University of Dar es Salaam Library Journal
Vol 16, No 2 (2021), pp 34-52
ISSN: 0856-1818

The Role of Indigenous Knowledge Systems (IKS) in Improving Farm Productivity in Kainam Village, Mbulu District –Tanzania

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Abstract

This article aims to contribute to the current debate on the role of Indigenous Knowledge Systems (IKS) in arable land productivity. The study uses the Kainam Village ecosystem as a case study to describe the Iraqw community-based knowledge that supports their livelihoods. The study applied both qualitative and quantitative research methods to analyse the indigenous knowledge practices applied in arable land resources utilization. The conceptual framework around which most of the IKS analyses have hinged over time are narrated. It is conceived that IKS have demonstrated a synergetic relationship between land and the use to which it's put as they support hundreds of people in the village. The findings have revealed that Kainam people living in Mbulu District, have applied IKS in land classification and use, over centuries. IKS practices have sustained household yields and crops quality in the study area. Despite the small farm sizes, traditional tools and tilling methods, the households produce enough for their families and have surplus to assist relatives in far-away villages. This is due to the system of cultivating their farms throughout the year and the culturally in-built knowledge on land resources management, which has been historically accumulated, and used for survival and sustainability of household productivity in the village ecosystems. It is recommended that in order to sustain these best practices of IKS, it is important to integrate it into the curricula of the formal education system at all levels but particularly in primary education which is accessible to most rural Tanzanians.

Keywords: Land resources, farm productivity, IKS, Kainam, Tanzania
https://dx.doi.org/10.4314/udslj.v16i2.4

Introduction

Over the past five decades there has been rapidly growing interest in the potential role of indigenous Knowledge Systems (IKS) in the sustainability of the land productivity, in rural communities. The contribution of knowledge is seen as a way of illustrating that environmental changes are happening, and making sense of its implications for vulnerable groups in rural areas (Naess, 2013). As a way of helping sustainable land use systems at national and local levels, the United Nations together with member countries in 1992 undertook to help advance people's rights and achieve multiple development goals (Hambati, 2013). For instance, the United Nations Resolution 164 declared 1993 the 'International Year of the World's Indigenous People'. This was aimed at strengthening international cooperation, in order to address the problems faced by indigenous communities, in such fields as human rights, the environment, development, education and knowledge information sharing. Indigenous awareness concerning land resources management was assured following the World Commission on Environment and Development (WCED, 1987) which emphasized that indigenous communities are repositories of accumulated knowledge and experience hereafter known as Indigenous Knowledge Systems (IKS), which large societies could learn from managing complex ecological systems. This is essentially information on land use systems, which support various livelihoods. Further, the Commission on Development and Global Change of 1995 issued a report titled "For Earth's Sake". The report listed, *inter alia*, priority research areas to find solutions to national and international environmental problems. One such area was IKS in conservation measures, where "approaches to rescuing and revaluing IKS about natural resources and their management formed the centre-stage" (IDRC, 1997; Naess, 2013). It is within this context that IKS and resource management systems (RMS) have been identified as research themes that, when studied critically, constitute an important and timely area of environmental research for sustaining land, land use systems and land productivity (Vandebroek *et al.,* 2011).

It is worth noting that in the second half of the 1990's, IKS entered the mainstream of activities and initiatives undertaken by developing countries and by the international donor community, including the World Bank. IKS were on the agenda of the first conference devoted to Global Knowledge for Development (GK 97), held in Toronto, Canada, and even more prominently on the agenda of the second conference (GK II), held in Kuala Lumpar, Malaysia, in 2000. The final action plan of the GK II Action Summit and Forum includes a strong endorsement of the IKS programme and specifically calls for the identification, development and dissemination of indigenous knowledge in various forms including local languages. It also calls for developing strategies for using IKS in development (UNESCO, 2005). There has been growing interest and appreciation among scientists on IKS. The body of scientific publications over the last two decades concerning IKS published by the United Nations Educational, Scientific and Cultural Organisation (UNESCO), have insisted that indigenous knowledge be integrated into the mainstream science framework (UNESCO, 2005). It is in this context that Agenda 21 seeks to address these initiatives by re-examining and applying IKS techniques, as opposed to the wholesome importation of Modern Knowledge Systems (MKS). The ultimate goal is to analyse and document the best practices of IKS which have sustained community livelihoods in a particular ecosystem that illustrate good use of land resources and develop cost-effective and sustainable survival strategies for wealth creation and income generation in rural areas.

This article is divided into six main sections. The first section introduces the background global position of IKS, while the second section covers empirical literature and the conceptual framework underpinning the study. The third section is on the study area and the methodology while section four is on the results of the study. Section five deals with the discussion of the results. Lastly, section six offers the main conclusion and recommendations from the study.

Related literature

Reconceptualising Indigenous Knowledge Systems

In asserting control and direction over their lives, in order to safeguard their social structures, Africans have utilized knowledge, practices, skills and tools that their societies have developed in the course of years and centuries (Richey *et al.,* 2021; Rugumamu, 2003). As observed by Vandebroek et al. (2011), indigenous knowledge is the sum of experience and knowledge within a given group in a specific geographical location, which forms the basis for decision-making related to familiar and unfamiliar problems and challenges. Nevertheless, formal knowledge generated in schools, universities, research institutes and industrial firms still dominates development thinking in the world (Hambati & Yengoh, 2018). This knowledge gradually spreads over the developing world as the dominant system shaping politics, values and careers - a system that puts great emphasis on the contribution of MKS to development. In this context, IKS were considered inferior and were denied a role in the development processes; as a consequence, they were classified as non-scientific and treated as contrasting with MKS. As noted by Hambati (2013), the situation is changing as decision makers in developing countries are becoming aware of how IKS can be put to good use. They are beginning to realize that IKS is the largest single resource not yet mobilized for development. It is a powerful asset that many developing countries possess (Richey *et al.,* 2021; Newsham & Thomas, 2011). Therefore, in this study, IKS refers to the knowledge possessed by indigenous people and practised over centuries in land resources utilization and management for the efficient use of the Earth's natural resources, to sustain individual and community livelihoods.

Community Recognition of IKS in Land Productivity and Management

Land resources are valuable entities of the Earth that support living organisms in a given ecosystem within a geographical area (Walker et al., 2013). For the case of this study, land resources are categorised into soils, vegetation, animals and water, which are utilized in an integrated manner within a given ecosystem (Gadigil *et al.,* 2000; John et al., 2014). An ecosystem is simply defined as a biological community of interacting organisms and their physical environment over space and time (ICSU, 2002). This implies that there is a link between people's indigenous knowledge and its use on their land resources, to earn their daily livelihoods. Local people through their traditional lifestyle, have ensured the productivity of various land resources enjoyed today (Haggan & Baird, 2007; Gilbert, 1995). For instance, studies by Chambers et al. (1989), Bizimana (1994), Fernandez-Gimenez (2000) and Kisiaya (2016) found that IKS on land resources management practices are easy for local people to adopt and are inexpensive to run due to the co-operation of every member of the community. Mapinduzi (2003) who studied the pastoral community in Monduli District in Northern Tanzania found out that IKS on land resource management especially pastureland was effective in promoting conservation of biodiversity. He observed that the community had knowledge of allocating different pastures to livestock over time to conserve the existing biodiversity, to improve land productivity. Borjeson (2002) studied the history of IKS of farmers in Mbulu Highlands, Tanzania, between 1880 and 2000, and showed that IKS had been used in this area since the pre-colonial period, especially in soil-water conservation in their agricultural systems. However, not much has been done on the roles of IKS on land productivity in Mbulu Highlands. Therefore, this study made an inventory of IKS practices on arable land and evaluated their efficacy in improving household farm yields in Kainam Village.

Conceptual Framework Underpinning IKS

The theory underpinning the study on IKS is that there is a complex relationship between individuals, communities, environmental components and land use systems in the whole process of earning livelihoods. IKS is analysed in four levels (Figure 1). Firstly, there is indigenous knowledge on land resources (i.e. arable land), which includes knowledge of soils, plants, animals, water and landscapes. The second level is land resources conservation and management systems (adoption of practices), which includes knowledge of land resource user, appropriate set of practices, tools and techniques. In this level, the local people seek mutual and harmonious relationship with their environment to enhance productivity; this requires an understanding of ecosystem processes to sustain their daily livelihoods. Thirdly, there are social institutions, which include a set of rules and code of social relationships that govern human behaviour. The fourth level is concerned about improved productivity of the land resources, which shapes traditional perceptions and gives meanings to observations of the practices experienced. From here, the successful IKS are disseminated to the whole community to improve productivity of their land resources. The four levels of IKS analysis are summarized in Figure 1.

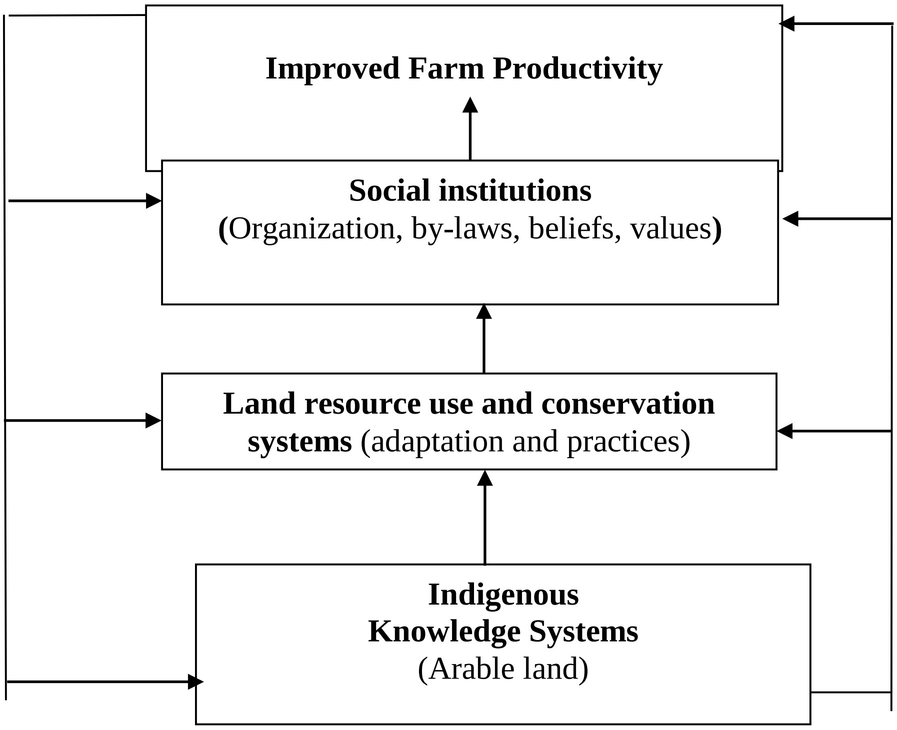

Figure 1: Level of Analysis in IKS
Source: Modified from Hambati (2013:3)

Methodology

Kainam Village is located in Mbulu District in Manyara Region, Tanzania. It approximately lies between 35^0 30′ and 35^0 40′ East and 3^0 50′ and 4^0 00′ South (Map 1). The village has unique features which make it suitable for the study of IKS. Firstly, the area, which is the heartland of the Iraqw people (the dominant ethnic group), is located 12km Southeast of Mbulu Town. Its selection has also been influenced by the unique cultivation and cattle keeping practices that have since sustained each other over centuries. Secondly, as a place where the Iraqw first settled before they migrated to other areas like Karatu, Babati, and Hanang districts, the land resources appear to be more integrated than those found in new settlements (Hambati, 2013; Loiske, 1995). Thirdly, Kainam Village is ecologically a vulnerable ecosystem characterized by highly dissected landscapes of the Mbulu Highlands, ranging from 1500 to 2500m above sea level. The landscape was a natural barrier to invaders, which enabled the community to maintain its cultural values in land resource conservation and management.

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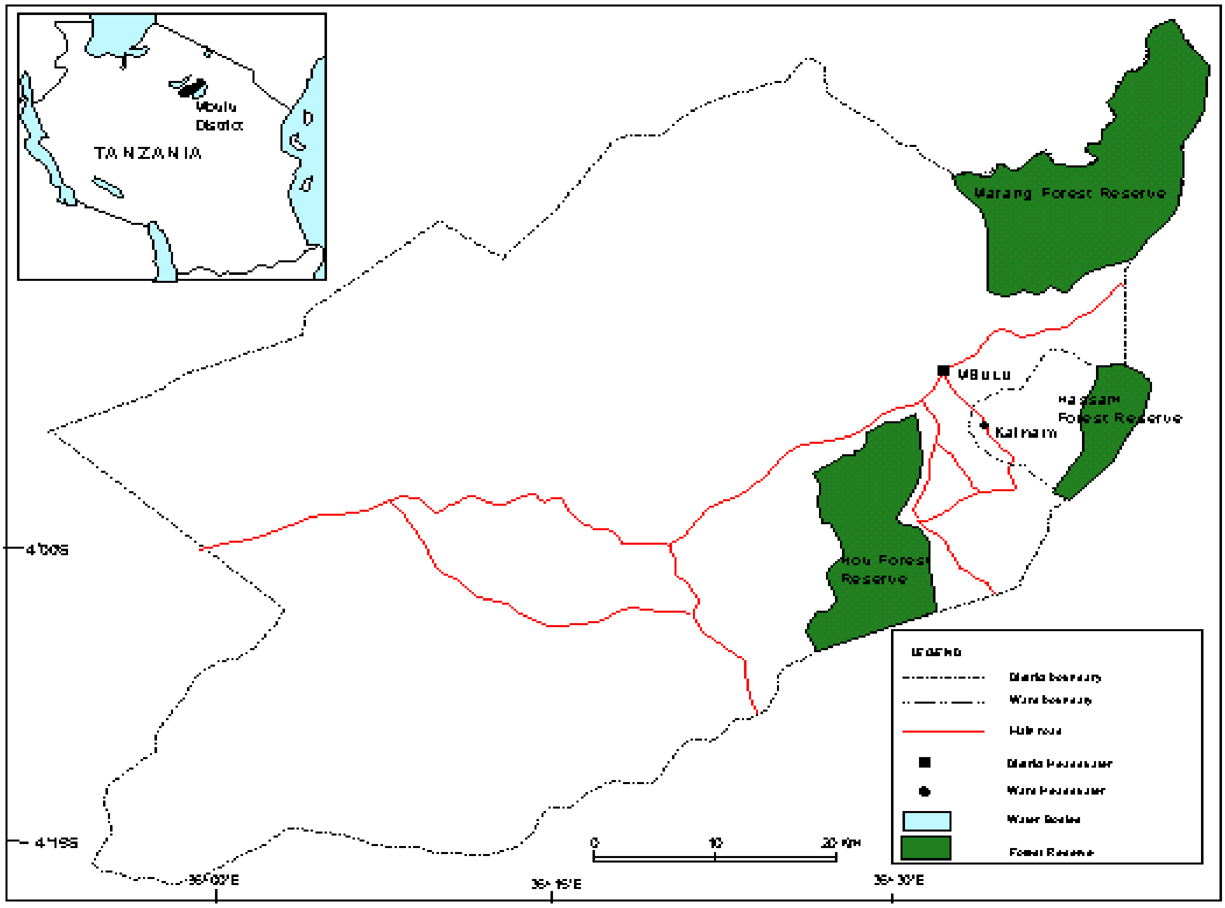
Vol 16, No 2 (2021), pp 34-52
ISSN: 0856-1818



Map 1: Location of Kainam Village in Kainam Ward, Mbulu District, Tanzania
Source: Hambati, (2021)

The study employed both qualitative and quantitative methods in data collection and analysis through the application of Participatory Rural Appraisal (PRA) techniques. PRA is capable of capturing the dynamic qualities of the environment and community in general (Longhofer, 2012; Rugumamu, 2003). It includes focus group discussion, household survey and field observation. A combination of these methods has been used in this study, to complement each other. In collecting data, three main operations were conducted: pre-field work (secondary data collection), field work (primary data collection) and post- fieldwork (data analysis).

Stratified sampling was conducted in order to identify farmers from different village land units, i.e. interfluves, slopes, and valleys. In each of these units, a sample of IKS practitioners in farming were purposefully drawn to get appropriate interviewees. This sampling procedure was operationalized through the help of the village leadership. From each sub-village, samples were taken purposefully to include relevant land users. Longhofer (2012) and Blocher (2018) recommend that for a sample to be representative in knowledge-based research, at least 10% of the entire study population should be taken for the study. In this study a sample of 20% (100 household members) of all the households in the entire village (500), were involved in the study. Proportionate sampling was done to get the required number of households from each sub-village. A total of 100 households were interviewed in this study.

A small group of ten to twelve people was formed by the researcher, representing a cross section of land users. It was composed of about five farmers, agricultural extension officer, ward councillor, ward executive officer, herbalist and two influential people in the community. Participants in the discussion volunteered information related to specific IKS practices and experiences of applying it in the area. The discussion that ensued raised people's awareness about the roles of IKS on land resources management. The information that was collected by this technique was further backed up by data acquired from household surveys and field observation.

This tool was used to collect information at the household level, provided the respondent was above 18 years old. The questionnaires, which were centred on IKS had open-ended and closed ended questions, and served to IKS practitioners and extension staff. The information gathered included socioeconomic and demographic information. A sample of 20% (i.e. 100 households) of the village household population was interviewed, and the information collected through this technique and FGDs was verified through field observation. Direct observation was used to collect information about people's daily practices in interaction with land resources. The materials that were used in the process of observation included a camera and an unstructured questionnaire. The process involved the researcher walking from household to household, accompanied by the sub-village leader of the particular land unit. This technique enabled the researcher to make on-the-spot observation and understanding of the constraints and opportunities for land resource use and management at household and community levels. This method was also used to increase the reliability and validity of data collected using other techniques.

Post fieldwork involves activities done after the fieldwork, especially analysing both qualitative and quantitative data. Qualitative data analysis was done in terms of content analysis by organizing the specific objectives into themes and sub-themes. This was done to assist the participants to discuss and authenticate the data before further analysis. Then the ranking of themes and sub-themes was done together with the involvement of FGD members to increase community awareness on the importance of the land resources conservation and management, to attain improved productivity. Quantitative data analysis was done after the data and information had been proved and verified by the researcher. The data was then coded electronically to facilitate further analysis and evaluation. The coded data was processed using SPSS Version 23 and later processed to derive a table of frequencies, percentages and mean. Cross-tabulation was done to establish the relationship between the application of IKS and land productivity. Data and analysis are presented in tables, graphs, and plates.

Results

IKS on Arable Land Resources Management to Enhance Farm Productivity

As noted during the FGDs, the community in the study area has knowledge of classifying land according to the position of the land unit and the nature of the slope. The main land units identified during the FGDs are interfluve (the top of the hill), slopes (hill sides) and valley bottoms (the foot of the hill). The land uses are classified according to the nature of the slope, drainage systems, and aspect. The community has long been applying indigenous knowledge in land classification, soil productivity management, farm input selection, farming practices, harvesting and storage practices. This has ultimately improved the household yields.

Classification of Land according to Quality

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According to FGDs, the fields in Kainam Village are classified traditionally into four land units. The first comprises interfluve fields traditionally known as '*dindirmo*'. These are flat fields, located near the homesteads, on the top of the hills. Secondly, there are eastern slope fields, traditionally known as *'intsi*', which are found on east-facing slopes; these get the morning sun. Thirdly, there are western slope fields, traditionally known as '*genei*', on the western slopes, which get the afternoon sun. Lastly, there are valley bottom fields, traditionally known as '*khatsa*'. These are flat fields, located on the valley bottoms, only exposed to the mid-day sun. During the FGDs, it was agreed that exposure to sunlight has some implications on crop growth and productivity in the area. As noted during the household survey, 88% of the sampled population classified their farming land due to the position of the land and the degree of the slope. Seven percent (7%) classified farming land due to the soil depth, 3% according to land flatness and 2% due to the slope aspect. This idea of land classification was also supported by the members of the FGDs who testified that the community classified their land units according to the nature of the slope and soil depth. The interfluve is composed of very deep dark greyish brown clay-loam soils; the mid-slopes have deep dark greyish brown sand-clay soils), while the valley bottoms have deep black fertile soils. (Table 1). These land units have different land uses and conservation measures.

Table 1: Farm Locations

Farm location	**Slope in degree**	**% of respondent**
Interfluves	1^0-3^0	3
Mid-slopes	4^0 -7^0	2
Valley bottom	$<1^0$	7
All the above		88
Total		100

Source: Field Survey, 2020

The fields in the study area are found in patches due to the nature of the landscape, thus according to the household interviewed, the average total farmed land in Kainam Village is 1.4 hectares per household. Table 2 shows the average farm size, in particular, land units. Most of the respondents (80%) have farms whose sizes range between 0.5 -1.5 hectares, 12% have farms smaller than one hectare, and 8% of the respondents have farms larger than 2 hectares. These belong to the chief's clan who is the owner of all clan's land. The science of farm location on different land units has been influenced by the nature of land configuration and average rainfall, which is 1200mm/year. This precipitation pattern supports two main planting seasons (rainy and dry season planting) and cropping all year round.

Table 2: Farm size

Land unit	Farm size in hectares (ha)	
	Range	Average
Interfluve	0.3-0.5	0.4
Mid-slopes	0.3-0.8	0.5
Valley bottoms	0.8-1.5	1.4

Source: Field Survey, 2020

Soil Productivity Management

The community in the study area applied manure to improve farm productivity. These is manure from rubbish heaps traditionally known as '*sihha*'. The *sihha* varies according to the type of organic waste collected. Household waste food and peels, ashes from fuel-wood, remains from cattle fodder, and floor-sweep are collected on a daily basis. The *sihha* can be covered with grass or banana leaves to hasten decomposition. Some farmers however dispose of household waste directly to the fields, depending on the proximity of the homestead to the field.

Manure from cows, goats, and sheep is heaped to form a heap traditionally known as '*ufa*'. Livestock dung is collected from the livestock-shed using a container made up of sedge traditionally known as '*luki*' (cf. plate 1). The dung is allowed to dry for a week in the sun before being applied as bedding for the livestock in the shed, aimed at concentrating the nutrients from urine and new-dung. Eventually, the dung is collected again and spread in the open to dry before transferring it to the farm for soil fertilization (cf. Plate 2). This is how IKS is applied on soil conservation and management. Figure 2 demonstrates the traditional manure-mediated circulation of nutrients to the fields, as discussed during the FGDs.

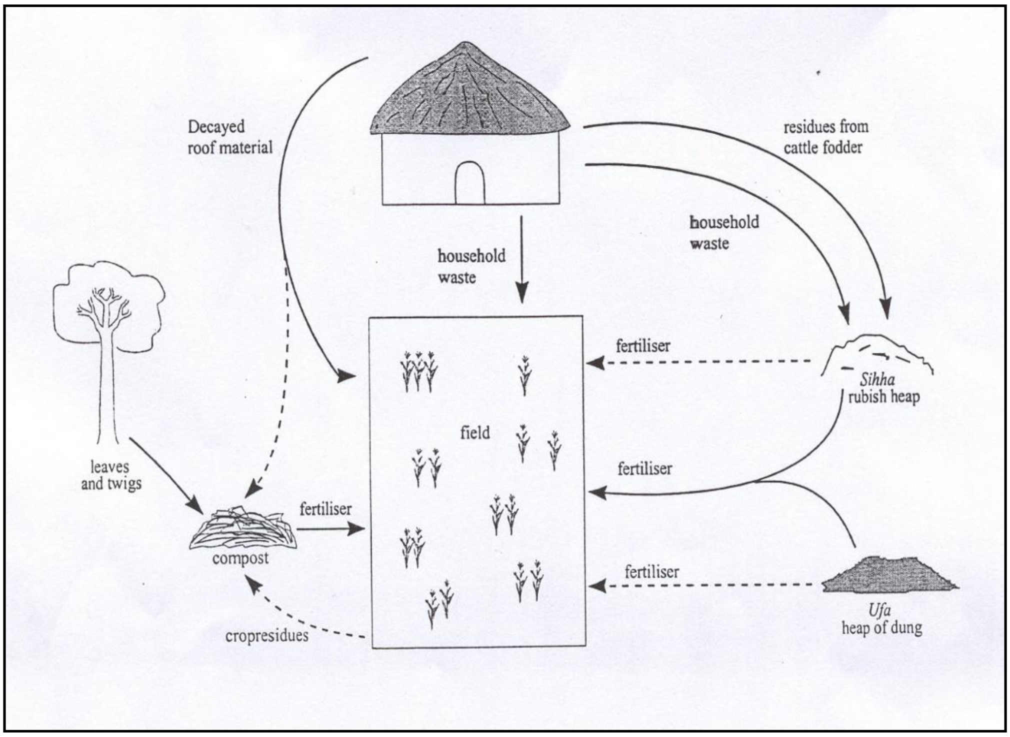

Figure 2: Different Sources of Organic Fertilizers for Soil Enrichment
Source: FGDs during field survey, 2020

Plate 1: Woman pilling cattle dung outside the house. This is the traditional way of conserving manure before spreading it to the fields. **Source:** Hambati, 2020

Plate 2 : The manure is spread all over the field before farm cultivation to enhance farm productivity. **Source:** Hambati, 2020

Farming Implements and Farm Preparation

The Iraqw community makes and uses traditional farm implements such as hand tools due to the nature of the landscape and the degree of slope (cf. Table 1). More than half of the respondents (56%) were using hand hoes, bush knifes, and axes to prepare their farms. While on the other hand more than on third, 34% uses only iron hand hoe, 3% uses only bush knife, 5% uses only wooden hand hoe and 2% uses only axes (Figure 3). There were two types of hand hoe - the wooden hand hoe traditionally known as '*taqwani*' and the iron hand hoe. The former is used along steep slopes due to the shallow soils that require minimum tillage, while the iron hand hoe is used where there are deeper soils, i.e. gentle slopes and valley bottoms. There were traditional craftsmen who had the technology of making these hand hoes known as '*karera'*, and this group of people in the community was exempted from any other communal works. These people would normally exchange a hoe or axe with one tin of maize or beans. This knowledge is handed down to their sons and daughters as the parents attain old age (over 50 years). This is how the clan of blacksmiths was formed in Kainam Village.

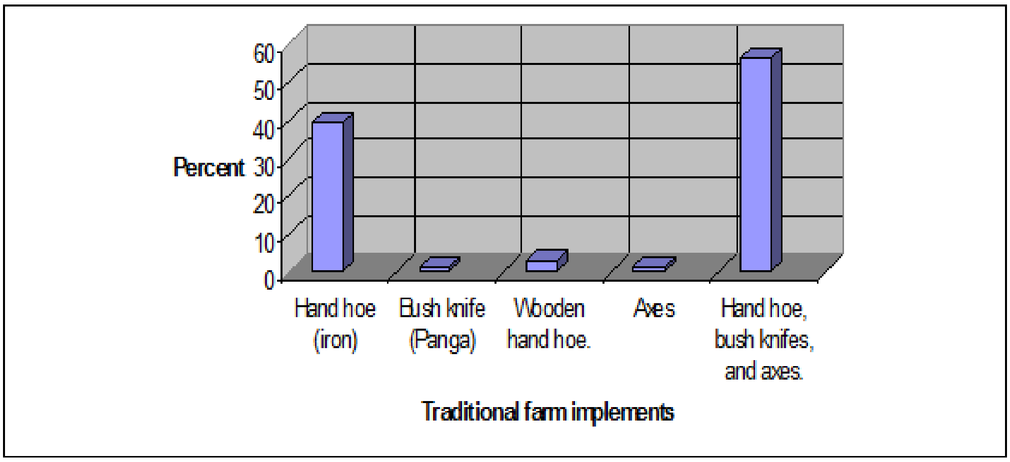

Figure 3: Use of Traditional Farm Implements
Source: Field Survey, 2020

Seed Selection Criteria

Traditionally, the Iraqw people have had their own knowledge of sorting out seeds to be planted the following season. During the household interview, most of the respondents (95%) reported that women are responsible for sorting out traditional seeds during harvesting season. They check on the germination efficiency and productivity of the seeds in the past year. They check on the taste, resistance to pests and tolerance to weather uncertainties. One old man aged 60 years explained:

> *My dear researcher, in our tradition we have a number of seed varieties; for instance, in maize we have two main types: one is known as Mehh', - maize seeds with a mixture of black and white seeds in the same cob; the other one is Irrquttoo, - maize seeds with only one colour, that is white colour. Traditional bean seed types include 'Mehh', 'Booh', 'Daateen', and 'Quangar'. We have used these types in our farms over centuries. These seeds are selected soon after the harvesting season depending on the shape, size, colour, and resistance to damage. Sweet potato cuttings, from former plants, are selected once every three years. The selection of the stem to be used as a cutting depends on its resistance to diseases and physical characteristics.*

During the household interviews, about 88% of the respondents confirmed that those types of seeds (maize, beans and sweet potatoes species) are resistant to drought, pests and diseases.

Normally, it is women who select the seeds under the supervision of traditional extension officers. This proves that IKS prevails in the study area.

Farming Practices

Traditional farming practices form the core of technologies employed by most farmers in the study area. As noted during the FGDs, traditional land use classification, which has been done over years puts various land units under different land uses and requires different land management systems. Fields in the study area are prepared, organized, and managed differently according to the cropping patterns in different land units.

Fields at valley bottoms are prepared in June and July and the cultivation is done through the hand hoe, to produce a rough seedbed that enables water infiltration, germination, and soil erosion control. In the valley bottoms planting is done along the constructed ridges, with mulching in the furrows (Plate 3 and 4). Planting is done in July, after the long rains, depending on how much water is in the valley bottoms. After planting, the farmer irrigates the field in order to allow seed germination. In the valley bottoms, the maize is intercropped with beans. Weeding is done between August and December using the hand hoe alongside thinning which is done before manure is applied for the second time in the field. Beans are harvested after three months while maize are harvested after four to five months. From March until May the valley bottom fields are left to fallow because the valleys become waterlogged during the long rains.

Plate 3: Along the valley bottoms, the intercropping of maize and beans is done on the constructed ridges with mulching in furrows. **Source**: Hambati, 2020

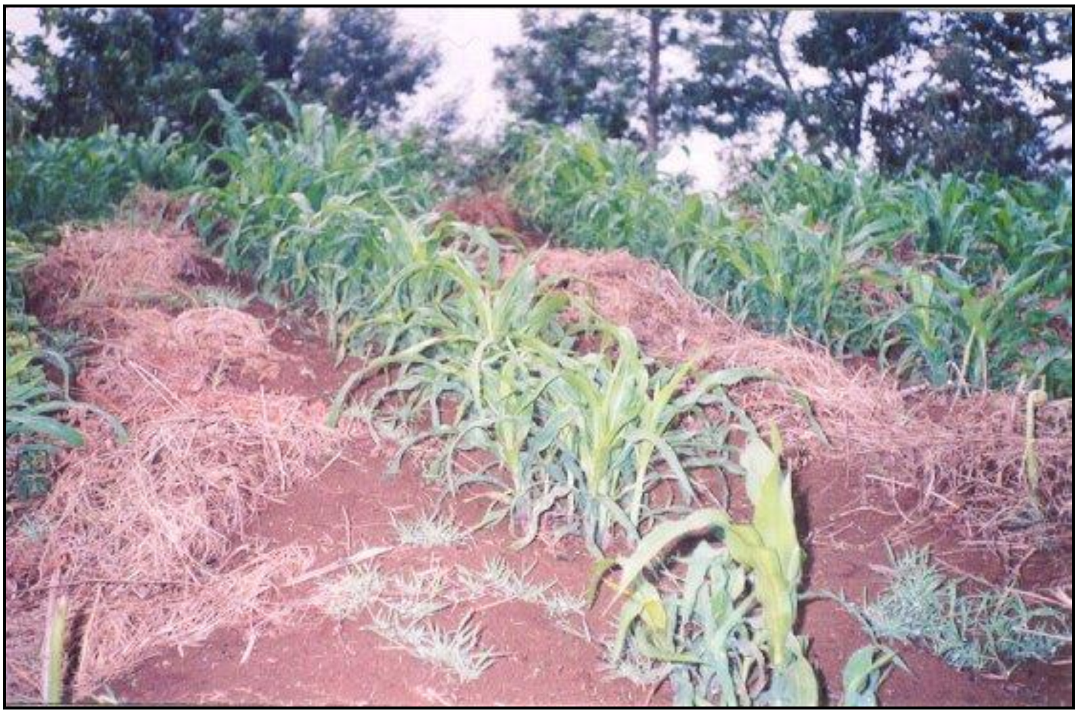

Plate 4: Traditional mulching is done between the furrows to preserve soil moisture and reduce desiccation. **Source**: Hambati, 2020

On the eastern mid-slopes, the fields are prepared continuously all over the year. The only crop grown on this land unit is sweet potatoes, the second most important staple crop to maize. Cultivation of this crop is done on ridges, which are closed at both ends to prevent surface runoff and enable water infiltration. These ridges are constructed one month before the planting season. Plant cuttings on these ridges propagate sweet potatoes. This is done during December to May, a rainy period, which enables the cuttings to produce roots. The weeding of this crop is done using the hand hoe and the thinned weeds are piled up between the ridges as mulch (cf Plate 4). Harvesting is done from June to December, which minimizes storage needs. The sweet potatoes fields are therefore covered with crops during the whole year. Because of the soil conservation practices used (ridges), potatoes are often grown on fields that have very steep slopes.

Fields on the western slope and interfluves are prepared depending on the crop to be planted, which included sorghum, finger millet, millet, wheat, maize, coffee, pyrethrum, and beans. Sorghum and millet are planted during September and October and harvested in March and April; while finger millet is planted during November and December and harvest during April and May. If the field has been fallowing for an extended period of time, sorghum and finger millet are grown to “soften the land” with their numerous roots. This makes the preparation of fields much easier, which is very important in a farming system that depends on the hand hoe. Finger millet is known to suppress “Coach Grass” (*Digitaria scalarum*), one of the most dreaded weeds in the study area, as it poisons other crops.

Pests and Disease Control Technologies

The FGDs reported that there were crop pests and diseases in the study area, e.g. armyworms, which attack maize, beans and sweet potatoes. During the household interviews, more than three quarter (78%) admitted to have experienced armyworms in their farms; whereas 22% acknowledged to have experienced crop diseases such corn smut (traditionally known as

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Vol 16, No 2 (2021), pp 34-52
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'*danuu*') which is caused by the fungus *Ustilago zeae* and can affect the stalks, leaves and tassels. A 50-year respondent had this to say:

> *Crop diseases symptoms are most commonly noticed when the leaves produce mushroom-like tumours or galls. These swellings begin as small, whitish-gray irregularities which expand and turn black as they fill with spores. Leaf galls can grow to 4 or 5 inches in diameter and release thousands of spores as they rupture. These fungal spores are blown by the wind for considerable distances to infect new plants. Galls on leaves remain small and eventually become hard and dry.*

This implies that corn smut hibernates in the soil. During the field observation it was noted that fungus from the infected plant was carried by wind, rain or irrigation to other fields and does best in hot, dry weather. Spores may remain viable for 5 to 7 years. Wounds from various injuries, including cultivation and abrasion from blowing soil, provide points for the fungus to enter the plant. During the FGDs, it became evident that smallholder farmers were applying IKS to fight crop pests and diseases. This was affirmed by one respondent aged 60 years old, who gave the following submission:

> *Normally, we select the resistant seeds during the planting season. When we notice symptoms of corn smut in our crops, we warn each other to take precaution during cultivation (weeding), not to injure plant roots, talks and leaves, to reduce the infection points. To prevent spread of diseases to new plants, we burn the infected plants. We don't use fungicides at all because the disease is so widespread and can remain in the soil for years. To fight army-worms we have developed a practice of planting more than six seeds per hole instead of two. When we detect signs of these pests, we irrigate our farms especially in the valley bottoms. Consequently, the armyworms will drink the water, burst their abdomen, and finally die.*

This narration implies that the local people have got the science of pests and diseases and their related effects. That is why they have developed a mechanism of dealing with them to reduce effects to crops, to improve farm productivity.

Crop Harvesting and Transportation Technologies

During the FGDs, it became clear that women are responsible for harvesting small fields near the homesteads, while men and youths harvest fields far in valley bottoms and mid-slope. When harvesting maize, bundles of maize cobs are tied such that they can be hanged on both ends of a stick (cf. Plate 5), and carried home. For the case of beans, the crop is harvested before complete physiological maturity is reached to avoid possible losses if they get completely dry. Solely, women and children do the harvesting of sweet potatoes. When ripe, the leaves become yellow and cracks may appear on the soil surface due to pressure from underground tubers. Harvesting is done after 3-5 months after planting, using hands and sticks, to avoid uprooting unripe tubers.

The harvested crops are carried using a locally-made container of 20kg capacity, known as '*lakwanti*'. Most of the households interviewed (95%) were using "*lakwanti"* to transport crops, while 5% were using locally-made sacks using animal skins, able to carry 100kg. The process of transporting crops from the fields is not gender-biased. Donkeys are also used to transport the produce from fields that are located more than one kilometre away from the homesteads. Transporting crops from the fields to homes and from homes to the monthly markets in Mbulu Town, which is fifteen kilometres from the village, is largely done by non-motorized transport.

Crop Storage Technologies

The harvested crops including maize, beans, wheat, millet, sorghum, and finger millet are stored for future use because they are less perishable than other crops. The FGDs clarified that such crops were stored in two ways: either on cobs or when shelled. For example, cobs of maize are stored outside hung on tree branches or inside on wooden scaffolds suspended from the ceiling over the cooking place. The farmers affirmed that the smoke and heat from the fire below kills weevils (Plate 5). The shelled grains are normally kept in a locally-built container, made using wet cow dung; the container is known as '*kunti*'. The shelled grain then stored in a *kunti* is mixed with sand and ashes from burned animal dung. This is all done to reduce insect damage in the stored grain. Sand occupies the air spaces between the grains, force out air, and suffocates any grain weevils. It also scratches the skins of such weevils causing dehydration and eventual death, especially if the grain is very dry. Burned cow dung and ashes have properties which repel insects; they are normally mixed with the grains while still hot to kill the insects.

Plate 5: Maize cobs stored inside wooden scaffolds suspended from the ceiling over the fire place. **Source**: Hambati, 2020

During field observation and household survey, it was learnt that the 'airtight storage' is a technology that had been used by local people over years. These clay airtight storage pots include traditional pots known as '*huttay*' or '*sirwi*' with special airtight seals. The farmers know that insects die if oxygen is not available for respiration. This system has been used over years and farmers have proved that insects are killed and rodents are kept away without using any other chemical substances.

Household Yields in Arable Land

During the interviews, the District Agricultural Officer informed that farmers are used to grow maize, beans and sweet potatoes as their staple food crops. Below is his narrations on crop yields against the targeted productivity, per hectare, in Kainam ecosystem per season (Table 3).

> *We have targeted for the period between 2015 – 2020, to produce 1000ks/ha of maize (district optimum yield) per season, although the actual harvest in this season (2019/2020) in the interfluve is 400kg/ha, in the mid-slopes is 500Kg/ha, and 800kg/ha in the valley bottom. This shows a slight difference in the yield compared to the optimum harvest (1000kg/ha); hence a good indicator of IKS application. The target for beans in the district was 500Kg/ha, while actual harvest in the study area is 200kg/ha in the interfluve, 300kg/ha, in the mid-slopes, and 400kg/ha in the valley bottom respectively, which is slightly less compared to the district optimum yield (500Kg/ha). The target for sweet potatoes in the district was 2000kg/ha, while the real harvest average was 1000kg/ha (equal to the district optimum yield).*

Table 3: Yields of Maize, Beans and Sweet Potatoes

Land unit	**Maize yield Kg/ha/season**		**Beans yield Kg/ha/season**		**Sweet potatoes yield Kg/ha/season**	
	Range	**mean**	**Range**	**mean**	**Range**	**mean**
Interfluve	200-600	400	100-300	200		
Mid-slope	400-600	500	200-400	300	1500-2500	2000
Valley bottom	600-1000	800	200-600	400		
District (ecological zone) optimum		1000		500		2000

Source: Field data, 2020

Evidence from Table 3 shows that the application of IKS in Kainam Village matters a lot in improving farm productivity. This has confirmed that the community's indigenous knowledge has played a great role in arable land resources management to enhance their land productivity.

Discussion

IKS in Enhancing Arable Land Productivity

In the study area, the community has traditional ways of classifying land units and the use to which it is put depending on the nature of the landscape in terms of slope, angle and aspect. Unlike the study by Sikina (1994), in the northern province of Zambia, rural farmers have their own ways of identifying soil and land types for agricultural uses. The main criteria used by farmers to classify soils were colour of the top layer, texture, consistency, and organic matter content. The same criteria were also observed in Kainam Village during field observation. For example, black soils are considered to be rich in organic matter, and are often found in valley bottoms and farmers normally plant maize and beans, their staple food. The interfluves for instance in the study area, are leached more than the other fields in the classification system but the proximity to the homesteads makes these fields more productive because some farmers heap household waste directly onto the fields near the house.

Loiske (1995) assures that each farmer in Kainam Village has access to fields in land units as described in Table 2. The same situation was observed during the household interviews where by most of the respondents had patches of fields in different land units. This demonstrates that IKS guides arable land classification in the study area. As observed by Kisiaya (2016), this traditional land classification system is efficient in land resources conservation, as it has supported people's lives and their livelihoods over centuries, without any significant land degradation.

As noted earlier, farm size, has an implication on management. The ability of an individual to cultivate and manage plot depends on one's knowledge, skills and accepted farming practices that promote land conservation over time and space. Tengo (1999), for instance, observed that the fragmentation of farms into small plots in the study area is done purposely to spread the risks involved; hence, application of IKS vary depending on plot status and needs. According to the findings, the average total farmland in Kainam Village is 1.4 hectares per household. Traditionally, the farms were fragmented into small plots ranging from 0.3 to 0.8ha and located at different land units with different management systems. Ecological conditions of different field-types together with the fact that the farmer may have fields that are located far away from each other, reduce the risk of total crop failure. It is also easier for a farmer to manage a small plot of 0.3ha over time to improve the productivity.

Traditional ways of conserving soil fertility and productivity practised by the community include manure application in all farming systems, collected and processed in different ways. As advised by Tengo and Andersson (2000), to maintain soil productivity on permanent fields, it is necessary to compensate for the leaching of nutrients by constant replenishment. The importance of livestock as manure producers is well recognized by the farmers of Kainam and this is said to be the main reason for keeping cattle. As Smalling and Braun (1996) noted, beans were rotated with cereals in inter-cropping practices. Nitrogen fixation by beans provides nutrient input. This is also supported by results in the study area whereby beans are used as a nitrogen fixation crop. On the valley bottoms, beans are inter-cropped with maize, while on the western hill side slope, beans are commonly rotated with other crops. However, crop rotation would not be possible in the valleys because these fields only give one yield per year. Maize from the valleys are so important for subsistence that people cannot plant beans in any one season and ignore maize.

In Kainam Village, as pointed out earlier, farmers re-cycle nutrients to maintain soil fertility. Mulching as a way of managing organic matter has other advantages. Hambati and Rugumamu (2005) noted that mulching and organic manure increase the soil porosity. This implies that large amounts of soil organic matter create a more porous soil structure, which increases water infiltration and water holding capacity. The elaborated management of cattle dung in Kainam Village (cf. Plate 1 and 2) is interesting as a practice to conserve nutrients, especially nitrogen. The use of dried dung as bedding material for cattle in the kraal overnight, and subsequent application on the fields capture extra nitrogen from the urine thereby increasing the nutrient quality of the manure.

Indigenous Knowledge Systems in Farming Practices and Inputs

Kainam farming systems may be said to represent a very well adapted system given the ecological and social limitations because it is diverse both in structure, crops, and management practices. Hambati (2013) noted that before colonialism, there was sound conservation and management measures, built upon indigenous agricultural practices that were quite effective. The practices were intended to improve land resources and agricultural production, and in the long run improve people's quality of life. Furthermore, traditional manure as well as traditional pesticides are used in the crop production cycle. As reported by Loiske (1995) these practices are appropriate in Kainam due to the nature of the terrain that hinders mechanization. Most of the farms are located on gentle to steep slopes, U-shaped and hanging valleys. According to FAO (1983), cultivation of land on slopes between 40%-70% in a mountainous topography can only be done using hand tools. In the study area, farmers have fields along slopes ranging from 20% to 70%. The terrain in Kainam Village, in part, determines farmers' reliance on the hand hoe for cultivation. This technology is rudimentary and labour-intensive during the agricultural season, yet appropriate given the environment. The storage system over the fire place and in 'kuntis' has already been discussed.

IKS and Households' Crop Yields Nexus

In a planning document produced by the Mbulu District Council in 2020/21, maize yield is estimated at 0.7-2 tones/ha, beans at 0.5-2 tones/ha and sweet potatoes at 1-2 tones/ha. According to the household interviews as shown in Table 4, the maize yield was 0.6 tones/ha, beans 0.5tones/ha, and sweet potatoes 0.8 tones/ha. This implies that yields in the study area are not significantly different from the estimation made in the planning document of the district. This is an indication that IKS performs better compared to other knowledge systems. As noted by Hambati (2013), IKS is cost-efficient and it is within the peoples' reach culturally, socially and economically. The farmers admitted that the harvest met their daily needs all year around. Loiske (1995) approximated that a household of six members in Mbulu District consumes ten bags of maize and five bags of beans per year, excluding other tuber crops like Irish and sweet potatoes. The average household size in the study area is six to eight members, and the average household harvest is fourteen bags of maize, eight bags of beans and sweet potatoes. This implies that the produce is enough for household food requirements for a whole year.

Conclusion and Recommendations

Following the findings and discussion, the Kainam community is practising indigenous knowledge in arable land management, to improve farm productivity. There are four types of farms (fields) in Kainam Village, classified due to the nature of landscape, slope and aspect. These fields are located at the interfluves, western and eastern mid-slopes and valley bottom. Through IKS, each field is conserved and managed differently depending on the nature of the crop, tools and cropping pattern in relation to the nature of slope and aspect. Their practices are site-specific and are based on a rational decision-making process incorporating farm management. IKS is environmentally friendly, as each particular land unit is put under a certain land use type with specific conservation measures. IKS has managed land resources effectively for generations in Kainam Village and it is more popular in the area compared to other knowledge systems. In order to sustain these best practices of IKS, it is important to incorporate and integrate it into the formal education system at all levels, but particularly primary education to which most rural Tanzanians have access. In the light of the preceding results, it is also suggested that a study should be conducted on the future of IKS, and how well smallholder farmers are going to survive under the pressures of privatization, liberalization and capital flows in relation to land resources conservation and management in Tanzania.

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