The Design and the Use of Knowledge Management System as a Boundary Object

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Abstract. Agricultural knowledge management system (KMS) involves various members coming from different social groups who possess their own knowledge which need to be combined in the system development. However, the current development of the technology ignored the indigenous knowledge of the local communities. The multi-methodological approach to KMS research in action research perspective was employed to understand the design and use of KMS for knowledge integration. Primary qualitative data were acquired through semi-structured interviews and observations. The research shall have theoretical contribution in addressing the incorporation of variety of knowledge in agriculture and practical implication to provide management understanding in developing strategies for the potential of a shared KMS as a boundary object for knowledge integration to support marginalized smallholder farmers.

Keywords: Agriculture · Knowledge · System development · Farmers

1 Introduction

Today, literature is awash with the potential of ICTs as enablers of socio-economic development [1]. 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 [2]. Technological advancements have been applied for the betterment of poor farmers and developed tools that are potentially capable of supporting agricultural sector [3]. However, their use and relevance are still alien to the local rural communities [3]. Agricultural knowledge management systems (KMS) are, therefore, unsuccessful to provide the full promised potential of ICTs in developing countries [1, 3].

Agricultural KMS development is a complex team activity involving participants coming from different CoPs, each of them contributing specific knowledge that needs to be incorporated in the IT system. In agricultural KMS, there are participants from different communities of practice (CoPs), who possess indigenous knowledge and scientific knowledge, for example, local farmers and scientific communities, respectively [1–3]. However, little has been realized for the integration of IK with the scientific knowledge in KMS development that can involve relevant participants from

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different CoPs. This research is interested in identifying boundary objects which links users from different CoPs. Boundary objects are any objects such as artefacts, documents, terms, concepts, and other forms of reification around which communities of practice can organize their interconnections [4]. Besides, research in KMS development must also address the design tasks faced by practitioners. Accordingly, the research is also interested in understanding the design of technological artifact as a boundary object and investigating the use of it.

2 Literature Review and Theoretical Framework

Davenport and Prusak [5] [p. 5] defined knowledge as a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. Despite the fact that knowledge is a key organizational asset, it is a resource difficult to access that is challenging to share, imitate, buy, sell, store, or evaluate [6]. 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 [6, 7]. Jennex [6] stated that in order to make knowledge repository useful, it must capture and store the context in which the knowledge generated such as when it occurred; who is knowledgeable about it; who provided it; and social conditions. It is crucial to understand knowledge with its context in order to facilitate the capturing of knowledge from individuals in agricultural KMS development and making it available for reuse.

Knowledge management (KM) is one that has come to be used to refer to explicit strategies and practices applied to make knowledge as a resource for the organization. Jennex [8] defined KM as the practice of selectively applying knowledge from previous experiences of decision making to current and future decision making activities with the express purpose of improving the organization's effectiveness. KM processes are viewed as cyclic process that encompasses processes 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 is applied, it also leads to new knowledge creation, thus the process follows a circular flow and a nonstop process that continuously updates itself.

Organizational knowledge creation and transfers takes place when all four modes are organizationally managed to form a continual cycle: combination, internalization, socialization and externalization [9] (see also Fig. 1).

- Internalization (explicit-to-tacit): this refers to the conversion of explicit knowledge into new tacit knowledge within an individual by learning and experience.
- 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.
- 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 shared experience among members of the organization.

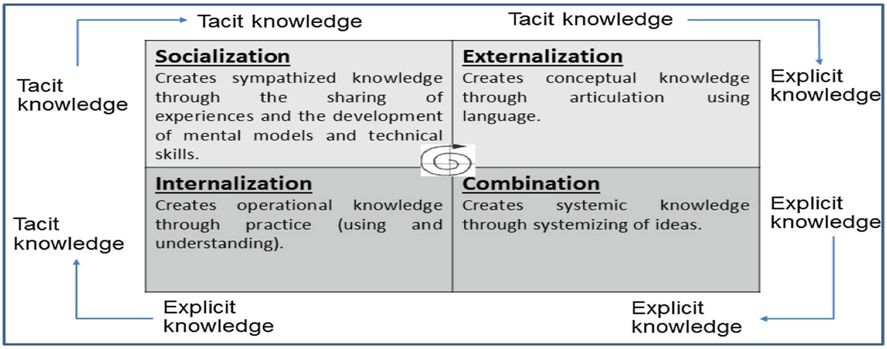

Fig. 1. Nonaka's [9] four modes of knowledge creation and transfer.

- Combination (explicit-to-explicit): the combination mode is the process of recombining discrete pieces of explicit knowledge into a new form [7]. It 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 [9].

Previous researches such as Jennex [7] and Jennex and Olfman [10] have suggested that the KM activities need to be supported through KMS in order to foster the organization effectiveness. A KMS, a class of information systems, is a managerial, technical, social, and organizational system structured to support the implementation of KM within an organization, thereby enables organization to manage knowledge effectively and efficiently [12]. A KMS can be seen as an activity system that involves people making use of objects such as tools and technologies to create artifacts and products that represent knowledge in order to achieve a shared goal [7] [p. 167]. It is not, therefore, the technology that distinct KMS from the other type of information systems; however, it is the highly involvement of human activity in their operation and designed to put organizational participants in contact with recognized experts in a variety of topic areas [13].

Web 2.0 tools are today widely used to develop an online KMS in order to understand users' interaction for knowledge sharing and integration. 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 [14, 15]. Web 2.0 tools are characterized by being user-centered, enhance social network formation, promote communication, interaction, and collaboration, and harness collective intelligence [15]; thereby help to systematize the processes of knowledge sharing, creation, and integration. For example, social networking tool can be used for connecting people and locate each other with similar interest; Wiki for collaborative, mediated, content production and organization; blogs enable user to subscribe to a blog and post comments in an interactive format; and real time collaboration tools to provide real time voice communication for interaction and knowledge sharing. These tools are important for KM processes including explicit knowledge publishing and the tacit knowledge extraction, dissemination, integration, and utilization across various CoPs having common interest.

In order to understand the integration of knowledge in agriculture, the theory of situated learning within community of practice (CoP) [16] is selected since it helps in creating a social infrastructure and view knowledge as socially constructed rather than view of knowledge as objective entities. 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 [4, 16]. In agricultural KMS development, IK having the tacit format possessed by the local communities needs to be captured and integrated in the system. The theory of situated learning within CoP [16] provides the concept of boundary objects important for understanding knowledge integration across CoPs.

Different communities through time develop their own practices, routines, documents, rituals, artifacts, symbols, tools, conventions, websites, stories and histories [4]. 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 [17, 18], and support collaboration, interaction, and knowledge sharing across CoPs [1]. Boundary objects mediate and coordinate productive breakdowns in collaboration across different social perspectives, distributed organizational workgroups and geographical boundaries [1, 4]. Previous researches are resulted in the identification of wide range of boundary objects in different context, for example, diagrams, system documentations, user training materials, standards, policies, technical extraction, physical prototypes, report printouts [17]. 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 work of Puri [1], 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.

Local rural communities and agricultural domain experts possess different knowledge types and individuals in each social groups use boundary objects for their interaction. 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 the objects possessed by local communities [1, 3]. As a result, the KMS does not allow local communities to use knowledge in the systems and contribute and share their knowledge through it. Information system professionals who develop and support the agricultural KMSs are, therefore, to learn the work practices and objects of each user community. Thus, in the development of agricultural KMS, system developers should involve objects possessed by relevant CoPs in particular local communities in turn the shared KMS as a boundary object enables all relevant participants coming from different CoPs to interact and collaborate for their common practice. As such, this research seeks to investigate the boundary objects possessed by different relevant social groups and integrate in the development of the shared agricultural so as to understand the use of a shared KMS as a boundary object.

3 Methodology

This research followed applied systems development action research approach. Accordingly, the multi-methodological approach to IS research in action research perspective which consists of four strategies including theory building, experimentation, observation, and system development was employed [19]. As stated by Burstein and Gregor [19], theory building refers development of new ideas and concepts, which guides the design of experiments, and conduct systematic observations. The KMS development in agriculture is considered to provide a theoretically relevant organizational setting for this investigation due to the presence of multiple project participants from different communities with differing expertise.

Primary data were collected by employing mainly in-depth semi-structured interviews. Participant observations were also carried out to understand the nature of the working relationships among the various local communities in agricultural practices. Of the total 23 informants, 5, 3, 8 and 7 were selected from domain experts, technologists, extension agents, and farmers, respectively. Data were immediately transcribed using respondents' own words as fast as possible. Through the iterative process of data collection and analysis, the initial concepts were expanded and revised. An agricultural KMS is further developed and applied in order to understand the use of KMS.

4 Result

The research has identified three different social groups in the agricultural KMS development: agricultural researchers, extension agents, and local farmers. Agricultural researchers possess scientific knowledge arises from their educational background, findings of researches and their everyday institutional practices. Local farmers are important source of indigenous knowledge and also use the scientific knowledge and technology from research. However, the KMS development process relies on data extracted from scientific 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. This research understood the potential of IK in order to bring the full potential of the KMS in agriculture and the development needs to involve both indigenous and scientific knowledge. In Ethiopian agricultural extension system, there are extension agents who are transferring knowledge and technology from research to local farmers.

Informants from all subjects reported a wide range of boundary objects for knowledge sharing process among others, EthioSIS (Ethiopian Soil Information Systems), oral mapping, audio visual, guidelines, procedure, system documentation, report printout, publication, newsletter, bulletin, user training manuals, websites, and ICT Kiosks. These all support the extension agents as boundary objects while they provide knowledge and technology transfer from research to local farmers. Local farmers employ observation, traditional music and ceremonies, symbols, farming materials, storytelling, oral expressions, and oral mapping for indigenous knowledge sharing which serve as boundary object. However, such boundary objects for sharing IK are not considered in the development of agricultural KMS. Consequently, the development efforts do not fully enable farmers to participate and collaborate in the use of such systems. A shared technological artifact such as a KMS as a boundary object needs to be created through participating all relevant social groups and their need of knowledge and information to establish common ground for different participants and enables to cross the knowledge boundary among participants [4].

4.1 Designing of a KMS

The 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 the agricultural KMS for knowledge sharing and integration and relevant issues are identified. Following the terminologies presented by Saade et al. [20] and Jung et al. [21], three basic subsystems of KMS for effective knowledge process specifically for knowledge sharing and integration were identified: the people, resources, and technological subsystems.

In building this research, the human subsystem includes the local farmers, agricultural researchers, and extension agents, who are the core of the KMS and it needs to be designed based on the capability of those agents. Table 1 indicated the human agents and their roles in the development of agricultural KMS. In order to share and integrate knowledge, active participation and collaboration among these social groups are highly critical in the KMS development process. There are also extension agents mediating knowledge exchange between the knowledge contributors and the users of the knowledge. Hence, development of the technological artifact as a boundary object is required for sharing and integration of knowledge by paying attention to those people.

Table 1. The roles of relevant social groups in KMS development

Social groups	Roles
Agricultural researchers	Scientific knowledge systems creation, recreation, and presentation Use IK from local farmers for further research Interact with extension agents Evaluate the ongoing implementation of new knowledge and technology
Local farmers	Indigenous knowledge creation, recreation and presentation Use scientific knowledge and technology from research Interact with extension agents and researchers
Extension agents as knowledge brokers	Extension agents exchange knowledge and technology between farmers and researchers, and coordinate the interaction and collaboration among users from different social groups

Resource subsystem consists of knowledge resources from the local and scientific communities, rules including guidelines and procedures for social interaction in system development. There are two different categories of domain-specific knowledge relevant in agricultural KMS development: farmers' indigenous knowledge and scientific knowledge from research. The scientific knowledge includes scientifically processed or analyzed data, which were collected from researchers through field survey, interviews, and observations and from documents such as publications, reports, newsletter, bulletins on soil fertility management and conservation. In the existing agricultural KMS, only the explicit scientific knowledge and procedures are considered and managed statically. However, the indigenous knowledge from local communities which is tacit and embedded in the minds of human being and practice is ignored. Few explicit indigenous knowledge are collected form documented on lesson learned, best practices, and storytelling. However, indigenous knowledge is mostly tacit and collected through ongoing interaction with local farmers in the development and the use of KMS. Explicit knowledge from researchers and local farmers is primarily stored in the knowledge repository of a KMS.

The KMS consists of technological artifact and processes used by users from different social groups to support KM activities [10]. The implementation subsystem entails the use of concepts derived from theory of social learning systems 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, the shared boundary object (i.e., KMS) can support human communication, interaction, collaboration, and negotiation for knowledge sharing and integration from the existing knowledge repositories and maps. The existing explicit scientific and indigenous knowledge are represented in knowledge repositories.

Primarily, users start KM activities through accessing 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 converts explicit knowledge to tacit knowledge. Additionally, knowledge users content communication can occur either via acquiring knowledge directly from the knowledge repositories and maps or by constructing meaning from interaction, dialog, and reflection. This socialization process enable users to sharing experiences by observation, imitation, and practice in order to create new tacit knowledge (i.e., tacit-to-tacit). Socialization promotes a mutual understanding by the sharing of mental models [7] which is important precondition for sharing tacit knowledge. The tacit knowledge from different members in particular from local communities with indigenous knowledge highly tacit can be transcribed. Consequently, tacit knowledge from different members can be converted into explicit knowledge. Finally, pieces of knowledge from members coming from different social groups can be shared and combined. For this purpose, through employing the people, the resource and rules, and technological components, a KMS prototype is developed using Web 2.0 tools.

4.2 The Use of the KMS for Knowledge Sharing and Integration

We provided access to 23 informants of this research to the online KMS following its development from January 2017 to March 2017, who were voluntary to participate in the research as respondent and informed in advance. Other users were also joining from different social groups. Finally, participants are observed while using the system and further interviewed for understanding the significance of the shared KMS as a boundary object.

The participants from the rural communities and agricultural researchers access the existing knowledge, enriching dialogue/forum to enhance interaction, contribute their knowledge and create new knowledge. Knowledge contents presented in different languages (i.e., farmers' local language) and presentation of content in different forms (i.e., textual, image, audio, and video) enables farmers and others to easily access information and be able them to interact. Farmers share their own knowledge (i.e., indigenous knowledge) using oral mapping, storytelling, and observation. Hence, audio blogging and podcasting, instant message, and visualization tools employed in the KMS help farmers to access knowledge from others and share their own through posting audio.

During the use time of the online KMS, it has been observed the communication and participation of participants from local communities and research groups who are geographically disparate. 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 the direct contact between participants whereby highly decrease the feeling of distance among them. Moreover, audio and video communication and mapping in the KMS foster the externalization of indigenous tacit knowledge from local farmers through visualization. The 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 provide distributed environment to disseminate knowledge two-way instantly. The use of the KMS can also eliminate the existing hierarchical structure of the country extension, which promotes one-way knowledge and technology dissemination from research to local farmers.

The online KMS enable users to connect with others informally in their CoPs and with other users from different CoPs. The social network tools in a shared KMS also enable them to identify the knowledgeable and interact on one-to-one, one-to-many, and many-to-many among users from different CoPs independent of the existing hierarchical structure of the extension systems. Such networking is important for exposing users to different knowledge. Consequently, users from different groups highly communicate, interact and collaborate for their common interest, whereby, knowledge sharing and integration are enhanced.

5 Conclusion and Recommendation

In order to integrate knowledge, it is critical to identify the relevant social groups who are capable of influencing the KMS development, information needs and the knowledge they possess. This research identified relevant social groups in agricultural IS development: local farmers who possess IK, researchers who practices scientific knowledge and extension agents who exchange knowledge. However, result of this research and extant literatures such as Puri [1] and UNDP [2] indicated that knowledge in agriculture have been applied in an isolated and fragmented manner.

Despite the fact that several boundary objects are identified in the agricultural KMS development process for knowledge sharing and integration; boundary objects employed by local farmers for IK sharing, preservation, and integration are not considered in the current KMS development process. In response, a shared KMS for knowledge systems sharing and integration is designed in this research to meet the challenges raised by diverse groups of participants. Thus, a shared boundary objects should be flexible to be used by different participants to promote communication, interaction, and collaboration among relevant participants for sharing and integration knowledge and support them to build shared understanding. 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 sharing and integration. Freely available social Medias with some modification such as Facebook, Twitter, Linked, and Wikipedia can also be used for knowledge sharing and integration in agriculture. Relevant agricultural organizations or policy makers need to understand the roles of Web 2.0 tools for their knowledge management activities.

The research can contributes to the extension of the theory of situated learning in CoP [16] for knowledge integration in KMS development. It also advances the literature on the roles of a shared KMS as a boundary object for knowledge sharing and integration. Practically, the research can provide management understanding in developing strategies for the potential of a shared KMS as a boundary object for the integration and sharing of knowledge ultimately to support marginalized smallholder farmers.

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