Application of Local Agro-biodiversity Knowledge for Climate Change Adaptation 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 local knowledge (LK) related to agro-biodiversity surrounding the local communities and how that knowledge contributes to adaptation to climate changes. The study employed two research designs namely a case study and a cross sectional survey. Hence, a combination of tools including Focus Group Discussions (FGDs), key informant interviews and semi-structured questionnaires, were used for data collection. The research findings showed that farmers possess a wide range of indigenous knowledge on agro-biodiversity which they use in adapting to climatic changes. The type of 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 promoted and used in other similar localities to foster the farmers' ability to adapt to climate changes.

Key words: *Local knowledge, agro-biodiversity, climate change adaptation*

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 temperature will increase by 0.2 - 0.5° c per decade (Chimbari, 2010). Such increase in temperature will likely be associated with increased disease and parasitic vectors, more severe droughts, increased rainfall and shortened rainfall seasons, which will not be enough for supporting growth of food crops and pastures production (Chimbari, 2010). Such negative impacts will likely lead to food shortage, health and economic problems in many African regions (op. cit).

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 unreliable onset of the rainy season as the worst stress factors associated with climate change. The study found further 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. In the light of these occurring and expected calamities, it has been found that Local Knowledge (LK) is increasingly being used by local communities to adapt to the situation. The term local knowledge (LK) is used interchangeably by various scholars from different school of thoughts to also refer to one of the following concepts: traditional knowledge, indigenous knowledge, community knowledge, traditional ecological knowledge, local knowledge, traditional environmental knowledge, cultural heritage, traditional medicine, cultural property, indigenous heritage, indigenous cultural and intellectual property rights, indigenous intellectual property, customary heritage rights, innovations and practices, and popular culture or intangible component (WIPO, 2002). In this study, local knowledge is used to encompass all the terminologies above.

The term local knowledge (LK) is often used to refer to indigenous knowledge. Local knowledge refers to the knowledge possessed by any group living off the land in a particular area for a long period of time (Langill, 1999). Meanwhile, indigenous knowledge (IK) tends to emphasize knowledge that is internal to a particular setting and thus differs from local knowledge, which also embraces exogenous knowledge that has entered into the local community over time (vanVlaenderen, 2000). In this situation, it is not important whether the people under study are the original inhabitants of an area or not. The main aim of this paper is to explore how people interact with the environment in order to improve their knowledge base and farming activities in order to adapt to climate change. The study adopted the broader concept of local knowledge, which encompasses both indigenous knowledge and knowledge that is brought from outside but has become a practice among the local people. The two terms (indigenous knowledge and local knowledge) are therefore used interchangeably in this paper.

Local knowledge (LK) is largely used by local communities to guide decision-making on various aspects of their livelihoods including maintenance of agro-biodiversity (Du Plessis, 2002; Ngulube, 2002; Ellen and Harris, 2000). Agro-biodiversity includes the diversity of species, varieties, breeds and natural population of fauna and flora that interact with agro-ecosystems or contribute directly to food security (Koda, 2003). Agro-biodiversity helps farmers to maintain livelihoods in the face of pest infestation, uncertain rainfall, fluctuating prices of crops that are marketed, socio-political disruption and unpredictable availability of agro-chemicals. For instance, the so-called minor or underutilized crops are frequently grown side by side with the main staple or cash crops, but, their importance is often underestimated. In many cases, from a livelihoods perspective, they are not minor or underutilized; rather they play an important role in food production systems (IK Notes, No 23, August 2000). Plants that grow in infertile or eroded soils, and livestock that feed on degraded vegetation, are crucial to household nutritional strategies. Many rural communities and urban markets make substantial use of these companion crop species.

It is acknowledged that application of LK for maintaining agro-biodiversity provides the rural poor with numerous benefits and opportunities. These include; the capacity to address environmental conditions, provision of food and nutritional supplies, access to local market opportunities, and options to cope with evolving needs such as adaptations and mitigations against climate change effects (Akuja, 2010). Most farmers, especially those residing in environments where high-yielding crop varieties and livestock species do not perform well apply LK for growing underutilized crops to adapt to climate change, thereby reducing its adverse effects. Thus, adaptation to climate change also helps local communities in ensuring food security (Westengen and Brysting, 2014; Otto, 2013).

Crop impact studies from sub-Saharan Africa (SSA) indicate that in developing countries, livelihoods depending on agriculture require adaptation because they are particularly vulnerable to changes in climate (Westengen and Brysting, 2014). 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, which involves changing to crop species or varieties that are resistant to climatic stress, is among the most cited adaptation measures (Westengen and Brysting, 2014). Climate adaptation measures have also included a combination of local and formal strategies. For instance, the top three ranking strategies including shifting cropping area, switching to drought tolerant varieties and shifting planting date were used to address climate change effects in Morogoro (Westengen and Brysting, 2014).

While it is known that local knowledge can contribute immensely towards reducing some of the negative impacts of climate changes to local community lives, LK remains largely not assessed in Masasi and Nachingwea districts in the southern part of Tanzania. Moreover, knowledge harnessed by farmers is not accorded the same importance by the scientific community as conventional knowledge (Kilongozi, Kengera and Leshongo 2005). The present study sought to establish how the existing local knowledge on agro-biodiversity contributes towards adaptation to climate change adverse effects in Masasi and Nachingwea districts in Tanzania.

Methodology

This study was carried out in Nachingwea district, Mtwara region and in Masasi district, Lindi region in Tanzania. The two districts are located in the southern part of Tanzania, approximately 600 km from Dar es Salaam. Purposive sampling was used to select two districts and four villages from each district under the study. The 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 (Lindi and Mtwara towns respectively) 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, therefore are not very suitable for farming activities (URT, 2009). Two criteria were used to select study villages: (i) Proximity to the Chiwale general land which has considerable biodiversity (ii) agriculture being the main livelihood activity for most people, and is currently climatically stressed.

The research employed case studies and a cross-sectional survey to address the study objectives according to Creswell and Plano-Clark (2007). Qualitative methods such as focus group discussion (FGD) and quantitative tools involving a structured questionnaire were used for data collection and analysis. Two key informants were selected from each village, making a total of 16 informants. Selection of FGDs participants considered age, education and gender in order to get a mixture of responses across demographic characteristics. The FGD in each village comprised of 8 to 12 people. Qualitative tools were used to collect data on socio-cultural aspects (which may influence use of local knowledge in the management of agro-biodiversity) while questionnaire was used to collect data on the socio-economic overview of households and dependence on indigenous knowledge in agro-biodiversity management for adapting to climate change.

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. The sample size for the survey comprise of 230 heads of households drawn from 8 villages as shown in Table 1.

Respondents for interviews using the structured questionnaire were selected using systematic sampling because there was a complete list of respondents in the village government registers in the study villages. The method was preferred in order to get evenly spread sample from the sampling frame which was developed for each village from the village government register.

Table 1: Number of respondents for the villages studied

Village	Number of households in the village	Sample size at minimum of 5%	Actual sample size
Mwenge	519	26	30
Ikungu	597	30	30
Kivukoni	1082	54	29
Mkwapa	550	28	26
Muungano	535	27	30
Naipingo	852	43	28
Namatula (B)	546	27	27
Nambaya	475	24	30
Total	**5156**	**259**	**230**

Survey data were 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 and content analysis was used for qualitative data.

Results and Discussion

Various types of LK that are available and used by local communities in adapting their farming practices and agro-biodiversity to climate change were identified. Adaptation of farming practices and agro-biodiversity to climate change and their contributions to livelihoods and food security among local communities were also identified.

Local knowledge on soil types

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% had soils rich in clay and 7% reported that their farms were rich in loam soils. Similar soil-types exist in the Coastal areas of Mtwara, which are dominated by two geological zones, have been reported in URT (2010). The first zone consists of 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 vertisals. Furthermore, coastal limestone as part of the coastal zone produce red, are well drained heavy textured soils. The second zone comprises of pre-Cambrian basement rocks consisting of gneisses and granulites that extend west of the coastal sediments (URT, 2010). Soils produced from this zone comprise of deep, well drained, red clays to the north of Masasi town. These are the best soils suitable for upland crops grown in the district.

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 an important criterion used by farmers to assess the quality of a piece of land for crop farming. Other important 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 reported by Bailey (2003) in Jamaica, Price (2007) the Philippines and Akullo *et al.* (2007) in Uganda. The latter 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. By growing appropriate crops based on the identified soil types, farmers are able to harvest a sizeable yield that affords them food and surplus for sale, contributing immensely to their livelihoods. 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 summer. This enabled farmers to obtain good crop yield in the event of rainfall scarcity and hence a mechanism for climate change adaptation.

Local 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 mono-cropping system. In both districts, the dominant intercropping system involved maize and pigeon peas, which was practiced by 21.3% of the respondents. This was followed by the combination of maize, cassava and pigeon peas which was practiced by 17% of the respondents (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**

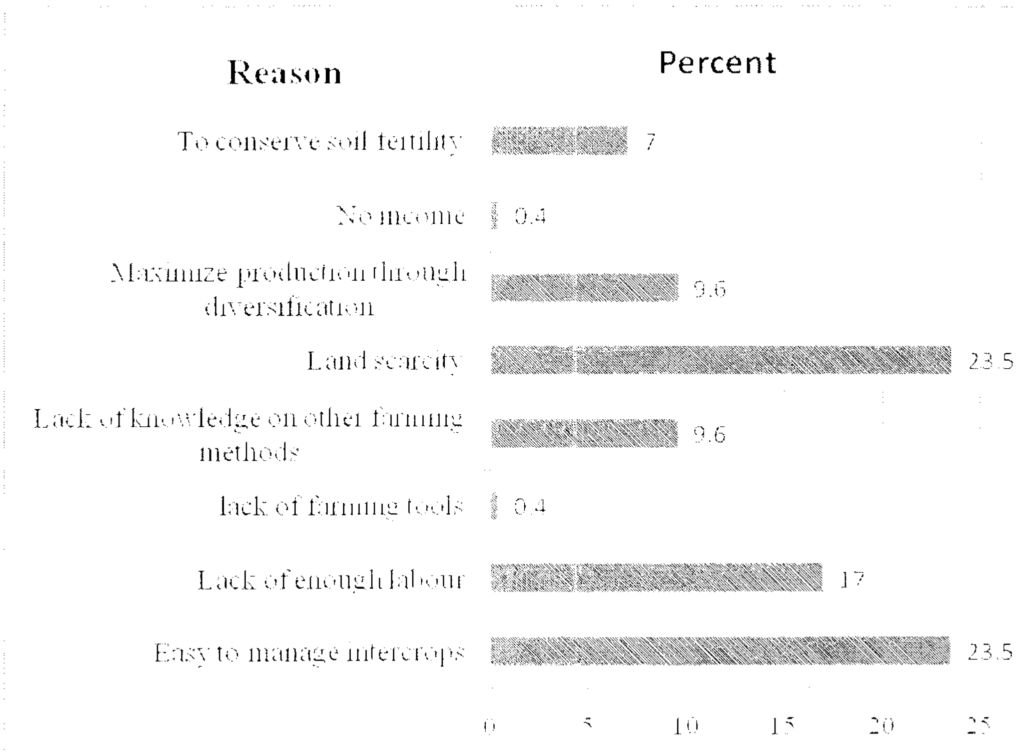

Figure 1: Reasons for intercropping

Respondents were asked to state why there was widespread use of intercropping in the study area. The results presented in Figure 1 indicate multiple reasons for adopting the practice. The reasons include land shortages.

easy to manage intercrops, inadequate labour, inadequate knowledge on other farming methods, and maximization of production through diversification. Other reasons were conservation of soil fertility, inherited culture, lack of farming tools and lack of income.

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. This is an important aspect in averting climate changes since some crops thrive better than others in the event of drought and wet situations. 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 used as a strategy for soil fertility restoration, which is consistent with findings by Dejene *et al.* (1997) who established that intercropping was a dominant practice that was used to enhance soil fertility in Dodoma region. However, some other studies in Tanzania have found more than one practice 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 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.

According to Jackson *et al.* (2007), maintaining agro-ecosystems using intercropping is beneficial in that there are lower pest and pathogen incidences within an intercropped area, and there is a 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.

Adapting farming practices and agro-biodiversity to climate change

The methods of adapting farming practices and agro-biodiversity to 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 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. Bamboo provide poles that 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.

Local knowledge on post-harvest preservation of crops

Centuries of practical experience in preserving planting materials have given local farmers 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. Local practices and facilities were used by more farmers than conventional inputs and facilities.

Table 3: Post-harvest preservation of crops (N=230)

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

Respondents mentioned a wide range of both conventional and indigenous crop preservation methods. For example, out of 230 respondents, 69.6% mentioned polythene bags, 42.2% mentioned hanging harvested crops over the kitchen hearth, 37.8% mentioned granary outside the house, 35.2% used granaries inside the house, 23.9% hanged crops on trees, 23.5% used plastic containers, 21.3% used synthetic pesticides and 4.8% used ash to store seeds. Only one (0.4%) farmer mixed crops with mud as a post harvest preservation method (Table 3). These methods were mainly used to preserve grains such as shelled maize and pigeon peas. Mixing crops with ash and hanging crops on trees were also used for storing unshelled maize and pigeon peas pods on stem. Many famers also used conventional methods of crop storage, polythene bags taking a lead among the other conventional methods.

Farmers stated that seeds stored using traditional methods were resistant to pests, viable and safe unlike those stored using chemical pesticides. Moreover, such seeds were affordable, since farmer did not have to buy from the market. In terms of climate change adaptation, farmers stated that such seeds are not subject to pest attack, resulting from changes in climate, because of having more resilience than seeds preserved using conventional methods. Moreover, they do not have to buy seeds therefore use the savings to supplement other household requirements. Other studies have also reported the superiority of seed preserved using traditional methods compared to seeds preserved using synthetic chemicals. In a study conducted in South Africa, maize seeds, which had been preserved by smoking showed higher germination and vigour than non-smoked seeds (Modi, 2004). Indigenous practices used in preserving crops by small-scale farmers in three villages in Nigeria were reported to be safe and cheap (Gana, 2003). Another study conducted by Agea *et al.* (2008) in Uganda similarly found that majority of households in Mukungwe sub-county stored their food in granaries, locally made sacks, on kitchen shelves, as well as in pots and baskets.

Application of agro-forestry IK in adapting to climate change

Farmers were asked why they left trees standing in their crop fields, in effect practicing agro-forestry. Most of them indicated that they had accumulated extensive knowledge and experience on how crops and trees contribute to their livelihoods, providing food (98.3%) and generating cash income (92.2%) from various timber and non-timber products. About 44.3% of the respondents also noted that the interaction between trees and crops improved soil fertility through soil conditioning. Another 26.1% provided soil nutrients from decomposing fallen leaves. Others (5.7%) stated that trees left standing within farms are used for fuel, yet other respondents (2.2%) said trees within farms were used as ornamentals. These included; Syzygium *cuminii, Adansonia* *digitata and Tamarindus indica.* A similar proportion (2.2%) said trees provided human and animal medicine (Table 4).

Table 4: Benefits from intercropping with trees (N=230)

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

In addition to indigenous related benefits that accrue from planted crops and trees, the respondents mentioned many benefits they derive from neighboring forests, where they use IK to obtain food and other benefits. Findings from FGD and household interviews showed that a number of Non Timber Forest Products (NTFPs) are extracted from the land adjacent to the communities. Again, out of 230 respondents, about 92.6% collected firewood from the forest, another 33.1% collected bamboo, 33.1% collected wild fruits, 27.2% collected poles, 26.5% charcoal, 22.1% wild vegetables, 14.8% mushroom, 5.9% honey and 5.1% plant medicine as NTFPs collected from the general land adjacent to the communities (Table 5). These have been useful, providing income to offset periods of food and cash income shortages, hence contributing to avert the negative impacts of climate change.

Firewood is the main source of energy in most rural areas in Sub-saharan Africa used for cooking, heating and bricks burning. Some of the tree species identified by the respondents that were used for firewood were similar to tree species identified by Kilonzo (2009) and Bevan (2003), which included *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.

Table 5: Percentage distribution of major wild products collected from surrounding land and forests by communities in Masasi and Nachingwea districts (N=230)

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

Fruits from nearby forests were collected seasonally mostly by female and male children especially during periods food shortage periods. The fruit types most frequently collected include: -*Syzygium cuminii* (*Zambarau*[5]), *Adansonia digitata* (*Ubuyu*[1]), *Tamarindus indica* (*ukwaju*[1]), *Schererocarya birea* (*embe ng`ongo*[1]) 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 food plants have been reported in other countries as well. For instance, Akuja (2010) reported that rural people in Ethiopia are endowed with profound knowledge of wild plants. The most common fruits consumed in Ethiopia are from plant species such as *Ficus*, *Carissa edulis* and *Roso abyssnica*. It is further reported that the consumption of wild plants is more common and widespread in food insecure areas. Thus local people know the importance and contribution that wild plants make to their daily diets.

Conclusions and Recommendations

This study examined the application of local agro-biodiversity knowledge in climate change adaptation by farmers residing in selected villages of Masasi and Nachingwea districts in Mtwara region. Findings revealed that local communities possess a broad base of LK which they have accumulated over generations as well as additional knowledge, which they have acquired from outside their areas. Such knowledge has been valuable for coping and adapting with climatic change, to ensure their survival. Based on the findings it is recommended that local agro-biodiversity knowledge such as on

[5] The name in brackets are names of fruits in Kiswahili

intercropping, preserving crops and the use of non-timber forest products should be used in similar localities to adapt to climate change. Moreover, it is recommended that there is need for promoting and sharing knowledge related to local practices of preserving crops.

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References

Akuja, E. T. (2010). Agrobiodiversity in Food Security and Nutrition. In: Mungai, 2010 (ed). *Agrobiodiversity Conservation and Sustainable use in Enhancing Food Security (a training manual).* Everton University with FAO-Netherlands Partnership Program, 2010.

Akullo, D., Kanzikwera, R., Birungi, P., Alum, W., Aliguma, L. and Barwogeza, M. (2007). Indigenous knowledge in agriculture: a case study of the challenges of sharing knowledge of past generations in a globalised context in Uganda. Paper read at the World Library and Information Congress: 73rd IFLA General Conference and Council, Durban, South Africa, 19-23 August 2007. [Online].http://www.ifla.org/IV/ifla73/papers/120-Akullo_Kanzikwera_Birungi_Alum_Aliguma_Barwogeza-en.pdf. Accessed 28 July 2012.

Bailey, S. W. (2003). Farmers' perception of land degradation in the Pindars River valley, Clarendon. *Caribbean Geography* 13:130-144.

Chimbari, J. M. (2010). The implications of climate change for health in Africa. (ed.). *Joto Africa Magazine*, (5). pp. 7

Creswell, J. W. and Plano-Clark, V. L. P. (2007). *Designing and conducting mixed methods research.* Thousands Oaks: Sage Publications. pp.488

Dejene, A, Shishira, K. E, Yanda, Z. P and Johnsen, H. F. (1997). Land degradation: perception from the village. World Bank Technical Paper No. 370. Washngton, D. C. pp. 79

Du Plessis, H. (2002). Indigenous knowledge systems and technologies among artisans in India and South Africa. Paper read at the 7th International Conference on Public Communication of Science and Technology, 5-7

Conference on Public Communication of Science and Technology, 5-7 December 2002. [Online]. http://www.saasta.ac.za/scicom/pcst7/duplessis.pdf. Accessed 14 February 2011.

Ellen, R and Harris, H. (2000). Introduction. In Ellen, R., Parkes, P. and Bicker, A. (eds). Indigenous environmental knowledge and its transformations. *Amsterdam: Harwood Academic Publishers. pp. 1-33.*

IK Notes, No 23. August (2000). Seeds of life: Women and agricultural biodiversity in Africa. [Online]. http://www.fao.org/docrep/007/y5609e/y5609e02.htm#TopOfPage. Accessed 12 November 2011.

Jackson L. E., Pascual U, Hodgkin T. (2007). Utilizing and conserving agro-biodiversity in agricultural landscapes. *Agric, Ecosyst. And Environ*, 121: 196-210

Jaipal S. C, Gopal S, Prabhakar C. S, Sudarshan M, Bikash D and Shivendra K (2012). Assessment of local perceptions on climate change and coping strategies in Chotanagpur Plateau of Eastern India. *Journal of Progressive Agriculture*, Vol. 3, No. 1; April 2012.[Online].http://www.academia.edu/4228628/Assessment_of_local_perceptions_on_climate_change_and_coping_strategies_in_Chotanagpur_Plateau_of_Eastern_India. Accessed 12 June 2014.

Kilongozi, N., Kengera, Z. and Leshongo, S. (2005). The utilization of indigenous knowledge in range management and forage plants for improving livestock productivity and food security in the Maasai and Barbaig communities of KIBAHA. Links Project 41. [Online]. http://www.fao.org/docrep/009/a0182e/A0182E00.HTM. Accessed 22 March 2007.

Kilonzo, M. (2009). Economic Valuation of Non-Timber Forest Products used by communities around Nyanganje forest reserve in Morogoro, Tanzania. MSc. Dissertation, SUA, Morogoro, 112pp.

Koda, B. (2003). Research needs for understanding of local knowledge systems for strengthening agricultural and rural development: the Tanzanian context. [Online]. http:// www.fao.org/sd/links. Accessed on 14 February 2011.

Langill, S. (1999). *Indigenous knowledge: a resource kit for sustainable development researchers in dryland.* Ottawa: IDRC. [Online]. http://idrinfo.idrc.ca/archive/corpdocs/114518/ikkit.pdf. Accessed 20 February 2010.

Lwoga, E. (2010). Application of knowledge management approaches and information and communication technologies to manage indigenous knowledge in the agricultural sector in selected districts of Tanzania. PhD theses. University of Kwazulu Natal. pp. 632

Modi, A. T. (2004). Short-term preservation of maize landrace seed and taro propagules using indigenous storage methods. *South African Journal of Botany 2004. 70 (1) : 16 2.* [Online]. http://www.nisc.co.za/oneAbstract?absId 284. Accessed 25 October 2013.

Price, L. L. (2007). Locating farmer-based knowledge and vested interests in natural resource management: the interface of ethnopedology, land tenure and gender in soil erosion management in the Manupali watershed, Philippines *Journal of Ethnobiology Ethnomed* 3 (30). [Online].http://www.ethnobiomed.com/content/3/1/30 16 June 2007. Accessed 28 July 2012

URT. (2009). The economic survey 2007. [Online]. http://www.tanzania.go.tz/bspeechf.html. Accessed 20 August 2010.

URT. (2010). Environmental and Social Impact Assessment (ESIA) final report for Tanzania Strategic Cities project – Mtwara municipality. January, 2010. pp. 20

Van Vlaenderen, H. (2000). Local knowledge: what is it, and why and how do we capture it? In Kauzeni A. S. (ed.) Selected papers from the First National Workshop held in Morogoro. FAO LinKS Report 2. pp. 1-11. [Online].
http://www.fao.org/sd/LINKS/documents/download/Selected%20paper s%20Morogoro%2099.pdf. Accessed 13 June 2011.

Westengen, O.T and Brysting, A. K. (2014). Crop adaptation to climate change in the semi-arid zone in Tanzania: the role of genetic resources and seed systems. Agriculture & Food Security, Vol. 3 (3): 2014. [Online]. http://www.agricultureandfoodsecurity.com/content/3/1/3. Accessed 13 June 2014.

World Intellectual Property Organization (WIPO) (2002). Intergovernmental committee on intellectual property and genetic resources, traditional knowledge and folklore. [Online]. http://www.wipo.int/edocs/mdocs/tk/en/wipo_grtkf_ic_3/wipo_grtkf_ic_3_9.pdf. Accessed 18 August 2010.