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THE RELEVANCE OF INDIGENOUS KNOWLEDGE FOR SMALL-SCALE FARMING IN TANZANIA

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ABSTRACT

This article is based on a study that sought to explore small-scale farmers' perceptions and understanding of indigenous farming with an ultimate goal of promoting the use of IK for agricultural development in Tanzania. This study was mainly qualitative, where semi-structured interviews were used to collect data from 181 small-scale farmers in six rural districts of Tanzania. Based on the study findings, it was evident that the local communities had an extensive base of IK and understanding of their environment, and they were able to put appropriate managerial skills and adaptive strategies to crop and animal farming. The findings also showed that IK was location specific, and farmers possessed IK on various farm tasks such as evaluation of soil quality, preservation of planting materials and crops, plant diseases and pest control and animal disease control. It is thus important to understand and facilitate the identification, documentation and use of this knowledge as well as integrating it with conventional knowledge for improved agricultural activities. The knowledge intermediaries (research, education, information and knowledge services, and agricultural support services) should thus conduct regular user studies to identify, validate and document IK in order to determine areas that need intervention, and to enable the incorporation of IK into research to enrich the agricultural technology development process and make it relevant for farmers.

Keywords: Indigenous knowledge, local knowledge, agricultural indigenous knowledge.

INTRODUCTION

Indigenous knowledge (IK), in the form of local creativity, innovations, and know how, is the basis for decision-making, the content of education in local societies and a strategic resource for sustainable development (Sukula, 2006). IK is an outcome of experiences and local innovations that have accumulated over generations, and shared by local people in their community through oral traditions and demonstrations. IK is unique to a given culture, and it is used in many aspects that are important to local people, including agriculture, healthcare, education, natural resource management and cultural activities. Over the recent years, increasing attention has been given on the importance of farmers' knowledge for agricultural and rural development (Hart, 2007). IK is important for the agricultural development, not just in terms of the description, proper management and harvesting of a product, but also in terms of the maintenance of the ecological processes and biodiversity linked to traditional economic activities, such as cultivation or husbandry (Miah, 2005).

The agricultural sector is the backbone of many economies in Africa. In Tanzania, the economy relies on agriculture, accounting for more than 25.7 percent of gross domestic product (GDP), provides 30.9 percent of exports and employs 70 percent of the work force (United Republic of Tanzania, 2009). The importance given to agricultural IK is evidenced by the fact that by 2006, the traditional export crops (cashew nut, coffee, cotton, sisal, tea, and tobacco) still accounted for 20% percent of the total of Tanzania's agricultural exports (Wolter, 2008). Despite its potential role for agricultural development, the production of traditional crops and animal farming has not translated into much growth in farm incomes in Tanzania (Amani, 2005). This situation is largely contributed by the fact that most of the farmers' innovations, practices and experiments are mainly incremental. Thus, the importance of IK in the agriculture sector is often under-estimated, and its incorporation into conventional agriculture is almost non-existent in most African countries including Tanzania.

New knowledge and technologies are still developed and disseminated by using the transfer-of-technology approach, based on the assumption that knowledge is created by scientists, to be packaged and spread by extension and to be adopted by farmers (Assefa *et al.,* 2009). These approaches leave little room for the IK resources of the community to be incorporated or merged with rural knowledge and information systems. This situation is partly due to the fact that researchers and extension agents are insufficiently conversant with participatory problem solving and decision making tools in Tanzania (Lema and Kapange, 2006). Farmers do not actually control decisions on the planning and implementation modes of agricultural research and development activities in Tanzania (Lema and Kapange, 2006). As a result, farmers continue to rely on their indigenous innovations and technologies. However, most IK is transmitted orally from one generation to another, and thus it is vulnerable to gradual disappearance due to memory lapses and death. IK is also not equally shared in the communities due to issues related to power relationships and cultural differences. Thus, most IK has remained undocumented in developing countries including Tanzania (Mascarenhas, 2004: 4). There is thus an urgent need to understand, identify and document IK for adoption in the farming systems and its integration into the conventional knowledge systems for agricultural developmental initiatives before much of it is completely lost.

In the view of these considerations, the main aim of the article was to identify the different aspects of agricultural IK so that it can be used to guide farmer-based research and training activities, with an ultimate goal of promoting the use of IK for agricultural development in Tanzania.

RESEARCH METHODOLOGY

This study used qualitative approach because it is an effective method in studying and understanding human action in its natural settings (Babbie and Mouton, 2001: 278). Various authors recommend this approach as an effective method for collecting data in IK studies rather than quantitative approach (Grenier, 1998; Sillitoe, Dixon and Barr, 2005). Purposive sampling was used to select research sites and study participants because it is confined to specific types of people who are particularly knowledgeable about the issues under the study (Polit and Beck, 2004). Six districts from six zones out of seven research zones were selected for the study due to their high agricultural production. Two villages were purposively selected from each of the six districts. These districts and villages included the following: Mpwapwa district (Vinghawe and Mazae villages), Karagwe district (Katwe and Iteera villages), Moshi Rural district (Lyasongoro and Mshiri villages), Kilosa district (Kasiki and Twatwatwa villages), Songea Rural district (Matetereka and Lilondo villages) and Kasulu district (Nyansha and Kidyama villages). High agricultural productive areas were identified based on their diversity in agro-ecology, ethnicity, population density and infrastructure which influence local agricultural knowledge and information systems (Röling, 1989). The same criteria were used by Adedipe, Okuneye and Ayinde (2004) to select areas when examining the agricultural indigenous knowledge systems in Ogun State, Nigeria. Qualitative data was collected through the semi-structured interview items and participant observation. A total of 181 smallholder farmers were purposively selected for semi-structured interviews, where the respondents ranged between 27 and 37 per region. The interview data were studied and analysed as they were collected, until it was clear that no new information was generated and data saturation was reached (Powell and Connaway, 2007). Qualitative analysis involved the process of the categorisation of themes contained in data, followed by linking of themes and ideas and exploring new ideas (Pickard, 2007: 280).

THE RESEARCH FINDINGS AND DISCUSSIONS

This section discusses study findings according to small scale farmers' perceptions and understanding of indigenous farming in the following aspects: evaluation of soil quality, preservation of planting materials and crops, plant diseases and pest control, and animal disease control. The respondents' demographic characteristics are also presented.

THE PROFILE OF THE RESPONDENTS

In the semi-structured interviews, 181 smallholder farmers participated in the study, where 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%; n=135) were between the age of 29 and 68 years. Most respondents (84%; n=152) had some level of formal schooling and about 91.2% (n=163) could read and understand simple instructions. Among those with formal schooling, male respondents dominated the higher education category, accounting for 62.5% (n=95) of those with primary school education, 9.2% (n=14) with secondary education, and 3.4% (n=5) with higher education (that is, 4 college diplomas and 1 university bachelor degree). The study mainly involved smallholder farmers, where nearly two thirds of the crop farmers (61.9%; n=104) had farm sizes below 4.9 acres. These findings are not surprising given the fact that most of Tanzania's farmers generally cultivate an average farm size of between 0.2 to 2 hectares (or 0.49 to 4.94 acres) (United Republic of Tanzania 2001). Most respondents (92.9%; n=168) were involved with crop farming, while (80.2%; n=146) were engaged in livestock keeping. Among those crop farmers and livestock keepers, 73.5% (n=133) respondents were engaged in mixed farming.

INDIGENOUS KNOWLEDGE IN CROP AND ANIMAL FARMING

The study findings showed that farmers had an extensive base of IK and understanding of their environment, and they were able to put appropriate managerial skills and adaptive strategies to crop and animal farming. The study findings illustrated that farmers employed various indigenous techniques and practices in crop production more than in livestock management. Similar observations were made in a study to assess the role of agricultural IK in Uganda (Akullo *et al.,* 2007). The high cost of livestock management and lack of skills may have limited most farmers' involvement in animal husbandry. The study also found that IK was location specific, and farmers possessed IK on various farm tasks such as evaluation of soil quality, preservation of planting materials and crops, plant diseases and pest control, and animal disease control. A similar observation was made by Eyong (2007), who reported that local people in Central Africa possessed an enormous wealth of IK that covered clearing the land, tilling, selecting seed varieties for planting, planting, harvesting and storage. The study findings pertaining various types of IK that farmers possessed are discussed in the following text.

Evaluation of soil quality

The study findings established that farmers had a broad base of knowledge on changes of soil fertility. Apart from low crop yield and poor growth of crops and weeds, farmers determined changes of soil fertility by using crop characteristics (that is, changes of crop colour, layers of rotten grasses and appearance of certain plant species). For example, farmers in Moshi Rural, Kilosa and Mpwapwa districts determined changes in soil fertility when maize leaves developed a yellow colour. Another farmer at Nyansha Village in Kasulu also reported that, "the occurrence of certain grass species known as *bichanda* in my plot show that the soil fertility has declined". Other factors which were used to determine changes of soil quality were soil characteristics (such as, presence of compact soil, and soil erosion), and common sense, prior experience and trial and error to evaluate soil fertility. The findings of this study were also similar to other studies, which showed that soil, and crop characteristics were major factors used by farmers to determine changes of soil fertility in Uganda (Akullo *et al.,* 2007).

Preservation of planting materials

In the preservation of planting materials, centuries of practical experience has given local farmers a unique decision making role and knowledge about what to conserve and how to store the planting materials. The present findings showed that farmers had an extensive base of knowledge on local herbs, cultural practices and traditional facilities, which they used for preserving these materials. However, the application of local herbs, indigenous practices and traditional facilities varied considerably across the surveyed districts due to differences in culture and the agro-ecological conditions. With regard to local herbs, farmers mainly used similar plant parts from particular species such as leaves, roots, bark and husks. Most farmers used chilli pepper (capsicum annum) and neem (azadirachta indica), which is called "*mwarobaini*" in Swahili, plant parts to preserve their planting materials across the districts.

Further, the study found that similar local inputs (such as chilli pepper, neem and ash) were applied in various districts to preserve the same planting materials. For instance, chilli pepper was used to preserve maize seeds in Moshi Rural and Kasulu, and bean seeds in Moshi Rural and Kasulu. Neem was used to preserve maize seeds in Mpwapwa and Songea Rural. Kitchen ash was mixed with bean seeds in Moshi Rural and Mpwapwa, and maize seeds in Kilosa and Karagwe for storage purposes. Similar observations were made by other studies that local knowledge can effectively be applied outside the spatial locales in which it was developed (Briggs, 2005). However, it is argued that a local innovation is developed to fit a particular biophysical and socio-economic setting and usually cannot be transferred "as is" to other settings (Waters-Bayer and van Veldhuizen, 2005). Other authors have argued that IK should not be up-scaled because it becomes decontextualized and ineffective when separated from its environment (Klees, 2008). Nevertheless, the documentation and sharing of local innovations can provide ideas and inspiration for others to try out and adapt new ideas to their own setting (Waters-Bayer *et al.,* 2006). Since IK is site-specific, it can therefore seldom be scaled up without adaptation, however it can be used to stimulate experimentation and innovation in other communities.

The use of local herbs, cultural inputs and practices, and traditional facilities for preserving planting materials across the surveyed districts is described in the following text. With regard to local herbs, the study findings showed that Moshi Rural farmers mixed their best maize seeds with a variety of local herbs, such as chilli pepper only, or a mixture of chilli pepper and leaves of *mabangi mwitu* or African marigold (tagetes erecta) and stored the seeds in a closed drum or tank. In Karagwe, farmers mixed maize seeds with *masaka* tree leaves, or ash from *kajashi* plant and put the seeds in a sack or granaries which were located outside their houses. In Mpwapwa, farmers mixed maize seeds with ground neem leaves, or *msakasaka* (rhus natalensis) tree leaves or with a concoction of burnt goat dung and maize cob ash. These seeds were then stored in polythene bags or granaries which were located outside farmers' houses. In the same district, roots of a tree known as *mkunguni* (salvadora persica*)* were put at the bottom and the middle of granaries which were filled with maize grains to preserve maize seeds. In Kasulu, farmers mixed maize seeds with chilli pepper*,* or a mixture of *mshindwi* (anisophyllea pomifera) tree ash and chilli pepper*,* or a mixture of any tree ash and chilli pepper*,* and the mixture was put in a sack. In Songea Rural, maize seeds were mixed with ground neem tree leaves and they were put in polythene bags.

For bean seeds, farmers in Moshi Rural selected the best seeds and mixed them with either a mixture of chilli pepper and wild tobacco (nicotiana tabacum), or a concoction of chilli pepper and *mabangi mwitu* leaves, or a mixture of *urutupa* or alcohol tree and *mabangi mwitu* plant leaves, or chilli pepper only, or a mixture of *mfifina* (commiphora zimmermannii engl) tree leaves and chilli pepper and stored the seeds in a closed drum. In Karagwe, farmers mixed bean seeds with either chilli pepper*,* or a mixture of *kajai* and *msonobali* (senna siamea) tree leaves and put the mixture in sacks or granaries which were located outside their houses. In Kasulu, farmers mixed bean seeds with either chilli pepper, or *teletele* tree dust, or *mshindwi* tree ash, or a mixture of chilli pepper and *mshindwi* tree ash, or a mixture of chilli pepper and ash from any type of tree and put the mixture in sisal bags or polythene bags.

For preserving peas seeds, Kasulu farmers' mixed chilli pepper *(*capsicum annum*)* and ash from any type of tree with peas seeds and put the mixture in sacks. In addition, farmers mixed sorghum seeds with *msakasaka* tree leaves, or a mixture of ash from pearl millet and groundnut leaves and stored the seeds in granaries which were located outside their houses in Mpwapwa. In the same district, sorghum seeds were mixed with ground neem tree leaves or *mkunguni* tree ash and the seeds were stored in polythene bags. For pearl millets production in Mpwapwa, farmers selected the best seeds from harvests and mixed them with a mixture of ash from pearl millet and groundnut leaves and stored the mixture in granaries.

Farmers had extensive base of knowledge on locally available inputs (such as burnt goat dung, cattle dung, kitchen ash, anthill soil), and cultural practices (such as, some crops were left in the soil, and selected cobs were hung over a tree) that they used for preserving their planting materials. For instance, kitchen ash was mixed with bean seeds in Moshi Rural and Mpwapwa, maize seeds in Kilosa and Karagwe and peas and sorghum seeds in Mpwapwa for storage purposes. Sorghum seeds were stored in the bags together with their bran without winnowing in Mpwapwa. Anthill soil was mixed with bean seeds for storage purposes in Karagwe. Burnt goat dung and maize cob ash were mixed with maize or sorghum seeds for storage purposes in Mpwapwa. Selected maize cobs were hung over trees in Mpwapwa, Karagwe and Kasulu. Selected planting materials for cowpea, cassava, sweet potato and vegetable were left in the ground for preservation purposes in Mpwapwa. Kilosa farmers also left sweet potatoes and cassava in the ground for storage purposes.

Farmers also used a wide range of traditional facilities for preserving their planting materials which included basket, clay pot and granaries that were located outside or within farmers houses or over the hearth. Granaries that were situated over the hearth were used to preserve vegetables in Moshi Rural, and maize seeds in Mpwapwa, Karagwe, Moshi Rural, Kilosa and Kasulu Districts. On the other hand, granaries that were situated inside farmers' houses were used to store maize seeds in Mpwapwa, and bean and unshelled groundnut seeds in Songea Rural. Further, granaries that were located outside farmers' houses were used to store bean seeds in Karagwe, and maize seeds in Karagwe, Mpwapwa and Kasulu. Farmers in Kasulu and Karagwe had two types of granaries that were located outside their houses. The first type was called *kichanja* in Swahili or locally called *yinza*, which was open at the top to expose maize cobs and sorghum heads to sunlight to enhance drying. The second type was locally called *kihenge* which was fully closed. In Kasulu, these granaries were used to store hulled maize, peas, cassava, unshelled groundnut and sweet potato. These granaries (*kilindo*) were also used to store vegetable, sorghum, pearl millet and unshelled groundnut seeds in Mpwapwa. These study findings showed that farmers possessed a wide base of knowledge that they used for preserving their planting materials, which included the use of local herbs, cultural inputs and practices, and traditional facilities.

Preservation of crops

The study findings showed that farmers had wide-ranging knowledge on the use of local herbs, practices and traditional facilities for preserving crops. The application of these local herbs, practices and traditional facilities varied across the districts due to different cultures and agro-ecological conditions. For traditional facilities, clay pots and granaries that were located outside or within farmers' houses or over the hearth were mainly used to preserve crops. Another study conducted by Agea *et al.,* (2008) in Uganda found that majority of the households in Mukungwe sub-county stored their food in granaries (80%), and locally made sacks, on kitchen shelves, in pots and baskets (42%). The high use of granaries was also found in Nigeria (Ogundele, 2006). However, the present study found that the use of granaries which were located outside farmers' houses were no longer common due to cases of rampant theft.

Further, farmers used similar plant parts of particular species such as leaves, roots, bark, and husks to preserve their crops. Most farmers used chilli pepper (capsicum annum) in combination with other plant parts to preserve their crops. It was apparent from the findings that a wide range of cultural inputs and practices were used to preserve crops, such as anthill soils, and sliced cassava which was boiled with salt, dried and preserved. It was also very clear from the literature that this technique for preserving cassava was also a common practice in the surveyed communities in Uganda (Akullo *et al.,* 2007). The present findings also showed that similar local inputs (such as, chilli pepper and ash) were used in various regions to preserve the same crops. For instance, chilli pepper was used to preserve bean and maize crops in Moshi Rural and Kasulu. These findings show that the same technique can be adapted in different localities with similar agro-ecological conditions.

The use of local herbs, cultural inputs and practices, and traditional facilities for preserving crops across the surveyed districts is described in the following text. The study findings showed that various local herbs were used to preserve crops across the surveyed districts. For instance, burnt rice ash was used to store maize in Kilosa. In Moshi Rural, farmers preserved bean or maize crops with either chilli pepper or wild tobacco, or a concoction of chilli pepper and *mabangi mwitu* leaves, or a mixture of *urutupa* and *mabangi mwitu* leaves, or chilli pepper. In Kasulu, farmers stored maize or bean crops with *mshindwi* tree ash, or a mixture of chilli pepper and *mshindwi* tree ash, or *mtundu* tree ash, or a concoction of chilli pepper and ash from any tree. In Mpwapwa, farmers preserved maize or bean crops with either *msakasaka* plant leaves, or ground neem leaves. In Karagwe, farmers stored maize crops with *kajai* plant leaves, or *kajashi* tree ash, or *masaka* plant leaves, or the mixture of *kaswagala* and *kajai* tree leaves. In the same Mpwapwa district, farmers preserved bean crops with either *kajashi* tree ash, or *kajai* tree leaves, or *mluku* tree leaves, or a mixture of *msonobali* and chilli pepper. For preserving peas farmers in Kasulu mixed their crops with a concoction of chilli pepper and ash from any tree and stored the crops in sacks. For preserving sorghum Karagwe's farmers used either *kajai* plant leaves or *mluku* tree leaves.

Farmers also used a wide range of locally available inputs (such as burnt goat dung, cattle dung, kitchen ash, anthill soil) and cultural practices (such as selected cobs were hung over a tree, sliced cassava were boiled) to preserve their crops. For example maize cobs were stored on top of trees in Kasulu and Karagwe. Kitchen ash was used to preserve maize (Kilosa, Karagwe and Songea Rural), bean (Moshi Rural, Karagwe, Kasulu and Songea Rural) and sorghum crops (Mpwapwa). Farmers either used mud or dry cow dung to preserve maize in Karagwe. In the same district, farmers used dry cow dung or anthill soil to store bean crops. Ash from goat dung and maize cobs was also used to store maize and sorghum crops in Mpwapwa. Farmers also sliced cassava and boiled them with salt and preserved them after sun drying in Kilosa.

For traditional facilities clay pots and granaries were used to preserve a wide range of crops across the surveyed districts. For instance, clay pots were used to store maize crops in Mpwapwa and maize and bean crops in Karagwe. Granaries that were situated over the hearth or the kitchen were used to preserve the following: maize in Kilosa; cowpeas, beans, groundnuts and maize in Karagwe; beans, sorghum and maize in Mpwapwa; and vegetables in Moshi Rural. Granaries situated within farmers' houses were used to store the following: maize in Kilosa; beans in Kasulu; maize, sunflowers, sorghum, bambara and groundnuts in Mpwapwa; and groundnuts in Songea Rural. Granaries that were situated outside farmers' houses were used to store the following: maize, sunflowers, sorghum, pearl millets and groundnuts in Mpwapwa; and maize and beans in Karagwe where both *vichanja (yinza)* and *vihenge* were used. In Kasulu, this technique was used to store maize, cassava and beans where both *vichanja (yinza or kingelengele)* and *vihenge* were used. Granaries that were situated outside farmers' houses (*ngokho*) were also used to store maize in Songea Rural and Kilosa. However, this method was no longer common because such storage facilities needed to be kept outside and there had been cases of rampant theft. Indications are that farmers possessed extensive base of knowledge on the preservation of crops, which included the use of local herbs, cultural inputs and practices, and traditional facilities. It is thus important to recognize, identify and document this knowledge before much of it is completely lost.

Control of plant diseases

While farmers mainly used synthetic insecticides to treat plant diseases, they also used local remedies such as local herbs and cultural inputs to control the diseases. IK was location specific due to differences in culture and agro-ecological conditions. Farmers described a variety of local herbs that they used to control plant diseases. In general various plant parts (barks, roots, leaves) were used alone or in combination with other ingredients such as water, cattle urine or kitchen ash to control plant diseases. For instance in Moshi Rural, farmers used various local herbs to control vegetable fungal diseases, which included the following: a mixture of ash and ground *mabangi mwitu* tree leaves; a concoction of *ufori* (cattle's urine) and ground *mabangi mwitu* leaves and water; and a mixture of water and ground wild sunflowers. To control coffee berry disease, Moshi Rural farmers' used the following herbs: a mixture of chilli pepper, *mabangi mwitu* and water; and a mixture of ground plant leaves of *mabangi mwitu*, *urutupa* and cattle urine. In Kasulu, a mixture of chilli pepper and ash from the *mshindwi* tree was also used to control vegetable fungal diseases. Farmers due to their affordability, simplicity and safety applied local herbs as insecticides. One farmer in Moshi Rural indicated that, "I have stopped to use blue copper pesticide for controlling CBD because the chemicals are not safe to human health. I currently use the mixture of chilli pepper and *mabangi mwitu* leaves to control the same disease".

Farmers used a wide range of cultural inputs (such as ash, urine, paraffin) to control plant diseases across the surveyed districts. The study findings showed that Moshi Rural farmers uprooted the infected banana plants and put ash in the pit as an insecticide and left the pit open for six months to control *kisori* (panama) diseases. Other farmers uprooted the infected banana plant and left the pit open for some time before using it again to control *kisori* (panama) diseases. Other farmers mixed ash with animal manure and put the mixture in the pit where the banana plants were uprooted to control *kisori* (panama) diseases. Kitchen ash was also used to control maize leaf rust disease (maize fungal disease) in Moshi Rural. A mixture of human urine and paraffin, or cattle urine was also used to control Coffee Berry Disease (CBD) in Moshi Rural. In Kilosa, farmers uprooted the infected crops to control maize streak disease (maize viral disease) and bean aranthcnose (beans fungal disease). Ash was also used to control bean fungal attack in Kilosa. Indications are that farmers possessed extensive base of knowledge on the control of plant diseases, which was safe, effective, affordable (such as ash) and simple to use. Thus, the importance of IK for sustainable agricultural practices cannot be over-emphasized.

Control of plant pests

The study findings indicated that farmers used a wide range of local herbs, cultural inputs and practices to control plant pests in the communities although the application of these inputs varied across the regions. Farmers either used various parts of a plant (roots, bark, leaves) alone, or in combination with other inputs to control various plant pests such as kitchen ash. Mugisha-Kamatenesi *et al.,* (2008) also reported similar findings in their study of IK on the field insect pests in Uganda. The present findings also showed that similar local inputs (such as ash) were applied in various regions to control the same plant pests. This finding shows that the same technique can be adapted in different local communities with similar agro-ecological conditions. The use of local herbs and cultural inputs and practices for controlling plant pests is explained in the following text.

The study findings showed that farmers used various local herbs to control plant pests across the surveyed districts. For instance in Moshi Rural, farmers sprayed a mixture of fermented cattle urine, chilli pepper and soap on maize to control stalk borer pests. Ground *msesewe* (rauvolfia caffra) tree leaves were used to control maize stalk borers. Farmers applied various methods to control cutworms in vegetables which included: a mixture of ash and *mabangi mwitu* leaves; or a mixture of *mabangi mwitu*, *msesewe* tree leaves, cattle's urine and water. A mixture of wild sunflowers, water and milk or a mixture of wild sunflowers, water and chilli pepper were also used to control *shipitiri* pests (vegetable insect pests). A concoction of ground plant leaves of *mabangi mwitu*, urutupa and cattle's urine was fermented for seven days and then it was used to control *shipitiri* (vegetable insect pests) or coffee leaf minors.

In Songea Rural, a concoction of ground *mtutu* (bridelia micrantha) tree leaves and water was poured into the maize funnel to kill *mbengimbengi* (stalk borer pests). In Mpwapwa, a mixture of goat dung, maize cob ash and leaves from the *msakasaka* tree was used to control maize stalk borers and weevils as well as *vimungu* or *surenje* or *scania* (stalk borers) in sorghum. In Karagwe, farmers used *kafaya* plant leaves or ash from *kajashi* tree to control *kamsokoine* pests (maize stalk borers). In the same region farmers also used *rugwe mwani* plants to control maize weevils. In Kasulu, ash from *mshindwi* tree or a mixture of ash and chilli pepper was used to control *dumuzi* pest (beetle) from attacking beans. A mixture of ash and chilli pepper was also used to control banana weevils in Kasulu.

Farmers also cultivated certain plants that repel rodents in Moshi Rural. For instance *maasa* plant was planted near banana trees to prevent *fuko* (rodents) from attacking the banana plantations. The *urutupa* plant was also planted around the farm to prevent *fuko* (rodents) from attacking banana, maize, bean, sweet potato, yam and Irish potato crops. Farmers also used ground neem tree leaves to prevent rodents from attacking maize or sesame crops in Kilosa.

Similar to local herbs, the study findings indicated that there were also variations on the use of cultural inputs (such as ash, paraffin, traps, urine, clay soil) and practices to control plant pests across the surveyed districts. For instance in Moshi Rural, ash was mixed with animal urine to control vegetable cutworms and *shipitiri* pests (vegetable insects). Farmers also used theft pins and paraffin or water to catch *kimatira* (leaf minor pests) and kill them in the coffee fields. Water or cattle's urine was also used to prevent rodents from attacking the banana fields in Moshi Rural. Locally designed traps were used to control rodents in Moshi Rural, Songea Rural and Kilosa. Other farmers made noises to scare birds from attacking the following crops: maize and rice in Kilosa; maize in Songea Rural and Kasulu and maize, sunflowers, groundnuts and sorghum in Mpwapwa.

Ash was also used to control maize stalk borers and rodents in Kilosa, while they were used to control maize stalk borers and bean American bollworms in Songea Rural. In Mpwapwa, ash was used to control cowpea beetles, maize weevils, stalk borers, groundnut termites and sorghum stalk borers. In the same district other farmers relied on heavy rain to control sunflower American bollworms. In Karagwe, farmers used either soil or a mixture of ash and soil to control *kamsokoine* pests (stalk borers) in the maize fields. Clay soil was used to control *ohuruka* pests (beetle) from attacking beans. In the same district farmers mixed kitchen ash, soil and thiodan insecticide to control *kamsokoine* pests (maize stalk borers) and *ohuruka* pests (beans beetles). In Kasulu, farmers put soil over the maize funnel to kill stalk borers. In the same district, farmers also uprooted the infected banana plants to control weevils. It is clear that farmers possessed extensive base of knowledge on plant pests and they used various measures to control them. It is thus important if these measures would be captured, documented and shared to various communities to stimulate experimentation and agricultural productivity in the local communities.

Control of animal diseases

The study found that farmers had developed fairly extensive methods for controlling their animal diseases, which included local herbs and cultural inputs and practices. The application of these local herbs and cultural inputs varied across the regions. Neem and chilli pepper were the most used herbs by farmers for controlling animal diseases. In local herbs, farmers used various parts of plants, such as leaves, barks, fruits and roots to control animal diseases. The plants were either used alone or in combination with any of the following local inputs: soda ash, soap, water, salt, charcoal, kitchen ash, contents from torch batteries and bran. Farmers mainly used neem and chilli pepper plants to control animal diseases. These findings suggest that farmers have been able to control and prevent animal diseases by using methods which are easy to use and locally available. The use of local herbs and cultural practices for controlling plant pests is explained in the following text.

The study findings indicated that farmers used a wide range of local herbs to control animal diseases. For instance, farmers in Moshi Rural used aloe vera (aloe barbadenis) plants to cure *ndigana moto* (ECF) in cattle. A mixture of ground *lelema* (basella alba L*)* leaves and *magadi* (soda ash) was given to cattle to cure *ndigana baridi* (protozoan disease - anaplasmosis) and *ndigana moto* (ECF). A mixture of ground mlatangao (calpurnia aurea Ait. Benth) tree leaves and water was given to cattle to treat roundworms and *ndasura* or *ndigana baridi* (protozoan disease - anaplasmosis). *Mabangi mwitu* leaves or a concoction of ground *mlatangao* tree leaves and soda ash was given to cattle as insecticide to control bloat disease such as indigestion.

External parasites, such as worms in goat and cattle, were treated by using a mixture of water and ground *mfurufuru* or *msesewe* tree leaves or barks. The ground wild sunflower was fed to cattle as a de-wormer. *Mabangi mwitu* leaves were used to cure external parasites such as fleas in goats. A concoction of hot water and *iyari* leaves was used to massage cattle when injured. A mixture of ground *kilawe* tree leaves and soda ash was filtered, and cattle were given one or two bottles per day depending on their age to cure viral diseases, while ground fungi plants were given to cattle as de-womers. In the same district of Moshi Rural, farmers used various herbs to control *kideri* (poultry viral disease, such as Newcastle), which included: squeezed cream from ground leaves of *ufuta pori* (wild sesame) plants; boiled sisal leaves; wild sunflower; mother in law hand (*mkono wa mama mkwe*) tree leaves; a mixture of ground *mabangi mwitu* plant leaves; wild sunflower leaves and water; a concoction of ground wild sunflower, chilli pepper and water; a mixture of ground aloe vera leaves and chilli pepper; boiled aloe vera leaves; and a mixture of *ngaponi* leaves, chilli pepper and water. Boiled aloe vera leaves were administered to poultry before the disease was in its advanced stages.

In Kilosa, pastoralists in Twatwatwa Village used various local herbs to cure their animal diseases. *Orkuluku* (Foot and Mouth Disease) disease in cattle was treated by using various local herbs which included the following: a mixture of ground *oti* and *mkambala* (acacia mellifera) tree bark and salt; a concoction of ground *oti* and *mkambala* tree bark, salt, charcoal and contents from batteries; or a mixture of boiled *olkiloriti* (acacia nilotica) tree bark, salt and ash. A mixture of *enguruoni* tree ash and salt or soda ash, or a mixture of ground and burnt *olaitur-day* tree fruits was smeared on cattle's feet and mouth to control *Orkuluku* (Foot and Mouth Disease (FMD). In the same district, *ortikana losedeli* (East Coast Fever) disease in cattle was treated by using a mixture of tobacco leaves and water, while ECF for calves was controlled by using neem tree juice. *Urmukatani* tree roots were boiled and given to calves to treat *ortikana losedeli* (ECF) or *orkikanopi* (Protozoan disease - anaplasmosis). On the other hand, in Kilosa (Kasiki Village), *mdonde* disease (viral disease such as Newcastle) in poultry was controlled by using various herbs which included: a mixture of neem tree leaves and maize bran; a concoction of neem tree leaves and water; a mixture of ground *madaka* tree roots and water; a mixture of chilli pepper and water*;* neem tree juice; and *madaka* tree leaves.

In Mpwapwa, neem tree leaves were used to treat viral diseases such as Contagious Bovine Pleural Pneumonia (CBPP) in cattle and *kitoga* (Newcastle) diseases in poultry. A mixture of crushed *takalang'onyo* plant and water was also used to cure *kitoga* or *mdonde* (Newcastle) disease in poultry. *Mzenge* tree leaves were smeared on poultry eyes to control viral disease such as fowlpox. In Karagwe, *kibirizi* tree leaves were given to goat and cattle as de-wormers. *Chibilize* tree leaves or *Mubanga* tree barks were given to goats as de-wormers. Sisal fluids and chilli pepper was fed to poultry to treat coccidiosis (protozoan disease). On the other hand, in Songea Rural a concoction of ground *mgwino* tree, sisal, eucalyptus tree, water and livestock a feed such as maize bran was given to poultry to control *kideri* disease (viral disease such as Newcastle). Tobacco was also used to treat *kideri* disease (Newcastle) in poultry.

The study findings also showed that farmers expressed extensive knowledge on cultural inputs (such as cooking oil, soap, urine, paraffin, ash, torch batteries) and practices which were used to control animal diseases. For instance in Moshi Rural, farmers used cooking oil or a mixture of water and soap to cure *ndigana baridi* (protozoan disease such as anaplasmosis) in cattle. Sunflower oil was given to cattle to treat *ndigana moto* disease (East Coast Fever). Bloat disease was treated by using human urine or cooking oil which was given to cattle and they were pushed to run as a healing process. Farmers also rebuilt the animal house and designed a flat floor to prevent miscarriages in cattle. In the same district, a concoction of contents from torch batteries and water was applied on the washed goat's hooves to control foot rot disease. On the other hand, farmers in Kilosa injected cattle with paraffin to treat bloat disease. Ash was applied on cattle's feet and mouth to treat *orkuluku* (viral disease such as FMD). In addition, cattle were given a concoction of ash and water to treat retained placenta disease. In Mpwapwa, cattle were given hot water three times a day to cure FMD disease. In Kasulu, farmers used a mixture of paraffin and ground *teletele* tree leaves to treat injuries in goats. Consequently, Kilosa farmers used taramise drugs and paraffin to treat East Coast Fever (ECF) in cattle, while antibiotics and neem tree juice were used to control *mdonde* (Newcastle) disease in poultry. On the whole, indications are that farmers possessed extensive knowledge on local herbs, and cultural inputs and practices which were used to control animal diseases in the surveyed districts.

CONCLUSIONS AND RECOMMENDATIONS

The study findings showed that the local communities had an extensive base of IK and understanding of their environment, and they were able to put appropriate managerial skills and adaptive strategies to crop and animal farming and forage resource management. Knowledge on farming activities seemed to be determined solely by the physical properties, unique qualities, behaviour and performance of crops or animals, historical processes and cultural values of a certain locality. This knowledge on farming systems was location specific due to differences in agro-ecological conditions, ethnic groups, farming systems, population pressure and existence of intermediaries who foster the application of organic farming. The study found that similar local herbs and cultural inputs were applied in various districts to preserve the same planting materials and harvested crops, and to control the same plant pests. Since IK is unique to a given culture, it can therefore seldom be scaled up without adaptation, but it can be used to stimulate experimentation and innovation in other communities. The identification of IK types was important to determine and understand what the communities knew and how that knowledge can be used to add value to the agricultural activities. IK identified in the present study forms the basis for local-level decision-making in various issues such as food security, animal and crop husbandry, natural resource management and other related agricultural activities in the rural areas.

The study findings showed that farmers used many indigenous technologies and practices in agriculture most of which may be unknown to the researchers, educators and policy makers. Most of these indigenous innovations could be incorporated into research to enrich the agricultural technology development process and make it more relevant for farmers. Indigenous technologies and practices need to be tested, validated and where necessary improved. Once these indigenous technologies have been validated and presented to farmers as extension information from the concerned public institutions, there would be a great potential for improving agricultural activities without deteriorating the environment. For instance, local herbs and cultural practices for preserving planting materials and crops, and for controlling plant pests and diseases, and animal diseases can be used as a substitute to chemical pesticides because they are safe to the environment, affordable, effective and simple to use. It is thus important to understand and facilitate the identification, documentation and use of this knowledge as well as integrating it with conventional knowledge for improved agricultural activities.

Based on the findings, the study recommends that knowledge intermediaries (research, education, agricultural support services, rural information and knowledge services) should conduct regular user studies to identify and document IK in order to determine areas that need intervention, and incorporate IK into conventional knowledge system for improved farming activities. Thus, mapping and preservation of the communities' knowledge would also be feasible to prevent knowledge loss and to make knowledge readily available in their communities and outside their communities' boundaries. The knowledge intermediaries should involve the local communities at every step of the knowledge identification process to bring the sense of ownership to empower them to manage their own knowledge, and adapt to other knowledge systems. Since IK is unique to a given culture, perhaps, it would also be important to modify and validate the preparation or ratio of mixing different local ingredients at the research laboratories so that it can be adapted to stimulate experimentation and innovation in other communities. The conventional technologies will only be successful and sustainable if the dimensions of indigenous knowledge of cultural, social and ecological systems are taken into consideration. It is also important to deploy multiple extension approaches such as face-to-face communication approaches, participatory approaches, printed materials and ICTs to recognise, identify and share IK in the local communities for sustainable agricultural development.

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