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Managing indigenous knowledge for sustainable agricultural development in developing countries: Knowledge management approaches in the social context

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Abstract This paper is based on a PhD study (Lwoga, 2009) that sought to assess the application of knowledge management (KM) approaches in managing indigenous knowledge (IK) for sustainable agricultural practices in developing countries, with a specific focus on Tanzania. This study used a mixed-research method which was conducted in six districts of Tanzania. Non-participant observation, semi-structured interviews, and focus groups were used to collect primary data from small-scale farmers in the selected districts. A total of 181 farmers participated in the semi-structured interviews, where the respondents ranged between 27 and 37 per district. Twelve focus group discussions were conducted in the selected districts. The study revealed that IK was acquired and shared within a small, weak and spontaneous network, and thus knowledge loss was prevalent in the surveyed communities. There were distinct variations in the acquisition of agricultural IK both in different locations and between genders. Information and communication technologies (ICT), culture, trust, and status influenced the sharing and distribution of IK in the surveyed communities. The research findings showed that KM models can be used to manage and integrate IK with other knowledge systems, taking the differences into account (for example, gender, location, culture, infrastructure). The paper concludes with recommendations for the application of KM approaches for the management of IK and its integration with other knowledge systems for agricultural development in developing countries, including Tanzania.

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Introduction

Indigenous knowledge (IK) is socio-economically viable and effective, involves minimum risk to rural farmers, and is an important asset for their livelihood and for conserving natural resources. IK is an important part of various fields, including agriculture, health, veterinary services, and arts and crafts. For instance, agricultural activities have been increasingly productive, sustainable and ecologically sound, even under difficult conditions, due to the utilisation of IK in developing countries including Tanzania (Mugurusi, 2001). In reality, the agricultural sector is the backbone of many economies in Africa. In Tanzania, the economy depends heavily on agriculture, which accounts for more than 25.7% of gross domestic product, provides 30.9% of exports, and employs 70% of the work force (United Republic of Tanzania, 2009).

However, the majority of Africans including Tanzanians rely on traditional agriculture, small land holdings, with little or no conventional inputs, and they depend on locally available resources for their livelihoods (Lwoga & Ngulube, 2008). Nonetheless, it is estimated that they produce as much as 20% of the world's food, largely without the benefit of conventional agricultural research (International Development Research Center, 2003). This production is mainly due to their application of indigenous skills and resources and their capacity to adapt to changing agro-ecological conditions through their local experiments. It is evident that farmers' knowledge, innovations and practices have provided the basis for thousands of years of agricultural development.

Farmers do not earn high incomes because their innovations and practices are mostly organised and accumulated through experience, and these indigenous technologies are applied in isolation (Mascarenhas, 2004, p. 4). Hence, IK has not been fully utilised for agricultural development purposes. The knowledge management model in most developing countries has been based on acquiring, organising and preserving explicit knowledge, which is mainly generated by researchers, laboratories and universities (Ngulube, 2002). At the same time, the dominant approach to research and extension still follows the pattern of transfer-of-technology, based on the assumption that knowledge is created by scientists, to be packaged and disseminated by extension, and to be applied by farmers (Assefa, Waters-Bayer, Fincham, & Mudahara, 2009). These approaches leave little room for farmers' IK to be incorporated into knowledge and information systems. There is thus an urgent need to acquire, document and preserve IK so that it can be available for agricultural developmental initiatives before much of it is completely lost.

Knowledge management (KM) approaches, including its theories, principles and practices, can be an effective mechanism for managing IK. Although local communities are composed of diverse groups with different organizational allegiances, KM approaches can harness isolated information, experiences, skills and know-how for sustainable socio-economic development (Mosia, 2002). Further, development of information and communication technologies (ICT) have contributed significantly to the growing interest in the potential of KM (Davenport, 2007). Within this context, there are a lot of theoretical studies that discuss the extent to which IK can effectively be managed by using KM approaches (Dlamini, 2005; Kaniki & Mphahlele, 2002; Ngulube, 2003). However, only a few studies (Boateng, 2006; Ha, Okigbo, & Igboaka, 2008; Noeth, 2004) have been conducted to assess the extent to which IK can be managed through KM approaches in the developing countries. While other studies (Mudege, 2005; Siebers, 2003; Wall, 2006) did not assess the application of KM approaches, they did investigate the management of IK in local communities, and thus they are relevant to the present study.

Boateng (2006) revealed that the circular KM model can be used by agricultural extension officers to inform farmers' decisions regarding technological improvements, and to incorporate farmers' knowledge in the design and development of such technologies in Ghana. Ha et al. (2008) found that Nonaka's (1994) knowledge creation model was partially fulfilled in their study of knowledge creation among farmers in Nigeria and they suggested that the collaborative model of knowledge dissemination can be partially effective among farmers in knowledge creation activities. Noeth (2004) found that the available information and knowledge were not managed effectively and suggested that a generic KM model can be an effective way to improve KM activities and the delivery of services in the rural communities of South Africa. Mudege (2005) established that agricultural knowledge was primarily social and its production was a social process; thus, gender dynamics, politics, power, conflicts, resistance, religious beliefs and government policies determined the production and socialization of this knowledge in Zimbabwe. In a Guatemala village, Siebers (2003) found that culture and power determined the knowledge sharing processes and integration of the external knowledge (*q'eqchi*) into the local knowledge system (*na'leb*). Wall (2006) also found that power and culture determined creation, sharing and use of agricultural knowledge in the rural Uzbekistan.

Certainly, it is evident that there are notable theoretical studies that help to better understand the application of KM principles and ICT in managing IK in local communities. It is also apparent that empirical findings on the use of KM models and ICT in managing IK in the Tanzanian context and elsewhere is lacking. Most of these studies (Mudege, 2005; Siebers, 2003; Wall, 2006) have focused on the social construction of knowledge, including its embedded nature in socio-cultural and power relationships. A few studies (Boateng, 2006; Ha et al., 2008; Noeth, 2004) have attempted to analyze the role of KM approaches in managing farmers' knowledge and there has been little attempt to examine the use of KM approaches and the role of ICT in managing IK in the local communities. In this regard, it is imperative to conduct a phased inquiry on these issues in order to provide empirical evidence about how KM principles and ICT can be applied to manage IK for improved agricultural activities in the rural areas of Tanzania. Thus, the following research objectives guided the study (Lwoga, 2009):

- To study the current status of managing agricultural IK in the local communities; and
- To determine the role of ICT in the management of agricultural IK in the local communities.

Indigenous knowledge

Indigenous knowledge is a cumulative body of knowledge created over decades, representing generations of creative thought and actions, within individual communities in an ecosystem of continuous residence, in an effort to cope with an ever-changing agro-ecological and socio-economic environment (Kaniki & Mphahlele, 2002). In Tanzania, as in other developing countries, IK is a social capital of the poor and a source of their social strategies. The physical/biological diversity and cultural diversity that embraces more than 130 tribes represents a wide variety of IK systems in Tanzania. Indigenous knowledge is an important part of various fields in Tanzania, including agriculture, traditional health services, veterinary services, arts and crafts, minerals, music, dance, and poetry. For instance, it is estimated that 80% of the population in Africa and about 66% of Tanzanians rely only on traditional medicine, due to its low cost and the large number of traditional healers (Kabudi, 2004, p. 37).

It is unfortunate that IK has largely been marginalized, neglected and suppressed due to ignorance and arrogance, politics, and the dominant ideology of a particular historical period (Ocholla & Onyancha, 2005, p. 248). Nevertheless, there is a renewed interest in IK in most developing countries due to its important role for sustainable socio-economic development. The politicization of indigenous groups and the indigenous rights movements have also increased the recognition of IK (Grenier, 1998). In spite of these positive developments, IK is threatened by socialization, the education system, the influence of western technology, and the lack of availability of certain crops, which limit local people's, especially youths', use of IK in these developing countries (Dube & Musi, 2002). It is estimated that each year two percent of the languages (and the cultures and knowledge expressed by them) of the world disappear and in one century 99% will have disappeared (Muñoz, 2004). Very little IK has actually been captured and recorded for preservation, limiting access and reach to an immensely valuable database in developing countries including Tanzania (Lwoga & Ngulube, 2008). There is an urgent need to manage IK to enhance its availability for developmental initiatives before much of it is completely lost.

Indigenous knowledge and agricultural development

Most farmers in developing countries practice low-input agriculture (approximately 80% of the agriculture) (Mella, Kulindwa, Shechambo, & Mesaki, 2007), something that shows the potential of IK for sustainable agricultural practices. Statistics show that at least 50% of the world's population depends on IK for crops and food supplies (Hart & Vorster, 2006). In Tanzania, the traditional sector accounts for about 99% of the country's cattle, 85% of the poultry (Hill, 2003, p. 1), and more than 90% of the seeds planted (Mushi, 2008).

Many of the traditional farming systems were sustainable only under low-input-low-output regimes. The introduction of mechanization, fertilizers and phytomedicines turned some of these systems into high-input—high-output systems, most of which were either not sustainable or did not produce the high outputs that were expected (Aluma, 2004, p. 24). The major causes for this problem include market restrictions, land use rights, inappropriate technology transfer, poor communication infrastructure, and poor access to rural finance (Kaburire & Ruvuga, 2006, p. 85). The modernization of agriculture has also reduced the genetic variability of crops and livestock. It is estimated by the Food and Agricultural Organization (FAO) that 30% of animal genetic resources are at high risk of loss due to neglecting IK in favour of conventional scientific findings (Muyungi & Tillya, 2003).

Researchers and producers are now counteracting this trend by re-introducing indigenous species back into the gene pool of domestic crops and livestock (Aluma, 2004, p. 24). As farmers in Tanzania, and in other parts in the world, are becoming more aware of the negative effects of agro-chemicals, they are returning to local inputs and practices (Aluma, 2004, p. 25). However, in developing countries, indigenous farming has received little agricultural research attention. For example, crop research policies in Tanzania emphasize research that is conducted on crops with export potential. As a result, researchers and extension services in Tanzania neglect the traditional crops that are vital for food security (Manda, 2002, p. 185). Thus, development of indigenous farming methods in Tanzania relies on the farmers' observations, experimentation, adaptation, and propagation of new ideas gained through experience (Mugurusi, 2001). There is a need to continuously recognise, identify, validate, preserve, and disseminate indigenous skills and practices for improved agricultural activities.

Application of KM in the management of IK

Knowledge management refers to a system of actions upon knowledge, which includes the establishment of strategies and procedures, with proper utilisation of technologies, so that the acquisition, storage, conversion, sharing, application and generation of knowledge can be effectively performed; the goal is to effectively use the available knowledge for problem solving and decision making (Lai, 2005). Knowledge management has been successfully applied to improve business performance in many organizations in the developed countries. Because knowledge is a key resource for development, it is important that KM be applied in the developing countries' rural communities for sustainable economic growth. However, IK is rapidly disappearing in developing countries. Indigenous knowledge custodians are aging and dying without a demonstrable plan to preserve their knowledge and transfer it to future generations (Mascarenhas, 2004, p. 4). Poor attitudes, knowledge culture and personal characteristics (age, gender, status, wealth, political influence and so on) also affect perceptions, actions and access to knowledge in the local communities. The low level of formal education of the early custodians and the need to protect their own intellectual property has also contributed to the failure to share and document IK in developing countries (Nwonwu, 2008).

Some of KM practices such as direct interactions, storytelling, and communities of practice are already in

existence. However, unless KM practices are strengthened, they will not solve farming, and other related problems, such as new plant diseases (Garforth, 2001). Certain factors are needed to enable developing countries to manage IK through KM practices, as is done in the developed world. These factors include: an educated population to absorb and apply new knowledge; supportive policies; behavioural, cultural and structural changes; transparency; political will; coordination of the public and private sectors; and improved ICT infrastructure (Mchombu, 2007). Africa's IK system can be used to improve agricultural activities if the KM approaches are put in place and are a priority. It becomes imperative to assess the applicability of KM principles for managing IK in the context of the local community.

Approaches towards the application of KM in the management of IK

This study was guided by four KM models, with each model adding new insights and providing a range of possible solutions for KM practices (Boisot, 1987; Nonaka & Takeuchi, 1995; Probst, Raub, & Romhardt, 2000; Small & Tattalias, 2000). These KM models were specifically used to provide a broad explanation and as a theoretical lens or perspective that guided the study. These models are briefly explained in the following text.

Nonaka and Takeuchi's (1995) model emphasized the creation of knowledge through the conversion of tacit into explicit knowledge, and vice versa, through: socialization (from tacit-to-tacit knowledge through shared experiences); externalisation (from tacit-to-explicit knowledge with the help of metaphors, models and analogies, such as printed materials and rock paintings); combination (from explicit-to-explicit knowledge through ICT), and internalisation (from explicit-to-tacit knowledge through learning by doing or translating theory into practice). Boisot's (1987) knowledge category model supports the Nonaka model by regarding organizational knowledge as either codified or uncodified, and as diffused or undiffused. The term codified means that knowledge can be captured and transmitted (for example, proprietary knowledge), while uncodified refers to knowledge that cannot readily be transmitted (for example, experience). The term diffused denotes knowledge that can be easily shared, and undiffused refers to knowledge that is difficult to share. In contrast, Probst et al. (2000) put major emphasis on KM processes, which include knowledge identification, acquisition, development, retention, distribution and utilisation. They identified two building blocks (knowledge goals and knowledge assessment) which influence KM processes in organizations. Similarly, Small and Tattalias's (2000) KM model insisted that second dimension elements (strategy, measurement, policy, content, process, technology, and culture) can enable or influence the knowledge creation activities in the first dimension perspective.

The four KM models that have been discussed all focus on business or organisational settings. Consequently, this study sought to assess the application of KM models in managing IK in local communities. This study adapted ideas from the four models in order to provide theoretical guidance for the application of KM models in managing IK in the local community setting. On one hand, it is evident that the models (Probst et al., 2000; Small & Tatalias, 2000) emphasize the implementation of KM processes for the effective management of knowledge in organisations. The KM models used different labels to show their KM processes, but they all emphasized the following processes: knowledge identification, acquisition, development, sharing, preservation and application. Boisot's (1987) knowledge category model is similar to Nonaka's model where the horizontal dimension of both models relates to the spread or diffusion of knowledge across the organization. It can be concluded that all these models emphasized the use of KM processes for effective KM activities in the organisations. On the other hand, the reviewed KM models (Probst et al., 2000; Small & Tattalias, 2000) also emphasized the identification of KM principles that could be used to guide or influence the implementation of KM processes in organizations. The designers of these models argued that KM principles need to be pre-determined for effective implementation of KM processes in the organization setting.

In this context, this study adopted the KM processes as deduced from the reviewed four KM models to allow the local communities to manage their knowledge based on pre-determined principles. Thus, the focus of the study was particularly on the following KM processes: knowledge acquisition, development, sharing, preservation and application. The study also adopted KM principles which were used to guide or influence the implementation of KM processes in the local communities, focusing on culture and ICT.

Methodology

This study used a mixed methods approach in order to triangulate various data collection instruments with the intention that they will all converge to support the research objectives of the study (Leedy & Ormrod, 2005, p. 99). A qualitative approach was the dominant approach because it is a useful method to study human action in their natural settings, attempting to make sense of, or interpret, phenomena in terms of meanings people bring them (Creswell, 2003, p. 181). The quantitative approach allowed patterns of IK acquisition, sharing, preservation and use to be rigorously described. This study was carried out in Tanzania, whereby six districts from six out of seven research zones were selected for the study. The districts were selected based on high agricultural production and the presence of ICT, such as telecenters, community radio, and cellular phone networks. These districts included Karagwe, Kasulu, Kilosa, Moshi Rural, Mpwapwa and Songea Rural districts. This study used concurrent design (also called parallel or simultaneous) of mixed methods research to collect both qualitative and quantitative simultaneously in a single data collection phase from small-scale farmers (Creswell & Plano-Clark, 2007). The qualitative data was collected through semi-structured interview items, focus groups, and non-participant observation, while quantitative data was gathered through closed questions which were embedded in the same semi-structured interviews. Interviews were used to study the current status of acquiring,

sharing, preservation and use IK, and the role of ICT in managing IK. Focus groups and non-participant observation were used to study the sharing of agricultural IK in the local communities in order to supplement data gained through interviews.

Two villages were selected from each of the six districts. A purposive sampling technique was used to select study participants in these villages based on age, sex, farming activity and ICT usage. A total of 181 smallholder farmers participated in the semi-structured interviews and there were 27—37 respondents per region. A total of twelve focus group sessions were held in the surveyed villages, with one focus group session held per village. There were 128 respondents who participated in the focus group discussions, with six to twelve participants per session. The focus group discussion and interview data were studied and analyzed as they were collected, until it was clear that perspectives were being repeated and data saturation was reached (Teddlie & Tashakkori, 2009). Quantitative and qualitative data were analyzed separately and then they were combined to compare and validate the findings. Some of the qualitative themes were also transformed into counts, and these counts were compared with descriptive quantitative data.

Research findings and discussion

Profile of respondents

In the semi-structured interviews, 181 smallholder farmers participated in the study, of which 112 were men and 69 were women. The gendered nature of the social, culture, economic and policy systems may have limited women farmers from participating in the study. The mean age of the respondents was 48, where the majority of the respondents (74.6%; 135) were between 29 and 68 years, while 13.8% (25) of respondents were between 19 and 28 years, and 11.6% (21) of respondents were above 69 years. The findings showed that 84% (152) of respondents had some level of formal schooling and about 91.2% (163) could read and understand simple instructions. Among those with formal schooling, male respondents dominated the higher education category, accounting for 62.5% (95) of those with primary school education, 9.2% (14) with secondary education, and 3.4% (5) with higher education (that is, 4 college diplomas and 1 university bachelor degree). The study mainly involved smallholder farmers, with the average farm size of 4.9 acres, where nearly two thirds of the crop farmers (61.9%; 104) had farm sizes below 4.9 acres.

For the focus groups, 128 smallholder farmers participated in the focus group discussions, where 50.8% (65) were males and 49.2% (63) were females. The mean age of the respondents was 45. Almost half of the respondents (48.4%; 62) were between 29 and 48 years, while 29.7% (38) respondents were between 49 and 68 years, 6.3% (8) respondents were above 69 years, and 15.6% (20) were between 19 and 28 years. About 89.1% (114) respondents had some level of formal schooling and 90.7% (116) could read and understand simple instructions. Among those 89.1% (114) respondents with formal schooling, male respondents accounted for 41.4% (48) of those with primary school education, 8.6% (10) with secondary education, 1.7% (2) with post-secondary education, and 0.9% (1) with adult education.

Management of agricultural indigenous knowledge

Despite the fact that various KM models (Nonaka & Takeuchi, 1995; Probst et al., 2000; Small & Tattalias, 2000) use different labels to identify KM processes, the following KM processes were found relevant for the current study and they are discussed in relation to the study findings: knowledge acquisition, development, sharing, preservation, and application.

Acquisition of agricultural IK from tacit and explicit sources of knowledge

The findings, consistent with the Probst et al. (2000) KM model, showed that the acquisition of knowledge involves the importation of substantial amounts of knowledge from internal and external sources of the organization. The research findings (see Table 1) showed that IK was mainly acquired through local sources such as parents or family (93.9%; 170), neighbours and friends (86.2%; 156), and personal experience (85.1%; 154). Farmers made little use of printed materials and formal sources of knowledge, such as Non Government Organizations (NGO) (6.6%; 12), seminars (6.6%; 12), and agricultural shows (6.6%; 12). These findings were supported by the results of other studies in developing countries, such as Uzbekistan (Wall, 2006), and other African countries such as Nigeria (Olatokun & Ayanbode, 2008) and Tanzania (Nathaniels & Mwijage, 2000), that informal sources were the dominant sources of agricultural IK as compared to formal sources of knowledge. The study findings were in line with Boisot's (1987) KM model which references diffusion and codification of knowledge in terms of personal knowledge. The study findings suggest that most farmers depended on their personal knowledge to carry out their farming activities. According to Boisot's KM model, personal knowledge can neither be codified nor shared to the public in the organization.

There were also differences in people's acquisition of IK from formal sources of knowledge in various locations. Personal experience was a major source of IK for farmers in Kilosa (18.2%; 33), Songea Rural (16%; 29), and Moshi Rural (15.5%; 28), while parents were the main source of knowledge for farmers in Kilosa (19.9%; 36), Karagwe (16.6%; 30), Moshi Rural (15.5%; 28), and Mpwapwa (15.5%; 28). Neighbours were the major sources of IK for farmers in Moshi Rural (15.5%; 28), Kilosa (15.5%; 28), and Karagwe (15.5%; 28) (Table 1). Formal sources of knowledge such as NGO, agricultural researchers, extension officers and farmer groups were important in Moshi Rural, while farmer groups were significant in Songea Rural.

Knowledge development in the local communities

The study findings were in line with the KM process of knowledge development as identified by the Probst et al. (2000) KM model. Knowledge development is an important building block in KM models, since it focuses on the development of new skills, new products, better ideas and more efficient processes (Nonaka & Takeuchi, 1995; Probst et al., 2000, p. 130). The research findings were in line with the

Table 1 Tacit and explicit sources of agricultural indigenous knowledge by district ($N = 181$).

Knowledge sources	Districts													
	Mpwapwa		Karagwe		Kasulu		Moshi Rural		Kilosa		Songea Rural		Total	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Personal experience	22	12.2	25	13.8	17	9.4	28	15.5	33	18.2	29	16.0	154	85.1
Parents/guardian/family	28	15.5	30	16.6	23	12.7	28	15.5	36	19.9	25	13.8	170	93.9
Neighbour/friends	24	13.3	28	15.5	25	13.8	28	15.5	28	15.5	23	12.7	156	86.2
Women meetings	—	—	1	0.6	1	0.6	3	1.7	5	2.8	2	1.1	12	6.6
Livestock headers	9	5.0	—	—	3	1.7	2	1.1	8	4.4	—	—	22	12.2
Demonstration and observation	9	5.0	1	0.6	3	1.7	21	11.6	14	7.7	9	5.0	57	31.5
Newsletters	—	—	1	0.6	—	—	9	5.0	1	0.6	2	1.1	13	7.2
Posters	—	—	—	—	—	—	—	—	3	1.7	2	1.1	5	2.8
Church/mosque	—	—	2	1.1	1	0.6	9	5.0	5	2.8	1	0.6	18	9.9
Social group gatherings	3	1.7	1	0.6	15	8.3	24	13.3	16	8.8	7	3.9	66	36.5
Village leaders	1	0.6	6	3.3	2	1.1	4	2.2	9	5.0	—	—	22	12.2
Farmers' groups	—	—	2	1.1	5	2.8	12	6.6	6	3.3	19	10.5	44	24.3
Village meetings	—	—	3	1.7	2	1.1	5	2.8	6	3.3	—	—	16	8.8
Newspapers	1	0.6	3	1.7	—	—	—	—	4	2.2	2	1.1	10	5.5
Books	—	—	3	1.7	—	—	3	1.7	2	1.1	5	2.8	13	7.2
Seminars	—	—	5	2.8	—	—	2	1.1	1	0.6	4	2.2	12	6.6
Agricultural shows	1	0.6	3	1.7	3	1.7	3	1.7	2	1.1	—	—	12	6.6
NGOs	—	—	1	0.6	1	0.6	10	5.5	—	—	—	—	12	6.6
Researchers	—	—	—	—	—	—	4	2.2	—	—	—	—	4	2.2
Extension officers	—	—	—	—	—	—	3	1.7	—	—	1	0.6	4	2.2
Cooperatives	—	—	—	—	—	—	1	0.6	—	—	—	—	1	0.6

Note: Multiple responses were possible.

Probst, Raub and Romhardt KM model which shows that knowledge can be constructed within the social and scientific paradigms. The social paradigm of the Probst, Raub and Romhardt KM model is also similar to the socialization sub-process (that is, transferring tacit-to-tacit knowledge) of the knowledge creation model of Nonaka and Takeuchi (1995). The research findings from interviews and focus groups showed that farmers created new knowledge through socialization processes such as face-to-face interactions, group interactions (that is, social gatherings and farmer groups meetings), and cultural roles such as apprenticeships, initiation rites during adolescent age, and age-set systems.

The socialization process enabled farmers to combine their knowledge with that of others to carry out their own experiments out of curiosity, to solve problems, and to adapt knowledge to their own environment. Firstly, farmers carried out local experiments in order to seek solutions to their problems, such as shortage of land, and to control animal diseases (that is, Moshi Rural (Lyasongoro Village) and Kilosa (Twatwatwa Village)). Secondly, new knowledge was generated through experiments driven by personal curiosity. Through experience, farmers conducted local experiments to test if their own ideas would work in their farms. Farmers in Kilosa (Kasiki Village) and Songea Rural (Lilondo Village) selected land for crop planting based on their personal experiences and trial and error; after some experiments, they successfully selected arable land for farming. Thirdly, farmers carried out experiments by adapting and transferring new knowledge to a new environment, which included new crop varieties and crop husbandry for the Moshi Rural farmers (Lyasongoro Village). The study results corroborate findings from a study of Andean farmers in the cultivation of potatoes, which found that farmers carried out three kinds of local experiments: curiosity, problem solving and adaptation to experiments (Rhoades & Bebbington, 1995). Similar observations were made in Zimbabwe (Mudege, 2005).

With reference to the scientific paradigm as indicated by the Probst et al. (2000) KM model, the study findings showed that farmers created knowledge within scientific paradigms when they were involved with research and extension officers in the development of agricultural technologies. However, the findings from the interviews indicated that few farmers acknowledged that rural knowledge intermediaries interacted with them in an effort to identify their IK (28.7%; 52) or to prioritize their knowledge (23.2%; 42) when developing and disseminating their agricultural technologies in the surveyed communities. Few farmers indicated that knowledge intermediaries interacted with them in an effort to determine their information needs (30.9%; 56) or prioritize them (28.2%; 51). These findings indicate that knowledge was created within the social paradigm more than the scientific paradigm in the surveyed communities.

Sharing and distribution of agricultural indigenous knowledge

Various KM models have emphasized that effective KM activities need to embrace policies, culture, content, measurement, legal frameworks, ICT, context and space to create a conducive environment for individuals to share and utilize their tacit knowledge and expertise to increase organisational performance (Probst et al., 2000, p, 33;

Small & Tattalias, 2000). Because they influence knowledge sharing activities in the communities, the following factors are discussed in relation to the study findings: culture, trust, and status.

Traditional culture and customs

The study findings are consistent with the KM principle that deals with culture as illustrated in the KM models (Probst et al., 2000; Small & Tattalias, 2000) which showed that culture, in terms of norms, values and principles, can enable or inhibit the sharing and distribution of knowledge in the local communities. Data from observation, focus group discussions and interviews showed that cultural structures and norms determined access to knowledge in four ways: public knowledge (such as, folklore activities); discretionary knowledge, which was accessed through clan-based structures (such as, blacksmithing work); secret knowledge, which was accessed through inheritance (such as, knowledge about local herbs); and social knowledge, which was accessed through social structures (such as initiation rites, the age-set system, apprenticeships and farmer groups).

The findings support the views of Kauzeni (2000) who reported that IK in Tanzania was shared in three basic categories: "public" knowledge which was accessed through traditional structures and norms; "discretionary" knowledge which was accessed along clan lines (i.e., iron smiths); and "secretive" knowledge which was accessed through inheritance. The findings further indicated that another category can be added to Kauzeni's IK sharing categories to include "restricted" or controlled knowledge which was accessed through social structures, such as initiation rites during adolescence and the age-set system. The research findings illustrated what Boisot's (1987) KM model had suggested; some knowledge can be codified and diffused (public knowledge), while other knowledge can be codified but cannot be diffused, namely proprietary knowledge. The former, can be related to public knowledge as shown in the research findings, while the latter, proprietary knowledge, can be related to the discretionary, secretive and restricted knowledge categories as identified in the present study. These four ways of sharing and distributing knowledge in the local communities are described in the following text.

For public knowledge, the study findings from the interviews showed that farmers used folklore activities (such as dances, songs, storytelling), seed and animal exchanges, messages on women's print cotton "kanga" wraps, and the animal lending system to share agricultural indigenous knowledge to everyone in the surveyed communities. Generally, despite their importance in sharing agricultural knowledge, folklore activities were practiced at a low rate (43.6%; 79) due to ignorance and the advancements of technologies such as radio and television broadcasts which have replaced the traditional dances and storytelling. Further, all these traditional forms of sharing knowledge were practiced in all the communities, with the exception of animal lending systems, which was practiced in Moshi Rural District to enable farmers, who had neither plots to grow fodder nor funds to purchase fodder, to lend their animals to other farmers.

With regard to secret knowledge (such as knowledge of local animal and plant medicine), data from focus groups indicated that this knowledge was specifically transmitted through inheritance to selected individuals in the family, and thus it was not disclosed to the public Typical responses included: "…knowledge on local herbs is normally transmitted in our community from grandmother or grandfather to the grandchild. It is actually not transmitted to any grandchild, but to the one who can be trusted and who has shown interest in learning about local herbs" (Iteera Village, Karagwe).

For accessing IK through social structures, data from participant observation, semi-structured interviews and focus group discussions indicated that the existing structures (such as farmer groups, apprenticeships, initiation rites, and the age-set system) were used to provide access to this knowledge. Despite the fact that farmer groups were important sources of agricultural IK, few farmers were involved in the farmer groups. The research findings showed that few farmers 40.9% (74 of 181) were involved in the associations that existed in their communities. About 85.1% (63) of the respondents were involved in agricultural related associations, while 18.9% (14) were involved in non-agricultural related groups. Out of 85.1% (63) respondents who indicated that they were involved in agricultural related groups, the majority of the farmer groups were registered (77.8%; 49), while 27% (17) were not. So few farmers were involved in farmer groups because of a variety of reasons, such as the farmers had not seen any good changes as a result of joining farmer groups, lack of awareness on the importance of farmer groups, social factors (such as age), and inaccurate perceptions about farmer groups. However, the existence of self-managed groups showed that the communities of practice, which are effective ways to share knowledge, were already there and they only need to be strengthened.

Other ways of sharing agricultural knowledge through social structures included apprenticeships, initiation rites, and the age-set system. These traditions were practiced in all the surveyed communities with the exception of the age-set system, which was practiced in Kilosa District (Twatwatwa Village). Generally, both apprenticeships and adolescent initiation rites were practiced to share agricultural knowledge in the surveyed communities at a low rate, with 26% (47 of 181 respondents) acknowledging apprenticeships, and 17.7% (32) of respondents indicating that initiation rites were used to share agricultural IK. The age-set system was practiced within a particular ethnic group, the Maasai Tribe, which allowed the transmission of knowledge about culture, livestock management and ethno-veterinary from one age group to another. Kilongozi, Kengera, and Leshongo (2005) also found that the age-set system enabled access to agricultural knowledge in the Maasai community of Kibaha in Tanzania.

The present findings also showed that there were cultural differences in various locations due to the ethnic groups' differences, population pressure and cross-cultural interferences in the surveyed districts. For instance, the sharing of IK through clan-based system, inheritance, seed and animal exchange system, and lady's print cotton "kanga" wrap were practiced across all the surveyed regions, while the age-set system was practiced by the Maasai ethnic group in Kilosa (Twatwatwa Village), the animal lending system was practiced by Chagga ethnic group in Moshi Rural (Lyasongoro and Mshiri Villages), and apprenticeships were practiced in five of six surveyed districts.

The study findings showed that IK was transmitted according to gender, due to cultural norms that existed in various communities under the sample of the study. For instance, various kinds of apprenticeships were transmitted according to gender in the surveyed communities. Young girls and children were allowed to learn how to build houses, make beads and milk gourds in the Maasai community (Twatwatwa Village, Kilosa), and make baskets and clay pots in all the surveyed communities. Meanwhile, young boys and children of appropriate age were allowed to learn about blacksmith work, traditional irrigation systems, wood carving, and car and bicycle repairs in the sample under the study. On the other hand, anyone was allowed to learn about weaving and tailoring in the communities. These findings were supported by a similar study in rural Uzbekistan, where peasant knowledge was transmitted within families following gender lines due to their cultural norms (Wall, 2006). Thus, traditional cultures and customs defined the extent to which women and men could access and share different forms of knowledge.

Trust

Access to agricultural indigenous and external knowledge in the local communities was determined by status and trust in the surveyed communities. With regard to trust, the study findings from focus group discussions established that parents/family were regarded as the most reliable sources of knowledge in the communities. Despite their infrequent contact with the extension officers, farmers regarded them as the most reliable sources of knowledge. Similarly, a study conducted in Eritrea found that the Ministry of Agriculture experts were less accessible and had less frequent contact, but their information and advice were more reliable and useful (Garforth, 2001). The present findings also showed that farmer groups, NGO, cooperative unions, and agricultural researchers were reliable sources of knowledge in those communities that they were active.

Despite their frequent contact with neighbours/friends and agricultural input suppliers, some farmers considered them as untrustworthy sources. Neighbours/friends were considered as unreliable due to perceptions of selfishness and jealousy. Similar observations were made in other studies in Eritrea (Garforth, 2001), where family and friend information networks were deemed untrustworthy. These findings also relate to what the knowledge creation model (Nonaka, Toyama, & Konno, 2000) had indicated; knowledge creates power, and individuals may be motivated to hide it even from their colleagues.

Status

With regard to status, similar to previous studies (Mudege, 2005; Siebers, 2003; Wall, 2006), this study found that factors relating to farmers, such as wealth, political issues and being knowledgeable, influenced access to agricultural indigenous and external knowledge in the local communities. The findings from discussion groups showed that some village leaders lacked authority in the villages they were supposed to head, despite the fact that they had institutional power invested in them (for example, Moshi Rural (Mshiri Village), and Kasulu (Kidyama Village)). The wealthy village leaders were more influential in making all decisions regarding village matters more poor leaders. Similarly, Wall (2006, p. 95) found that some masters who are socially determined experts hold a special place within the agricultural knowledge system; they are consulted for advice and often possess political or economic power on the basis of their knowledge in the rural Uzbekistan.

Other influential people in knowledge sharing were progressive farmers, richer people, or the more knowledgeable farmers. The importance of their power was exercised once they recognized their power. For instance, one farmer in Songea Rural (Matetereka Village) who was more knowledgeable than other farmers served as a model farmer in that village, according to the extension officer. Further, in some focus group discussions, the knowledgeable farmers dominated the discussions since they knew a lot more than others, such as in Karagwe (Kitwe Village), Moshi Rural (Lyasongoro Village), and Songea Rural (Matetereka Village). Wealthy people, regardless of whether they occupied a position or not, also dominated the discussions in the focus groups held in Songea Rural (Matetereka Village) and Karagwe (Kitwe Village). A similar observation was made by Mudege (2005) that the status of person (political position, best farmer, and richer person) influenced access to knowledge in the local communities of Zimbabwe. The findings from the present study and the literature indicate that farmers' decision to act on knowledge was based on the status of the knower from whom it was derived in the local communities. Thus, there is a need to consider all these socio-economic factors as they affect the sharing and distribution of knowledge in the communities for effective KM activities and sustainable agricultural practices.

Preservation of agricultural indigenous knowledge

Similar to previous studies (Mosia & Ngulube, 2005; Wall, 2006), this study found that IK was limited by knowledge loss due to the lack of prescribed structures and rules in the surveyed local communities to facilitate the preservation of knowledge as one would find in formal organisations. The present study showed that IK was largely preserved in human minds and thus it was disappearing at a high rate. Few respondents (13.3%; 24 of 181) acknowledged preserving their agricultural IK. Written formats (87.5%; 21) were the dominant method used by farmers to preserve agricultural IK, followed by carvings (16.7%; 4), and still pictures (7.4%; 2). These findings call for a need to preserve knowledge by embodying it within people's understanding, practices and awareness, and through the development of explicit knowledge repositories. These KM interventions would enable the communities to learn from their own experience and that of others drawn from a wealth of tacit knowledge held in people's minds as well as updated explicit sources held in repositories.

Application of indigenous knowledge and technologies in the farming systems

The research findings demonstrated the position of various KM models that KM practices are neither complete nor successful if no efforts are made to ensure the use of stored and shared knowledge (Probst et al., 2000; Small & Tattalias, 2000). The study findings showed that most farmers (86.7%; 157) applied IK which was obtained from tacit and explicit sources of knowledge in their farming systems. These findings are consistent with the research

results of Olatokun and Ayanbode (2008) who reported that the majority of women used IK to ensure food security (62.8%; 143) and improve their farming activities (44.3%; 101) in Nigeria. It is apparent that farmers rely on their IK to improve their agricultural practices in the surveyed rural societies. The present study indicated that farmers applied indigenous techniques for crop husbandry (63.1%; 99), new techniques and varieties (25.5%; 40) and animal husbandry (24.2%; 38). The least applied indigenous techniques were control of animal diseases (18.5%; 29), value added techniques (15.3%; 24), soil fertility (12.1%; 19), control of plant diseases and pests (7%; 11), agricultural tools (5.7%; 9), and environment conservation (1.9%; 3). The high use of crop husbandry techniques explains why intercropping and random sowing techniques were the dominant techniques applied by farmers despite their ineffectiveness for farming activities, as revealed by data obtained from the participant observation.

Role of ICT in managing agricultural indigenous knowledge

Various KM models (Nonaka & Takeuchi, 1995; Probst et al., 2000; Small & Tattalias, 2000) have indicated that ICT are significant in KM since they allow the movement of knowledge at increasing speeds and efficiencies, thus facilitating sharing as well as the accelerated growth of knowledge. This section discusses the role of ICT in the acquisition, sharing, preservation and use of agricultural IK by farmers.

The acquisition of agricultural indigenous knowledge through ICT

The study found that farmers rely more heavily on person-to-person communication than ICT for acquiring IK, although ICT were already in existence in the surveyed villages. The study findings showed that almost half of the respondents (45.3%; 82) had used ICT to acquire agricultural IK. Thus, while developments in ICT have enabled access to IK, the digital divide is still prevalent in the surveyed regions despite the fact that the study was carried out in those areas which had ICT. These findings are in line with the various KM models (Probst et al., 2000; Small & Tattalias, 2000) which emphasize that people should be central to any technological intervention in KM.

Radio (89%; 73) was the predominant tool used by farmers to acquire IK in the surveyed communities. Radio was more likely to have high use due to low cost, as well as being an appropriate tool that fulfills the farmers' needs. Previously, Akullo et al., (2007) found that radio programmes were the major ICT channels used by farmers to acquire agricultural IK in Uganda. In this study, most farmers in the surveyed districts used national radio (Tanzania Broadcasting Corporation — TBC) to access IK on farming practices, while farmers in Karagwe district also used rural radio broadcasts (that is, radio FADECO) to access knowledge on indigenous farming practices. Moshi Rural farmers' used private radio stations (Radio Injili, Kili FM and Radio One stations) to acquire knowledge on effective indigenous farming practices.

Cell phones (47.6%; 39) were becoming an important communication medium for accessing agricultural IK mainly due to high ownership in the surveyed communities. In this study, cell phones were used by farmers to share their indigenous practices across the surveyed communities. For instance, Cell phones were used by pastoralists in Kilosa (Twatwatwa Village) to communicate with the livestock herders to know the conditions of their animals in the grazing field and advise them incase of any disease outbreak, and to inquire about a good location for good pasture and safe drinking water for their animals. Farmers in Moshi Rural also used cell phones to communicate with FLORESTA NGO to access IK on new varieties and techniques such as local herbs for treating animal and plant diseases. Another major ICT was television (36.6%; 30), where most farmers in the surveyed communities used national TV (Tanzania Broadcasting Corporation — TBC) to access IK on farmig practices. There was no community TV station in the surveyed communities.

Other ICT such as audio cassettes (8.5%; 7), email (7.3%; 6), Internet (6.1%; 5), video cassettes (3.7%; 3) and film shows (3.7%; 3) were used less to acquire IK in the communities. There was low use of email and Internet to acquire agricultural IK, in spite of the availability of Internet facilities in the surveyed communities. Farmers in Songea Rural accessed IK (that is, local techniques for controlling coffee diseases) from TACRI (Tanzania Coffee Reseach Institute) through email with the help of WIDA NGO. The Internet was used by farmers in Moshi Rural and Kilosa to access knowledge on indigenous farming and pastoralism. For instance, one farmer in Moshi Rural (Lyasongoro Village) reported that, "I always look for websites at FLORESTA NGO newsletter and browse the Internet to look for effective indigenous techniques especially on vegetable farming." It was clear that Internet use was not very common and did not have any significant effect on knowledge acquisition in the rural populations of India, Mozambique and Tanzania (Souter et al., 2005). Nevertheless, a study by Ha et al. (2008) in Nigeria established that telecentres could help to make knowledge flow from the local communities outward (indigenous practices) and from the global community inward (external practices). It is thus important to create relevant knowledge and information services at the telecentres, and to promote the use of telecentres, in order to improve the management of IK in the local communities. On the whole, the findings of the present study and those from literature indicate that ICT, especially radio and cell phones, can play a key role in equipping farmers with relevant IK, while capacity building programmes and a knowledge culture are needed to enable the communities to fully exploit advanced ICT (such as Internet and email) to access IK in the rural areas.

Sharing of agricultural indigenous knowledge through ICT

The study findings showed that few farmers (18.8%; 34) had used ICT to share IK. Most farmers (94.1%; 32) had used cell phones to share IK, while 14.7% (5) had used email, and 5.9% (2) had used radio to share IK. Local villagers had limited access to personal telephones, faxes, computers and other modern communication means. These findings show that knowledge culture, capacity building programmes and improved infrastructure are important aspects for improving the use of ICT for sharing IK in the surveyed communities.

Preservation of agricultural indigenous knowledge through ICT

There was low use of ICT to preserve agricultural IK in the sample under investigation. Only 1.1% (2 of the 181) respondents acknowledged of using ICT to preserve their IK. These respondents used personal computers, cell phones, audio cassettes, and email. In actual fact, the use of ICT to preserve IK was related to the education status of the respondents. The findings showed that, of the farmers who had sought to preserve IK, one farmer had attained secondary education, and the other farmer had a university bachelor's degree. However, a research project in Bolivia showed that it is possible for farmers to document their knowledge and experience themselves, provided that guidance and capacity development in the use of audiovisual means are given (IICD, 2008). In Tanzania, Lwoga (2009) and Lwoga and Ngulube (2008) demonstrated that IK can be documented by the local people and disseminated through telecentres and online databases. It is thus possible for small-scale farmers in the surveyed communities to document and share their knowledge if they are guided and empowered.

Application of agricultural indigenous knowledge through ICT

There was low use of agricultural IK which was received from ICT. The study findings established that the majority of the respondents applied IK (86.7%; 157) received from tacit and explicit sources of knowledge in the farming systems, as compared to the IK received from ICT (9.9%; 18). The majority of the respondents used IK on animal disease control 10 (33.3%; 10) and animal husbandry (33.3%; 10), followed by new varieties and techniques (16.7%; 5), and soil fertility (16.7%; 5). Generally, the study findings showed that use of ICT was low for farming activities. It is thus important to foster a knowledge culture and capacity building programmes in the communities in order to increase the use of ICT in managing IK since they can play a key role in improving farming activities.

Conclusions

The study findings showed that KM models can be used to manage agricultural IK in the local communities. The study findings showed that farmers managed their knowledge through the following processes as indicated in the KM models (Probst et al., 2000; Small & Tattalias, 2000): knowledge acquisition, development, sharing, preservation, and application. The study findings illustrated that IK was acquired and shared within a small, weak and spontaneous network, and thus knowledge loss was prevalent in the surveyed communities. There were distinct variations with regard to the acquisition of agricultural IK both in different locations and between genders. Few farmers acknowledged accessing IK from the formal sources of knowledge which showed the predominance of the external knowledge system over IK in the surveyed local communities. The study findings showed that various factors determined access to IK in the communities, which included ICT, the culture of a certain locality, trust, and status. With regard to ICT, the study findings showed that farmers are more likely to continue using face-to-face communication and probably radio and cell phones, while other advanced ICT, such as the Internet and email, will have low use. On the whole, it is important to adapt and apply KM approaches to manage IK and integrate it with other knowledge systems in the local communities, otherwise IK will continue to disappear, and the rural farmers will have nothing to rely on for their farming practices. Thus, this paper recommends the following:

- The village leaders, knowledge intermediaries (that is, extensionists, researchers, educators, information specialists, NGO, telecentres, community radio), and private and government officers of a particular locality should create a conducive environment for knowledge development such as by rewarding farmers in terms of recognition when they innovate. They should also encourage a positive attitude and tolerance to mistakes towards innovation;
- The extension and research officers should identify local innovators, and involve them in participatory research for joint learning as a way to create knowledge in the scientific paradigm, and integrate it with the external knowledge system;
- Knowledge intermediaries should also consider the differences in access to IK according to location and gender so that women and other vulnerable groups are not marginalized in the rural KM strategies;
- The village leaders, knowledge intermediaries, and private and government institutions in the rural areas should promote knowledge sharing between individuals, groups, and through communities of practice, and existing cultural structures (such as folklore) in the following ways: encourage active participation in the existing structures and networks such as farmer groups; encourage farmers to build relationships, and to carry out collaborative work to create mutual trust; encourage individual farmers and groups to establish links with other communities; create time and space for communities to share and create new knowledge; and to identify IK holders and motivate them to share their knowledge through farmers' forums, and other social networks in the local communities;
- Communities should continuously share (thus creating new knowledge), and preserve knowledge in tacit and explicit formats in their communities. Tacit knowledge can be preserved through oral demonstrations such as folklore, initiation rites, apprenticeships, and various social networks, such as farmers' groups, communities of practice, and seminars. Knowledge maps can be used to show where knowledge experts are located in a certain locality. On the other hand, explicit formats can include print and electronic formats which can be accessed from the rural knowledge centres or libraries, and traditional tools such as carvings and artifacts;
- The government should focus on the improvement of rural electrification, telecommunication signals, and access to affordable power sources such as solar power to improve KM practices through ICT in the rural areas;
- The government should improve its extension and research services by increasing the number of extension

officers, and providing adequate training programs to update their skills in the farming activities, management and integration of IK into conventional research and extension services, and KM practices. On the other hand, both the public and private sectors should conduct continuous capacity building exercises for local leaders and the communities (especially vulnerable groups) to improve the management of IK, access to exogenous knowledge, and use of ICT in the local communities. The social capital of the local leaders should be strengthened and their roles in KM activities should be properly defined; and

- The agricultural actors (such as telecentres, community radio, extension and research officers, NGOs) in the local communities should network and collaborate in content generation, dissemination and preservation for effective KM practices in the local communities. These agricultural actors can explore the possibility of establishing linkages, such an association of rural agricultural actors in order to build their capacities and promote the exchange of knowledge and experience and the sharing of resources where possible for effective KM practices in the rural areas.

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