoPs. However, the existing infrastructure lacks the integration of data mining tools for extracting patterns and knowledge from the existing knowledge and documents.

A shared KMS boundary object provided interpretatively flexible to be used by different participants to promote communication, interaction, and collaboration among relevant participants and supports them to build shared understanding. The KMS enables all relevant users to perform the KM activities through possessing both indigenous and scientific knowledge. The past experience applied for developing and managing scientific knowledge can also be used for possessing indigenous knowledge. Additionally, the system provides a user friendly interface with appropriate language of users and enhances communication and interaction among users so as to support the users' roles and practices and delivers relevant information and knowledge timely to individuals.

Integrating the technological infrastructures and organizational capabilities enables the KM/KMS form and KM/KMS level constructs (Jennex & Olfman, 2006). With regard to the KM/KMS form, the knowledge resources from relevant social groups and KM activities possessed by participants in agriculture are computerized and integrated. As discussed in section 6.2.3, appropriate Web 2.0 tools have been integrated in the development of KMS in order to support KM activities and representation of knowledge systems following the Nonaka's (1994) model of knowledge creation and transfer. In order to integrate various aspects of the KMS for knowledge sharing and integration, the research utilized Web 2.0 tools in-line with the suggestion of Jimoyiannis et al. (2013) and Wang et al. (2007). Web 2.0 tools provided a rich knowledge sources and design environment for users to incorporate the users' knowledge and modify the interface and function of a shared KMS. However, attention should be given when technological tools as boundary objects are chosen (Karner et al., 2011; Zaitsev et al., 2014) to provide flexibility of use by various groups of users. For this purpose, appropriate Web 2.0 tools have been carefully selected and integrated in a shared KMS according to the participants' capabilities, boundary objects, and knowledge resources.

As a result of supporting the KM activities and acquisition and representation of diverse knowledge systems via a shared KMS, it helps users to contribute their knowledge and experience and access knowledge from different sources timely. A shared KMS boundary object enables users from different CoPs not only to access and modify the existing knowledge and to add their knowledge to the repository but also, they can modify or customize the interface and function of the KMS. This is because, the KMS was designed through the participation of users to provide variety of system's components, functions, and knowledge services, and be able users to filter knowledge and self-service in their own language. As a result, indigenous and scientific knowledge are stored and integrated in the knowledge repositoriy of the KMS.

Regarding the KM/KMS level, the KMS has the capability to provide knowledge from different sources to support the current agricultural extension services through KM/KMS mnemonic functions of knowledge searching, visualization, retrieval, assessment, and manipulation. In-line with the suggestion of Zack (1999) and Alavi and Leidner (1999), the architecture of this KMS incorporated integrative and interactive applications in order to provide knowledge assessment, visualization, searching, and content management and supports network formation, interaction, collaboration, and negotiation among members coming from different CoPs as discussed in section 6.3. Additionally, search-ability facilities in the KMS allow users to access knowledge systems necessary to get jobs done. Also, a shared KMS fosters the roles and practices of knowledge brokering. Subsequently, the interplay of a shared KMS and the roles of knowledge brokering allows users to access diverse knowledge from a number of users in different social groups and an efficient exchange of different forms of knowledge. It also offers enhanced learning environment through supporting local farmers' participation, formal and informal conversations, and open dialogue. Consequently, the KMS helps users to access, share, and integrate knowledge so as to support their roles and practices effectively.

7.3.3.2 Knowledge Quality

It is measured through the constructs including KMS/KM strategy and process, knowledge richness, and knowledge linkages. The KMS/KM strategy and process construct is crucial for ensuring the contents and effectiveness of the constructs of the knowledge linkages and richness of the knowledge systems (Jennex & Olfman, 2001, 2006). An online KMS boundary object supports the roles and practices of individuals from local communities, extension agents, agricultural researchers, and system developers' groups and represents associated knowledge systems. It is essential to store, share, and integrate relevant knowledge for agricultural productivity in the knowledge repository. Also, the KMS supports knowledge access through locating knowledge and experts. KM activities for knowledge sharing and integration through capturing, disseminating, and combining the tacit indigenous knowledge with explicit scientific knowledge are clearly articulated and easily understood to ensuring the users' knowledge requirements and expectations. As a result, the KMS with knowledge brokers provides an online open learning environment in the agricultural extension system through creating participative, interactive, and collaborative culture.

Regarding the knowledge richness, knowledge and information from various sources in different formats have been provided through the KMS including numeric, audio, video, text, and image formats with appropriate users' language. Accordingly, a combination of indigenous and scientific knowledge is shared among participants and available timely for decision making. Additionally, the construct knowledge linkages is crucial to access the knowledge and experts' maps in the KMS/KM to locate the source of knowledge and experts to the participants (Jennex & Olfman, 2006). Users can join different social groups such as local communities, researchers or extension agents to locate experts and exchange knowledge among members within a social group or among different social groups. Also, knowledge and documents possessed by each social groups are available to users in a shared KMS. As a consequence, novice users can learn and apply new knowledge and reflect and share their own knowledge and experience. This is essential to exchange IK having tacit format and for sourcing to the richness of knowledge systems.

7.3.3.3 Service Quality

The service quality dimension is measured through the constructs: management support, KMS/KM service quality, and user KMS/KM service quality (Jennex & Olfman, 2006). In order to support the management support, the KMS provided open non-hierarchical organizational structure through promoting one-to-one, one-to-many, and many-to-many communication and interaction among participants. As a result, KMS enables users from different CoPs to connect with others from different communities; in turn users are exposed to different perspectives and knowledge. A shared KMS is highly important not only to reach too many users geographically disparate and enhances the interaction between researchers, extension agents and farmers but also provides distributed environment to disseminate knowledge in two-way mode instantly. The KMS allows users to bypass the existing bureaucratic hierarchies and creates informal communities having common interest. Pervious researches have also indicated that nonhierarchical structure are emerged when ISs such as KMS and DSS are developed using Web 2.0 tools and used for fostering knowledge sharing in organization (Al-Taee, 2013; Choi et al., 2014).

The interplay of brokering and a shared KMS witnessed a paradigm shift in Ethiopian agricultural extension program from hierarchical structure to decentralized structure, networked, dynamic, and open learning environment. Decentralizing the organizational structure can eliminate organizational layers by fostering interaction and communication (Becerra-Fernandez & Sabherwal, 2010). As a result, collaborative culture is more likely to occur through the support of the KMS/KM, which is vital for knowledge sharing. However, it is important to note that high level of joint trust among participants needs to be developed in the Ethiopian agricultural extension program (Margila & Bello, 2015). This is because participants particularly the local farmers may be skeptical about the behavior of scientific communities towards them, in turn they may not share their knowledge. Then, the management support construct further enables the other two constructs: user KM service quality and KMS/KM service quality.

With regard to user KMS/KM service quality, the support includes raising awareness and providing training to users on how to use a shared KMS for supporting their roles and practices and incentives to reward user for knowledge sourcing and encouraging participants to communicate and collaborate with others. The research resulted in identifying limited skills and knowledge of extension agents in the Ethiopian extension system to enhance their roles to knowledge exchange and integration. This is due to shortcoming in most educational curricula in higher education which lack knowledge about knowledge management and knowledge brokering for extension agents. This finding is also consistent with the work of Karner et al. (2011) and Robeson et al. (2008) on the need of academic program to prepare extension agents as knowledge brokers. This research pointed the two required skill and knowledge about KM activities and brokering for effective and efficient knoweldge brokering roles and practices. These skill and knowledge are expected to enable brokers to be efficient and effective, thereby they can facilitate knowledge exchange.

All relevant users of a shared KMS further need to know and apply KMS tools to support their KM activities. Education to the relevant participants is cricial to aware them with the KMS/KM benefits. Extension agents require knowledge of KMS tools for their daily practices of knowledge brokering. Local farmers also need awareness about the KMS tools and take an advantage for their practices. In order to raise awareness and enhance the participation of users in the KMS development and use, training is highly critical. Wenger et al. (2002) also indicated that regular training session and technical support are required to foster the use of online KMS tools since users may be relatively reluctant in participating in online communication and interaction in the beginning. Participants should be encouraged to express their doubts and questions regarding their practices and others' thoughts. Additionally, providing appropriate reward system is essential to build knowledge sharing culture through supporting and encouraging user to contribute their knowledge and experience (Becerra-Fernandez & Sabherwal, 2010).

In addressing the KMS/KM service quality, the KMS developers are required to identify the KM activities and objectives, knowledge users and sources, and knowledge systems shared and integrated in the KMS. Accordingly, the developers can create databases, knowledge repositories, and knowledge maps in a shared KMS to providing a learning environment platform for knowledge sharing and integration. Interaction between human agents and the technological artifact in an organization requires rules that govern legitimate conduct

(Orlikowski, 1992). In building this research, the KMS developed using Web 2.0 involves procedures, guideline, and privacy issues since they are essential in an open system to allow participation, communication, and negotiation of individuals. Additionally, complementing traditional agricultural extension system with the KMS is considerably changing the roles of relevant social groups in the context of knowledge sharing and integration, especially the roles of extension agents as knowledge brokers. As a consequence, their roles need to be clearly defined and appropriate training needs to be provided by KMS developers on KM activities and KMS use. In addition, the participants' roles and practices need to be well thought out to enhance online participation, content provision, and to foster collaboration through a shared KMS boundary object (Flor, 2013). Accordingly, there is a need to set up clear rules and procedures with regard to how local farmers, extension agents, and researchers behave when they use the KMS.

Common problems in using an online shared KMS employed Web 2.0 tools are intellectual property issues such as copyright and privacy, in particular the documentation of IK and practice. In this regard, website's terms and conditions are considered as copyright for the materials uploaded. It is further important to document and present general 'Dos' and 'Don'ts' to the participant regarding the use of a shared KMS. Additionally, users may require to presenting their knowledge content to some other selective users. Users may also afraid to ask others publicly over the online the KMS. For this purpose, this KMS has activity privacy setting which allows the members to choose who can read/see his/her activities and media files. Overall, a comprehensive set of policies needs to be well prepared to foster knowledge sharing and integration.

7.3.3.4 Intent to Use/Perceived Benefit

This research discusses the perceived benefit of the KMS usage by extension agents through examining the roles and practices of extension agents as knowledge brokers and by the end-users (i.e., farmers and agricultural researchers) for knowledge use and contribution in an increase in job performance and productivity. A shared KMS in this research has been developed to support brokering roles and practices and users from local farmers and researchers to access and contribute their knowledge and perspectives. Despite the significant roles of a shared KMS boundary object for knowledge sharing and integration, the KMS did not replace the need of knowledge brokers. Extension agents as knowledge brokers in this regard still contribute a mediation role among geographical distributed social groups and technically support local communities in the use of the KMS. Previous researches also suggested the dynamics of the interplay of technological artifact and human agent as a knowledge broker to understand knowledge sharing and integration among relevant social groups having common interest (Gasson, 2005; Levina & Vaast, 2005; Pawlowski & Robey, 2004; Rosenkranz et al., 2014). As such, the following sections discuss the social factors in using of a shared KMS boundary object by extension agent as a knowledge broker.

7.3.3.4.1 In-betweenness of Extension Agents

While literature is rich in providing the significance of in-betweenness of extension agents for brokering (Hellin, 2012; Karner et al., 2011; Kislov et al., 2016). This role of brokering is very challenging for extension agents to work closely and exchange knowledge and technology with all relevant social groups who are geographically dispersed in different organizations and rural districts of the country. A shared KMS boundary object can, hence, support extension agents to reach to distributed relevant social groups and fosters interaction among them. Extant researchers also shown that the roles of technological artifact as a boundary object positioned as an interface between different social groups that connects and enhances participation and interaction among them (Gasson, 2005; Levina & Vaast, 2005).

The interplay of the KMS and knowledge brokering creates an interactive and multidirectional open environment for participation and interaction. For instance, interactive applications such as real time collaboration tools, instant messaging, social networking, and Wiki in a shared KMS create an open online environment for all social groups to virtual meat each other and access contents and reflect on others' knowledge and experience. A shared KMS supports in-betweenness of extension agents through enabling them to reach to geographically disperse social groups, peer review, and the evolution of collective intelligence, whereby fosters knowledge sharing and integration. Therefore, a KMS and extension agents occupying in between position as intermediary role among participants from different CoPs having a common goal are brought about interesting result in knowledge sharing and integration.

7.3.3.4.2 Enhance Participation

The current agricultural extension system lacks technological artifact which can support extension agents' roles of the ongoing involvement of participants from different social groups who are geographically distributed. However, with the rise of Web 2.0 tools today; learning in CoPs is no more bounded by geographical distance to interact. A shared KMS as a boundary object in this research was designed using Web 2.0 tools to promote the users' engagement (Jimoyiannis et al., 2013). It was designed through establishing a common ground for all relevant social groups and enabled brokers to cross knowledge boundaries among CoPs in accordance with the suggestion of the works of Carlile (2002) and Star and Griesemer (1989). A shared KMS needs to flexibility enough to support and sustain the practices all relevant social groups and enables the extension agents to work closely with them so as to help them to crossing relevant CoPs for knowledge sharing and integration. Therefore, active participation of different social groups was observed both in the design and the use of a shared KMS in the same social context of time and space. This is in-line with the suggestion of Orlikowski (1992), Sahay (1998), and Sahay and Robey (1996) in order to avoid discontinuities in the design and the usage of technological artifact.

The ongoing active participations of users in the development of a shared KMS are resulted in the involvement of all relevant users in the use of the KMS for knowledge sharing and supports extension agent's role of crossing knowledge boundaries. For example, the Wiki and forum in a shared KMS enhance interaction among individuals within a CoP and with other CoPs and support extension agents to engage in different practices of social groups such as local farmers, researchers who are located in distributed geographical locations, thereby foster the externalization of tacit knowledge from individuals. A shared KMS can, hence, transform the notion of farmer training center by extending the learning space both physically and virtually. Extension agents through the KMS can reach to local farmers located in other local districts and scientific communities located in different agricultural offices in different parts of the country, whereby facilitate knowledge and technology exchange.

Young people are more likely aware about the Web 2.0 tools than the old ones but youngsters are not interested with indigenous knowledge from elders. Thus, sharing indigenous knowledge through online KMS can foster the transfer of such knowledge from elders to youngsters. Web 2.0 tools have potential advantages to participate relevant social groups and the usage of KMS for knowledge sharing. In closing, extension agents as knowledge brokers with a shared KMS positioned themselves in ways that enabled them not only transfer knowledge and technology from research to local farmers but also the vice versa through participating local farmers in the KMS development and use. Simultaneously, indigenous knowledge of local farmers having tacit format can be shared and integrated in KMS design and use. This is consistent with the work of Choi, Huang, Palmer, and Lenore (2014).

7.3.3.4.3 Network Formation

Despite network formation is a crucial role of an extension agent; the task is very difficult without the support of technological artifact due to geographically disparate of relevant social groups. Web 2.0 tools offer enhanced opportunities for Internet based communication and interaction among participants, and can develop social groups or networks, thereby support communities of practice and interest (Jimoyiannis et al., 2013). As a result, an online shared KMS fosters the network formation of participants from formal and informal CoPs having a common interest. For example, the social networking applications integrated in the KMS help to foster connection among individuals within a formal or informal CoP and with other CoPs and support extension agents to facilitate their role of network formation for collective action. Choi et al. (2014) also indicated the significance of shared Web 2.0 application for fostering formal and informal network. Social networking Web 2.0 tools in agricultural sector can help relevant users to get connected each other and develop collective intelligence important for exchange knowledge and technology (Jimoyiannis et al., 2013; Klerkx et al., 2009). A shared KMS, thus, helps users to identify experts, supports the network formation with others, enables users to be exposed to different knowledge from different sources and share their own to others, thereby knowledge sharing and integration can be highly enhanced in a community of interest. Web 2.0 based KMS fosters social ties among relevant social groups for their common interest.

7.3.3.4.4 Knowledge and Technology Translation

An online KMS also supports the knowledge and technology translation role of brokers through creating distributed open structure and linking users from various formal and informal networks having their own knowledge (Al-Taee, 2013; Choi et al., 2014). The KMS provides users with a variety of readings, videos, audio, images, and events from various sources. Additionally, the KMS encourages users to incorporate their own expertise and reflecting on others' expertise. Furthermore, the visualization feature incorporated in the KMS helps agents for demonstration of agricultural technology to local farmers. For this purpose, the KMS integrates various Web 2.0 tools such as Wiki and blogs, audio blogging and podcasting to access different forms of knowledge and encourage for drawing their thoughts, social networks for locating and connecting knowledge experts, and mashup, aggregator (RSS), social tagging and social bookmarking for knowledge integration.

Additionally, the language translator application is integrated in a shared KMS to translate the content from English to local Amharic language. As a consequence, two-directional knowledge and technology translation and interpretation are promoted between relevant social groups. However, knowledge exchange through KMS has limited impact without the involvement of skilled human facilitators (Gasson, 2005; Levina & Vaast, 2005). Thus, extension agents can promote knowledge translation and interpretation through the support of a shared KMS into different local contexts. The KMS enables extension agents to access knowledge from diverse sources, locate agricultural researchers and technologists, and integrate knowledge from different sources, thereby agents can translate and interpret the knowledge and technology into the local context of use. Consequently, the roles of knowledge and technology translation can be fostered through interplay of a shared KMS and knowledge brokers to effectively share and integrate knowledge among relevant CoPs.

7.3.3.4.5 Coordinate Collaboration and Negotiation

Participants from different social groups do not have to be in the same geographical location or the same organization to work together due to the advances in Web 2.0 tools. Technological artifact as a boundary object can further be used to enhance collaboration and negotiation among relevant social groups (Gasson, 2005; Levina & Vaast, 2005; Wenger, 1998, 2000). The process of collaboration and negotiation can be realized through fostering discussion by utilizing Web 2.0 tools such as IM, forums, or Wiki (Wang et al., 2007). A shared KMS as a boundary object was designed based on the roles and practices of relevant social groups to allow participants from different communities to negotiate on their practice through its social interaction applications for open dialogue in-line with the suggestion of Wenger (2000). During the use of a shared KMS, it has been observed that users were coordinating their collaboration and negotiation for their practices with the support of knowledge brokers. Gasson (2005) also indicated that individuals coordinate their practices, interaction, and exchange of knowledge in a shared technological artifact through employing role-definitions. For example, the forum and Wiki features integrated in a shared KMS enable users to contribute their knowledge, modify and comment on others' contents, interact with other in defense position, and to reach to a consensus.

The ongoing participations, interactions, collaborations, negotiations, and reifications drive the social system as a learning process (Brown & Duguid, 1991; Lave & Wenger, 1991). The KMS encourages participants to explore issues that need discussion in order to develop a consensus around an issue. As a result, users exposed to diverse knowledge sources, consequently users learn from others, deepen with expertise, and develop a shared understanding (Germonprez et al., 2011; Karner et al., 2011; Wenger, 1998). Finally, mutual understanding among members of different social groups creates rich knowledge and experience and a common ground for knowledge exchange. Therefore, the interplay of knowledge brokering and shared KMS boundary object enables participants to collaborate and negotiate on their practices, whereby, enhances knowledge sharing and integration.

7.3.3.4.6 Knowledge Access and Sourcing by End-Users

Through the interplay of the KMS and knowledge brokers, users particularly the local community have been encouraged to participate and specify their requirements and contribute their knowledge and experience. A shared KMS employed highly distributed architecture in order to support collaboration among distributed users from different CoPs. The KMS supports users to identify, rate, and rank information and knowledge that is important to them, and the system is also used to record the knowledge contribution of every user. This is highly important for the recognitions of users so as to share their tacit knowledge in particular IK from local farmers. A shared KMS allows those users not only to access and contribute but also customize their interface as they interact with it. As a consequence of the use of a shared KMS boundary object and the roles of extension agents, a culture of more participative and collaborative paradigm in the agricultural extension system is emerged.

A shared KMS with the support of the brokers is not only allowing users to participate and collaborate but also fostering the interaction among participants in a defense position. For instance, wiki integrated in the KMS enables users to interact through offering alternative, inclusion and exclusion of contents, reflecting on others' thought, and acknowledging the consensus with others. Therefore, communication, interaction, and collaboration among participants through a shared KMS and knowledge brokering for common interest is observed. The interplay provides users with diverse knowledge and perspectives from different social groups and also enables them to collaboratively generate knowledge contents. Additionally, the interplay allows users to interact with others so that they can add their own knowledge and reflect on others' thought.

The value of knowledge is circumscribed with the ability to access it when needed for decision making (Tubigi et al., 2013). As users indicated the KMS allows them to continuously access knowledge content from different sources in different formats through the use of query supported mechanisms. It also supports the connection among users and to the documents. In particular, visualization feature and audio information in a shared KMS help local farmers to access and contribute their own through the KMS. The KMS's integrative and interactive applications allow users to search, assess, validate, and manage knowledge contents from the diverse sources. As a result, the KMS enhances the provision of quality knowledge timely for decision making. As indicated by majorities of the informants, they are pleased with the knowledge contents and value provided in different forms, quality of the knowledge, and search-ability of the knowledge resources via the KMS. Additionally, knowledge use through the system enhances their performance by supporting participants'' expectations, roles, and practices from different social groups. Consistent with the previous KMS studies such as Jennex (2013), Jennex et al. (2016), Jennex and Olfman (2006), and Velasquez, Durcikova, and Sabherwal (2009), the users' satisfaction derives an increase in use and usually more likely continued voluntary usage of KMS/KM. The satisfied users from all relevant social groups in Ethiopian agricultural extension systems are expected to continue using the KMS with the help of extension agents through using the existing knowledge and contributing their knowledge as depicted in the process framework (see also Figure 7-1).

7.3.3.5 The Consequence of Using a Shared KMS and Knowledge Brokering

Several studies indicated that job satisfaction is a key determinant factor for the impact of technological artifact use. Jennex and Olfman (2011) derived two constructs to understand the impact of using KMS/KM: ***individual impact*** and ***organizational impact***. Increase in the individuals' performance can be fostered when the KMS/KM has given the user a better understanding of the decision context, the users perform their roles and practices quicker or make better decisions (Jennex & Olfman, 2006, 2011). Organizational impact relates to the performance of the organization as a whole in which each individual impact contributes (Jennex & Olfman, 2006). The use of the interplay of a shared KMS and knowledge brokering can produce an impact on the roles and practices of participants' performance. Impact on the performance of participants from different CoPs can bring efficiency and effectiveness in agricultural extension systems for agricultural productivity.

The interplay of a shared KMS and the roles of brokering has changed the knowledge boundaries between local and scientific communities, formal and informal CoPs, and extension agents as open structure for interaction. As a result, an open learning environment conducive for participatory and interactive learning has been emerged, in turn common shared understanding is derived (Rosenkranz et al., 2014; Wenger, 1998). This also plays a major role in how knowledge (i.e., scientific and indigenous) is created, shared, preserved, remixed, and co-created. Previous researches revealed that common shared understanding is a precursor for knowledge sharing and integration (Bechky, 2003; Karner et al., 2011) through creating common ground for participants coming from different CoPs. Shared understanding through common ground relies on common language and knowledge, symbolic conversation, common practice, and recognition of others' knowledge (Carlile, 2004; Levina & Vaast, 2005). The context of the problem situation is also crucial, which is the story behind the knowledge, and situations which make the knowledge sharable and understandable (Jennex, 2007). Subsequently, the roles of extension agents as knowledge brokers and a shared KMS boundary object have brought the consequences on individual performance and overall organizational effectiveness for knowledge sharing and integration. These are:

1. Knowledge exchange
2. Knowledge integration
3. Knowledge creation

Agricultural development such as KMS development involves participants from different occupation groups for their collective actions (Hellin, 2012; Klerkx et al., 2009). A shared KMS with knowledge brokering supports further-reaching and more innovative to connect with a large number of users from different CoPs. The mediators (KMS and broker) aid users to accelerate the flow and reach of divergent knowledge. As this study demonstrated, the interplay enables users to freely contribute their knowledge, experience, reflection, and perspectives to others. For example, blogs, forum, and wiki enable users to express their thought storytelling and open dialog, which are critical for the articulation of tacit knowledge (Jimoyiannis et al., 2013; Wang et al., 2007). Consequently, mediators brought an increase in users' performance so as to foster the externalization of tacit knowledge since they promote the participation of all relevant users and enable them to interact and collaborate with each other. Especially, mediators help local farmers to share their indigenous knowledge and practices to others. The interaction among participants from different CoPs enables users to share their knowledge and experience, in turn, knowledge with tacit format can be shared among participants, tacit knowledge can be converted into explicit knowledge and diverse knowledge systems are preserved in the knowledge repository of the KMS. As a result, the KMS increased the knowledge content and access in the agricultural extension system, thereby, it minimizes the loss of knowledge due to death and retirement of human agents. In general, the KMS supports the extension system to retain its knowledge through capturing lesson learnt and experiences and share them with its members.

Articulated knowledge from different CoPs can be combined with the existing explicit knowledge in a shared KMS's knowledge repository. In order to combine knowledge from different sources, the process of coordination is facilitated by knowledge brokers and KMS/KM. As such, knowledge boundaries which exist across different occupation groups become an opportunity to integrate knowledge (Carlile, 2004; Lave & Wenger, 1991) through the interplay of mediators. The interplay creates an ongoing two-way communication and interaction across participants from different CoPs. Users from different groups are exposed to diverse knowledge and linked to key knowledge resources. Consequently, users can access knowledge from different sources, reflect on others thought, and learn from others, in turn knowledge from different sources are integrated. As such, the interplay enhances the quality of knowledge for decision making.

The rich integrated repository of knowledge with a greater breadth and depth of knowledge is critical to increase problem-solving abilities by users (McCall et al., 2008). Agricultural developments demand collective action of individuals from relevant social groups possessing different kinds of knowledge (Hellin, 2012). Accordingly, the ability to support users' performance increases in knowledge use through the interplay of mediators is critical to the overall agricultural extension system effectiveness for agricultural productivity. Moreover, iterative process of knowledge combination, users interactions, and '*learning by doing'* (Nonaka, 1994) brought a performance increase for users and the extension system as a whole for new knowledge creation. Learning by doing and discovering and collaborative learning through the interplay of mediators leads to co-creating new knowledge, concepts, and developing new form of thinking by remixing knowledge. This is in-line with the works of Jimoyiannis et al. (2013) and Madar and Abdikadir (2015), users created new knowledge by utilizing the existing knowledge in the knowledge repository and fostering interaction with others through an online KMS developed using Web 2.0 tools.

7.4 The KMS/KM Success and Evaluation of the Study

This action research system development research formulates concepts through analyzing the KMS development for soil fertility management and conservation by interpretive research. Additionally, the research designed the KMS and reanalyzed the data gathered in the use of the KMS in a real organization (i.e., the Ethiopian agriculture extension system) to demonstrate the KMS/KM success dimensions defined in Jennex and Olfman (2006) and Jennex, Smolnik, and Croasdell (2016). Accordingly, the research discusses the success of the KMS/KM in the Ethiopian agriculture extension system. Additionally, the study overall process is evaluated in-line with the suggestions of the interpretive research.

7.4.1 The KMS/KM Success

The KMS success dimensions indicated that the KMS is effective and successful to design, implement, and use the KMS for knowledge sharing, creation, and integration in the organization. As the research indicated, the implementation of the KMS/KM cannot be successful without the quality of the KMS/KM. In this organization (i.e., the agricultural extension system), the integration of KM/KMS infrastructures have the capability to support the relevant users and for managing knowledge. Multiple channels for communication, interaction, and collaboration have been also provided via the KMS for knowledge exchange. Without solid integration of KMS infrastructures and organizational capabilities, the extension system cannot enable the relevant participants to share knowledge resources on a large scale at distributed environment. Moreover, the integration of the KM activities and mnemonic functions in the KMS allows users both to access and source knowledge.

Successful KMS/KM should also provide quality knowledge to the right users in extension program. Through the interplay of brokering and a shared KMS, knowledge from different sources are identified with relevant experts so as to support the KM activities in collecting knowledge from different sources as an asset. This is crucial to understand the knowledge need and how it is applied for the users' roles and practices. Additionally, providing the quality knowledge within the context of users enhances the re-use of knowledge and effective decision making. This is also in-line with the KMS/KM success definition, that is providing the right knowledge to the right user at the right time (Jennex, 2017; Jennex et al., 2016).

The KMS/KM is also successful in providing conducive organizational culture that encourages knowledge sharing and sourcing. In building this research, it has been demonstrated in creating open collaborative culture in the extension program, which is critical for knowledge exchange and use. However, organizational culture regarding KMS/KM activities such as rewarding system, mutual trust, and trainings are required in the Ethiopian extension system. Successful KMS/KM can bring open learning environment to facilitate knowledge sharing but needs a trust-based organizational culture. Additionally, the research revealed the potential of IS experts in the organization who can provide help to the KMS users and sustain the KMS implementation, maintenance, and use.

The KMS success dimensions including KMS quality, knowledge quality, and service quality affect the KMS use and user satisfaction. The use of KMS has been investigated relying on the roles and practices of relevant participants from different social groups in Ethiopian agricultural extension system. The findings of the study have been revealed the KMS/KM use through understanding how the KMS/KM supports the roles and practice of extension agents as knowledge brokers. In this regard, the KMS is successful in supporting the enhance participation, in-between position of agents, knowledge and technology translation, network formation, and coordinate collaboration and negotiation. Additionally, it is successful in supporting participants from local farmers and agricultural researchers for accessing and sourcing knowledge systems.

The KMS/KM success dimensions are indications that the KMS is more likely used by the relevant participants. Hence, it is easier to access and search knowledge from the KMS and users spent less time to submit, share, and sourcing knowledge. Access to multiplicity of knowledge from various sources timely and easiness of the KMS usage allow all relevant users (i.e., farmers, researchers, and extension agents) to increase their ability of knowledge use for decision making and foster the amount of work done. Consistent with previous KMS studies such as Jennex (2013) and Velasquez, Durcikova, and Sabherwal (2009), enhancing the exchange of quality knowledge through the quality KMS leads the more satisfied users with the KMS. This is an indication for continued voluntary usage of KMS by members of the extension system and future use of the KMS/KM when appropriate. This is also supported by the extant literatures Jennex (2013), Jennex et al. (2016) and, Velasquez, Durcikova, and Sabherwal (2009), among others. Consequently, the user satisfaction with the KMS use is critical factor for the success of the KMS for knowledge sharing and integration.

Finally, the findings of the study indicated that the development and use of the KMS/KM are successful in improving the individuals' performance and the organization effectiveness. Previous KMS/KM studies also support the idea that successful KMS/KM leads to greater individual and organizational performance (Jennex & Olfman, 2006; Jennex, 2008, 2013; Jennex et al., 2016; Velasquez et al., 2009). Accessing quality knowledge timely by relevant participants is highly important to make decision effectively. Local farmers in Ethiopia are not productive and vulnerability to food insecurity due to the lack of timely quality knowledge about soil fertility treatment and climate change. Hence, the successful development of KMS/KM helps users to access the quality improved knowledge. The KMS supports users to share, re-use, and contribute knowledge, thereby improves the users' performance to get job done. Obviously, users' task performance is the most significant human output contributing to the effectiveness of organization. Additionally, the successful KMS/KM benefits users to communicate, interact, and collaborate in the extension system, thereby facilitate learning among team members and enabling knowledge sharing. Improving individuals' performance in knowledge sharing, sourcing, and re-using helps the extension program in order to capture, exchange, and integrate knowledge systems. As a result, leveraging knowledge as an organizational asset can support overall organizational performance for agricultural productivity.

7.4.2 Evaluation of the Study

Interpretive research approach helps IS researcher/s to be able to understand the existing human thought and action, and meaning shared by actors within social and organizational contexts so as to understand the IS phenomena through interpretation (Klein & Myers, 1999; Orlikowski & Baroudi, 1991). As a consequence, the interpretive research approach has been increasingly applied in IS research (G. Walsham, 1995), for example, the work of Mlitwa (2010), Pawlowski and Robey (2004), Puri (2007) and, Sahay and Robey (1996). Interpretive researches should take care during data generation and analysis to ensure that themes or concepts in a conceptual framework are actually represented in the transcripts (Brocki & Wearden, 2014). However, guidelines on how to conduct interpretive research and how to evaluate the quality of the research are scared. The seven principles of interpretive research coined by Klein and Myers (1999) are now widely applied for evaluating the interpretive research quality. This research is also applied those principles to evaluating the development of a process conceptual framework and take actions accordingly.

7.4.2.1 The Hermeneutic Circle

According to Klein and Myers (1999, p. 71), the hermeneutic circle is the process of creating interpretative understanding within context about a complex whole from preconceptions about the understanding of the meanings of its parts and their interrelationships. A hermeneutic process enables the researcher to focus on the extent to enter into the research process and the understanding of the parts related to the larger whole iteratively without compromising the validity of the enquiry. For this purpose, the research has been consulted theoretical background to develop the initial process conceptual framework. The study is also grounded to the KMS development for supporting agricultural KM activities through detail investigation of the relevant cases in the developing country context, Ethiopia.

In addition, the research makes senses and interpretations through system development process and interact with various participants, who have different roles and practices but work together for common interest (i.e., agricultural productivity) in-line with the recommendation of Butler (1998). Therefore, the process conceptual framework has been developed by iterating through blending the parts of meaning of various senses and interpretations to the context of the whole message throughout the case study in the development and use of KMS in agriculture. For this purpose, the research is designed to develop a process conceptual framework (whole study) through understanding its part and grasping meaning (i.e., specific objectives or sub-questions) following systems development action research approach (Burstein & Gregor, 1999). Hence, the study was conducted in conformance with the hermeneutic cycle principle of Klein and Myers (1999) and suggestion of Butler (1998) in system development process.

7.4.2.2 Contextualization

This principle requires "*clear reflections of the social and historical background of the research setting to ensure the intended researcher able to see how the current situation under* *investigation emerged*" (Klein & Myers, 1999, p. 73). In order to understand meaning in IS research, it is critical to seek the research context such as historical, social, and cultural (Klein & Myers, 1999). For this purpose, the research has applied the principle through generating a firm understanding of the historical roots of the initiative under investigation and through a detailed literature review.

Additionally, in analyzing and understanding of the agricultural knowledge systems sharing and integration and the challenges including scientific and IK from different participants, the historical, social, and cultural context of them have been investigated and well-addressed. Thus, during the data collection from respondents' particularly local farmers, the principle of contextualization is carefully integrated in utilizing the data collection tools. Furthermore, the investigation of the design, the use, and impact of the shared KMS as a boundary object have been performed in the same time and space to understand further the study context. In the development of the process conceptual framework, the research clearly documented the context and demonstrated its importance. Thus, this principle has helped the researcher to decide on what context and level of understanding should be investigated for developing a process conceptual framework (Klein & Myers, 1999).

7.4.2.3 Interaction between Researcher/s and the Subjects

This principle is more focused on describing the ways in which data collection and interpretation affected each other and on how the research materials (or "*data*") were socially constructed for their interaction (Klein & Myers, 1999, p. 73). Interpretive research suggests that facts are produced as part and parcel of the social interaction of the researcher/s with participants (Klein & Myers, 1999, p. 74). In building the research, the social interaction with respondents during data generation is not only involved in understanding of the knowledge brokering practice, but also in the identification of boundary objects from relevant research subjects and the design and the use of a shared KMS boundary object. Thus, there were high social interactions between the researcher with multiple subjects of participants (i.e., farmers, extension agents, technologists and agricultural researchers) during the different stages of the research including concept formation, the KMS prototyping, and measuring the success of the KMS use. However, clear data collection instrument and follow-up are critical in this regard. For this purpose, instruments were clearly defined based on the extant literatures to avoid unnecessary confusion during interaction with the research respondents. The research also employed participant observations besides to in-depth structured interviews, which strengthen the interaction with informants.

7.4.2.4 Abstraction and Generalization

The principle of abstraction underlines the use of appropriate theories for understanding the situations through data interpretation under investigation (Walsham, 1995). Accordingly, the principle enables some level of generalization that helps in the development of concepts, the generation of theory, the drawing of specific implications, and the drawing of inferences from rich insights from case study (Walsham, 1995). In conformance to this principle, this research primarily employed the situated learning in communities of practice (Lave & Wenger, 1991) social learning theory for understanding of the concepts for knowledge sharing and integration in KMS development and use. Furthermore, a structurational model of technology by Orlikowski (1992, 2000) has been used for a deep understanding the design, the use, and the consequence of a shared KMS as a boundary object relaying on the concepts from the primary conceptual framework development. Moreover, the Jennex and Olfman KM/KMS Success Model (2006, 2011) was used in order to measure the success of an agricultural KMS boundary object for knowledge sharing and integration. Finally, implications from different directions were drawn from the study.

7.4.2.5 Dialogical Reasoning

Interpretation of social phenomena is not a straight-forward activity in which ambiguity and conflict characterized interpretation may resides (Butler, 1998). Such ambiguity and conflict of interpretation can argued be resolved only through a discursive dialectic process (Butler, 1998). Dialogic reasoning is described as the process in interpretive research in which investigator/s *"require sensitivity to possible contradictions between the theoretical preconceptions guiding the research design and actual findings will subsequent cycles of revision*" (Klein & Myers, 1999, p. 72). Therefore, the study primarily developed the initial process conceptual framework based on Lave and Wenger's (1991) theory of situated learning in communities of practice. Then, a structurational model of technology by Orlikowski (1992, 2000) modified from Giddens's structuration theory (Giddens, 1984) has been employed, and further investigated concepts based on the empirical evidences through understanding of the KMS design, use, and consequence. Consequently, the researcher revised the emergent themes when the study findings were not supported with the initial preconceptions in-line with the suggestions of the dialogic reasoning principle of Klein and Myers (1999). The holistic process conceptual framework was developed through dialectical movements with the understanding of parts. Hence, the principle suggests the need of applying objectivity rather than biased reasoning during the analysis, thereby, enables the researcher to avoid personal prejudgments and bias.

7.4.2.6 Multiple Interpretations

Participants from different CoPs may have different meanings to similar concepts or situations due to historical, cultural, and social contexts, which shape the people's views of knowledge (Butler, 1998; Klein & Myers, 1999). Therefore, the principle of multiple interpretations emphasis the researcher/s to account for multiple interpretations in an inquiry and to seek clarity on their motivations (Klein & Myers, 1999). In this regard, the research attempts to understand participants' actions and interpretation from different social context and/or CoPs, in turn applied the multiple interpretations principle of Klein and Myers (1999). Through in-depth interviews and participant observations, data were gathered from farmers, extension agents, technologists and agricultural researchers and different support from organizational documentations. As a result, the research integrates the various interpretations of concepts from individuals coming from different social groups or CoPs in agricultural KMS development and use.

7.4.2.7 The Principle of Suspicion

According to Klein and Myers (1999, p. 72), the principle of suspicion requires "*sensitivity to possible biases and systematic distortions in the narratives collected from the responds*". Consequently, a critical perspective on the researcher suspicion was taken into consideration at all times during the data collection as presented in section 4.5 and analysis of the data as reported in chapter five for contradictory evidence. For this purpose, the interview transcripts, notes from the participant observations, and organization documents were carefully examined for contradictory evidence and the findings are critiqued against the theoretical assumptions. Moreover, researchers and system developers ignored the rural communities and their indigenous knowledge and practice in agricultural development. Due to this, the research involved the perspectives of different social groups. Additionally, interviews transcript and participant observations during the designing and the use of a shared KMS were also further examined the contradiction by involving participants coming from different CoPs, since users may reflect their experience and thought of their interest.

7.5 Summary

This chapter presented the discussion of the finding in-line with relevant extant literatures. The chapter first provided the challenges to knowledge sharing and integration in agricultural KMS development and resulted in: ignorance of IK, lack of awareness, lack of guideline, and non-end user participation. Consequently, the research developed a comprehensive process conceptual framework for understanding of the KMS development and use. The process conceptual framework discussed concepts in-line with the system development action research phases.

Theoretical concepts on the roles and practices of extension agents for knowledge brokering and boundary objects are essential to understand the users' expectations and requirements and KM activities to develop the KMS. Interplay of knowledge brokering and boundary object enables relevant social groups to participate, work together, and negotiate for their daily practices and resulted in the following concepts: enhance participation, in-between position of agents, knowledge and technology translation, network formation, and coordinate collaboration and negotiation. Technological artifacts are a result of users' actions, roles, and practices. Accordingly, the system development stage designed and implemented a shared KMS relying on the theoretical concepts. The last observation stage measured and discussed the success of the KMS using Jennex and Olfmans' (2006, 2011) KMS/KM success model to understand the use and the impact of the system. The benefits from the KMS foster the use of the system and users' satisfaction. Ultimately, the interplay of knowledge brokering and KMS boundary object has brought the individual and organization consequence in increasing the performance for knowledge sharing and integration. Finally, the research is evaluated the process conceptual framework using Klein and Myerss' (1999) seven interpretive research code of conduct and evaluation principles to ensure the quality of the research result.

CHAPTER

8. CONCLUSION AND CONTRIBUTIONS OF THE STUDY

The unique contribution of this study is the development of a process-based conceptual framework for understanding for the development and use of an agricultural KMS for knowledge sharing and integration.

8.1 Revisiting the Research Questions

The findings of many previous ISs researches, among others Masinde (2013), Mercer et al. (2009), Puri (2007), UNDP (2012), and World Bank (1998, 2005) have indicated the benefits of hybridized knowledge that links scientific and IK. Consequently, few researchers such as Puri (2007) have investigated how the two knowledge types can be shared and integrated in agricultural KMS development. Moreover, Rosenkranz et al. (2014) indicated that development of IS involves the communication, interaction, and collaboration of diverse groups of participants. IK of local farmers have highly tacit format; hence, the participation of local farmers is required not only in the design of KMS but also in the use of it to share users experience and knowledge with other participants and integrate IK with scientific knowledge. Against these backdrops, this research is aimed at readdressing the agricultural KMS development and use for knowledge sharing and integration to support relevant stakeholders. Accordingly, the research examined the main research question:

> ***How the agricultural KMS are developed to share the indigenous knowledge and integrate it with the mainstream of scientific knowledge in agriculture?***

In order to answer the main research question, the study employed systems development action research approach (Burstein & Gregor, 1999; Nunamaker et al., 1991) and aimed at answering five research sub-questions. Primarily, extant literatures pertinent to each sub-question have been reviewed. Through literature review, the study develops an initial process conceptual framework for understanding of the KMS development and use for knowledge sharing and integration. For this purpose, the research employed the theory of situated learning in CoPs (Lave & Wenger, 1991; Wenger, 1998). Several researches suggested to link the theoretical study (basic research) with practice (applied research) (Burstein & Gregor, 1999; Jennex & Olfman, 2011; Orlikowski & Baroudi, 1991). As a result, the initial conceptual framework is extended to understand the design, the use, and the consequence of using the KMS in agriculture.

Prior to investigating the first two research sub-questions, the research investigated how indigenous and scientific knowledge are shared and challenges of sharing and integrating IK in the existing agricultural extension system. For this purpose, the study deeply investigated the EthioSIS as a case study for underlying aspects of the practice of soil fertility management and conservation. The communication, collaboration, and interaction between participants are a major determinant for the success of IS development and use, in turn system development method needs to refocus on people-centered rather than pure engineering (Rosenkranz et al., 2014). It is, hence, important first to identify relevant social groups having common interest and their roles and boundary objects possessed by those groups in KMS development process. Accordingly, this study investigated to answer the first two sub-questions relying on the theory of situated learning in community of practices (Lave & Wenger, 1991; Wenger, 1998). These are:

> ***Question 1: How do the roles and practices of extension agents as knowledge brokers contribute for the sharing and integration of the variety of knowledge in agricultural KMS development and use?***

> ***Question 2: What are the boundary objects used by participants from different CoPs in agricultural KMS development for knowledge sharing and integration?***

Situated learning in CoP (Wenger, 1998) which provided concepts of knowledge brokering and boundary objects is a crucial building blocks for understanding of the knowledge sharing and integration in KMS development process. The knowledge brokering roles and practices by extension agents and boundary objects take place the overall frame of communities of practice (Wenger, 1998). These broad concepts have been applied for understanding of the knowledge sharing and integration from different CoPs in different organizations.

In order to address the above two sub-questions in phase I, analysis of 43 interviews and participant observations was carried out from different organizations (i.e., ATA, MoARD, and North Gondar agricultural office and woreda level) and two kebeles in North Gondar of Amhara Regional State of Ethiopia. The research revealed the roles and practices of extension agents as knowledge brokers for knowledge sharing and integration in KMS development and resulted in with five themes: enhance participation, in-betweenness of extension agents, knowledge and technology translation, network formation, and coordinate collaboration and negotiation. Consequently, the roles and practices of extension agents as knowledge brokers can have a potential to bridge the knowledge boundaries through exchanging knowledge, experience, and perspectives among participants. However, extension agents require skill and knowledge for their roles and practices of knowledge brokering as the research result indicated. These are skill and knowledge about KM and brokering.

Understanding of the roles and practices of knowledge brokers is not only enough to understand knowledge sharing and integration, but there is also a need to probe the role of boundary objects. Boundary objects can facilitate the connection among people within a social group and participants from different social groups. A number of boundary objects possessed by relevant social groups in agricultural KMS development for knowledge sharing and integration were identified. However, the research revealed that boundary objects possessed by local farmers were not involved in the development of an agricultural KMS. As a result, KMSs in agriculture were inappropriately developed and failing to address the problem of local farmers. Consequently, technological artifacts do not allow local farmers to use the systems and reflect their knowledge and perspectives to other social groups. Boundary objects used for knowledge sharing and understanding in particular for IK of farmers need to be identified and utilized while KMSs are developed.

For a community of interest having different groups of participants, one shared KMS is suggested to be developed, thereby fosters shared understanding to share and integrate knowledge. This research, for example, identified oral mapping which can enhance the participation of local farmers, thereby to increase shared understand. Hence, there is a need to create a shared KMS for communication, interaction, and collaboration through system development. Such shared boundary object should be flexible and adaptable to the needs of different social groups (Sahay & Robey, 1996) and tailorable for adding and updating the content and modifying the function and application of the KMS during the use time

(Germonprez et al., 2007, 2011). As a result, the research further investigates the design of a shared KMS.

Question 3: How a shared technological artifact is designed for knowledge sharing and integration?

In order to address this and next two sub-questions in phase II, analysis of 39 interviews and participant observations were carried out. A shared KMS should be developed relying on the roles and practices of knowledge brokers, and needs and expectations of other social groups. The development process participates all relevant social groups and involves their need of knowledge and information to establish common ground for different participants and enables to cross knowledge boundaries among participants (Carlile, 2002; Star & Griesemer, 1989; Wenger, 1998). Previously, the design and use of technological artifacts were usually takes place and investigated in different social context of time and space (Orlikowski, 1992; Orlikowski & Baroudi, 1991; Orlikowski & Robey, 1991; Sahay & Robey, 1996), in turn resulted in discontinuities in social context (Orlikowski, 1992). However, "*all social interaction is situated interaction- situated in time and space*" (Giddens, 1984, p. 86). Therefore, there is a need to understand the duality of technological artifact in the design and the use time in the same social context.

Orlikowski and Robey (1991) suggested the investigation of system development processes: the design and the use of IS in the same context to understand human interaction with the technology in the two iterative IS development processes: the design and the use. In response to Orlikowski's (1992, p. 409) "*technology as a product of human action*", a shared KMS boundary object has been developed based on the roles and practices of knowledge brokers and the roles of other social groups and boundary objects possessed by relevant CoPs. Then, the research further investigated how a shared KMS boundary object is used by the relevant social groups "*technology as a medium of human action*" (Orlikowski, 1992, p. 410) in the same social context.

The widely accepted design science research model as articulated by Hevner and his colleagus (2004) is concerned with the participation of users in the primary design of a system artifact prior to the use of the system. However, there is a need to probe the participation of users in the use time. Accordingly, the KMS is created for understanding of the design and the use based on the concepts of roles of each social groups, brokering roles and practices, and boundary objects and to uncover people who encounter and modify the system while they are using it. Web 2.0 tools utilized in this KMS offer a participatory, interactive, and read/write platform, which are critical for knowledge sharing and integration by participants from different social groups in agriculture with the interplay of extension agents who will support farmers who can not read and write and having skill limitation in ICTs usage. The build and evaluate phases by Hevner et al. (2004) are informed by both technical and behavioral theory but do not address the secondary design of a system by users based on their contexts (Germonprez et al., 2007). According to Germonprez et al. (2011), system is primary designed to provide function support for users and the secondary design supports users for interaction and modification, whereby users can contribute their expertise and redesign a shared KMS. Additionally, it is almost impossible to completely design a system and incorporate knowledge appropriate for all social groups in all context (Germonprez et al., 2007) in the design time. Thus, the notion of the secondary design is highly important in this research to further understand the conceptual framework for KMS development and use for knowledge sharing and integration through understanding of the participation and the redesign of a system in the use time.

The KMS is essential to ensuring knowledge exchange through supporting the roles and practices of participants from relevant social groups. Users from different CoPs have been participated in the development of KMS and the use of it, therefore, a shared KMS enables users to shape it not only in the design time but also in usage time. Ultimately, time, distance, and formal and informal organizational knowledge boundaries are crossed through via the KMS. For this purpose, the development process should emphasis on the identification of the users' needs and expectations, the organizational capabilities, boundary objects possessed by relevant social groups, knowledge systems, and technological infrastructures and integrate all together to support KM activities.

> ***Question 4: How significant is the roles of a shared technological artifact as a boundary object and agricultural experts as knowledge brokers for improving knowledge sharing and integration?***

Measuring the success of KMS/KM initiatives in the organization settings provides management understanding how KMS/KM systems should be designed, implemented and used (Jennex & Olfman, 2001, 2006). Against this background, the study discusses the critical success factor for the success of the KMS/KM for knowledge sharing and integration to bring individuals and organizational effectiveness. The study indicated that the KMS/KM development and use integrated technological infrastructures, knowledge systems, and users' competency to use and perform KM activities, thereby interpretative flexibility of KMS has been realized. Integrative and interactive applications in the KMS also automated electronically the knowledge systems and KM activities and provide knowledge assessment, visualization, and searching facilities. This leads to the use of the KMS to address the sharing and use of both indigenous and scientific knowledge by relevant users through supporting networking, interaction, and negotiation among members.

The study further found that KM/KMS strategies to enhance open learning environment for knowledge sharing by providing a platform to find experts and knowledge sources and link with knowledge users. The KMS developed through Web 2.0 tools provides multiple channels appropriate for individuals' communications and interactions from different social groups and helps users to produce and access knowledge in different formats timely. Also, the KMS allows users to contribute different form of information in their local language through the knowledge repositories. Moreover, the research revealed that management supports are critical for the success of KMS/KM through providing resources to relevant participants, conducive learning environment, and incentives to share knowledge. Also, KMS developers need to apply their knowledge and experience in developing, running, and maintaining an online KMS for KM activities and in helping participants through training and support them for sharing and integrating multiplicity of knowledge systems. The benefits of the KMS for knowledge brokers and end-users discussed through the constructs of KMS quality, knowledge quality, and services quality are essential for knowledge sharing, use, creation, and integration through the KMS. The KMS enables users to access and sourcing quality knowledge timely in different formats from diverse sources. Consequently, these benefits increase users' performance in decision making and, thereby, lead to overall use of the KMS and users' satisfaction.

Question 5: What are the consequences of using the technological artifact as a boundary object and knowledge brokering?

The use of the interplay of knowledge brokering and KMS boundary object created open learning environment. This is critical for increasing the ability of users' decision making performance; in turn owners of the problem can collectively solve their problem. The KMS allows extension agents to join both experts and local farmers virtually, which is essentially to access knowledge from different sources and exchange knowledge among users. The research indicated that the KMS enhances the performance of extension agents through supporting their roles and practices of knowledge brokering by capturing knowledge. Then, the knowledge brokering role of extension agents and the KMS boundary object increase the users' competency applied for KM activities so as to make decision effectively.

Despite the fact that the roles of knowledge brokers and boundary objects are the central point for knowledge sharing and integration, the existing hierarchical structure requires restructuring to support brokering and a shared KMS. The interplay of brokering and KMS with the institutional conditions brought shared understanding by users coming from different social groups. Development of shared understanding is a prerequisite for knowledge sharing and integration (Bechky, 2003; Karner et al., 2011). Increasing individuals' decision making performance should have an impact on the performance of the whole organization (Jennex & Olfman, 2001, 2006). Additionally, the KMS fosters the interaction, communication, and collaboration among distributed users and supports the knowledge sharing and other KM activities in agricultural extension agents for agricultural productivity. Corollary to this, the roles of knowledge brokers and a shared KMS boundary object have brought the consequence on individuals' performance and the overall organization effectiveness for knowledge sharing and integration: knowledge sharing among participants from different CoPs, knowledge from different users and in the KMS repositories combined, and new knowledge creation through integration. Ultimately, it is crucial for an organization to understand and consider the KMS/KM success dimensions in designing, and using the KMS.

Finally, Klein and Myers (1999) provide us the principles for conducting interpretive field studies in order to seek for the evaluation and standardization of the research process. The explanation of the interpretive principles in this study helps the application of the related philosophical concepts, methods, and techniques qualitative research in KM and KMS development and use.

8.2 Contributions of the Study

The research investigated the blending of IK alongside the stream of scientific knowledge by developing a process conceptual framework that involves all relevant social groups together through developing the KMS and understanding of the use and consequence of it. The KMS development research that follows system development action research method of this kind can generally contribute for knowledge of research methodologies and knowledge of research domains. Additionally, Lau (1997) indicated that action research in IS such as KMS can provide a unique opportunity to bridge theory (basic research) with practice (applied research), which can allow for solving real-world problems and contributes to the generation of new knowledge. Therefore, this research is an innovative and original work in terms process conceptual framework development for understanding of the agricultural KMS development and use for knowledge sharing and integration. The contributions of the research include theoretical, methodological, and practical implications.

8.2.1 Theoretical Implications

The findings of the research in general provide theoretical contributions through the empirical evidence on how to develop the KMS development and use to share knowledge and best integrate indigenous and scientific knowledge and provide an insight for sharing all-inclusive knowledge in to support relevant stakeholders. The theoretical implication of this research is organized into three and discussed as follows.

First, the research developed a process conceptual framework for understanding of the KMS development for knowledge sharing and integration through interpretative action system development approach. The research framework can contribute to the grounding with an empirical study for the multiplicity of knowledge systems with interactions of associated communities of practice for integration of indigenous and scientific knowledge, in turn to contribute to the development of a more effective strategy for KMS development. The framework can advance KM and KMS literatures on various aspects of KMS development through the conceptual framework. Furthermore, the framework is important for conducting further empirical researches in understanding of various issues in knowledge integration in KMS development, among other, treatment of knowledge and associated social groups, how knowledge is shared in system development and use, the roles of different participants, and boundary objects. The study's contribution is significance since it seeks to develop conceptual framework that extends from the situated learning in CoPs (Lave & Wenger, 1991; Wenger, 1998) in the context that involve both formal work units (i.e., practices in agricultural institutions) and informal CoPs (i.e., local rural farmers practice).

Secondly, the study contributes to the roles of agricultural experts (i.e., extension agents) as knowledge brokers for knowledge sharing. The role of extension agents in the current agricultural extension system in Ethiopia and other developing countries is to transfer knowledge and technology to local rural communities from research. However, this research result in the various roles and practices of extension agents as knowledge brokers beyond knowledge and technology transfer in one direction including, enhance participation, in-betweenness of extension agents, knowledge and technology translation, network formation, and coordinate collaboration and negotiation. These concepts are critical for knowledge sharing and integration in two directions among diverse groups of CoPs. Additionally, it is resulted in the skill and knowledge requirement by extension agents as knowledge brokers, namely knowledge management and brokering. Thus, the findings of this research theoretically contribute in extending roles and practices knowledge brokering and the skill and knowledge requirement for extension agents as knowledge brokers.

Thirdly, the study investigated to identify boundary objects used by CoPs for their practices, which are important for knowledge sharing and integration. The research is resulted in the identification of several boundary objects for knowledge sharing and integration. Consequently, the research implicated the importance of one shared KMS as a boundary object to support users, thereby to foster knowledge sharing and integration. In the course of this study, a structuration model of technology has been employed to blend the theoretical and practical aspects of the KMS development through further understanding of the design, the use and the consequence of the KMS. As stated by Rose and Scheepers (2001), practitioners using technological artifacts are usually unaware of the concepts theoretically investigated for technological artifact development. Consequently, this study illustrated the identification of concepts through theoretical investigation and development and use of technological artifacts together. Hence, the research contributes theoretically for the role of technological artifact for knowledge sharing and integration in KMS development and use.

8.2.2 Methodological Implications

The methodological implication of this research is two-fold: understanding of the application of systems development action research approach on the one hand and in extending the design science approach, on the other. In order to develop a conceptual framework for KMS development and use for knowledge sharing and integration, the study used the multi-methodological approach to IS research proposed by Nunamaker et al. (1991) and Burstein and Gregor (1999) in action research perspective which consists of four strategies: theory building, experimentation, prototyping, and observation. Therefore, the research contributes methodologically for the use of system development approach for a complete understanding of a complex research area like KMS (e.g., Jennex, 2014) of this kind. It is significant for investigating the requirement through theoretical understanding, further important to examine how technological artifact is designed, and finally enables to understand the use and the consequence of the technological artifact, whereby a comprehensive conceptual framework for KMS development can be coined.

Secondly, the research contributes methodologically through extending the design science approach. The knowledge systems relevant to the problem is contained among participants from different social groups in this research context. The communication, interaction, and collaboration among diverse groups of users are highly significant in KMS development and use as illustrated in this study to foster knowledge sharing and integration. Development of knowledge management system is therefore, to provide technical support to users by enabling knowledge exchange to occur freely and openly across the many different stakeholders. Hence, during the design time of the KMS, it is hardly possible to provide complete system since users' requirement and contexts cannot be completely anticipated only in the design time (Fischer & Giaccardi, 2004; Germonprez et al., 2011). Particulary, it is almost impossible to extract all tacit knowledge from users in design time of the KMS.

The secondary or meta-design approach followed in this research tried to provide solution space to allow users to provide their knowledge, requirements, and modify the functions in the system during the use time. As such, this study extends the design science research approach proposed by Hevner et al. (2004). Hevner's et al. (2004) approach assumed the design of an information system is completed before it is placed in use context and engaged by users (Germonprez et al., 2011). However, users can also influence the technological artifact while using it through knowledge sharing and modifying the technology. This research can, therefore contribute in extending the design science approach in an understanding of the participation of end users in the use time of the technological artifact.

8.2.3 Practical Implications

The research has several practically contributions for policy makers, practitioners, relevant social groups, and society at large. Primarily, the research is significant for relevant policy makers in understanding of the importance of IK and participation of associated rural communities. The study is important because the agricultural knowledge in Ethiopia and other developing countries, if sensitively and wisely applied, can provide important insights into resource process, possibilities, and problems in a particular area and can serve as a link between ecological gaps. Essentially, IK provides opportunities for designing development projects that emerge from priority problems identified within a community and which build upon and strengthen community level knowledge systems and organizations.

The research also implicated the roles and practices of extension agents for knowledge brokering to enhance knowledge exchange among technologists, agricultural researchers, and local communities. Policy makers need to consider the concepts identified for the roles and practices of extension agents for knowledge brokering. In addition, the research identified the knowledge and skill required for knowledge brokering roles. Accordingly, the relevant organizations can provide relevant training and resources to foster the roles and practices of extension agents as knowledge brokers.

In the areas of ICTs, the conceptual framework can be used as a foundation for KMS development in agriculture to best integrate indigenous and scientific knowledge. ICTs can play an important role in knowledge transfer particularly the indigenous and contribute for empowerments of small-scale farmers. For this purpose, the study illustrated the application of Web 2.0 tools for sharing, integration, and preservation of IK among a large number of users in a distributed environment. The findings of the research indicated the role of Web 2.0 to foster the participation, interaction, collaboration, and negotiation among social groups having a common interest, in turn knowledge from them in particular IK can be shared and integrated. Moreover, the study contributes for understanding how Web 2.0 tools and KM activities can be blended each other in particular to share, preserve, and integrate IK and scientific knowledge. The study is significant for practitioners in providing insights how Web 2.0 tools are designed and used for knowledge sharing and integration. Therefore, the research offers management insight in developing strategies for the potential of ICTs (i.e., Web 2.0 tools) in sharing of IK by different communities and provides a lesson for KMS developers, policy makers, and researchers.

Moreover, various social groups can be benefitted from this research including local farmers, agricultural researchers, extension agents, and technologist. Recognition and exchanging of IK alongside scientific knowledge can lead rural communities to participate in agricultural KMS development (Byrne & Sahay, 2007; Masinde, 2013; Puri, 2007). Appreciation and exchanging of IK can result in sense of belongingness that local communities feel respected and become confident to participate in various ICT-based initiatives. Therefore, this research is significant for rural communities. Extension agents are also benefitted from the research since a shared KMS facilitates the roles of extension agents as knowledge brokers. Another social group benefitted from the research is the agricultural researchers through supporting their research output sharing to distributed large number of local farmers throughout the country by utilizing an online shared KMS. In addition, researchers can also get feedback from farmers directly through a shared KMS. Finally, technologist can be benefitted from the research since it provides how the local farmers are participated and their indigenous knowledge are shared and integrated in the KMS development.

In closing, the investigation of the KM/KMS success in an organizational setting is essential for KM/KMS developers and other practitioners in agricultural development to understand the critical success factors for KMS/KM. The KMS/KM success dimensions are vital to justify investments in KMS/KM. Additionally, these support the managers and KMS developers to understand the KMS design, implementation, and use in organization.

8.3 Limitations of the Study

This study has several limitations. First, this research has a limitation in that it has only been considered local farmers in districts from North Gondar Amhara Regional State of Ethiopia having the same language and culture. Additionally, the research is performed through employing the practices of soil fertility management and conservation for understanding of the indigenous and scientific knowledge sharing and challenges to integrate knowledge systems. Although worthy of consideration of IK for other aspects of local communities, this was not the objective of this study. The findings of this research, therefore, have limited in generalizability to other social context in other regions of the country. However, interpretive research is conducted for understanding of the structure of phenomenon within a specific social context rather than generalizing from the setting underlying investigation to a population (Orlikowski & Baroudi, 1991; Sahay & Robey, 1996).

Second, the research demonstrated the development of a process framework for agricultural KMS development and use. While the developed shared KMS boundary object appears to be successful, the study is limited in surveying to assess the effectiveness of the KMS. Although this research is limited in this regard, it is important for the relevant agricultural organizations and researchers to understand the agricultural KM/KMS success factors through a deep analysis of different cases and surveying. Additionally, this KMS is developed intending to support individuals' KM activities so as to bring organizational effectiveness. However, organizational effectiveness is how well the organization perform functions and business processes in it critical to making the organization competitive (Jennex, 2008). Hence, the research is limited in understanding of the concepts in the development and the evaluation of the KMS through integrating the functions and business processes in relevant organizations to agricultural extension system.

In the course of this study, the KMS developed is highly interactive, integrative, and tailorable to incorporate new knowledge and to modify the interface, and supports the languages of Amharic and English since most farmers in the case area know only Amharic language. However, the system is still difficult for farmers especially for those who cannot read and write Amharic language. In addition, informants pointed several suggestions towards the developed KMS for further improvements of its features, for example, to integrate Amharic language text-to-speech tool (advanced-voice recognition system) that can read documents in a shared KMS for farmers. These issues were not deeply investigated in this dissertation and taken as a limitation.

Fourthly, the KMS can support the development of new knowledge through socialization among users and experts and discovering interesting patterns in observation (Becerra-Fernandez & Sabherwal, 2010). The KMS in this study addresses only the support of the knowledge creation through socialization and combination of the tacit and the existing explicit knowledge. Hence, it is limited in addressing the knowledge discovery by combination from multiple bodies of explicit knowledge (i.e., data and information) through the KMS technologies and mechanisms.

Finally, the use of the shared KMS has been observed from April 2017 to September 2017, which is a short period of time to understand individual and organizational effectiveness. In particular, it is difficult to measure the success of the KMS/KM on organizational performance without looking the organization in deep (Jennex, 2008). Therefore, this research is further limited for understanding of the KMS/KM impact on individuals' performance and organizational effectiveness.

8.4 Future Research Directions

The research has developed a process conceptual framework (see also Figure 7-1) for understanding of the KMS development and use for knowledge sharing and integration through employing system development action research approach in the context of the EthioSIS for underlying aspects of the practices of soil fertility management and conservation. Based on the research findings and limitations of the study, it suggests the following future research directions.

First, this study was investigated to develop a process conceptual framework for understanding of the IK and scientific knowledge sharing and integration in KMS development and use using the specific case of soil fertility management and conservation. However, farmer and scientific communities have ample IK and scientific knowledge, respectively in different areas of agriculture, among other, climate change, forestry, and fishery. Therefore, further researches are required through considering different domain areas with wider contexts for understanding of the KMS development and use for knowledge sharing and integration and to come up with validated and a more comprehensive conceptual framework. In addition, the study considered communities of practice from local community in one region of the country. Hence, such research should be replicated in different parts of the country and abroad through involving different local CoPs in different regions of the country having different languages and cultures. Additionally, feature research needs to be also conducted to extend the conceptual framework to other organizations or social settings like health within and outside Ethiopia by taking into consideration the different cultural contexts. As such, a comparison between different case studies may contribute to the betterment of research findings and to improve the generalizability.

Secondly, additional research needs to be conducted to evaluate the success or the effectiveness of the KMS/KM with quantitative method through a larger sample size for further understanding, thereby, to ensure the sustainability of the system. Informants need to be also sampled from different local CoPs with different languages and cultures. More research is needed to test and validate not only the proposed conceptual framework but also to drive the research propositions and validate. Hence, this study is an avenue for future research to understand agricultural KM and KMS success factors through pondering large sample from different organizations. Additionally, KM/KMS enables efficiency and effectiveness organizational functions/processes (Becerra-Fernandez & Sabherwal, 2010). Hence, it is critical to conduct further investigation to understand the design of KMS through integrating the organization business processes and functions and evaluate its success for organizational effectiveness accordingly.

Thirdly, the study recommends to carrying out more on the KMS development by incorporating the suggestions of relevant users in the use time of the KMS. For instance, advanced KMS that can support voice portal (advanced-voice recognition system which performs Amharic language text-to-speech) needs to be advanced to support local farmers who cannot read and write. It is also open for future research in the application of data mining tools to foster and understand knowledge creation. Additional researches need to be further performed in the design and use of full-fledged KMS which can support the needs and expectations of all relevant stakeholders. Fourthly, despite the research addresses the knowledge creation through socialization, future research will be necessary to addressing knowledge discovery from data and information. Knowledge discovery systems can be developed by using data mining tools to support the knowledge creation from data and information (Becerra-Fernandez & Sabherwal, 2010).

Finally, the study suggests for a need to understand the consequences of a shared KMS through allowing the participation of a number of users for long period of time. Therefore, a longitudinal study of KMS use needs to be performed for understanding of the impact of KMS for organizational effectiveness in sharing and integration of knowledge. Longitudinal qualitative research is suggested for deeper investigation into the organization to find the KMS/KM success measures and validation of the concepts and their relationships identified in the underlying research. Additionally, more case studies should also be carried out through in-depth analysis of situational factors that influence the consequences of the KMS for KM activities in particular for the integration of IK in the stream of scientific knowledge.

8.5 Concluding Remarks

The research has resulted in the importance of bringing different knowledge systems together through participation of all relevant stakeholders especially the IK of local farmers in which it was ignored so far in the development of agricultural KMS. The KMS development process should organize a collective process of knowledge sharing and integration around the problems. The research findings indicated that the knowledge brokering roles and shared KMS boundary object can facilitate and coordinate the interaction of heterogeneous social groups or CoPs having a common interest. Therefore, the KMS development and use can provide new ways for sharing, integration, and preservation of the local farmers' IK.

Extension agents in the Ethiopian agricultural extension systems are there to transfer knowledge and technology from research to local farmers. Additionally, their roles of brokering have given low priority in the program, which provides little support, resource allocation problem, limitations in providing appropriate training, no reward and recognition for their intermediary roles. Accordingly, extension agents often face lack of role clarity and guidance, with no clearly established role, and limited opportunities for acknowledgement and promotion in various endeavor performed like agricultural system development and knowledge management initiatives. Such problems are also reported by various researches in different parts of the world in agriculture and health areas (Kislov et al., 2016; Robeson et al., 2008). Consequently, relevant organizations are required to give attention to the roles and practices of extension agents as knowledge brokers to enhance the KM activities. Additionally, academic institutions need to develop an academic program regarding to knowledge brokering so as to provide the required knowledge and skill for extension agents. Knowledge brokers need to build skill and knowledge for their brokering roles and activities besides to their professional background to understand, facilitate, and coordinate knowledge systems integration and sharing. Intensive training, awareness, and incentives need to be again deployed in relevant agricultural organizations to support and encourage users coming from different social groups in particular local farmers to foster knowledge sharing and integration for their daily practices.

Moreover, indigenous knowledge is powerful knowledge and practice possessed by local communities for decision making in various areas in particular for sustainability of the environment and culture. However, it is not readily accessible and difficult to preserve and share. Agricultural organizations need to focus on the informal CoPs to foster knowledge sharing and integration. According to Wenger et al. (2002), CoPs are highly important for the sharing of explicit and tacit knowledge since CoPs foster the interaction and informal learning process. Informal CoPs among relevant participant need to be promoted for knowledge exchanging particularly important for sharing IK having tacit format and embodied experience. Furthermore, academic programs are required to incorporate the local communities' knowledge and practice in the school science program.

Designing and using of a shared KMS as a boundary object need to be performed in the same social context of time and space to avoid discontinuities in KMS development and use. As such, relevant agricultural organizations are required to consider the local context in the design and use of agricultural KMS. The research demonstrated the use of a shared KMS by a large number of users coming from diverse CoPs in a distributed environment. Therefore, KMS using Web 2.0 tools can be implemented for various areas of agriculture with low cost for knowledge exchange. Freely available social Medias such as Facebook, Twitter, Linked, and Wikipedia can also be used for knowledge sharing and integration in agriculture with some modification. These can be accessible through Cell phone, which is ubiquitous and affordable by people in developing countries. The KMS utilizing Web 2.0 technologies interplay with knowledge brokering role can connect the IK and practice with the scientific concepts and principles. Consequently, organizations can attempt to capture and share knowledge and experience from diverse social groups through participative, collaborative, and negotiable Web 2.0 tools so as to support local farmers and other relevant stakeholders dispersed in a distributed geographical space and time. Therefore, agricultural organizations or policy makers need to understand the roles of Web 2.0 tools for their KM activities.

KMS/KM success is critical to bring in increasing the performance of individuals and the overall organizational performance in decision making through the use of right knowledge. However, the overall organizational structure needs to be more open and decentralized to foster sharing and integration of diverse knowledge through the interplay of a shared KMS and knowledge brokering, thereby, relevant stakeholders can be benefitted. A shift to openness, participative, and collaborative environment need to be encouraged so as to reduce hierarchies from research to local farmers and significant for knowledge exchange. Finally, relevant agricultural organizations need to develop a compressive policy (i.e., guidelines, procedures, privacy, and legal issues) towards the development and use of agricultural KMS and knowledge brokering to support the participation of all relevant social groups in order to achieve their common goal. Ultimately, KMS/KM success is an important issue to be probed for understanding factors associated with the design, implementation, and use of KMS by KMS/KM academicians and practitioners.

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10. APPENDICES

Appendix I: Interviews Checklist, English Version

A. Interviews Checklist for Farmers

1. Background information
    a. Please tell me about yourself such as your name, age, your agricultural practice.
2. What knowledge sources do you use for your task accomplishment?
3. On which aspects of knowledge do more rural communities depend for survival? (scientific technology, indigenous practices, or the integration of the two)
4. How do you share information and knowledge among members of your communities and other communities about agricultural practice?
    a. What is your own knowledge of soil fertility management and conservation?
5. Is the knowledge from agricultural research center helpful for your agricultural practices?
    a. If yes, how?
6. How do development agents share agricultural information, knowledge and introduce you the new technology for your tasks?
7. What are the boundary objects such as documents, procedures or technologies which help you to transfer knowledge and introduce technology to others and among yourself?
8. Do you use computerized agricultural information systems for decision making?
9. Do the knowledge management systems provided by Agricultural Transformation Agency (ATA) consider your needs and expectations?
10. Do you participate in the development of knowledge management systems at ATA?
11. Knowledge management system use
    a. Do feel that you have adequately skilled to use the available KMS (please elaborate)?
    b. Does the KMS support you to get accurate information and/or knowledge to carry out your practices? How?
    c. Does the KMS allow you to search relevant information and/or knowledge and link with experts?
    d. Does the management in the extension system support you to use the KMS?
    e. Does the agricultural KMS allow you to share knowledge with others?
12. Knowledge management system consequences
    a. What do you feel about the impact of using the KMS for knowledge sharing and integration for your work lives?
    b. What are the outcomes of the KMS and knowledge brokers for knowledge sharing and integration?
13. Concluding questions
    a. Is there anything else that came to your mind that you would like to add?
    b. Can you suggest me other people in this district that I should interview?

B. Interviews Checklist for Extension Agents

1. Background information
    a. Please tell me about yourself such as your professional background, and your responsibilities at Ethiopian the agricultural extension system.
2. Knowledge management practice
    a. What knowledge sources do you use for task accomplishment?
    b. On which aspects of knowledge do more rural communities depend/rely on more for survival? (scientific technology, indigenous practices, or the integration of the two)
    c. How do you share knowledge with employees and end users (i.e., local farmers)?
    d. What are the challenges and opportunities in integrating IK with scientific knowledge?
3. Informant's role as a knowledge broker
    a. In your current position, do you find yourself providing connections between people coming from different social groups—like facilitating the exchange of knowledge between groups or helping to coordinate or align the activities of different groups?
    b. If so, can you describe some specific examples of how you have played this type of role in sharing and linking scientific and indigenous knowledge?
    c. Is there anything in particular about the extension agents that may place them in a position to facilitate the exchange of knowledge between different groups?
    d. Are there language and other barriers to transfer knowledge and introduce technology to farmers and among you?
4. Brokering skills and knowledge
    a. Do feel that you have adequate skill for your roles of knowledge brokering?
    b. What are the skills and knowledge that might enable extension agents to transfer knowledge and introduce technology between agricultural experts and with farmers?
5. Boundary objects
    a. What are the boundary objects such as documents, procedures or technologies which help you to transfer knowledge and introduce technology to farmers from research and among yourself?
    b. What are specific procedures you adhere to brokering for knowledge and technology transfer?
    c. What are the documents, procedures which help you in the KM activities?
6. KMS use
    a. What did people felt about the manner in which the implementation of KMS was organized and managed?
    b. Do feel that you have adequately skilled to use the available KMS (please elaborate)?
    c. Does the KMS support you to get accurate knowledge to carry out your practices?
    d. Does the KMS allow you to search relevant information and link with experts?
    e. Does the agricultural KMS allow you to share knowledge with others?
7. KMS consequence
    a. What do you feel about the impact of using the KMS for knowledge sharing and integration for your work lives?
    b. What are the outcomes of the interplay of extension agents as knowledge brokers and KMS as a boundary object in agriculture?
8. Concluding questions
    a. Is there anything else that came to your mind that you would like to add?
    b. Can you suggest other people in this office or others that I should interview?

C. Interviews Checklist for Agricultural Researchers

1. Background information
    a. Please tell me about yourself such as your professional background, and your responsibilities at Ethiopian agricultural transformation agency (ATA).
2. Knowledge management practice
    a. What knowledge sources do you use for task accomplishment?
    b. How do you share knowledge with employees and end users (i.e., local farmers)?
    c. On which aspects of knowledge do more rural communities depend/rely on more for survival? (scientific technology, indigenous practices, or the integration of the two)
    d. What are the challenges and opportunities in integrating IK with scientific knowledge?
    e. What ICT services do you use to promote knowledge management processes?
    f. What do you suggest to improve the current problems to improve access to existing knowledge resources?
3. General information on KMS development in ATA
    a. What are the agricultural information systems developed and managed by agricultural transformation agency (ATA)?
    b. What are the services provided by the Ethiopian Soil Information System (the EthioSIS) of ATA?
    c. Who are the beneficiaries of the KMS in ATA? And How?
    d. What knowledge sources do you use while developing agricultural KMS?
    e. Do you integrate IK of the local farmers in the KMS development?
4. Informant's role as a knowledge broker
    a. In your current position, do you find yourself and/or extension agents providing connections between people coming from different social groups—for example facilitating the exchange of knowledge between groups or helping to coordinate or align the activities of different groups?
    b. If so, can you describe some specific examples of how you and/or extension agents have played this type of role?
    c. Is there anything in particular about the extension agents that may place them in a position to facilitate the exchange of knowledge between different groups?
    d. Is there language and other barriers to transfer knowledge and introduce technology to farmers and among you?
5. Brokering skills and competencies
    a. What are the skills and competencies that might enable extension agents to transfer knowledge and introduce technology to farmers?
6. Boundary objects
    a. What are the boundary objects such as documents, procedures or technologies which help you to transfer knowledge and introduce technology to farmers?
    b. What are specific procedures you adhere to brokering for knowledge sharing?
    c. What are the documents, procedures which help you in the KM activities?
7. KMS use
    a. What people felt about the manner in which the implementation of KMS was organized and managed?
    b. Do feel that you have adequately skilled to use the available KMS (please elaborate)?
    c. Does the KMS support you to get accurate information and/or knowledge to carry out your practices? How?

d. Does the KMS allow you to search relevant knowledge and link with experts?
e. Does the management in the extension system support you to use the KMS?
f. Does the agricultural KMS allow you to share knowledge with others?

8. KMS consequence
   a. What do you feel about the impact of using the KMS for knowledge sharing and integration for your work lives?
   b. What are the outcomes the interplay of extension agents and the KMS in agriculture?
9. Concluding questions
   a. Is there anything else that came to your mind that you would like to add?
   b. Can you suggest other people in the company or others that I should interview?

D. Interviews Checklist for KMS Developers

1. Background information
   a. Please tell me about yourself such as your professional background, and your responsibilities at Ethiopian agricultural transformation agency (ATA).
2. Knowledge management practice
   a. What are the roles of extension agents in knowledge transfer and the introduction of technology to the end users (i.e. farmers)?
   b. What are the problems to access the necessary knowledge for different aspects of soil fertility management and conservation?
   c. Is there any attempt made in order to integrate IK with scientific knowledge?
      i. If yes, mention?
   d. What are the challenges and opportunities in integrating IK with scientific knowledge?
   e. What ICT services do you use to promote knowledge management processes?
   f. What do you suggest to improve the current problems to improve access to existing knowledge resources?
3. Informant's role as a knowledge broker
   a. Do you find the role of yourself and/or extension agents providing connections between people coming from different social groups—for example facilitating the transfer of knowledge between groups or helping to coordinate or align the activities of different groups?
   b. If so, can you describe some specific examples of how you and/or extension agents played this type of role?
   c. Is there anything in particular about the extension agents that may place them in a position to facilitate the transfer of knowledge between different groups?
4. Brokering skills and competencies
   a. What are the skills and competencies that might enable extension agent to transfer knowledge and introduce technology to farmers?
5. Boundary objects
   a. What are the boundary objects such as documents, procedures or processes technologies which help you to transfer knowledge to farmers?
   b. What are specific procedures you adhere to brokering for knowledge sharing?
   c. What are the documents, procedures which help you in the design of KMS?
6. KMS development
   a. How do you gather requirement from the relevant potential users of the system?
   b. Which design approach you followed in the development of the KMS?

   c. What are the services provided by Ethiopian Soil Information System (the EthioSIS)?
   d. What knowledge sources do you use while developing agricultural KMS?
7. KMS architecture
   a. If you had to design a typical architecture for agricultural KMS, what would it be?
   b. How do KM activities contribute to the architecture of the KMS?
   c. What are specific procedures and resources you adhere to KMS development?
   d. How do an organizational policy, procedures, and resources inform the design of agricultural KMS?
8. KMS use
   a. What did people felt about the manner in which the implementation of KMS was organized and managed?
   b. What do you think is about your roles in sustaining the KMS services to the users?
9. KMS consequence
   a. What do you feel about the impact of using the KMS for knowledge sharing and integration for your work lives?
   b. What are the outcomes of the interplay of extension agents and the KMS?
10. Concluding questions
   a. Is there anything else that came to your mind that you would like to add?
   b. Can you suggest other people in this organizations or others that I should interview?

Appendix II: Interviews Checklist, Amharic Version

ለአርሶ አደሮች የተዘጋጀ የቃለ መጠይቆች ዝርዝር

1. መሰረታዊ መረጃ

   ሀ. እባካዎ ስለራስዎ ማለትም ስምዎን፣ እድሜዎን፣ የግብርና ስራዎ ልምድዎን ይንገሩኝ.

2. ለግብርና ሥራዎ ስኬት ምን አይነት የመረጃ ምንጮችን ይጠቀማሉ?

3. የገጠር ማህበረሰቦች ለስራና ኑሮ ህልውናና ስኬታቸው በየትኞቹ የእውቀት ዘርፎች የበለጠና እንዴት ይጠቀማሉ? (1. ሳይንሳዊ ቴክኖሎጂ, 2. የራሳቸውን ባህላዊ እውቀትና ልምዶች፣ ወይም 3. የሁለቱም ጥምረት)

4. የግብርና አሰራሮችና ዕውቀቶችን መረጃዎች ከአካባቢው ማህበረሰብና ሌሎች ማህበረሰቦች ጋር እንዴት ያገኛሉ፣ ያካፍላሉ? ለምሳሌ

   ሀ. ስለ የአፈር አያያዝና ለምነት አጠባባቅ፣ እንዲሁም የማዳበሪያ አጠቃቀም ዕውቀትዎ ምንድ ነው፣ መረጃዎችን እንዴት ይለዋወጣሉ?

5. በግብርና ምርምር ማእከላት የወጡ ቴክኖሎጂዎችና ዕውቀቶች ለግብርና ስራዎ አስተዋጽዖ አላቸው?

   ሀ. መልስዎ አዎን ከሆነ፣ ከምርምር ማዕከላት የሚወጡ ቴክኖሎጂዎችና ዕውቀቶችን እንዴት ያገኛሉ ይጠቀማሉ

6. የግብርና ልማት ጣቢያ ሰራተኞች የግብርና ዕውቀቶችና መረጃዎችን እንዲቡም አዳዲስ ቴክኖሎጂዎችን እንዴት ነው ለአርሶ አደሮች የሚያስተዋውቁት?

7. ከሌሎች አርሶ አደሮች ጋር የግብርና መረጃዎችን፣ ዕውቀቶችንና አዳዲስ አሰራሮችን ለመለዋወጥ ምን ምን የመረጃና የዕውቀትን ማስተላለፊያ መንገዶችና ቁሶችን ይጠቀማሉ?

8. የኮምፒዩተር የመረጃ ስርዓት (ዕውቀት አሰራር ሥርዓትን) ለግብርና ስራዎ ውሳኔ አሰጣጥ ይጠቀማሉ?

9. በግብርና ትራንስፎርሜሽን ኤጀንሲ የሚሰጡት የእውቀት አስተዳደር ስርዓቶች የአርሶ አደሮችን ፍላጎት እና የምትጠብቁትን አገልግሎት ግምት ውስጥ ያሰገቡ ናቸው (ያስገባሉ)?

10. በበግብርና ትራንስፎርሜሽን ኤጀንሲ የእውቀት አስተዳደር ስርዓቶች ውስጥ እየተሳተፉ ነው?

11. የመረጃና ዕውቀት ማኔጅመንት/ አስተዳደር ዘዴ አጠቃቀምዎን በተመለከተ

   ሀ. በስራ ላይ የሚገኙትን የመረጃና ዕውቀት ማኔጅመንት ዘዴዎች ለመጠቀም በቂ ችሎታ አለኝ ብልው ያምናሉ? እባክዎን በዝርዝር ይግለጹል?

   ለ. በስራ ላይ የሚገኙትን የመረጃና ዕውቀት ማኔጅመንት ዘዴዎች የሚተላለፉ መረጃዎችን፣ እውቀቶችና አሰራሮችን የግብርና ስራዎትን ለማከናወንና ለማዘመን እገዛ ያደርጋሉ? የሚያግዙ ከሆነ እንዴት?

ሐ. የመረጃና ዕውቀት ማኔጅመንት ዘዴ (ኬኤምኤስ) ጠቃሚ መረጃን እና/ወይም እውቀትን ለመፈለግና ከ ከባለሙያዎች ጋር ለመገናኘት ያስችልዎታል?

መ. በመረጃና ዕውቀት ማኔጅመንት ዘዴ/ስርዓት በቅጥያው ስርዓት ውስጥ ያለው መረጃ እንዲጠቀሙ ያግዝዎታል?

ሠ. የግብርና በመረጃና ዕውቀት ማኔጅመንት ዘዴ/ስርዓት ከሌሎች አርሶ አደሮች ጋር መረጃና እውቀትን ለመጋራት ያግዝዎታል?

12. የእውቀት አስተዳደር ስርአት ውጤቶች

ሀ. የመረጃና ዕውቀት ማኔጅመንት ዘዴ (ስርዓትን) መጠቀም በእርስዎ የስራ ህይወት እንዲሁም በአካባቢው እውቀትን እና ውህደትን ለማካፈል ምን ዐይነት ውጤትና ተጽዕኖ ሊኖረው ይችላል ብለው ይገምታሉ?

ለ. በግብርና ምርታማነትና የግብርና ኤክስቴንሽን ስርዓት ውስጥ የግብዓት ኤክስቴንሽን ስርዓትን በመውሰድ የግብርና ኤክስቴንሽን ሰራተኞች በግብአት ኤጀንሲዎች መካከል በግብአት ኤክስቴንሽን አማካይነት በተግባር መጋራትና ግንኙነት መካከል የመረጃና ዕውቀት ማኔጅመንት ዘዴ/ስርዓትን መጠቀም ያለው ውጤት ምንድን ነው?

13. የማጠቃለያ ጥያቄዎች

ሀ. ከላይ የተጠቀሱትን ጥያቄዎች እያነሳን ስንነጋገር ሌሎች በዓእምሮዎ የመጡ ሃሰቦች ና ተጨማሪ ሃሳቦች ካሉ ቢያካፍሉን?

ለ. በዚህ ወረዳና ቀበሌ የህን ቀለመጤቅ ለማድረግ ሌሎች መረጃ ሊሰጡን የሚችሉ ሰዎችን ቢጠቁሙን?

Appendix III: Data Collection Tools: Field Observation Checklist

Typology and selected features of indigenous and scientific agricultural knowledge and practices and KMS development and use practice in the respective community.

Observation background
Location of observation: ____
Date of observation: ____

Table 10-1. Data Collection Tools: Field Observation Checklist

Agricultural Areas of Knowledge	Bearers of Knowledge	Time of Practice	Area/site of Practice	Purpose of Practice	Knowledge Manifestations (examples) of Knowledge

Additionally, participant observations were carried out to understand the following situations in knowledge sharing and integration in agricultural KMS development and use.

1. How do local farmers practice the indigenous knowledge?
2. How do extension agents transfer knowledge and technology from research to local farmers?
3. How do participants coming from different social groups interact each other?
4. How do participants in each social group use and interact with boundary objects?
5. How do participants use and interact with a shared KMS as a boundary object?
6. How a shared KMS as a boundary object do flexible to support participants?

Appendix IV: Respondents Profile

Table 10-2. Informants' Background Information

No.	Informant Code	Sex	Qualification	Specialization	Job title/position	Experience in year	Organization location	Interview Phase I	Interview Phase II
1	HRM-Rspondent#1	F	MA	Business administration	HRM	6	ATA	X	
Agricultural-Experts/Researchers									
2	Agricultural-Expert-Respondent#1	M	MSc	Soil science	Lead analyst	4	ATA	X	X
3	Agricultural-Expert-Respondent#2	M	MSc	Soil conservation and management	Expert	13	Amhara agricultural regional office	X	
4	Agricultural-Expert-Respondent#3	M	MSc	Soil and water engineer	Expert	21	Amhara agricultural regional office	X	X
5	Agricultural-Expert-Respondent#4	M	MSc	Natural resource management	Regonal representative	28	ATA Amhara Region	X	X
6	Agricultural-Expert-Respondent#5	M	MSc	Soil science	Agricultural researcher	18	MOARD	X	X
7	Agricultural-Expert-Respondent#6	M	MSc	Natural resource management	Agricultural researcher	21	North Gondar agricultural office	X	X
8	Agricultural-Expert-Respondent#7	F	MSc	Soil science	Agricultural researcher	13	North Gondar agricultural office	X	X
9	Agricultural-Expert-Respondent#8	M	MSc	Soil conservation and management	Agricultural researcher	18	ATA	X	
10	Agricultural-Expert-Respondent#9	F	MSc	Soil science	Expert	5	ATA	X	X
11	Agricultural-Expert-Respondent#10	M	MSc	Natural resource management	Expert	21	ATA	X	X
12	Agricultural-Expert-Respondent#11	M	MSc	Soil science	Agricultural researcher	12	MOARD		X
13	Agricultural-Expert-Respondent#12	M	MSc	Soil and water engineer	Agricultural researcher	9	MOARD		X
Extension-Agents									
14	Extension-Agents-Respondent#1	M	MSc	Extension system	Extension worker	18	North Gondar agricultural office	X	X
15	Extension-Agents-Respondent#2	M	BSc	Extension system	Extension worker	6	Gondar Zuria woreda	X	X
16	Extension-Agents-Respondent#3	M	MSc	Extension system	Extension worker	16	North Gondar agricultural office	X	X
17	Extension-Agents-Respondent#4	F	Diploma	Generalist	Development agent	8	Gondar zuria woreda	X	X
18	Extension-Agents-Respondent#5	M	Diploma	Generalist	Development agent	5	Gondar Zuria woreda	X	
19	Extension-Agents-Respondent#6	M	BSc	Extension system	Development agent	9	North Gondar agricultural office	X	X
20	Extension-Agents-Respondent#7	M	Diploma	Generalist	Development agent	5	Gondar Zuria woreda	X	X
21	Extension-Agents-Respondent#8	M	Diploma	Generalist	Development agent	6	Gondar Zuria woreda	X	X
22	Extension-Agents-Respondent#9	M	BSc	Extension system	Development agent	3	North Gondar agricultural office	X	X
23	Extension-Agents-Respondent#10	F	BSc	Extension system	Development agent	7	North Gondar agricultural office	X	
24	Extension-Agents-Respondent#11	M	Diploma	Generalist	Development agent	8	Gondar Zuria woreda	X	X

25	Extension-Agents-Respondent#12	M	BSc	Extension system	Extension worker	17	Amhara Regional agricultural office	X	
26	Extension-Agents-Respondent#13	M	Diploma	Generalist	Development agent	8	Gondar Zuria woreda		X
27	Extension-Agents-Respondent#14	F	Diploma	Generalist	Development agent	9	Gondar Zuria woreda		X
28	Extension-Agents-Respondent#15	M	MSc	Extension system	Extension worker	15	Amhara Regional agricultural office		X
29	Extension-Agents-Respondent#16	M	BSc Diploma	Generalist	Development agent	4	Gondar Zuria woreda		X
Farmers									
30	Farmer-Respondent#1	M	-	-	Farmer	26	Ambachira	X	
31	Farmer-Respondent#2	M	8th grade	-	Farmer	13	Debreselam	X	X
32	Farmer-Respondent#3	M	-	-	Farmer	15	Ambachira	X	X
33	Farmer-Respondent#4	M	-	-	Farmer	10	Ambachira	X	X
34	Farmer-Respondent#5	M	-	-	Farmer	17	Debreselam	X	X
35	Farmer-Respondent#6	M	-	-	Farmer	9	Ambachira	X	
36	Farmer-Respondent#7	M	Diploma	-	Farmer	28	Debreselam	X	X
37	Farmer-Respondent#8	M	12th grade	-	Farmer	13	Debreselam	X	X
38	Farmer-Respondent#9	M	-	-	Farmer	32	Ambachira	X	
39	Farmer-Respondent#10	M	-	-	Farmer	26	Ambachira	X	
40	Farmer-Respondent#11	M	-	-	Farmer	18	Debreselam	X	
41	Farmer-Respondent#12	M	-	-	Farmer	40	Debreselam	X	
42	Farmer-Respondent#13	M	12th grade	-	Farmer	8	Ambachira		X
43	Farmer-Respondent#14	M	8th grade	-	Farmer	11	Debreselam		X
44	Farmer-Respondent#15	M	6th grade	-	Farmer	17	Ambachira		X
45	Farmer-Respondent#16	M	10th grade	-	Farmer	12	Debreselam		X
46	Farmer-Respondent#17	M	10th grade	-	Farmer	5	Debreselam		X
IS/IT-Developer-Respondents									
47	IS/IT-Developer-Respondent#1	M	MSc	Information system	System analyst	9	ATA	X	X
48	IS/IT-Developer-Respondent#2	M	BSc	Computer science	Programmer	7	ATA	X	X
49	IS/IT-Developer-Respondent#3	M	MSc	GIS	System analyst	8	ATA	X	
50	IS/IT-Developer-Respondent#4	F	BSc	Computer science	Database administrator	5	MOARD	X	X
51	IS/IT-Developer-Respondent#5	M	BSc	Software engineering	Programmer	5	ATA	X	X
52	IS/IT-Developer-Respondent#6	F	BSc	Information system	Programmer	6	MOARD	X	
53	IS/IT-Developer-Respondent#7	M	MSc	GIS	System analyst	8	ATA	X	
54	IS/IT-Developer-Respondent#8	M	BSc	Information technology	Database administrator	4	ATA	X	X

Source: *Author own compilation*

Appendix V: Sample Data Transcript

Table 10-3 indicated the sample interview and response transcript conducted with one of the extension agent informants in phase I and II interviews at North Gondar agricultural bureau.

Table 10-3. Sample Interview Data Transcript from the Informant Extension-Agents-Respondent #7

	Question Categories	**Question**	**Response**
Phase I **Date:** May 13/2016 **Time:** 14h32-15h13 **Interviewer:** Dejen Alemu **Institution:** Addis Ababa University, IT PhD program, Information Systems stream **Venue:** North Gondar Agricultural Bureau **Research Interview:** Dejen Alemu Thank you very much for being voluntary to participate in this research as an interview respondent. I am conducting a PhD research on understanding agricultural knowledge management system development for knowledge sharing and integration. May we get started?			
1	Background information	Please tell me about yourself such as your experience, role agricultural practice.	I work in North Gondar 'Zuria' woreda as a development agent and I have been working here for five years. I have Diploma.
		What about your specialization?	We graduate and expected to work as a generalist in order to support farmers in different aspects such as natural resource management, marketing, crop utilization.
2	Knowledge types in agriculture	What knowledge sources do you use for your task accomplishment?	I gather new agricultural knowledge and technology from researchers for my carrier. In addition, I also consult documents provided from ministry of agriculture, agricultural transformation agencies and universities. Then, we transfer them to local farmers through training and demonstration.
		Please elaborate how you get information knowledge or information from researchers?	I collect information from agricultural researchers and extension workers at zonal and regional level and transfer the information to the local farmers. Researchers provide us different information and agricultural technologies for our carrier through training. Documents are also provided from research center and agricultural offices.

		What are the agricultural technologies?	Agricultural technologies include new farming materials, best crops, and different ways of farming.
		What is your own knowledge for soil fertility treatment?	NA (Not Applicable)
3	Knowledge management/ knowledge treatment	How do you share information/knowledge among members of your communities and other communities about the agricultural practice?	We do make use of various ways to transfer scientific knowledge and agricultural technologies to local farmers. For example, we train farmers when new knowledge and technologies are provided from research at farmers training center in our district. We also demonstrate how new agricultural technologies are applied in farmers farming land. We also visit farmers. We also use traditional forms of ICTs (i.e., TV and radio), modern forms of ICTs (i.e., Internet, ubiquitous mobile phone) to transfer knowledge with different stakeholders.
		How IK is shared? What are those informal groups?	Farmers transfer their indigenous knowledge and practice to others in various ways. They usually observe when others practice. Sometimes they discuss with different aspects of agriculture when they meet together. In our kebele, there are different informal groups and they share ideas and their experience. *'Eder'*, *'senbetie'*, and different ceremonies such as *'tezkare'* in which farmers meet together. Through these they share their knowledge and practices.
		What are the challenges to integrate IK and scientific knowledge?	We do not know communication style and indigenous terms used by the rural communities in each kebele. In addition, most of us trained as generalists to support farmers in different aspects. Lack of specialization limits our capacity to serve farmers.
4	The role of knowledge brokering	Do you find yourself providing connections between different areas of an organization—for example facilitating the transfer of knowledge between groups or helping to coordinate or align the activities of different groups? How networks help you to share knowledge?	We usually discuss about different agricultural practices conducted in our respective kebele where we work when we meet at zonal, regional or national level during training. Through, we share knowledge and experience and form network through exchanging phone number. Then, we communicate and share knowledge and experience at our work place through phone. The link/network among different participants is important to enhance knowledge and technology transfer. This role can be strengthening if there is modern technology supporting communication and collaboration available for establishing networking among extension agents and other relevant participants. I asked them why do not use mobile phone and social

			Media application like Facebook for this purpose and they responded that we are not aware of it to use it for such purpose.
		What are some of the skills and competencies that might enable you to transfer knowledge and introduce technology between agricultural expert and technologist with farmers?	Communication, coordination, ICTs.
5	Boundary objects	What are the documents, procedures or technologies which help you to transfer knowledge and introduce technology to farmers and among yourself?	Local level Participatory Planning Approach (LLPPA), Participatory Rural Appraisal (PRA), Farming System Development (FSD), Participatory Land Use-Planning, and Community-based Participatory Watershed Development (CPWD) guidelines. Traditional forms of ICTs (i.e., TV and radio), modern forms of ICTs (i.e., Internet, ubiquitous mobile phone) to transfer knowledge with different stakeholders.
6	Concluding Questions	Is there anything else that came to mind as we talked today that you would like to add—anything that maybe I should have asked you that I didn't?	No
		Can you suggest other people in the company or duty area that I should also interview for this study? Tell me one?	There are many model farmers who are successful in applying the new knowledge and technology for their agricultural practices that you can make interviewed. …
Thank you very much			

Phase II

Date: June 3/2017 **Time:** 12h05-12h27

Interviewer: Dejen Alemu

Institution: Addis Ababa University, IT PhD program, Information Systems stream

Venue: North Gondar Agricultural Bureau

Research Interview:

Dejen Alemu

Thank you very much for being voluntary to participate in this research as an interview respondent for the second time. May we get started?

1	KMS use and consequence	Do feel adequately skilled to use the available KMS (please elaborate)? Does the KMS support you to carry	Yes, it is easy to use. I can also access the knowledge and functions from the application in Amharic and English language that I am familiar with them. Yes,

		out your practices?	
		Can you mention some?	I easily find people through the system and get connected. I can also get different forms of information from different sources in one place. Accessing contents in different formats such as audio, textual, document, images, and video and in different languages in which farmers and researchers utilized. This highly helped us to translate knowledge from research to local farmers and vice versa.
		Do the agricultural KMSs allow you to contribute and share your knowledge to others?	Yes, for instance I participated in the forum and I contribute my experience on it.
		What are some of the organizational consequences or outcomes of knowledge sharing and integration through the interplay of extension agents as a knowledge brokers and KMS as a boundary object?	As I work with local farmers, they recommend using their indigenous knowledge to maintain the soil fertility. For example, manure in this district is the commonly used method to maintain soil fertility by local farmers. It is important to increase and maintain the soil organic matter and to enhance the soil moisture storing capacity. Chemical fertilizers are suggestions from scientific research to raise the productivity of the soil in which we the extension agents recommend to local farmers but less used by farmers. Hence, we exchange knowledge between research and local farmers to support knowledge exchanges and integration.
		How the shared online KMS helps you and other for knowledge and integration.	In this regard, the KMS support us to foster the communication and interaction among the local and scientific communities. Consequently, all relevant communities exchange knowledge and experience and remix their knowledge for agricultural productivity. In particular, model farmers in our district frequently communicate with us to get scientific advices and share their indigenous knowledge and develop a competency to integrate knowledge. For instance, as a result of knowledge exchange among participants both local and scientific communities believed that, the indigenous manure and scientific chemical can be mixed together and the integration reduces vulnerability of crops to rainfall variations, leads crops to growth and drought tolerance, and raises yield crop growth.
Thank you very much.			

Source: *Author own compilation*

Appendix VI: Final Coding Scheme

Table 10-4 presents the final coding scheme of the research resulting from the depth analysis of data collected from phase I and phase II through in-depth semi-structured interviews, participant observations, and document analysis.

Table 10-4. Final Coding Scheme

SNO	Theme/Category	Sub-theme or Indicators	Indicators
1	***Knowledge Types***		
1.1	Application domain knowledge of agricultural experts	• Soil sample • Soil test result • Slop/topography • Land management history • Land use/ cover • Crop growing	• Soil color • Recommended blending fertilizer • Research results • Observation • Policies • Chemical fertilizers
1.2	Technical knowledge of IS/IT experts	• Communication skills • KM activities • Requirement gathering • System designing • Programming	• System testing • Database development • System administration • Mapping • Spatial analysis
1.3	Indigenous knowledge of local farmers	• Soil type	• Soil type identification • Soil characteristics • Soil color • Crop management • Local soil type naming
		• Soil fertility management	• Mixed cropping • Crop rotation • Manure • Compost • Fallowing
		• Soil conservation	• Traditional ditches (i.e., farmers named it as 'feses') • Traditional waterways ('boi') • Stone terraces ('yedengay erken') • Traditional cut off drain ('tekebkeb') • Vegetative barriers ('Geta') • Plant trees on the edges of their plots • Plough across the slop of the farm land • Contour ploughing
2	***Knowledge sharing***		
2.1	Scientific knowledge	• Audio visuals • Websites • Intermediaries/brokers (i.e., extension agents) • Trainings • Field visits • Exhibitions • Demonstration • Publications • Traditional forms of ICTs (i.e., TV and radio), • Modern forms of ICTs (i.e., Internet, ubiquitous mobile phone) such as mobile-based market information systems; SMS, Interactive Voice Response (IVR) service, E-mail and Website (www.ecx.com.et) of Ethiopian Commodity Exchange (ECX). 808 of MoARD, 8028 and the EthioSIS of ATA	
2.2	Indigenous knowledge	• Oral expression	• Observation

		• Practicing • Storytelling	• Trial and error • Informal groups
3	***Challenges of knowledge systems integration***		
3.1	Challenges of knowledge systems integration	• The result of ignorance • No comprehensive guideline • Lack of trust • Lack of resources • Lack of awareness • Knowledge and skill gap • Technological limitations	
4	***The role and practice of knowledge brokering***		
4.1	In-betweenness of extension agents	• Closely working with IS professionals, agricultural experts, and local farmers • Learning the work practices of research, technologists, and local farmers • Involve all voice demand especially the local farmers • Sitting together with relevant CoPs • Uncover needs of relevant CoPs • Align their position with the IS units • Understand the perspectives held by different CoPs	
4.2	Enhance participation	• Encourage participation • Encourage interaction • Mobilize across local farmers, researchers, and KMS developers • Involve the interests of all stakeholder groups taken into account in the process	
4.3	Knowledge and technology translation	• Communicating knowledge and technology • Translation of knowledge and technology into practice • Interpretation of knowledge and technology into the local context of use • Explanation • Advise • Help people to make sense • Help people to apply knowledge into practice	
4.4	Network formation	• Link local farmers with research • Align the formal and the informal groups of common interest • Connect people from different CoPs • Bridging people together • To help them to build relationship • Forming partnerships with other brokers • Encourage informal groups	
4.5	Coordinate collaboration and negotiation	• Engagement • Discuss • Dialog • Consensus • Persuade	• Two-way interactions • Debate • Mutual appreciation • Efforts to understand each other • Shared understanding
5	***Skill and knowledge required by the extension agents***		
5.1	Knowledge brokering	• Teaching skills • Mentoring skills • Interpersonal skill • Facilitation skills • Communication skills • Mediation skills	• Negotiation skills • Networking skills • Writing skills • Participants management • Influencing skills
5.2	Knowledge management	• Information and knowledge gathering • Searching knowledge • Storing knowledge • Retrieving knowledge • Synthesizing knowledge • Document and content management • ICT tools skills	
6	***Boundary objects***		
6.1	Boundary objects	• EthioSIS	• Procedures

		• Mapping • Storytelling • Symbols • Prototypes • Audio visuals • Mobile hotline • IVR • SMS • GIS • GPS • Guidelines • Diagrams	• System documentations • User training manual • Farming materials • Report printouts • Publications • Bulletins • Newsletters • Websites • Observation • Oral mapping • ICT Kiosks
7	***Design of the KMS***		
7.1	Components of the KMS	• People	• Farmers • Extension agents • Agricultural researchers • KMS developers
		• Resource	• Knowledge resource • Policies and procedures • Skill and knowledge
		• Technological	• KM processes • Web 2.0 tools
		• The KMS Layers	• Interface • Interactive • Integrative • Knowledge repositories • Database
8	***Evaluation of the KMS/KM success***		
8.1	KMS quality	• Technological resources of the organization	• Integrated technological infrastructure in a shared KMS • Networks • Databases • Knowledge repositories • Web servers • Database servers • Web server software • Clients • Clint-side scripting • Server side scripting • Users' requirements • Relevant social groups' competency in KM activities • Knowledge brokering roles • Boundary objects possessed by relevant CoPs
		• KM/KMS form	• Automation of knowledge • Computerization of KM activities
		• KM/KMS level	• Knowledge searching and retrieval • Knowledge visualization • Knowledge assessment • KMS for interaction, communication, collaboration
8.2	Knowledge quality	• KMS/KM strategy and process	• Knowledge repository • Locating knowledge • Experts map
		• Linkages to knowledge	• Knowledge from diffent sources • Knowledge map
		• Richness of knowledge	• Knowledge from diffent sources • Knowledge formats • Textual, image, vidio, audio
8.3	Service quality	• Management support	• Learning environment • Nonhierarchical open structure

			• Knowledge and skill development • Participative, collaborative, and negotiation culture • Guideline and privacy issues
		• User KM/KMS service quality	• Awareness • Training • Incentives • Promotion • Knowledge brokering skill • KM activities skill
		• KMS/KM service quality	• Gethering requirement • KM activities • KM/KMS objectives • Designing KMS • Implement KMS • Maintain KMS • Incorporate procedures • Train users and extension agents
8.4	The use of a shared KMS	• Participants (farmers and researchers)	• Fosters interaction, communication and negotiation • Access knowledge • Reuse the existing knowledge • Contribute knowledge • Integrate knowledge • Create new knowledge.
		• Extension agents	Perform their roles of knowledge brokering through a shared KMS: • In-betweenness of agents • Enhance participation • Knowledge and technology translation • Network formation • Coordinate collaboration and negotiation.
8.5	The consequences of KMS and knowledge brokering	Individuals' performance increment and organizational effectiveness for • Knowledge exchange • Knowledge integration • New knowledge creation	• Common language • Two-way communication • Reflect on others thought • Collaboration • Knowledge sharing • Recognition of individual knowledge domains • Develop richness of knowledge • Develop elements of specialized knowledge • Knowledge combination • Apply knowledge

Source: *Author own compilation*

Appendix VII: Description of the KMS Developed using Web 2.0 Tools

The prototype is developed by integrating freely available Web 2.0 tools in the Internet. WordPress (V. 4) was used to develop the Web-based KMS. WordPress is a free and open-source content management system. To run the WordPress (V. 4), the required PHP version 7 and MySQL version 5.6 were installed. WordPress plugin architecture allows extending the features and functionality of a website or blog, for example, BuddyPress for social network, BBPress for forums and BBPressDocs for knowledge repositories development. Table 10-5 provides summary of WordPress plugins integrated in the Web-based KMS.

Table 10-5. Summary of Web 2.0 Tools Applied in the KMS

Plugins	Description
BuddyPress	It helps site builders and WordPress developers add community features to their websites, with user profile fields, activity streams, messaging, and notifications. BuddyPress is a powerful tool for creating online communities, which you can use for anything from a small team to a massive network of people across the world.
bbPress	Forum software with a twist from the creators of WordPress.
BuddyPress Docs	Displays the most recent BuddyPress Docs that the visitor can read. Shows only group-associated docs when used in a single group sidebar.
Google Language Translator	This plugin adds Google Translator to your website by using a single shortcode, [google-translator]. Settings include: layout style, hide/show specific languages, hide/show Google toolbar, and hide/show Google branding. Add the shortcode to pages, posts, and widgets.
Buddypress Geodirectory	A light weight plugin which integrates Geodirectory plugin with Buddypress.
rtMedia	This plugin adds missing media rich features like photos, videos and audio uploading to BuddyPress which are essential for building social network.
bbPressContributors	Shortcode to show the authors that have posted more
AnsPress	The most advance community question and answer system for WordPress. It consists of features such as voting, featured questions, comments, activity, notification.
Events Manager	Event registration and booking management for WordPress. Recurring events, locations, google maps, booking registration, and more.
A podcast	It is an episodic series of audio files which users can subscribe to download and listen.
WP Voice Recorder	It records a user voice and play your posts content in front end.
WPNewsletter	It allows users to subscribe their email.
BuddyPress Activity Plus	A Facebook-style media sharing improvement for the activity box.
BuddyPress Activity Privacy	Add the ability for members to choose who can read/see his/her activities and media files.
GD Rating System	Powerful, highly customizable, and versatile ratings plugin to allow users to vote for anything you want.
WordPress FAQ Manager	Uses custom post types and taxonomies to manage FAQ section.

Source: *http://www.wordpress.com/*

Appendix VIII: Sample Prototype Interfaces

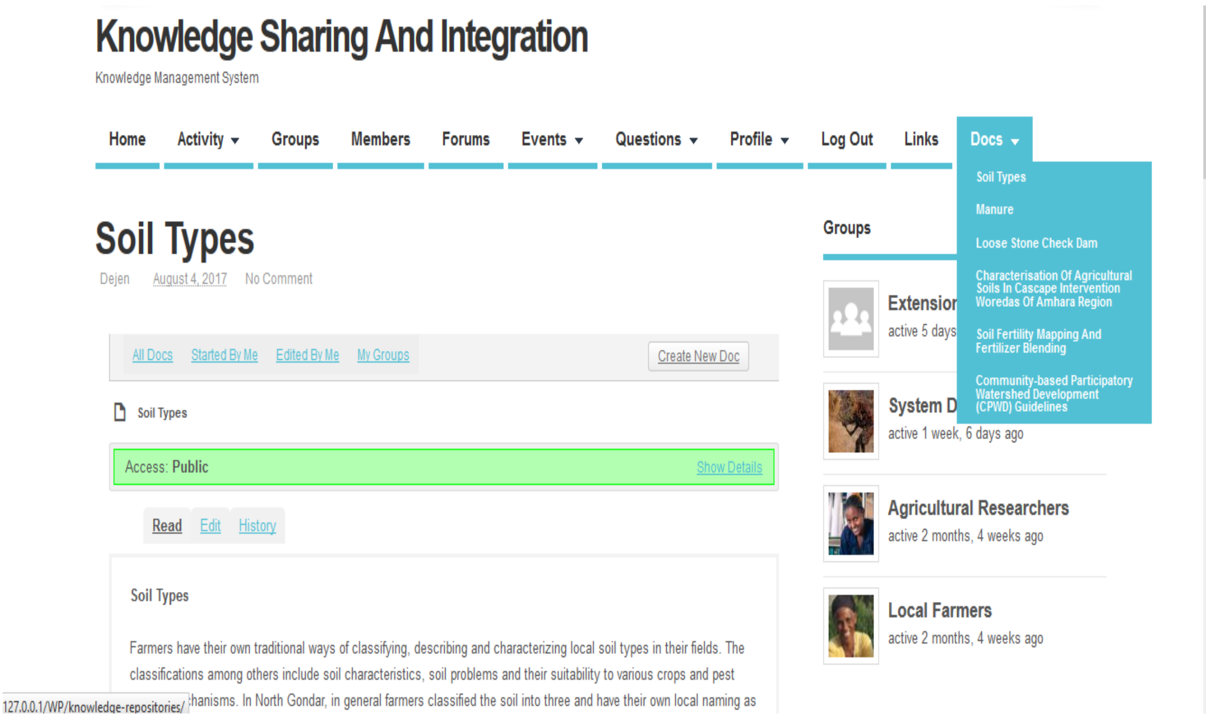

Figure 10-1. Sample Webpage of Knowledge Repository of Web-based KMS

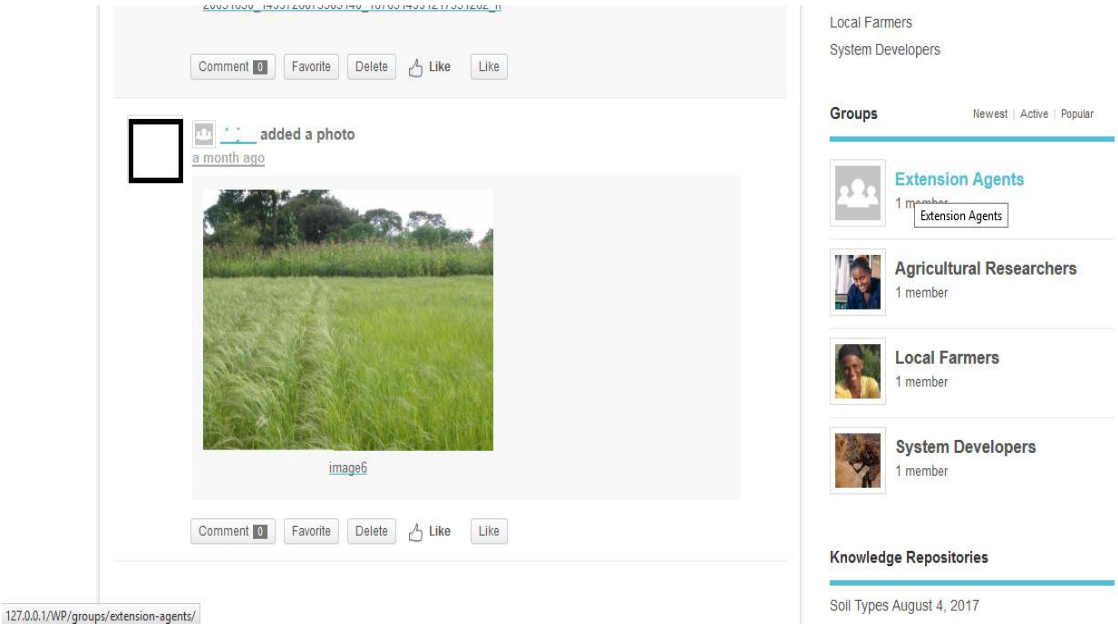

Figure 10-2. Sample Webpage of Knowledge Map of Web-based KMS

Appendix IX. Papers Published

Alemu, D., Jennex, M. E., & Assefa, T. (2017). Interplay of knowledge brokering and boundary object for knowledge integration in agricultural knowledge management system development. A poster presented in the *First National Conference on SLM – Knowledge Fair. UNECA Conference Centre*. Addis Ababa, Ethiopia.

Alemu, D., Jennex, M. E., & Assefa, T. (2017). Understanding agricultural KMS development for the integration of indigenous and scientific knowledge. In *the 10th Ethiopian Information and Communication Technology Annual Conference* (pp. 17–26). Addis Ababa, Ethiopia.

Alemu, D., Jennex, M. E., & Assefa, T. (2017). Roles and Practices of Extension Agents for Knowledge Integration in Agricultural Information Systems Development. In *Proceedings of the 11th European Conference on Information Systems Management* (pp. 9–16). Genoa, Italy.

Alemu, D., Jennex, M. E., & Assefa, T. (2017). The Design and the Use of Knowledge Management System as a Boundary Object. European Alliance Innovation International Conference on ICT for Development for Africa. Bahir Dar, Ethiopia.

Alemu, D., Jennex, M. E., & Assefa, T. (2018). Agricultural Knowledge Management System Development for Knowledge Integration. In *51th Hawaii International Conference on System Sciences, HICSS51* (pp. 4317-4326), *IEEE Computer Society*.

Appendix X. Participant's Consent Form, English Version

Research Title: Constructing Conceptual Framework of Agricultural Knowledge Management System Development for Knowledge Sharing and Integration: The Case of Ethiopian Soil Information Systems

You are being invited to participate in a research about conceptual framework construction for the agricultural knowledge management system development and use for indigenous and scientific knowledge integration. This research project is being conducted by Mr. Dejen Alemu as part of his PhD study at Addis Ababa University. The objective of this research project is to understand the roles and practices of extension agents as knowledge brokers and knowledge management systems for knowledge exchange and integration. For this purpose, extension agents, farmers, agricultural researcher, and system developers will be interviewed and observed across the agricultural research centers and bureaus, farmers training centers, and farming places.

There are no risks associated if you decide to participate in this study. The information that you provide will help the researcher to understand how to utilize the interplay of knowledge brokering and a shared online KMS for knowledge sharing and integration. The interviews and participant observations conducted will remain anonymous; no one will be able to identify you. Hence for the data collection process, I provide you this written informed consent. Please read this consent form carefully and be confident that you understand its contents before signing the consent form. If you have any questions about the research project, please feel free to contact me. A copy of signed consent form will be given to you for your records.

I ____________________ hereby accept the invitation to participate in this research on my own free will. I understand that I may stop participating at any time without penalty to you.

Signature: ____________________

Date: _______________________

Appendix XI. Participant's Consent Form, Amharic Version

የተሳተፉ ፈቃደኛዎች ቅጽ

የምርምር ርዕስ፡ በግብርና እውቀት ማኔጅመንት ስርዓት ግንባታ ውስጥ እውቀት መጋራት ማቀላጠፍ የማሳያ ማዕቀፍ- የኢትዮጵያ የመሬት መረጃ ስርዓት ጉዳይ.

ስለ ግብርና እውቀትና አያያዝ ስርዓት አጠቃቀም በአገሬው ተወላጅ እና ሳይንሳዊ እውቀትና ውህደት ውስጥ በተደረገው ጥናት ውስጥ እንዲሳተፉ እየተጋበዙ ነው. ይህ የምርምር ፕሮጀክት በአዲስ አበባ ዩኒቨርሲቲ በዶክትሬት ዲግሪያቸው በአቶ ደጀኔ አለሙ ተወስኗል. የዚህ የምርምር ፕሮጀክት ዋና ዓላማ የኤክስቴንሽን ተወካዮችን እንደ እውቀተኛ አጀማመር እና በእውቀት መለዋወጥን እና ውህደት ውስጥ የእውቀት አስተዳደር እና የእውቀት አስተዳደር ስርዓቶችን መገንዘብ ነው. ለዚህ ዓላማ የኤክስቴንሽን ተወካዮች፣ አርሶ አደሮች፣ የግብርና ተመራማሪዎችና የስርዓት ገንቢዎች በምርምር ማዕከላት እና ቢሮዎች፣ በአርሶ አደሮች ማሰልጠኛ ማዕከሎች እና በእርሻ ቦታዎች ላይ ቃለ መጠይቅ ይደረግላቸዋል.

በዚህ ጥናት ውስጥ ለመሳተፍ ከወሰኑ ምንም አደጋ የለም. የሚሰጡት መረጃ ለተግማሪው የእውቀት ሽምግልና እና በመስመር ላይ KMS ለእውቀት ማካፈል እና ውህደት እንዴት መጠቀም እንዳለባቸው እንዲገነዘቡ ይረዳቸዋል. ቃለመጠይቆች እና ተሳታፊ የሆኑ ምልከታዎች በስማቸው የማይታወቁ ይሆናሉ. ማንም ሰው እርስዎን መለየት አይችልም. ስለዚህ የመረጃ አሰባሰብ ሂደትን ይህን ስምምነት ላይ በተቀመጠው ተስማምቻለሁ. ይህን የስምምነት ቅጽ በጥንቃቄ ያንብቡት እና የስምምነት ቅጹን ከመፈረምዎ በፊት ይዘቱን እንደተረዱት እርግጠኛ ይሁኑ. ስለ የምርምር ፕሮጀክቱ ጥያቄዎች ካለዎት እባክዎ እኔን በነፃ ግንኙነት ያግኙ. የተፈረመ የስምምነት ቅጅ ለርስዎ ሪኮርዶች ይሰጥዎታል.

እኔ በዚህ የምርምር ሥራ ላይ እንድሳተፍ ግብዣዬን ተቀበልኩ. ምንም ሳይቀጡ በማንኛውም ጊዜ መሳተፌን ማቆም እንደምችል ተረድቻለሁ.

ፊርማ: ________________________

ቀን: ___________________________

Appendix XII. Permission Paper

አዲስ አበባ ዩኒቨርስቲ
አይ ቲ ዶክቶራል ፕሮግራም

Addis Ababa University
IT Doctoral Program Office

Date /ቀን 04/02/2016
Ref. No. /ቁጥር IT-DPO-135/2008/16

To Whom It May Concern

Subject: Request for Collaboration

Mr. Dejen Alemu Abtew (ID. NO. GSR/3634/05) is a PhD candidate in the IT Doctoral Program, Information Systems Track at Addis Ababa University. Dejen is conducting a research entitled **"Framework for Integration of Indigenous and Scientific Knowledge in Agricultural Knowledge Management System Development in Ethiopia"**. This study intends to develop and test a conceptual framework for better understanding and integration of knowledge incorporation in agricultural knowledge management system by employing system development action research. The research work holds a valuable importance to the users/smallholder farmers and other stakeholders and the country at large having an international scene.

This is, therefore, to kindly to request your good office for cooperation and willingness to allow him to collect data from your organization regarding agricultural knowledge management practice and knowledge management system development through interviews, participatory observations and participatory workshop.

I would like to assure you that the candidate is well aware matured and ethically fit to take all the necessary measure on confidentiality/privacy matters regarding your organization.

Thank you in advance for your cooperation.

Sincerely,

Salehu Anteneh (PhD)
Director, IT Doctoral Program
Addis Ababa University

Ethiopian ATA
05 APR 2016
RECEIVED

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DECLARATION

In accordance with the Addis Ababa University Honor Code, I certify that my submitted dissertation entitled: **Constructing Process Conceptual Framework of Agricultural Knowledge Management System Development for Knowledge Sharing and Integration: The Case of Ethiopian Soil Information Systems** here is my own work and has not been presented to any university in the same or different form to merit a PhD degree other than that for which I am now a candidate and that I have appropriately acknowledged all external sources that were used in this dissertation.

Dejen Alemu Abetwe

Signed: ____________________ on: _________________________