Application of indigenous agro-biodiversity knowledge for climate change adaptation and its effects on food security and cash income among local communities in Masasi and Nachingwea districts, Tanzania

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Abstract

This study was carried out in Masasi and Nachingwea districts in Tanzania to provide empirical evidence of existing indigenous knowledge (IK) related to agro-biodiversity surrounding the local communities and how that knowledge contributes to adaptation to climate changes and their livelihoods. The study employed two research designs namely case study and cross sectional survey. Hence, a combination of tools including semi-structured questionnaires, Focus Group Discussions (FGDs) and key informant interviews were used for data collection. The research findings showed that farmers possess a wide range of indigenous knowledge, which they use in the management of agro-biodiversity, adaptation to climatic changes and for improving their livelihoods. The indigenous knowledge identified include those on soil characteristics, soil fertility and infertility, cropping systems, seed storage and use of wild food products. It was recommended that such indigenous knowledge be harnessed and used in other similar localities to foster ability of farmers to adapt to climate changes and improve livelihoods of local communities.

Key words: *Indigenous knowledge, agro-biodiversity, climate change, livelihoods.*

1.0 Introduction

Climate change has been cited to bring many negative impacts in the African continent today and is likely to perpetuate such impacts in future. For instance, climate change projections for Africa show that temperatures will increase by 0.2-0.5° c per decade. Such increase in temperature will likely be associated with increased disease and parasite vectors, more severe droughts, increased rainfall and shortened rainfall seasons for food crops and pastures production, thus leading to food shortage and consequent health and economic problems in many African regions (Chimbari 2010). In the light of these occurring and expected calamities, it has been found that Indigenous Knowledge (IK) is increasingly being used by local communities to adapt to the situation. IK is tacit, orally communicated, experiential, unique and embedded in the heads, activities and practices of communities that have long histories of close interaction with the natural environment, spanning across cultures and geographical spaces. IK is largely used by local communities for decision-making (Du Plessis, 2002; Ngulube, 2002; Ellen and Harris, 2000). It is suggested that the interaction between indigenous knowledge and agrobiodiversity provides the rural poor with numerous benefits and opportunities such as the capacity to address environmental conditions, provision of food and nutritional supplies, access to local market opportunities, and options to cope with evolving needs (Akuja, 2010).

Agro-biodiversity includes the diversity of species, varieties, breeds and natural population that interact with agro-ecosystems or contribute directly to food security (Koda, 2003). Most farmers, especially those in environments where high-yielding crop varieties and livestock speicies do not prosper on a wide range of crop and livestock types, the use of underutilized crops have been used to reduce these effects. Agro-biodiversity helps them to maintain their livelihoods in the face of pathogen infestation, uncertain rainfall and price fluctuation for crops, socio-political disruption and unpredictable availability of agro-chemicals.

According to Westengen and Brysting (2014) and Otto (2013), adaptation to climate change is a major issue in the current food security discourse. Furthermore, crop impacts studies from sub-Saharan Africa (SSA) indicate that livelihoods depending on agriculture in developing countries require adaptation because are particularly vulnerable to changes in climate. Adaptation options in agriculture involve changes in farm management practices as well as changes in the policy and institutional decision environment. Within the portfolio of common on-farm and non-farm livelihood adaptation strategies, crop adaptation (changing to crop species or varieties that are resistant to climatic stress) is among the most cited adaptation measures.

A study conducted by Westengen and Brysting, (2014) in Mangae village in Morogoro district and Laikala in Dodoma district, ranked drought, conflict or competition over water and the unreliable onset of the rainy season as the three worst stress factors for climate change. The study further found that problems of availability and access to water and seasonal variability are considered worse than biotic stress caused by crop diseases, destruction of fields by wild animals, problems with market access or floods caused by excessive rains. In terms of adaptation to these stresses, the study found that several strategies combining local and formal strategies were used as indicated in Figure 1.

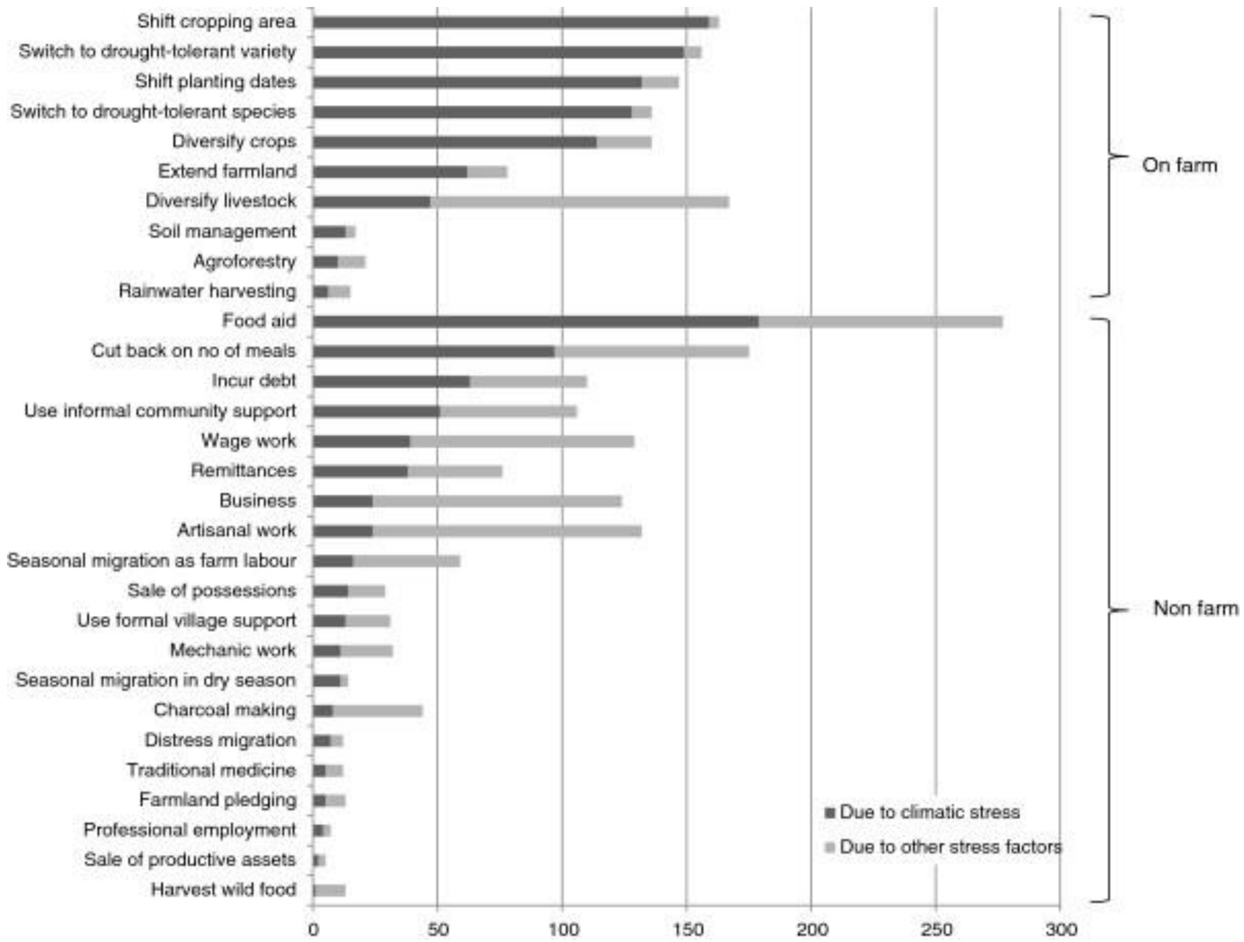

Figure 1: Coping activities in times of stress at Mangae and Laikala villages (Westengen and Brysting, 2014)

While it is known that indigenous knowledge can contribute immensely towards reducing some of the negative impacts of climate changes to local community lives, it remains largely not covered over the whole country in Tanzania. Moreover, knowledge harnessed by farmers is not accorded the same importance as conventional knowledge. The present study sought to identify how the existing indigenous knowledge on agro-biodiversity contributes towards adaptation to cope with the adverse effects posed by climate changes and how such adaptation impacts on the livelihoods of local communities in terms of food security and cash income in Masasi and Nachingwea districts in Tanzania.

2.0 Methodology

This study was carried out in Nachingwea and Masasi district in Lindi and Mtwara regions respectively. These districts are located in southern part of Tanzania, approximately 600 km from Dar es Salaam. The two districts were selected because their agro-biodiversity richness is under threat due to environmental degradation resulting from deforestation, bush fires and bad farming practices. The districts are remotely located from major towns where explicit formal knowledge for agro-biodiversity management could be obtained. The districts are also found at low altitudes with most parts having low soil fertility, which are not best for farming activities (URT, 2009). It is important to study how local communities in these two districts cope up with the challenges associated with climate change in order to earn their living.

The research employed mixed research designs namely cross-sectional survey and case studies to address the study objectives according to Creswell and Plano-Clark (2007). Thus, both qualitative and quantitative approaches were used in this study. The study population constituted: (i) Local communities – small holder farmers and village leaders; (ii) IK intermediaries such as – Agricultural extension officers, and forest officers located in the study areas. A non-probability, purposive sampling technique was used to select two districts and four villages from each district under the study. Three criteria were used to select study villages: (i) the villages are located near the Chiwale general land with considerable biodiversity (ii) agriculture is the main livelihood activity for most people in the area and (iii) agriculture is today climatically stressed in the area. This makes it important to undertake this study to examine how the use of indigenous knowledge in management of agriculture and biodiversity impacts on the community's climate change adaptation, food security and income in the study area. The final sample consisted of 230 heads of households drawn from 8 villages, 4 villages and 2 districts.

Respondents for the structured interviews were selected using systematic sampling. Their names were picked from the village government register, which is supposed to record all the households within a village. From the register, systematic sampling was used to select household heads, after determining the sampling interval. The numbers of respondents selected from each village are shown in Table 1.

Table 1: Number of respondents for the villages studied

Village	Number of households in the village	Sample size at minimum of 5%	Sampling interval	Total sample per village	Number of Respondents			
					Nachingwea		Masasi	
					Female	Male	Female	Male
Mwenge	519	26	17	30	17	13	0	0
Ikungu	597	30	20	30	17	13	0	0
Kivukoni	1082	54	36	29	0	0	17	12
Mkwapa	550	28	18	26	0	0	10	16
Muungano	535	27	18	30	0	0	3	27
Naipingo	852	43	14	28	10	18	0	0
Namatula (B)	546	27	18	27	15	12	0	0
Nambaya	475	24	16	28	0	0	7	23
Total	**5156**	**259**		**230**	**59**	**56**	**37**	**78**

In addition, two key informants were selected from each village, making a total of 16 respondents. Between 8 and 12 people participated in one FGD in each village. Selection of FDG participants considered age, education and gender in order to get a mixture of responses across demographic characteristics. Data was analyzed using the Statistical Package for Social Sciences (SPSS) to generate frequencies and percentages while bar charts for categorical variables were generated using the Excel program. Qualitative data analysis was done through content analysis.

3.0 Results and Discussion

Farming practices and biodiversity management around community surroundings were used to identify various types of indigenous agro-biodiversity knowledge possessed by local communities and how that knowledge contributed to climate change adaptation and livelihoods.

Indigenous knowledge on soil characteristics

Local communities possess a range of knowledge on various soil types existing in their farms. About 56% of the respondents reported that their farms were rich in a mix of sandy, clay and loam soils. Another 20% of the respondents indicated that their farms were rich in sandy soils, 16% rich had clay soils and 7% reported that their farms were rich in loam soils (Figure 2).

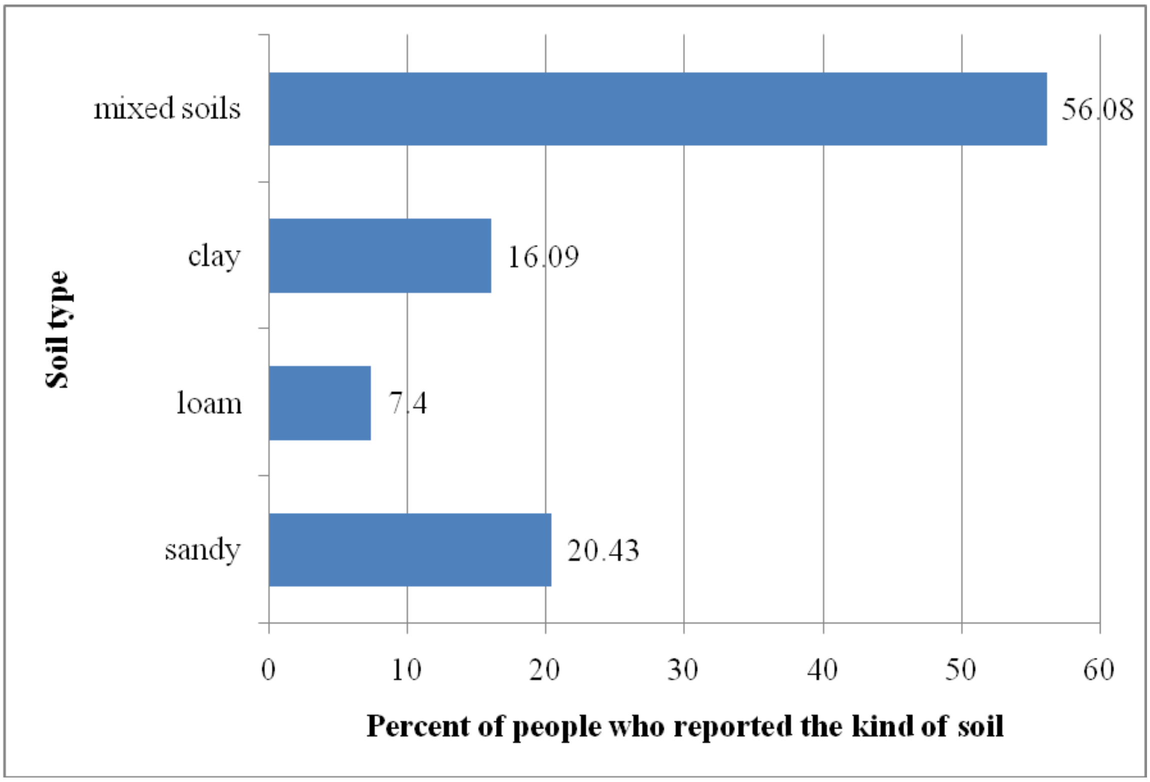

Figure 2: Indigenous knowledge on soil characteristics among communities' farms

Similar soil characteristics have been reported in URT (2010) for the Coastal areas of Mtwara, which are dominated by two zones. The first zone is geologically the coastal sedimentary rocks which produce deep, well drained, sandy soils of low fertility and low moisture holding capacity. These are produced from sandstones and some areas give rise to marine heavy clay soils or verticals. Further, coastal limestone as part of the coastal zone produces red, well drained, heavy textured soils. The second zone geologically comprises of pre-Cambrian basement rocks consisting of gneisses and granulites that extend west of the coastal sediments. Soils from this basement are variable. They are deep, well drained, red clays to the north of Masasi town. These are the best soils in the region since they are suitable for upland crops grown in the region.

Knowledge in terms of soil type has implications on the kind of crops that are grown by farmers. The findings from the present study established that the type of soil was important criteria used by farmers to assess the quality of a piece of land for crop farming. Other major criteria included good water holding capacity, the suitability of a plot for a specific crop, and growth of certain plants in the area. For example, farmers reported that the occurrence of certain types of grasses such as *nambanawe (Bidens pilosa)*, *chikungulu* (witch weed) and *mbuta* (nut grass) indicate that the soil was sandy, suitable for growing pigeon peas and groundnuts only. The soil identified as black was suitable for growing maize, millet and sorghum. These findings are similar to those of Bailey (2003) in Jamaica, Price (2007) in the Philippines and Akullo *et al*. (2007) in Uganda who found that apart from low crop yield and poor growth of crops and weeds, farmers determined changes of soil fertility by using plant characteristics such as; changes of crop color, layers of rotten grasses, and appearance of certain plant species as well as soil characteristics such as presence of compact soil.

Indigenous knowledge on cropping systems

Intercropping was a widespread practice among local communities in Masasi and Nachingwea. Nearly all (97.4%) respondents used intercropping practice in their farms whereas only 27% practiced monocropping system. In both districts, the dominant intercropping system involved maize + pigeon peas which was practiced by 21.3% of the respondents. This was followed by the combination of maize + cassava + pigeon peas which was practiced by 17% of the respondents as shown in Table 2.

Table 2: Kinds of crops intercropped N=230

Crops intercropped	**Frequency**	**Percent**
Maize + pigeon peas	49	21.3
Maize + cassava + pigeon peas	39	17.0
Maize + pigeon peas + groundnuts	5	2.2
Maize + pigeon peas + cashew nuts	4	1.7
Maize + pigeon peas + Sesame	3	1.3
Maize + pigeon peas + cashew nuts + cowpeas	3	1.3
No intercropping	127	55.2
Total	230	100

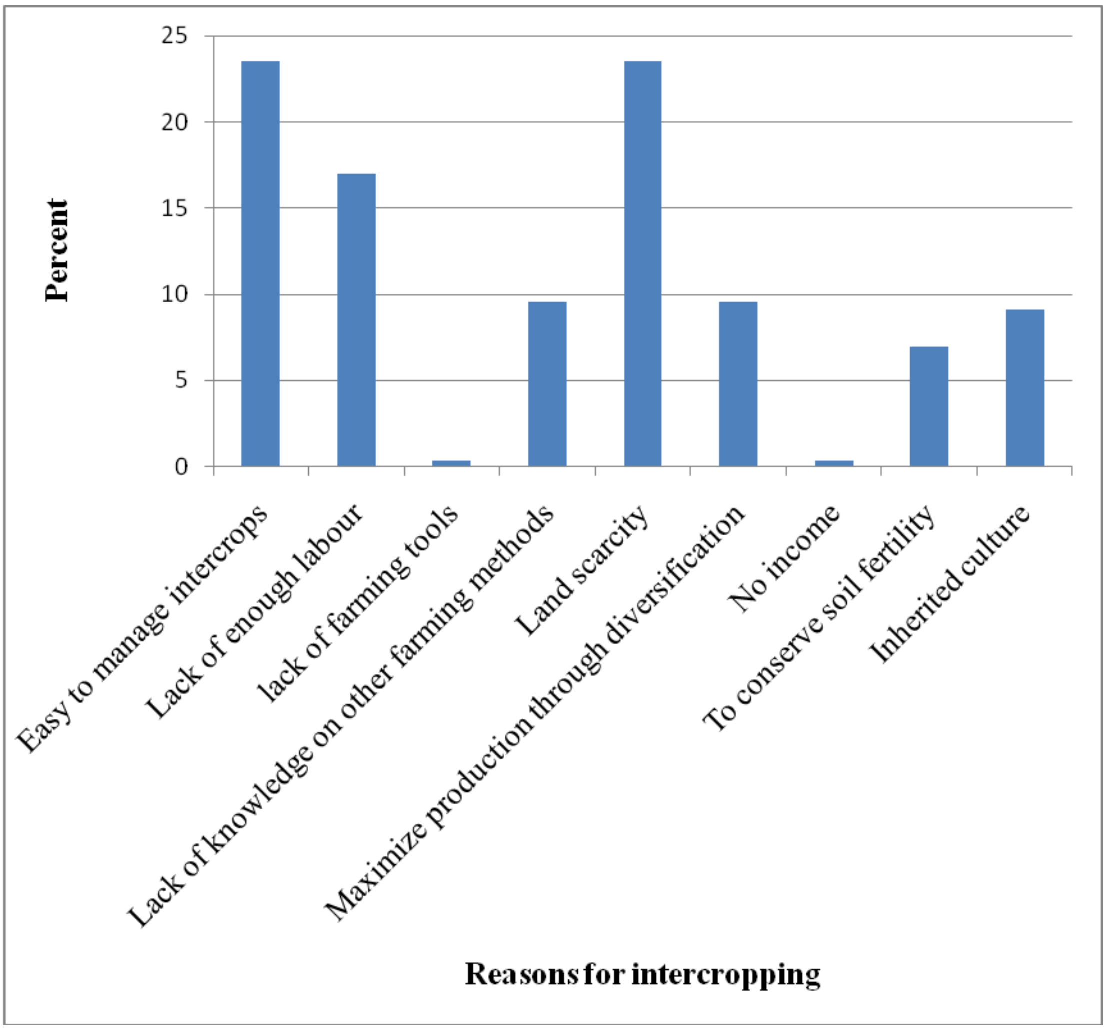

Figure 3: Reasons for intercropping

Respondents were asked to state why there was widespread use intercropping in the study area. The results are presented in the Figure 3 indicate multiple reasons for adopting the practice. Respondents stated that intercropping is determined by land shortages, easy to manage intercrops, inadequate labor, and inadequate knowledge on other farming methods, and in order to maximize production through diversification and in order to conserve soil fertility. Other reasons mentioned for inter-cropping include: inherited culture, lack of farming tools and lack of income.

The findings revealed further those community members also posses knowledge on cropping systems. Intercropping is an effective means of spreading risk in areas where rainfall is unreliable. Since the coastal zone does not get adequate rainfall throughout the year, most communities in Masasi and Nachingwea practice intercropping to minimize crop failure. Studies done by Lwoga (2010) and Dejene *et al.* (1997) similarly found that apart from soil fertility restoration, local communities practiced intercropping to avert risks in case one crop fails, getting early maturing crops, weed control, and prevention of plant diseases.

Intercropping was also predominantly sues as a strategy for soil fertility restoration, which is consistent with findings by Dejene *et al.* (1997) in Dodoma region who established that intercropping was a dominant practice used to enhance soil fertility. However, some other studies in Tanzania have found more than one traditional practices used for soil fertility restoration. For instance, a study by Lwoga (2010) in five districts in Tanzania (Kilosa, Mpwapwa, Karagwe, Songea rural and Kilimanjaro rural) found that most (57.9%) of the respondents used manure to improve their soil quality, followed by crop rotation practices (44.5%), use of crop residues (35.4%), and organic materials (31.7%). Planting nitrogen fixing crops and leaving land in long-term fallowing were least used involving only 8.5% and 2.4% of the respondents respectively. Other techniques were deep tillage, mulching and cultivating at the valley bottoms.

Indigenous knowledge and post-harvest preservation of crops

Centuries of practical experience in preserving planting materials have given local farmers a unique knowledge and roles in this respect. The knowledge relates to what to preserve and how to store the harvested crops both as sources of planting materials, for food and for sale. While modern inputs were important for preserving planting materials, farmers had an extensive knowledge base on cultural practices and traditional facilities they used for crop preservation. Traditional practices and facilities were used by more farmers than conventional inputs and facilities.

Table 3: Post-harvest preservation of crops

Method	Frequency	Percent
Hearth over kitchen	97	42.2
Polythene bags	160	69.6
In granary outside the house	87	37.8
Mix with mud	1	0.4
Plastic bags to avoid termites	81	35.2
Plastic containers	54	23.5
Synthetic insecticides	49	21.3
Mix with ash	11	4.8
Place on tree top	55	23.9

Source: Field survey, 2012

Respondents mentioned a wide range of both conventional and indigenous crop preservation methods. For example, 160 (69.6) of the respondents mentioned polythene bags, 97 (42.2%) mentioned hanging over the kitchen hearth, 87 (37.8%) mentioned granary outside the house, 81 (35.2%) said granary inside the house, 55 (23.9%) said they hang crops on trees, 54 (23.5%) said they use plastic containers, 49 (21.3%) use synthetic pesticides and 11 (4.8%) said they add ash to seeds. Only 1 (0.4% farmer said they mix crops with mud 1 (0.4%). (Table 3). These methods were mainly used to preserve grains such as shelled maize and pigeon peas. Cultural practices such as mixing with ash and hanging on tree tops were also used primarily for storing unshelled maize and pigeon peas pods with stem. Many famers also used conventional methods of crop storage, with use of polythene bags taking a lead among the other conventional methods.

Farmers stated that seed that was stored using traditional methods was resistant to pests, and that they were viable and safe unlike those stored using chemical pesticides. Moreover, such seed were affordable, since the farmer did not have to buy them from the market, they only selected and stored from their own harvest. Other studies have also reported the superiority of seed that has been preserved using traditional methods. In a study in South Africa, Modi (2004) reported that when maize seeds, which had been preserved by smoking over the fireplace, were tested for germination, they showed higher germination and vigour than non-smoked seeds.

Other studies also indicate that indigenous practices are still used for preserving crops in other African countries. For instance, Gana (2003) found that small-scale farmers in the three villages in Nigeria had developed an interest to use indigenous materials, which were deemed effective, safe and cheap for preserving food crops. The study concluded that there was need for promoting and sharing knowledge related to local practices of preserving 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, locally made sacks, on kitchen shelves, in pots and baskets. The present study found that the use of granaries which were located outside farmers' houses and hanging cobs of maize on tree tops were still very common in the studied villages because there were very few cases of theft.

Application of IK on agro-biodiversity to climate change adaption

Respondents of FGD were asked to state how they used IK to cope with vulnerability, especially those arising from climate change. Their responses revealed that IK was used in several ways including use of fruit stands 7 (87.5%), cover crops 7 (87.5%), early maturing crops 7 87.5%), drought resistant crops 6 (75.0%), use of NTFPs 6 (75.0%), use of ridges 6 (75.0%), mixed and row intercropping 6 (75.0%), long term fallow 4 (50.0%) and other methods as shown in Table 4.

Table 42: Methods used by local communities to cope up with vulnerabilities and shocks caused by weather and soil fertility changes: data from FGDs N=8

Method used	Frequency	Percent
Use of mineral fertilizer	1	12.5
Use of legume crops	3	37.5
Use of long term fallow	4	50.0
Use of short term fallow	3	37.5
Use of Agroforestry	3	37.5
Use of tree leaves	1	12.5
Uses mixed and row intercropping	6	75.0
Plants crops on ridges	6	75.0
Plants cover crops such as sweet potato	7	87.5
Plants early maturing crops like sesame	7	87.5

Plants drought resistant crops like cassava, sweet potato	6	75.0
Uses fruit stands that have been planted long time	7	87.5
Uses forest products (NTFPs)	6	75.0

Source: Field survey, 2012

According to Jackson *et al.* (2007), the maintenance of agro-ecosystems using intercropping is beneficial in that there are lower pest and pathogen incidences found in intercrops, and there is higher resource use efficiency of crops with different root systems and leaf morphology. Thus, the communities in the study area have practised intercropping for a long time, exploiting the benefits resulting from these cropping systems, including sustaining crop yields thereby enhancing food security.

Other methods of coping with climate change include; (i) soil moisture conservation technique such as growing crops on ridges instead of flat cultivation and using of cover crops such as sweet potato, (ii) growing early maturing crops like sesame, (iii) growing drought resistant crops like cassava and sweet potato and sesame, (iv) using fruit tree stands (mangoes and cashew) which have been planted in the past to provide food and cash income during periods of bad weather to short seasonal crops, and (v) using forest products to compensate for poor crop yield during periods of bad weather. Some families engaged in making various marketable products bamboo products and buy food from the sale proceeds. For instance indigenous knowledge regarding the diversity of products, which can be made from bamboo have attracted many families in the study area to collect bamboo for sale to craftsmen local artisans. The use of bamboo is because poles are cheaper, available and can be used to produce a wide range of artisanal items like woven mats and baskets, as well as baskets for harvesting, drying, winnowing *(nyungo)*, large baskets for carrying different products (*tenga*), and containers for storing agricultural produce (*vihenge*). Bamboos are also used for construction of walls, roofing and fencing during house construction.

Similar findings have been observed in Chotanagpur plateau in India where Jaipal *et al*. (2012) also found that rain water harvesting and soil conservation techniques were also used by the farmers to avoid the scarcity of water during the summer.

3.2 Contribution of IK on agro-biodiversity to livelihood enhancement

The second objective of the present study sought to identify how the existing indigenous knowledge on agro-biodiversity contributes to adaptation to the adverse effects posed by climate changes and how such adaptations impact on livelihoods of local communities in Masasi and Nachingwea districts in Tanzania.

Effects of livelihood strategies to climate change adaptation following application of IK

Farmers were asked why they left trees standing in their crop fields, in effect practicing agroforestry. Most of them indicated that they had accumulated extensive knowledge and experience on how crops and trees contribute to their livelihoods, providing food 226 (98.3%) and generating cash income 212 (92.2%) various timber and non-timber products. Some of the respondents also noted that the interaction between trees, crops, which improved soil fertility through soil conditioning 101 (44.3%) and providing soil nutrients from decomposing fallen leaves 60 (26.1%). Others stated that trees left in farms are used for fuel 13 (5.7%), ornamentals such as *Syzygium cuminii, Adansonia digitata and Tamarindus indica* 5 (2.2%), provided human and animal medicine 5 (2.2%) (Table 5).

Table 5: Benefits from intercropping with trees

Benefits	**Sex**			
	Female		**Male**	
	Frequency	**Percent**	**Frequency**	**Percent**
Food	92	40.7	134	59.3
Fuel	4	30.8	9	69.2
Income	86	40.6	126	59.4
Medicine for humans and animals	2	83.3	1	16.7
Ornaments	2	40.0	3	60.0
Soil conditioner in farms	46	45.5	55	54.5
Soil nutrients from decomposing leaves	30	50.0	30	50.0

Source: Field survey, 2012

In addition to indigenous related benefits that accrue from planted crops and trees the respondents also mentioned many other benefits they derive from neighboring forests, where they use IK to obtain food and other benefits.

Focus Group Discussions and household interviews showed that a number of NTFs are extracted from the land adjacent to the communities. This is done using indigenous knowledge on seasonal availability, type of plants, use of wild plants, processing of edible plants and preservation of these products. 126 (92.6%) respondents reported firewood, 45 (33.1%) bamboo, 45 (33.1%) wild fruits, 37 (27.2%) poles, 36, 26.5%) charcoal, 30 (22.1%) wild vegetables, 20 (14.8%), mushroom, 8 (5.9%) honey and 7 (5.1%) plant medicine as NTFs collected from the general land adjacent to the communities (Table 6). These have been useful, providing income to offset periods of food as well as cash income hence contributing to avert the negative impacts of climate change.

Table 6: Percentage distribution of major wild products collected from surrounding land and forests by communities in Masasi and Nachingwea districts

Product	Sex			
	Female		Male	
	Frequency	Percent	Frequency	Percent
Firewood	59	46.8	67	53.2
Poles	13	35.1	24	64.9
Plant medicine	0	0.0	7	100
Honey	1	12.5	7	87.5
Mushroom	4	20.0	16	80.0
Fruits	15	33.3	30	66.7
Vegetables	8	26.7	22	73.3
Wild animals	3	23.1	10	76.9
Charcoal	16	44.4	20	55.6
Bamboo	17	37.8	28	62.2

Source: Field survey, 2012

Firewood is the main source of energy in most rural areas in subsaharan Africa used for cooking, heating and bricks burning. The respondents in this study also used IK in using firewook for different purposes. Some of the tree species identified by the respondents and used for firewood were similar to tree species identified by Kilonzo (2009) and Bevan (2003). These includede *Burkea africana*, *Brachystegia bussei*, *Pseudolachnostylis maprouneifolia, and Dalbergia melanoxylon.* Local communities prefered these species due to their high calorific value, having less ash and less smock.

Fruits were collected seasonally mostly by female and male children especially during food shortage periods. The fruit types most frequently collected include: -*Syzygium cuminii (Zambarau), Adansonia digitata (Ubuyu), Tamarindus indica (ukwaju), Schererocarya birea (embe ng`ongo pori)* and *Annona senegalensis (mtope mwitu)*. Other fruit tree species identified during focus group discussion using local names include; *Nachipondo, Nakasonga, Msakalawe, Mpindimbi, Ndawatawa, Mpitimbi and Mpulukututu*. Similar utilization of wild plants as food have been reprted in other countries as well. For instance, Ermias, *et al.* (2011) reported that rural people in Ethiopia are endowed with profound knowledge on the use of wild plants. .

4. CONCLUSIONS AND RECOMMENDATIONS

This study examined the application of indigenous agro-biodiversity knowledge in climate change adaptation by farmers residing in selected villages of Masasi and Nachingwea districts in Mtwara region. The paper also discussed the effects of such adaptation on food security and cash income of among local communities in the study area. The findings revealed that local communities possess a broad base of IK which they have accumulated and used over the years. Such knowledge has been valuable for coping with climatic change to ensure their survival. Based on the findings it is recommended that:

- Indigenous agro-biodiversity knowledge should be harnessed to foster survival of local communities and experiment and adapt similar knowledge at other localities.
- There is a need for promoting and sharing knowledge related to local practices such as intercropping, preserving crops, and the use of Non Timber Forest Products.

6. Acknowledgement

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