Global Advanced Research Journal of Agricultural Science (ISSN: 2315-5094) Vol. 8(2) pp. xxx-xxx, February, 2019 Issue.
Available online http://garj.org/garjas/home

Full Length Research Paper

Potentials and Utilization of Indigenous Fruit Trees for Food and Nutrition Security in East Africa

Benard O. Muok

Director Centre for Research, Innovation and Technology (CRIT) Jaramogi Oginga Odinga University of Science and Technology (JOOUST) P.O. Box 210, Bondo, Kenya
Email: bmuok@yahoo.com

Accepted 19 February, 2019

Although global food production has substantially increased in the past few decades, nearly 870 million people still live in hunger today, most of them in South Asia and sub-Saharan Africa. The harvesting, utilization and marketing of indigenous fruit trees and nuts have been central to the livelihoods of majority of rural communities throughout Africa and can make a difference during period of famine and food scarcity. Given the important role that IFTs play, concerted effort is needed to promote their utilization and commercialization for improved livelihoods in eastern Africa. This paper is based on a survey conducted to identify priority IFTs in east Africa with market potential. The survey was conducted in three east Africa countries of Kenya, Tanzania and Uganda particularly targeting the dry land areas. Selection of study villages in all the three collaborating countries was based on the on the abundance of IFTs and their utilization. A total of 10, 14 and 11 villages were used in the study from Uganda, Kenya and Tanzania respectively. The results showed that IFTS is still playing an important role as a dietary supplement in the rural areas. The study identified four IFTs as a priority in the Eat African region, which includes *Tamarindus indica*, *Vitex doniana or Vitex mombassae* and *Sclerocarya birrea*.

Keywords: drylands, East Africa, indigenous fruit trees, priority

INTRODUCTION

Food insecurity, poverty, malnutrition and environmental degradation are the major unprecedented challenges that confront developing countries today. Africa is facing a serious problem of not being able to feed its population or adequately meet its fuelwood demand (FAO, 2001). It is estimated that at the turn of this century the highest incidence (33%) of people chronically malnourished (especially vulnerable groups - women and children) will be found in sub-Saharan Africa (FAO, 2004). Frequent crop failure in the drylands often results in poor nutrition of the local people (Jama *et al.,* 2008). Therefore, it is imperative to find other sources of getting food for the growing population. Surprisingly, Africa has abundant wild plants and cultivated native species with great agronomic and commercial potential as food crops, but many of these species, particularly the fruit trees have not been promoted or researched and therefore remain underutilized (Gebauer *et al*., 2002).

Indigenous Fruit Trees (IFTs) are recognized as a significant source of essential nutrients as well as a source of income (Mithofer and Waibel, 2003; Gunasena and Hughes, 2000; Leaky and Simon, 1998). Rural people in

Africa periodically rely on wild fruits to supplement their diet and to generate cash income essential for purchasing required household goods in rural areas. While East Africa possesses high potential resources like IFTs, poverty, food insecurity, malnutrition and environmental degradation remain some of the major problems facing the region. There is a considerable wealth of indigenous knowledge among farmers and rural communities in the drylands on the value and uses of these fruit tree species. However, there is little domestication of these trees. Most of what is used is collected from the wild, and communities living in drylands often rely on nature to supply indigenous fruit tree products. Unfortunately, each year more and more of these wild trees are being destroyed through processes such as charcoal production and expansion of agriculture because IFTs simply do not hold their own in commercial terms - even though this means losing favored food items and a source of insurance against critical scarcity during drought (Muok *et al.*, 2000).

Despite the huge contribution of edible IFTs to local communities, it is noted that less importance is given to these species by research institutions in East Africa (Chikamai *et al.,* 2004), hence they are not highly promoted due to lack of basic information on their indigenous and conventional knowledge for their domestication, processing and commercialization. The national research institutions in east Africa have long recognized the role and potential of indigenous fruits as a reliable supplemental household food and income supply source, especially in dryland areas. Improving production/domestication and marketing of IFTs is one way to improve rural livelihoods, food security and national economies as a whole. However, there are big gaps in knowledge, which need to be filled beforehand. The synthesis report on IFTs in east Africa (Chikamai *et al.*, 2004) revealed that there very limited research work on IFTs in the region. It is however, surprising to note that fruit diversity in East Africa is not exploited as elsewhere in West and Central Africa for the benefit of poor people, where few emerging fruit trees such as shea butter trees (*Vitellaria paradoxa*) and African plum tree (*Dacryodes edulis*) have an important local and international market.

Given the important role that IFTs play, concerted effort is needed to promote their utilization and commercialization for improved livelihoods in eastern Africa. This paper is based on a survey conducted to identify priority IFTs in east Africa with market potential.

MATERIALS AND METHODS

The survey was conducted in three east Africa countries of Kenya, Tanzania and Uganda. Field activities in Uganda focused in the northeastern and mid northern drylands of Teso and Lango sub-regions respectively. Most of the areas in these two sub-regions lie in the dryland belt and are popular for production and consumption of IFTs. Teso sub-region lies between $0^0$55' – 2025'N and $22^0$55' - 34030'E. It covers an area of 14,879.6km^2 and has a population of about 1.2 million people. The rainfall received ranges from 850 – 1,500 mm annually and means annual temperature is 23.8^{0}C. Altitude ranges between 1,036 – 1,219 m above sea level (Fountain Publishers, 2005). Lango sub-region lies between $1^0$30' - 2^0 35'N and $32^0$05' – $33^0$35'E and it covers an area of 13,741.9 km^2 with a population of approximately 1.3 million people. Annual rainfall ranges from 1,000 – 1,500 mm and average minimum and maximum temperatures are 22.5^{0}C and 25.5^{0}C, respectively. Altitude ranges from 700 – 1,140 m above sea level (Fountain Publishers, 2005).

In Kenya, field activities covered four counties, namely; Homabay, Kilifi and Migori. These districts were selected based on abundance and availability of IFTs. Kilifi County is one of the six counties in the coast region. The county lies between latitude 2^0 20 seconds and 4^0 0 seconds South, and between longitude 39^o 05 seconds and 40^0 14 seconds East. It borders Kwale County to the southwest, Taita Taveta County to the west, Tana River County to the north, Mombasa County to the south and Indian Ocean to the east. The county covers an area of 12,609.7 km^2. The average annual rainfall ranges from 300mm in the hinterland to 1,300mm at the coastal belt. The coastal belt receives an average annual rainfall of about 900mm to 1,100mm with marked decrease in intensity to the hinterland. Areas with highest rainfall include Mtwapa and to the north of the coastal strip around the Arabuko Sokoke Forest. Evaporation ranges from 1800mm along the coastal strip to 2200mm in the Nyika plateau in the interior. The highest evaporation rate is experienced during the months of January to March in all parts of the county. The annual temperature ranges between 21^{0}C and 30oC in the coastal belt and between 30^{0}C and 34^{0}C in the hinterland.

Migori County has an altitude varying between 1140m at the shores of Lake Victoria in Nyatike Sub-county to 4625m in Uriri Sub-county and annual rainfall averages between 700 and 1,800 mm. The survey was conducted in lakeshore divisions of Nyatike, Karungu, Kegonga and Muhuru divisions have comparatively harsher climatic conditions than other divisions. The lakeshore divisions experience unreliable and poorly distributed rainfall. Temperatures show mean minimum of 24^{0}C and maximum of 31^{0}C, with high humidity and a potential evaporation of 1800 to 2000 mm per year.

In Baringo County the study targeted the lower catchment, focusing on the administrative locations of Ng'ambo and Loboi of Marigat Division. The area is mainly a rangeland classified as an arid and semi-arid land (ASAL). The area is a host to Lake Bogoria. Lake Bogoria (34 km^2) is a salt-water lake that is globally renowned for supporting a large population of migratory birds. Average annual rainfall is 650 mm and temperatures vary from 30°C to 35°C. Native vegetation comprises Acacia trees (mainly

Table 1: Study villages in Uganda, Kenya and Tanzania

Uganda		**Kenya**		**Tanzania**	
District/sub county	**Village**	**County/Division**	**Village**	**District/Division**	**Village**
Dokolo		***Kilifi***		***Tabora***	
Dokolo	Aturi/Atama	Bahari	Kibarani	Kanyenye	Tabora
Bata	Onekocaani	Bamba	Mikamini		Mjini
Agwata	Agengi	Chonyi	Dzitsoni	Ndevelwa	Inara
Lira				***Uyui***	
Adekogwok	Awangdyang	Malindi/Dabaso/Gede	Gede-Magangani	Lolangulu	Lolangulu
Amac	Odipabung				Mbola
Abako	Abako corner			Misha	Misha
Katakwi					Itanga
Magoro	Ajamaka	**Migori**		Mabama	Mabama
Usuk	Amoru	Karungu	Rabuor	***Mufundi***	
Soroti		Nyatike	Obware	Komolo	Changarawe
Katine	Ogwoolo	***Homabay***			Luganga
Gweri	Abia	Nyarongi	Nyarongi r	Nyororo	Nyororo
			Nguku		
			Kwabuai		
		West Karachonyo	Samanga		
			Kowili		
			Kodhoch		
		Baringo Marigat	Iljamus		
		Lobai	Lake Bogoria		

Acacia tortilis) in association with *Boscia* spp. and *Balanites aegyptiaca*, and bushes of *Salvadora persica*. Human population density is relatively low, about 20 persons per km^2. The main sources of cash income are from sale of livestock and honey. The main land use is livestock grazing, combined with some crop agriculture around homestead sites. Lake Bogoria National Reserve is reserved for habitat and species conservation, with local and international tourism generating some revenue. The two locations have faced a serious problem of invasive species *Prosopis juliflora* adding to the misery of the already marginalized communities.

In Tanzania, the project field activities were carried out in the semi-arid western region of Tabora (4° to 7° S and 31° to 34° E) with estimated population of 1.7 million (URT, 2003). Tabora is one of the areas in Tanzania facing severe poverty and food shortages. The region covers an area of about 76,500 km^2 out of which 31% is arable land and 69% is forest reserves. The regional population density is estimated at 23 people per km^2. The region has a unimodal rainfall pattern with a long dry season of 5-6 months. Annual rainfall, mainly from November to May, ranges between 700 and 1,000 mm often very erratic and poorly distributed. Temperatures are uniformly high, ranging from a mean minimum of 17°C to a mean maximum of 28°C. Tabora is part of the vast central plateau of Tanzania, an area of generally low relief most of which lies between 1,100 and 1,300 m above sea level. Soils are sandy and the vegetation is typical of the deciduous miombo woodlands, which occurs throughout the southern interior of Africa.

Selection of study villages in all the three collaborating countries was based on the on the abundance of IFTs and their utilization. A total of 10, 14 and 11 villages were used in the study from Uganda, Kenya and Tanzania respectively (Table 1).

In each district, the research team in consultation with the district technical staff recruited field assistants who were briefed about the IFTs research work and trained on how to conduct the focus group discussion and administer the individual questionnaire. In each selected village, the first task consisted of identification of stakeholders (farmers, processors, collectors) involved in IFTs-related activities. This was followed by focus group discussions,

Table 2: Percentage of respondents familiar with different IFTs in East Africa

Species	*Uganda (N=130)*	*Kenya (N=61)*	*Tanzania (N=91)*
Adansonia digitata	-	4.9 (7)	7.7 (8)
Annona senegalensis	6.2 (8)	-	-
Balanites aegyptiaca	10.8 (7)	4.9 (7)	-
Borassus aethiopum	16.9 (5)	-	
Boscia coriacea	-	6.6 (5)	-
Bridelia micrantha	1.5 (12)	-	-
Carissa edulis	40.0 (3)	23.0 (2)	-
Dioscorea bulbifera	1.5 (11)	-	-
Flacourtia indica	-	-	9.9 (7)
Friesodielsia obovata	-	-	2.2 (15)
Garicinia buchananii	-	-	7.7 (8)
Grewia molis	2.3 (9)	-	-
Hymenaea verrucossa	-	1.6 (14)	-
Landolphia kirkii	-	3.3 (9)	-
Manilkara sansibarensis	-	-	-
Pappea capensis	-	6.6 (5)	-
Pappea capensis	-	3.3 (9)	-
Parinari curatellifolia	-	-	6.6 (11)
Psidium guajava	-	-	3.3 (13)
Rhus natalensis	-	6.6 (5)	-
Rubus aperatus	-	-	3.3 (13)
Saba comorensis	-	3.3 (9)	-
Sclerocarya birrea	0.8 (14)	8.2 (4)	-
Strychnos cocculoides	-	-	31.0 (2)
Strychnos spinosa	0.8 (15)	-	-
Strychnos spinosa	-	1.6 (14)	-
Syzygium guineense	-	-	11.0 (6)
Tamarindus indica	83.8(1)	21.3 (3)	12.1 (5)
Uaparka kirkiana	-	-	25.3 (3)
Uvaria scheffleri	-	3.3 (9)	-
Vanguelia infausta	-	-	23.1 (4)
Vitellaria paradoxa	69.2 (2)	-	-
Vitex doniana	20.0 (4)	-	4.4 (12)
Vitex mombassae	-	-	54.0 (1)
Vitex payos	-	3.3 (9)	-
Ximenia americana	11.5 (6)	29.5 (1)	-
Ziziphus mauritiana	-	1.6 (14)	-

The values in parentheses are ranks

and individual interview using a semi-structured questionnaire.

Big community groups of 20 - 30 people were used to generate a list of the common IFTs in the village. In most cases a list of 10 - 20 IFTs were generated which the group then reduced to 10 species. After this exercise, the big group was sub-divided into smaller groups of 3 - 6 people based on gender and age. Much as there was variation from village to village, the following groupings were common; youth (below 25 years), Adults (25-45 years) and elderly (above 45 years). These three groupings were further sub-divided into male and female giving a total of six sub-groups per village.

In these sub-groups, the five top IFTs were then subjected to weighed scoring of ten (highest) - one (lowest) as developed during the project inception workshop (Muok and Kweka, 2006). The attributes scored were; food value, economic value, availability and other uses or attributes. After the scoring, the top three IFTs were considered for detailed discussion in the areas of processing, storage, marketing, conservation status and pest and diseases. Field assistants then guided the sub-groups to fill in a table, detailed information on each of the five priority IFTs. Finally, one farmer was randomly selected from each sub-group for administration of the individual questionnaire. A total of 282 respondents, were interviewed from the three countries, including 130 in Uganda, 61 in Kenya and 91 in Tanzania.

Data were coded and entered into MS Excel sheets. The percentage of respondents' preference was calculated for each IFT, as follow:

$$X_i(\%) = \frac{n_i}{N} \times 100$$; where:

X_i,: the percentage of groups having ranked the species *i* as priority IFT;

n_i,: the total number of groups having selected the species *i* as priority IFT;

N, the total number of groups surveyed.

For each IFT, X_i was calculated for the overall value, the food value and the commercial value. However, only the overall value was considered in the selection of priority IFTs, as it already integrates the food value as well as the econmomic/commercial value. The species with the highest percentage of respondents' preference were selected as priority IFTs. For each country, a short list of three priority IFTs was established. Regional priority species were drawn from that list taking into account the following criteria: species abundance and distribution in all participating countries; overall value; food value; and economic/commercial value.

RESULTS AND DISCUSSION

Familiarity with IFTs

In Uganda, a large number of respondents (84%) were familiar with *T. indica*. This was followed by *V. paradoxa, Carissa edulis, Vitex doniana* and *Borassus aethiopum* respectively. In Kenya, respondents were more familiar with *Ximenia americana*, *Carissa edulis*, *Tamarindus indica, Sclerocarya birrea* and *Rhus natalensis* while in Tanzania they where more familiar with *Vitex mombassae, Strychnos cocculoides, Uaparka kirkiana,Vanguelia infausta* and *Tamarindus indica* respectively (**Table 2**). Familiarity with IFTs seems to be linked to the availability and usage of the species.

According to Franzel *et al*., (1996), choosing species is much more complex in agroforestry than in plantation forestry in both socioeconomic and biophysical terms. Despite of this, participatory selection for domestication is advantageous since it allows farmers to be the beneficiaries and the guardians of the use of their indigenous knowledge (Leaky *et al*., 2003). Furthermore, the input of farmers in selecting priority species is key to farmers' acceptance of the fruit trees, hastening domestication, understanding the uses of these fruits and the products made and marketed from them and understanding limitations to producing IFTs (Kadzere *et al*., 1998). A report by ICRAF (2003) revealed that integration of trees on farm is usually based on farmers' preferences such as; fast growth, less shading to crops and quick adaptability to particular agro-ecological zones.

In the drylands of Uganda, a large portion of agricultural landscape is characterized by dispersed trees such as; *V. paradoxa, T. indica* and *B. aethiopum* selectively spared by farmers. These trees are deliberately retained on cultivated or fallowed land and are well known for their multiple products such as income, fruits, fodder, wood, charcoal, timber and medicine (Okullo *et al*., 2004). Although there were sub regional differences in species prioritization, five priority indigenous fruit trees for Uganda are *V. paradoxa, T. indica, V. doniana, B. aethiopum and C. edulis*. The sub-regional differences in species prioritization can be explained by several factors but most noted being, ethinicity, species abundance, markets for tree products and availability of technical services, especially on fruit processing.

Local communities in Uganda have been reported to choose plants that can be used for fruits, firewood, medicine, shade, construction materials and hedge (Eilu *et al*., 2007). Division of labour based on gender, family and land sizes usually have a direct bearing on IFTs selection process. In this study, majority (85%) of households were male headed and the average household size was about 8 persons. Findings by Okiror *et al*., (in press) revealed sex of household head and family size to be influencing tree species selection. It is also reported that men are the most influential in families and in some cases they have the discretion to plant or cut down trees and women are considered to be usurping men's power by planting trees (Okullo *et al*., 2003). Earlier, Andersen (1994), reported that the size of the household determines the ability to satisfy basic needs. Therefore, people with larger family sizes could be prioritizing IFTs because of their role in providing food resources during the lean seasons of farm cultivation.

Current studies have demonstrated that there is abundant knowledge of indigenous tree species among the inhabitants of the drylands of Kenya and Tanzania (Muok, 2009; Mbwambo and Balama, 2009). This knowledge could be attributed to the central role IFTS play in the livelihoods of the dryland communities, especially during the period of food scarcity. For years, livestock forms the main backbone of the drylands economy. However,

Table 3: Major indigenous fruits used during hunger periods in East Africa

Species	*Uganda (N=130)*	*Kenya (N=61)*	*Tanzania (N=91)*
Adansonia digitata	-	6.5(5)	6.6(6)
Annona senegalensis	29.6(4)	-	-
Borassus aethiopum	20.4(5)	-	-
Boscia coriacea	-	18.0 (2)	-
Carissa edulis	30.6(3)	23.0(1)	-
Dialium orientale	-	4.9(7)	-
P. uratellifolia	-	-	7.7(5)
Rhus natalensis	-	8.2(4)	-
S. cocculoides	-	-	20.9(4)
Strychnos spinosa	-	4.9(6)	-
Tamarindus indica	19.9(6)	13.1(3)	4.4(7)
U. kirkiana	-	-	27.5(2)
V. infausta	-	-	25.3(3)
V. mombassae	-	-	50.6(1)
Vitellaria paradoxa	81.6(1)	-	-
Vitex doniana	61.2(2)	-	-
Ximenia americana	15.2(7)	18.0(2)	-

The values in parentheses are ranks

frequent droughts and recurrent violent animal raids by cattle rustlers have affected peoples' capacity to recuperate and adapt to the drought stresses (Muok *et al*., 2000). With no livestock or regular source of livelihood, many people have routinized survival strategies such as use of indigenous fruits, burning charcoal, collecting wild foods and relying on irregular food aid distributions.

Although *S. birrea* was not listed among the five priority indigenous fruit trees in Uganda and Tanzania, possibly due to limited knowledge on its utilization, it is a focus for commercial development in South Africa (Hall *et al*., 2002). It is used for making wines, and other products, which has made it a priority for domestication (Hall *et al*., 2002). Although there is considerable variation, the fruits of *S. birrea* are rich in vitamin C, about five times higher than that of the citrus fruit (Leakey, 1999, Jama *et al*., 2008). At 96% dry matter; the marula kernel is 57.3% fat, 28.3% protein, 6% total carbohydrates, 2.9% fibre, and rich in phosphorus, magnesium and potassium (Glew *et al*., 2004). Marula pulp is used to extract popular commercial alcoholic drinks sold under different trade names in the South African region. According to Jama *et al*., (2008), there are no reports on commercialization of marula in eastern Africa. There is, indeed, considerable knowledge on marula that can guide its greater use and production. The Southern Africa's advances in commercialization can guide the same in the eastern Africa (Jama *et al*., 2008). Market prospects must, however, be determined before large investments in product development are made.

Usage of IFTs during periods of food shortage

In Uganda, a majority (83%) of the respondents did not harvest enough food during the season preceding the study. In this situation, 75% of the respondents reported having used IFTs as alternative or complementary food source. The IFTs commonly used during months of food shortage include *V. paradoxa* (82%) *T. indica* (61%), *C.edullis* (31%) and *V. doniana* (30%). The other IFTs used to a lesser extent are *B. aethiopum, B. aegyptiaca, A.seneglansis* and *X. americana* (**Table 3**). They are mainly used as food (fruit), oil extraction (kernnel), juice and local brew and spices. In some cases, IFTs were also reported to be used for fuelwood and construction purposes.

In Kenya, 69% of the household interviewed suffered a food shortage the preceding year. This group recognized the key role played by IFTs in their livelihood. Thirty four IFTs species are used during hunger periods. *C. edulis* was the most frequently used species (23%). This was followed by *X. americana* (18 %), and *T. indica* (13%). IFTs are used as food (directly or processed). Moreover, they are sold, and therefore provide households with income that is used to buy food. In Tanzania, 26% of the responded depended on IFTs during periods of food shortage. *Vitex mombassae* (51%), *U. kirkiana* (28%) and *V. infausta* (25%) were reported to be the most utilized IFTs during periods of food shortage (**Table 3**).

In many parts of sub-Saharan Africa, indigenous fruits remain one of the major options for coping with hunger,

Table 4: Priority IFTs *in drylands of East Africa*

Species	*Uganda (N=130)*	*Kenya (N=61)*	*Tanzania (N=91)*
Adansonia digitata	-	80.0 (2)	-
Ancybotrys tayloris	-	56.0 (5)	-
Annona senegalensis	53.1 (6)	-	-
Borassus aethiopum	70.3 (4)	-	-
Carissa edulis	64.5 (5)	66.7 (4)	-
Dialium orientale	-	48.0 (7)	-
G. buchananii	-	-	68.6 (6)
P. uratellifolia	-	-	70.6 (5)
S. cocculoides	-	-	90.9 (2)
Tamarindus indica	85.2 (2)	84.0 (1)	33.3 (7)
U. kirkiana	-	-	84.3 (3)
V. infausta	-	-	84.3 (4)
V. mombassae	-	-	98.0 (1)
Vitellaria paradoxa	97.0 (1)	-	-
Vitex doniana	71.0 (3)	-	-
Ximenia americana	37.0 (7)	66.7 (3)	-
Ziziphus mauritiana	-	48.0 (6)	-

The values in parentheses are ranks

nutritional deficiency and poverty. For instance, in Malawi, Mozambique and Zambia where 65-80% of rural households lack food (Akinnifesi *et al*., 2004), indigenous fruits were found to play vital roles in livelihood security for many rural community members, especially during periods of famine and food scarcity, and as important major food to supplement in better times (Saka *et al*., 2004). Indigenous fruits are also an important source of income for poor people since barriers for collection and use are relatively low.

A study in Zimbabwe, Mithofer *et al*., (2006) found the probability of households falling below the poverty line in the worst-case scenario at about 70% during the critical food insecure season when agricultural crops are planted with indigenous fruits being unavailable and about 25% during maize harvesting time. However, if indigenous fruits are available, the probability of households falling below poverty level is reduced by about 30% during the critical period. It was concluded that the collection, processing, storage and marketing of indigenous fruits are notable coping strategies adopted by rural Zimbabwean communities to reduce hunger, improve nutrition and generate income (Mithofer *et al*., 2006).

There is high reliance on IFTs in the Teso and lango sub-regions of Uganda (75%) as a coping strategy during periods of food shortage. This could be attributed. In Kenya a high percentage of respondents (69%) suffer from food shortage (Muok, 2009). To fill up the food deficit gap, many dryland communities resort to use of IFTs for food. Species such are *Boscia coriacea* and *Dobera glabra* are known to be highly used by many communities such as Pokot, Samburu and Turkana as food. Some other species such as *Vangueria infausta* are dried and stored for food during the famine periods while seed of *Acacia tortilis* are ground to flour which is cooked for food (Muok, *et al*., 2000). Kamondo and Muok (2007) identified five species used as beans by different tribes in Kenya *Boscia coriacea, Maurua edulis, Balanites pedicellaris*, *Dobera glabra* and *Vatovaea pseudolablab*. It has been reported that fruits like *Adansonia digitata, Annona senegalensis, S. birrea* and *Flacourtia indica* have high nutritional value. This means that use of indigenous fruits by dryland communities can therefore play an important role in their nutrition especially during the famine period (Maghembe 1995; Saka, 1994; Thiongo and Jaennicke, 2000).

Priority IFTs in East Africa

The five priority species for the drylands of the three study countries found to be; Uganda: *Vitellaria paradoxa, Tamarindus indica, Vitex doniana, Borassus aethiopum* and *Carissa edulis.* Kenya: *Tamarindus indica*, *Adansonia digitata, Ximinia americana, Carissa edulis* and *Ancybotrys tayloris* and Tanzania: *Vitex mombassae, S. cocculoides, U. kirkiana, V. infausta* and *P. uratellifolia* (**Table 4**). The ranking of these five priority IFTs in all the three countries was based on their general use, food value and economic value. In all the countries, farmers' preference on IFTs varied according to sub-regions. In Uganda, the five priority species were the same for the two study sub-regions though there was interchange of their respective score positions. *T. indica*, for instance was priority IFT number one in Teso but in Lango it became number two being overtaken by *V. paradoxa*. In Tanzania, ranking showered that despites the sub-regional variations, there was convergence on *V. mombassae, S. cocculoides* and *U. kirkiana* in the two sub-regions of Tabora and Mufindi in sub-regions and communities have been using them in similar ways. In the same way, *T. indica* and *A. digitata* were ranked highly in the all the study sites in Kenya. The sub-regional differences in IFTs prioritization in all the study sites can be explained by factors such as species abundance, ethnicity, and availability of markets for the products.

According to Muok (2009), respondents are able prioritize the species according to their opinion of importance. The ranking varied with ethnic groups and also the species availability in the area. Species that are not locally available got low ranking even though the same could be highly ranked in the areas where it occurs. Furthermore, Muok *et al.,* (2000) indicated that what is edible fruit in one ethnic group may be considered not edible in another. For example while Kamba community does not eat *Boscia coriacea* but among the Pokot, *B. coriacea* is not only edible but also a source of survival during the drought and times of food scarcity.

Selecting three priority IFTs for East Africa

From table 4, reveals that only *T. indica* is the only top ranked IFT that is common in the three countries. It was ranked as number one, two and seven in Kenya, Uganda and Tanzania respectively. For collaboration purpose, which was the major aim of the project, two additional species were than be selected through consultations with key national stakeholders. This was geared towards identifying commonalities in the three country species and also considering the other IFTs available in region but with demonstrated potential elsewhere. Analysis of data from the three countries revealed that:

1. *Tamarindus indica* is common in the three countries.
2. *Vitex doniana/payos/mombassae* was selected by farmers in Uganda, Kenya and Tanzania respectively. Thus, three countries can work on this species. Kenya and Uganda selected to work *Vitex doniana* since the species has a development potential is common in the two countries. On the other hand, Tanzania selected *Vitex doniana mombassae* since it was it priority IFT number one.
3. *Sclerocarya birrea* was mentioned by interviewees in all the three countries during but it is not widely utilized. No trade of its products was also reported. However, the species was reported to be more abundant and given its demonstrated potential in the Southern Africa region e.g. trade in marula cream, the three countries selected it as priority IFT number three for the region.

Therefore, the four IFTs identifies as a priority in the Eat African region are *Tamarindus indica*, *Vitex doniana or Vitex mombassae* and *Sclerocarya birrea*. These species occur across east Africa can be used to improve livelihoods and increase incomes of rural farmers in the drylands of East Africa through their growing, processing and marketing.

Growing and management of IFTs

Deliberate planting of IFTs is not common in the Eastern Africa. The main reasons for not planting IFTs are; they are considered to grow naturally, they can be readily found both in wild and farms, lack of planting materials, their slow growth rate and lack of knowledge and skills in their propagation. Some of the IFTs reported to be commonly grown are; *T. indica* and *V. paradoxa, U. kirkiana, V. mombasai* and *C. edulis*. IFTs are planted mainly because, they provide food (fruits and nuts), are multipurpose (for shade, poles fuelwood and windbreaks), they are believed to enhance soil fertility and the sale of their products (fruits, nuts and leaves) are a source of income for the resource poor communities. IFTs are mostly planted in home gardens and in home compounds. Only in a few cases are IFTs planted on farm and in orchards. The planting materials are mostly seedlings. The use of wildings and seeds is by fewer farmers. Many farmers obtain their planting materials from friends and rest use materials they collected from the wild. Local tree nurseries and research stations provided a lesser proportion of the planting materials.

Throughout Sub-Saharan Africa, integration of trees such as IFTs on farms has been viewed as a solution to problems of land. According to Franzel (2002) such trees are an answer to the shortage of food, fuelwood, cash income, animal fodder and building materials and contribute to the sustainable land use. By providing a supply of fuelwood from the farm, IFTs can help reduce pressure on remaining forests and communal woodlands. Other services that trees provide, such as boundary markers, windbreaks, soil erosion barriers, beauty and shade are difficult to quantify but are also of substantial importance to farm families and for natural resource protection (Franzel, 2002).

Constraints and opportunities for utilisation of IFTs in East Africa

The major constraints to IFTs utilization identified in this study were; other competing uses (especially fuelwood and in construction), increasing scarcity of fruit trees, difficulty in harvesting fruits from tall trees, lack of appropriate processing techniques and short shelf life of most fruits. As has also been reported by Akinnifesi *et al*., (2006), the Miombo fruit trees were perceived to be slow growing and inappropriate for cultivation. This perception has been aggravated by the limited understanding of the natural variability, reproductive biology, propagation and the lack of techniques for adding value and cultivation. Although many rural households rely on IFTs as sources of cash and subsistence in the Southern Africa Development Community (SADC), there has been little effort to cultivate, improve or add value to these fruits (Akinnifesi *et al.,* 2006). Additionally, wild harvested products can be very unreliable in the quantities and qualities due to the vagaries of the weather (Shackleton, 2004; Mumba *et al*., 2002). Quantities may also be affected by the existence of competing opportunities for producers, for whom NTFP production typically contributes just a small part of their income (Belcher and Schreckenberg, 2007).

To address the above constraints, many respondents proposed a need to build farmers capacity in value addition through improved fruit harvesting, processing and storage**.** There were also suggestions on large scale planting of IFTs and the formulation and enforcement of by-laws to regulate use thus, ensuring conservation of important IFTs. Some of the respondents called for better management of IFTs through weeding, pruning and spraying to improve their productivity while other proposed selection of healthy trees for propagation purposes. Interventions suggested by Jama *et al*., (2008) include: (1) diversifying and increasing tree cover in the emerging agricultural systems that are dominated by annual crops; (2) binding the labour force of local communities and farmers on a smaller area and allowing them to use it sustainably, thereby reducing the need to convert remaining woodlands and forests into agriculture or for extraction of charcoal and other wood products; (3) creating a landscape 'matrix' for dryland forest reserves that preserves the integrity of dryland ecosystems, while allowing humans and wildlife to co-exist better than under annual crop systems. According to them, testing these hypotheses should be an important component of research and development efforts to expand the production of priority IFTs. Barrow (2002) and NEMA (2001) also reported that that law enforcement, collaborative management and sensitization of local communities are very important factors for the success of tree management programmes by local people.

Required improvements on IFTs

Required improvements on the indigenous fruit trees, were the need to; shorten tree height, increase growth rate, shorten the juvenile phase, increase pest and disease resistance, and increase fruiting frequency. For the fruits, the required improvements were; increasing fruit size, making the fruit sweet, increasing fruit pulp size, increasing pest and disease resistance, increasing oil yield, increasing the fruit load per tree and making the pulp more juicy.

Okiror *et al*., (in press) in a study of on-farm conservation of *V. paradoxa* in eastern Uganda recommended propagation research aimed at shortening the juvenile phase, sweetening and softening fruit pulp of priority IFTs. According to Okullo *et al*., (2003), it is the desire of every farmer to have fast growing, high yielding and high quality trees on their compounds, farms, hedges and boundaries.

CONCLUSION

Rural communities have strong social and economic attachment to indigenous fruit trees. A majority use IFTs as alternative or complementary food source. Fruits commonly used during months of food shortage include. These fruit trees are retained on farms during cultivation for consumption, fuelwood, soil fertility enhancement and income generation among the resource poor communities. Several constraints have hindered the development of IFTs and hence their contribution to livelihoods in the region has not yet been realized. Research for development is needed in the areas of domestication and processing technologies starting with priority IFTs for the respective countries.

ACKNOWLEDGEMENT

This study was supported by SIDA-SAREC through Africa Forestry Research Network (AFORNET). We wish to thank all the respondents who spared their valuable time to share with us their knowledge on indigenous fruit trees.

REFERENCES

Akinnifesi F.K., Kwesiga F.R., Mhango J., Mkonda A., Chilanga T. and Swai R. 2004. Domesticating priority miombo indigenous fruit trees as a promising livelihood option for smallholder farmers in southrn Africa. Acta Horticulturae 632: 15-30.
Akinnifesi FK, Kwesiga F, Mhango J, Chilanga T, Mkonda A, Kadu CAC, Kadzere I, Mithofer D, Saka JDK, Sileshi G, Ramadhani T, Dhliwayo P (2006). towards the Development Of Miombo Fruit Trees As Commercial Tree Crops In Southern Africa. Forests, Trees and Livelihoods, 2006, Vol. 16, pp. 103–121.
Barrow CJ (2002). Land Degradation. Cambridge University Press, Great Britain.
Belcher B, Schreckenberg K (2007). Commercialisation of Non-timber Forest Products: A Reality Check. Development Policy Review, 2007, 25 (3): 355-377.
Chikamai B, Eyong-Matig O, Mbogga M Eds (2004). Review and Appraisal on the Status of Indigenous Fruits in Eastern Africa. A report preared for IPGRI-SAFORGEN in the framework of AFREA/FORNESSA. IPGRI, Nairobi, 152pp.
Eilu G, Oriekot J, Tushabe H (2007). Conservation of indigenous plants outside protected areas in Tororo District, eastern Uganda. African Journal of Ecology, Afr. J. Ecol., 45 (suppl.3), 73-78.
Etengu N (2006). Karamoja has amarula tree. New vision publication. Friday, 27th October, 2006. URL: http://www.newvision.co.ug/D/8/13/529011
Fountain Publishers (2005). Uganda districts information handbook: Expanded Edition 2005 – 2006. Fountain Publishers, Kampala, 182pp.

Franzel S, Jaenicke H, Janssen W (1996). Choosing the Right Trees: Setting Priorities for Multipurpose Tree Improvement. ISNAR Research Report No. 8. The Hague: International Service for National Agricultural Research.

Franzel S, Scherr SJ (2002). Trees on the Farm: Assessing the Adoption and Potential of Agroforestry Practices in Africa. CABI. Wallingford.

Glew RS, VanderJagt DJ, Huang YS, Chuang LT, Bosse R, Glew RH (2004). Nutritional analysis of the edible pit of Sclerocarya birrea in the Republic of Niger (daniya Hausa). J. Food Composition Anal. 17, 99–111.

Gunasena HPM, Hughes A (2000). Tamarind Tamarindus indica. Fruits of the future 1. International Centre for underutilized crops, Southampton.

Hall JB, O'Brien EM, Sinclair FL (2002). Sclerocarya birrea: a monograph. School of Agricultural and Forest Sciences, University of Wales, Bangor. 157 pp.

ICRAF (2003). Farmer-driven strategy in rebuilding valuable tree diversity on farms. ICRAF, Nairobi.

Jama BA, Mohamed AM, Mulatya J, Njui AN (2007). Comparing the ''Big Five'': A framework for the sustainable management of indigenous fruit trees in the drylands of East and Central Africa. *Ecol. Indicat.* 8(2):170-179.

Kadzere I, Chilanga TG, Tunu R, Lungu S, Malembo LN, Rukuni D, Simwanza PP, Rarieya M, Mahembe J (1998). Choice of priority indigenous fruits for domestication in Southern Africa, *Summary of case studies in Malawi, Tanzania, Zambia and Zimbabwe*: In: Selecting indigenous fruit trees for domestication in southern Africa. Priority setting with farmers in Malawi, Tanzania, Zambia and Zimbabwe. Maghembe J.A.; Simons, A.J.; Kwesiga, F. and Rarieya, M. (Eds). Nairobi International Centre for Research in Agroforestry.

Kamondo B, Muok BO (2007). Use of wild plants for food in Kenya's arid and semi arid lands. Discv Innov. 19:170-176.

Katende AB, Segawa P, Birnie A (1999). Wild Food Plants and Mushrooms of Uganda. Nairobi: Regional Land Management Unit (RELMA), Sweedish International Development Cooperation Agency (Sida), 1999. (RELMA Technical Handbook Series; 19)

Leakey RRB, Simons AJ (1998). The domestication and commercialization of indigenous trees in agroforestry for the alleviation of poverty. Agroforest Syst. 38, 165–176. Leakey, R.R.B., 1999. Potential for novel food products from agrofroestry trees: a review. Food Chem. 66, 1–14.

Leaky RRB, Schreckenberg K, Tchoundjeu Z (2003). The participatory domestication of West African indigenous fruits. International Forestry Review 5(4), 338-347.

MAAIF (2000). Plan for Modernization of Agriculture. Government Printery, Entebbe, Uganda.

Maghembe JA (1995). Achievements in the establishment of indigenous fruit trees of miombo woodlands of southern Africa. In: Maghembe JA, Ntupanyama Y, Chirwa PW, eds., improvement of indigenous fruit trees of the miombo woodlands of southern Africa. Proceedings of a conference held 23 - 27 January 1994, Mangochi. Malawi. Nairobi: ICRAF.

Mbwambo L, Balama C (2009). Use And Conservation Of Indigenous Fruit Tree Diversity For Improved Livelihoods In Eastern Africa, Tanzania Country Report.

Mithofer D, Waibel H (2003). Income and labour productivity of collection and use of Indigenous fruit tree products in Zimbabwe. Agroforestry Systems 59: 295-305.

Mithofer D, Waibel H, Akinnifesi FK (2006). The role of food from natural resources in reducing vulnerability to poverty: a case study from Zimbabwe. Paper accepted for the 26th Conference of the International Association of Agricultural Economists (IAAE), August 12-18, 2006, Queensland, Australia.

Muok BO (2009). Use And Conservation Of Indigenous Fruit Tree Diversity For Improved Livelihoods In Eastern Africa, Kenya Country Report.

Muok BO, Owuor B, Dawson I, Were J (2000). The potential of Indigenous fruit trees: Results of survey in Kitui District, Kenya. Agroforestry today, Volume 12 No 1 13-16.

NEMA (2001). State of the Environment Report for Uganda. National Environment Management Authority, Ministry of Water Lands and Environment, Kampala, 153 pp.

Okafor JC (1988). Domestication and Conservation of Indigenous Fruit Trees in Africa. Paper presented at the workshop on utilization and exploitation of Indigenous and often neglected plants and fruits of Eastern and Southern Africa, Zambia, Malawi.

Okiror P, Okullo JBL, Okia CA (In press). On-farm Conservation and Agroforestry potential of *Vitellaria paradoxa* in Amuria district, Teso Sub-region, Uganda.

Okullo JBL, Obua J, Kaboggoza JSR, Aluma RW (2003). Traditional agroforestry systems, tree uses and management in northern Uganda. Uganda Journal of Agricultural Sciences. 2003, 8: 5–10. Shackleton, C.M. 2004. Use and selection of Sclerocarya birrea (Marula) in the Bushbuckridge lowveld, South Africa. Pp. 77–92 in Rao M.R. and Kwesiga F.R. (eds.). Proceedings of Regional Agroforestry Conference on Agroforestry Impacts on Livelihooods in Southern Africa: Putting Research into Practice: World Agroforestry Centre: Nairobi, Kenya.

Okullo JBL, Obua J, Okello G (2004). Use of indigenous knowledge in predicting fruit production of shea butter tree in agroforestry parklands of north – *eastern Uganda. Uganda Journal of Agricultural Sciences, 9:*

Saka JD (1994). The nutritional value of edible indigenous fruits: Present research and future directions. In Maghembe J. A., Simons, A. J., Kwesiga Freddie and Rerieya Marie, (eds.). Selection of indigenous fruit trees for domestication in South Africa. ICRAF Nairobi.

Thiongo MK, Jaennicke H (2000). Preliminary nutritional analysis of marula (*Sclerocarya birrea*) fruits from two Kenyan provenances. Acta Hort. 531: 245-249.

United Republic of Tanzania (2003). National Bureau of Statistics, Planning and Privatisation. 32pp.