# UTILIZATION OF WOODY PLANTS DURING TIMES OF FOOD SCARCITY FROM SELECTED DRYLANDS OF IRINGA DISTRICT, TANZANIA

**BY**

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## DECLARATION

This is my original work and has not been presented for a degree in any other University.

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# DEDICATION

This study is dedicated to my parents, sisters and brothers who tirelessly laid the foundation of my education. To my wife, Rahel and our children, Julieth and Jacqueline who suffered a lot during my absence but remain my richest source of confidence.

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ANOVA | Analysis of Variance |
| AOAC | Association of Official Analytical Chamists |
| C | centigrade |
| CITES | Convention on the International Trade on Endangered Species of Wild Flora and Fauna |
| Cm | centimetre |
| DANIDA | Danish Development Agency |
| DBH | Diameter at Breast Height |
| Dwt | Dry weight |
| EAPRLA | East Africa Plants Red List Authority |
| *et al.* | and others |
| FAO | Food Agriculture Organization |
| G | gram |
| Ha | Hectare |
| IDI | Iringa District Investment |
| IUCN | International Union for Conservation of Nature |
| Kcal | Kilocaries |
| Kg | kilogram |
| M | meter |
| Mg | milligram |

| | |
|---|---|
| NGO | Non –Govenmental Organization |
| PRA | Participatory Rural Appraisal |
| RUFORUM | Reagional Universities Forum |
| sp | species |
| SPSS | Statistical Package for Social Sciences |
| UDSM | University of Dar es Salaam |
| UNDP | United Nations Development Programme |
| UNEP | United Environmental Programme |
| URT | United Republic of Tanzania |
| WRI | World Resources Institute |

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# ABSTRACT

Communties inhabiting marginal drylands are the most vulnerable to the impacts of drought and climate change. In order to survive they utilize various woody plants as food sources in times of food scarcity. This study was undertaken to assess the utilization of woody plants in times of food scarcity from the drylands of Iringa District, Tanzania. Information on plant use was collected by using semi-structured and informal interviews in six randomly selected villages. Inventory of woody plant resources was done in six woodland sites and a total of 120 rectangular plots were assessed. The families were identified, Fabaceae, Rubiaceae, Anacardiaceae and Combretaceae were the most diverse families. Among the studied woody plants, 66 species were used as food and were distributed in 28 families. The preference ranking process showed that *Adansonia digitata* L. and *Sterculia Africana* (Lour.) Fiori were most preferred by the local communities as sources of oils. *Opilia amentacea* Roxb. and *Maerua angolensis* DC were preferred woody plants for vegetables whereas *Vangueria infausta* Burch. and *Vitex mombaseae* Vatke were preferred as a source of fruits. Ecological study of the most preferred woody species revealed that *Opilia amentacea* had the highest average number of individuals per ha accounting for 29% of all individuals followed by *Vangueria infausta* Burch. with 26%. *Opilia amentacea* Roxb. had highest average number of seedlings per ha amounting to 28,733 followed by *Adansonia digitata* L. with 27,999 seedlings per ha. Saplings were also enumerated and the results showed *Opilia amentacea* Roxb. leading with 4,788 saplings per ha compared with other species. The preferred species had rare to low range of occurrence, with frequency from 0-40 %. The studied most preferred plants were within the DBH size class of 10-20 cm and this revealed that the diameter size class distribution of species and individuals decreased with increase in diameter size classes. These results suggest that the population of large diameter size classes is decreasing and thus conservation of low diameter size classes should be given priority. Nutritional analysis showed that the edible parts of *Vangueria infausta* Burch. and *Adansonia digitata* L. contain high percentage of carbohydrate of 77.07% and 70.74% respectively. *Maerua angolensis* DC which is commonly used as vegetables had highest crude protein amounting to 33.21% followed by *Sterculia Africana* (Lour.) Fiori with 25% and 27.55% of crude protein and crude fiber respectively, which make it a good source of energy for human nutrition. The fruit and vegetable plants had high values of Potassium ranging from 747.26 ± 7.2 to 3590.51 ± 0.5. Additionally, wild food plants contain anti-nutritive factors including tannins and phenols but they were below the toxic levels acceptable for daily intake. Futhermore, results revealed that *Adansonia digitata* L., *Bauhinia kalantha* Harms, *Tamarindus indica* L. and *Vitex doniana* Sweet were the edible woody plants that have high prioritization scores. Therefore, these species require an urgent need for conservation because they are currently overutilized by the local communities. Based on nutritive value, preferences and ecological status of woody plants it can be concluded that edible woody plants make a major contribution to dietary intake of rural people in the drylands of Iringa District during times of food shortage. Consequently, food plants that are most preferred need to be conserved either in their natural habitats or farmlands. Therefore both *in situ* and *ex situ* conservation practices are of vital importance in this scenario.

# CHAPTER ONE

## 1. INTRODUCTION

### 1.1 Background information

Tanzania has an area of 945,087 square kilometers of which 81% of the area is covered by forests, woodlands, bushland and grassland. Only 11% is cultivated land and the rest is open land (URT, 1998). According to Liweng (2009), almost half of the country's area is semi-arid land, in which agriculture and the livelihoods that depend thereon, are greatly affected by erratic and unreliable rainfall regime and extreme poverty. FAO (1995, 2000a) report showed that due to ecological and socio-economic constraints in the drylands, agricultural production alone does not cater for the nutritional needs of the local people and the alternative livelihood practices including reliance on forest products is unavoidable.

Declining agricultural productivity and consequently food levels is a result of climatic changes, poverty, diseases, rainfall-dependent agriculture and increasing population pressure (Jama and Zeila, 2005). Climatic change in particular has affected the livelihoods and human well-being as a result of increasing temperatures, floods and severe drought which have in turn reduced agricultural production and alter plant species composition and their distribution pattern in ecosystems (Mackey, 2007). In addition, Mackey (2007) reported that changes in long-term environmental conditions influenced by climate change had enormous impacts on plant species diversity and distribution patterns in the past and have significant current impact. As a result of climatic changes, FAO (2008) reported that local communities rely on food relief, remittances, migration and casual labour. In addition the predominantly use of the edible forest products from woody plants to cope with the situation of food self insufficiency.

Earlier studies, for example WRI (2008) showed that the use of trees and shrubs in times of food scarcity is increasingly used by the majority in rural areas as one of the rural non-farm sector. Food insecurity has been of long time been experienced in the drylands and for this reason, Mbuya *et al.* (1994) and Maundu *et al.* (1999) recommended proper use of natural resources, as one of the adaptive strategies to cope with climate change to curb food insecurity worldwide. Experience has shown that in the drylands of Tanzania and elsewhere, the use of alternative livelihood practices such as utilization of woody plants as food in periods of food shortage is a common practice.

### 1.2 Problem statement and justification

The most vulnerable communities to the impacts of climate change inhabit the marginal drylands. For instance, people inhabiting drylands survive harsh environments by practicing various sustainable livelihood practices including seasonal movements and pastoralism (Millennium Ecosystem Assessment, 2005).

However, with the threats of changes in climate and exacerbating current trends of food scarcity, agriculturists and other dryland dwellers are forced to consider other livelihood options, including use of edible woody plant resources including seeds, fruits, roots and vegetables in order to cope with cumulative food shortages. Therefore, woody plants have an important role to play in food security in times of famine, although forests cannot replace agricultural production as a food production system to any significant extent (FAO, 1990a&b).

Thousands of people in semi-arid areas of Tanzania including Iringa District drylands do not have enough food to meet their daily requirements and furthermore, people are deficient in one or more micronutrients in their diets (Njau, 2005). According to Iringa District Investment IDI (2008), Iringa District has about 4,982.2 hectares under district ownership and communal forest reserves, of which 90% are located in the drylands. Many people rely on these forests and woodlands for daily sustainance of their livelihoods. Despite the use of edible woody plants as a component of local response to increasing food insecurity being widely known, yet the consumption of wild-foods has been and is still being under-estimated (Ruffo, 1989).

Numerous studies provide detailed knowledge of edible woody plants in different locations in Tanzania (Luoga, 2000; Ruffo *et al.* 2002; Njau, 2005). These studies show that plants are essential components of many diets in periods of seasonal food shortage but nevertheless, none of the studies assessed the composition of edible woody plants.

A study conducted in Nyang'olo Forest Reserve in Iringa District revealed that some poor households rely heavily on edible woody plants as an alternative to cultivated food plants for a quarter of all dry season's meals (Njau, 2005). Similarly, in Kitapilimwa Division, leafy vegetables and other wild foods especially from woody plants are collected as daily supplements to relishes and soups (DANIDA, 2000). Also, Njau (2005) revealed that in Iringa District, edible woody plants are consumed regularly by rural communities especially during times of heightened drought and these plants have provided stable supply of food to the deprived people.

FAO (1990b); Hamza (1990); Kavishe (1993); FAO (200b) and Ruffo *et al.* (2002) concluded that the use of wild edible plants in different localities provide optimum source of nutrients. However, very few Tanzanian wild food plants have been analyzed for their nutritional and anti nutritional contents, although Ruffo *et al.* (2002) and Amaechi (2009) reported that many local However, Mahammad *et al.* (2010) reported that some edible plants contain anti-nutritional factors such as tannins, phenols, saponins and cyanides that affect availability of other nutrients required by the body.

DANIDA (2000) and Njau (2005) reported that about 60% of the nearly 82 trees and shrubs in Iringa District are edible. Of these, less than 8% of wild plant species are documented (Njau, 2005). Still many more wild species especially trees and shrubs in many areas of the district are edible and yet undocumented (IDI, 2008). More recently, comprehensive ethnobotanical studies were undertaken in some parts of the District including Nyang'olo and Kitapilimwa Divisions, that documented many useful plants such as *Azanza garckeana* F. Hoffm., *Adansonia digitata*, *Vitex doniana* among others (Njau, 2005). However, most of these studies dealt with medicinal plant species, mushrooms and herbaceous plants but placed little emphasis on plant community composition, conservation and ecological dynamics of edible woody plants.

Lack of quantitative data on overall composition of woody plants in the area, density, diameter size class distribution, frequency, regeneration patterns and nutritional qualities of important tree and shrubs were some of the main limitations in understanding dryland forest resource dynamics, underutilization and overexploitation. For the design of appropriate conservation and management plans, this study aimed to document the knowledge on edible woody plants, density, diameter size class distribution, frequency and their regeneration patterns. In this study, the levels of nutrients composition and conservation priorities of edible woody plants in the area were also assessed. The results of this study will form the baseline data for future sustainable exploitation of woody plants in Iringa

District. This study will also create a basis for further research on edible dryland woody species of Tanzania.

## 1.3 Research objectives

### 1.3.1 General objective

The overall objective of this study was to increase the knowledge base on the diversity and potential of woody plants to support the livelihoods of the people in dryland ecosystems so as to enhance their appropritate conservation and sustainable management strategies.

### 1.3.2 Specific objectives:

i. To determine the overall composition of woody plant species in the study area

ii. To determine the woody plants commonly used and prefered as food in the study area

iii. To assess the ecological status of key woody plants in the study area

iv. To assess nutritional and anti-nutritional qualities of selected key woody plants used as food in the study area

v. To prioritize for conservation the woody plants used as food in the study area

### 1.3.3 Research questions

i. What woody plant species exist in the area?

ii. What are the woody plants commonly used and prefered as food?

iii. What are some of ecological parameters (including density, diameter size class distribution, regeneration and frequency of occurrences) of key woody plants in the study area?

iv. What are the nutritional and anti-nutritional components of key woody plants used as food from the study sites?

v. Which are the edible woody species that need to be prioritized for conservation in the study area?

# CHAPTER TWO

## 2. 0 LITERATURE REVIEW

### 2.1 Food security status in the drylands

In the drylands of Africa especially in the Sub Saharan Africa, land degradation exacerbated by human activity, has a negative effect on overall food security (UNDP/UNSO, 1997). Land deprivation in drylands will likely be more dramatic under a scenario of climate change, due to projected increases in evapo-transpiration demand, increased spatial and temporal variability of rainfall (300-700 mm annually), and high rainfall intensity. Thus, this scenario will affect agricultural productivity and lead to severe food shortages (FAO 2000a).

According to Blay *et al.* (2004), food security and particularly in the drylands, is a complex system that is affected by income stability, availability and access to alternative livelihood especially in this era of climate change. Household food security level is a function of the activities that make up a livelihood; each household will have separate challenges to maintaining food security in light of climate change (FAO, 1999). Hence, adaptation measures are needed in order to counteract severe food scarcity in the drylands including utilization of wild food plants.

## 2.2 Utilization of woody plant products in the drylands

Rural communities in Tanzania are heavily dependent on woody plant resources which they utilise for provision of food and income (Nduwamungu, 2001). Almost 50% of the country is covered by arid and semi-arid rangelands that are generally characterised by low human population compared to the high rainfall potential areas (URT, 2001). Nyingili (2003) asserted that for decades communities living in arid and semi-arid rangelands had insignificant impact on the locally available tree and shrub resources. This trend is changing rapidly, exacerbated by the rangeland's characteristic of low and erratic rainfall and consequently, low productivity. Hence, the use of trees and shrubs usually the only standing crop, is inevitable.

Sene (2000) reported that many tree and shrub species have potential for multiple uses. In the dry areas, many of these products from multipurpose tree and shrub species are central to household food security (FAO, 1990a). However, there is scanty information on utilization of tree and shrub parts, such as bark, leaves, flowers, fruits and seeds as food. Although, they cannot replace agricultural food source to any significant extent, forest trees and shrubs contribute to the food supplement as other food source at different levels (FAO, 1990b; 2010).

Though it is widely recognized that meals derived from woody plants may not be consumed in great quantities in comparison to main staple foods, they add variety to diets, improve the palatability of staple foods and provide essential vitamins and proteins. FAO (1990a) has shown that forest foods can offer vital insurance against malnutrition or famine during times of seasonal food shortage or emergencies such as droughts and floods. Forest gathering activities are not restricted to groups that are poor, landless or nomadic (Sene, 2000). Nevertheless, these are the groups most likely to be affected by reductions in the availability of foods from plants as a result of degradation. Therefore, forest products especially from woody plants have an important role to play in household livelihoods but it is unclear whether the use of woody plants will result in increased conservation of natural forests.

### 2.3 Status of woody plants utilization in Tanzania

According to Ruffo *et al.* (2002), the vast woodlands of Tanzania have mostly regenerated, after long time degradation that was reported in these areas in the 1960s. The main cause of woodland degradation in Tanzania as in other parts of the world was the increasing demand of the local communities for agricultural land and forest products for food and income. However, over time such products were increasingly marginalized as emphasis in forest management shifted to timber production. At present, increased interest in wild food plants has been prompted by the rediscovery of their role to small-scale livelihoods and has resulted in a rapid rise in interest among stakeholders (Campbell *et al.*, 1993). Addressing rural poverty must be seen in the context of the available resources including woodland resources (Cavendish, 2000). The importance of woodland plant resources in relation to rural poverty has been emphasized by researchers (Cavendish, 2000; Luoga, 2000; Monela *et al.*, 2000). A number of studies have indicated that poor households within rural communities obtain a larger share of their total income from natural resources than more well off rural households (Cavendish, 2000). It was further reported that poor households are highly dependent on forest resources for subsistence products, especially in periods of adverse climatic conditions when agricultural activities cannot support their livelihoods (Cavendish, 2000; Monela *et al.*, 2000).

Campbell and Byron (1996) reported that interest in woodland plant resources has generated a proliferation of studies into the potential of woody products for income generation and as a means of involving local people in forest management and benefit sharing to ensure sustainable utilization of these resources. Ruffo *et al.* (2002) also reported that although many wild plants are used by the majority of Tanzanians for income and primary healthcare, they are still not valued as their exotic analogues. To a certain extent these wild plants are still regarded to be inferior and only appropriate for the poor. There has been a widespread decline in indigenous knowledge about woody products, especially among young people and those who live in urban areas (FAO, 1990; Kavishe, 1993). Previous study by Njau (2005) showed that more that 60% of identified plant species in Nyang'olo range were edible and most of them were woody plants. Nonetheless, this extent is not quantified in other areas of Iringa District.

## 2.4 Role of woody plants to the livelihoods of the people

According to FAO (1997; 2000), 80% of the people living in developing countries use wild plants to meet some of their health and nutritional needs. It was further revealed that over two billions of people especially those living in rural areas in developing countries make use of products from the forests on a daily basis. This involves thousands of plant species, most of which are consumed within the household of the gatherers and are not traded in markets (FAO, 1997).

FAO (2000) reported that trees and shrubs provide critical supplies of food during periods when agricultural crops fail or are otherwise scarce particularly in drylands. For a developind country like Tanzania, products from trees and shrubs contribute to economic and social benefits to its people. In general, the use of woody plants is an integral part of the daily lives of the rural population of Tanzania (FAO, 1995). Therefore, development of rural economy in relation to environmental resources conservation has become an integral part of sustainable development policy.

URT (1998) estimated that Tanzania loses approximately 92,000 ha or 0.2% of its forest land through over exploitation of wood resources. Despite, the high rate of over-exploitation, efforts to study and promote the existing resource management and conservation practices is still undocumented. Njau (2005) recommended that there was a need to assess different conservation practices of woody plants in Nyang'oro range, to ensure sustainable and equitable use of resources to meet the needs for food without degrading the environment.

**2.5 Nutritional value of wild food plants**

Wild foods are part of rural people's diets not only during periods of food shortages, but also on a daily basis (Campbell, 1996). Most dietary studies emphasize the value of calorific intake from staples. However, the amounts of wild foods consumed, their frequencies of consumption as well as their nutrient contents have also been explored (Fleuret, 1979). According to FAO (1990) wild foods have different chemical composition and hence they can be analyzed to demonstrate their nutritional significance.

The most important nutrients present in plants include carbohydrates, such as the starch and free sugars, oils, proteins, minerals, ascorbic acid, and antioxidant phenols, such as chlorogenic acid and its polymers (Ekanayake and Nair, 1998).

Nutritional analysis of wild food plants from many parts of Africa has shown that wild food plants are very nutritious and not inferior to domesticated varieties. Wild grains, seeds and kernels provide significant amounts of calories, proteins and oils (Ruffo *et al.*, 2002). Their calorific value is frequently higher than that of the cultivated varieties. The calorific values of grass grains are impressive within a range of 310 - 391 kcals per 100 gms, which compares well with those reported from sorghum and maize of 355 and 363 kcals/100gms respectively (FAO, 1990; Kavishe, 1993 and Ruffo *et al.*, 2002). Wild fruits, leaves and tubers are rich in Vitamin C, for example *Adansonia digitata* fruits and *Ziziphus* sp contain 360mg /100g and 1000mg /100g, respectively of vitamin C whilst an orange only contains approximately 57 mg / 100g (Kavishe, 1993). In Southern Sudan, it is a common practice to increase consumption of wild fruits or wild fruit juices such as *Tamarindus indica*, *Ziziphus mucronata* Willd. or *Borrasus aethiopium* Mart, which help sick people to recover (Hamza, 1990). Leaves of many wild plants have higher iron content than the cultivated species. *Gynandropis gynandra* (L.) Briq. and *Tamarindus indica* have an iron content of up to 6.2 mg/ 100g, while the domesticated species such as broccoli have 1.5 mg/100g, cabbage 1 mg/100g and cauliflower 0.5 mg/100g. Potassium levels tend to be high in all leafy vegetables and fruits (Ruffo *et al.*, 2002).

Chandare (2010) reported that *Adansonia digitata* (baobab) pulp is particularly rich in vitamin C; the leaves are particularly rich in calcium (307 to 2640 mg/100 g dwt), and they are known to contain good quality proteins with a chemical score of 0.81. Whole seeds and the kernels have a relatively high lipid content of 11.6 to 33.3 g/100 g dwt and 18.9 to 34.7 g/100 g dwt respectively.

Duke and Ayensu (1985) reported high nutritional content of key elements in *Asparagus officinalis* L. stem (fresh weight) as protein 2.5g/100g; fat 0.2 g/100gm; carbohydrates 5g/100g; fibre 0.7g/100g; Ash 0.6g/100g; Calcium 22mg/100g; Iron 1mg/100g; Sodium 2mg/100g; Potassium 278 mg/100g; Zinc 0 mg/100g.

Certain wild foods may enhance palatability of food for instance those leaves with a mucilaginous sap which gives the food a slimy texture is a recognized way of easing ingestion of accompanying foods (Kavishe, 1993). According to Fleuret (1986), improvements of texture and taste resulting from wild foods are of particular importance to children who are often unable to consume the quantity of the bulky staple foods needed to meet their nutritional requirements.

**2.6. Anti-nutritional factors**

Wild plants are important sources of minerals, fiber and vitamins, which provide essential nutrients for the human health (Eromosele *et al*., 1991). However, Spiller (2001) reported that wild foods may contain the so-called 'anti-nutritional' factors such as phenols and tannins that can reduce the nutrient bioavailability, especially if they are present at high levels. Some of these foods contain anti-nutritional factors that can affect the availability of nutrients required by the body. According to Binita and Khetarpaul (1997), anti-nutritional factors interfere with metabolic processes. Oxalate, for instance, binds to calcium to form complexes (calcium oxalate crystals) which prevent absorption and utilization of calcium by the body causing diseases such as rickets (Ladeji *et al*., 2004). Calcium crystals may also precipitate around the renal tubules thereby causing renal stones. The formation of oxalate crystals takes place in the digestive tract (Thompson and Yoon, 1984). Umaru *et al.* (2007) reported highest level of oxalate in *Ziziphus spinachristi* (L.) Desf. fruits of 16±1.12%. However this level is still tolerable in the human body as it is below the established toxic levels of 200-300mg/100g of phenols and 65,000mg/ka, tannins. Nevertheless, Gilani (2005) reported that these anti-nutritional factors could help to prevent and treat several important diseases. As an example, the anti-carcinogenic activity of phytic acid has been demonstrated by *in vitro* and *in vivo* assays (Aberoumand, 2008).

Herdt (1997) reported that phytic acid is an organic acid found in plant material and combines with iron, calcium, zinc and phosphorus to form insoluble salts called phytate, which are not absorbed by the body thereby reducing the bioavailability of these elements. Furthermore, Umaru *et al.* (2007) reported that phylate levels in *Phoenix dactylifera* L. and *Sclerocarya birrea* (A. Rich. ) Hachst. were 0.52±0.03% and 3.56±0.54% respectively. Saponins are naturally oily glycosides occurring in wide variety of plants and whenever injected to the blood stream quickly haemolyses red blood cells.

Taninns have the ability to precipitate proteins when combined with digestive enzymes thereby making them unavailable for digestion. High levels of tannins impose astringent taste that may affect palatability. In general, tannins are distributed in most species throughout the plant kingdom. They are commonly found in both gymnosperms as well as in angiosperms. Botanically, tannins are mainly physically located in the vacuoles or surface wax of plants. These storage sites keep tannins active against plant predators, but also keep some tannins from affecting plant metabolism while the plant tissue is alive; it is only after cell breakdown and death that the tannins are active in metabolic effects. Tannins are classified as ergastic substances i.e. non-protoplasm materials found in cells (Umaru *et al.* 2007)

Tannins are found in leaf, bud, seed, root, and stem tissues. An example of the location of the tannins in stem tissue are often found in the growth areas of trees, such as the secondary phloem and xylem and the layer between the cortex and epidermis. Tannins may help regulate the growth of these tissues (Aberoumand, 2008). .

## 2.7 Conservation of wild edible woody plants

For many species of plants, loss of their habitats represent the greatest threat to their survival (Cunningham, 2001). While there is considerable uncertainty about the extinction rate caused by human activities, it is generally acknowledged that species loss and erosion of genetic diversity is highest in the tropics (Myers, 1988; Whitmore and Sayer, 1993). This is a result of high deforestation rates in many tropical countries (FAO, 1993).

Great efforts have been made to conserve areas of natural vegetation and give them various degrees of protection. This continues to be an important and urgent task, but it is clear that severe disturbance and destruction will not stop soon (Whitmore and Sayer, 1993). Myers (1988) suggested that it is necessary to study not only diversity in pristine environments but also the impact of alternative uses and management practices on biodiversity to conserve as much as possible where disturbance and deforestation cannot be prevented and, where possible, to improve the conservation value of areas already degraded.

In Tanzania, as a result of increased deforestation, exploitation and changes in land use systems it has lead to dwindling of edible woody plants diversity (Mwihomeke *et al.*, 2000). Some important wild foods plants are becoming rare for example the orchids in the Southern Highlands and the solution for this trend has been suggested by Ruffo *et al.* (2002): There is a need for these food plants to be domesticated since they are easy to propagate, starting with those that have high nutritive values. Conservation of natural resources in Tanzania is now carried out by numerous sectors including wildlife, forestry, national environmental facilities and government supports. Also various Non-governmental Organizations including Tanzania Forest Conservation Group and Wildlife Conservation Society of Tanzania have played a significant role to conserve natural resources in the coastal forests and Udzungwa Mountain forests for more than a decade. Yet, there has been reluctance in conserving wild food plants compared to other economically important resources such as timber, may be because of lack of knowledge about edible plants.

**2.8 Prioritization for conservation of wild food plants**

As demand for wild edible plants continue to accelerate, species preservation is perceived to depend on sustainable harvesting methods and cultivation. The importance of different wild food plants and their depletion in the wild has called for conservation (UNEP, 1995). Some of the wild food plants commonly used by people are no longer available and it is likely that among those wild food plants, some have already disappeared or are becoming rare. According to Ruffo *et al.* (2002) plants such as *Habenaria* and *Satyrium* spp are among orchid species that have become endangered because of massive utilization in the southern Highlands of Tanzania. These species are highly traded in the neighbouring countries of Malawi and Zambia.

It was further observed that over-harvesting coupled with unsustainable natural resource management could bring about the extinction of some of these species (UNEP, 1995). In response to the threats and neglect that wild edible plants are facing, Kariuki and Simiyu (2005) proposed that prioritization for conservation of wild edible plant species as a means of contributing towards conservation of endangered, endemic and economically important plant species.

Margules *et al.* (2003) reported that a set of information was necessary for setting conservation priorities of a given site to include multiple criteria such as vegetation type, species richness, socio-economic and socio-cultural value of the site, endemism concentration of red listed plants and stresses on the biota. Likewise, conservation priorities are based on the use value as set by the local community. For example *Adansonia digitata* and *Tamarindus indica* are among the top five most promising species recommended for prioritization after a priority setting exercise within the East and Central African region, which identified a number of indigenous fruit species useful in the drylands of the region (Jama *et al.*, 2007). Consequently, a survey to gather information on the current level of production, use and commercialization of these important wild food species will provide appropriate information needed for conservation of species. Other criteria set by Kariuki and Simiyu (2005) included use values, mode of harvesting, growth habit, endemism and distribution range. These criteria have facilitated successful domestication and conservation priorities for species such as *Parinari curatellifolia* , Planch. ex Benth *Vitex mombassae* Vatke, *Strychnos cocculoides* Bak., *Vitex doniana* Sweet, *Uapaca kirkiana* (Muell.Arg.), *Flacourtia indica* (Burm. f.) Merr., *Berchemia discolor* (Klotzsch) Hemsl, *Adansonia digitata* L., *Tamarindus indica* L. and *Sclerocarya birrea* (A. Rich. ) Hachst. in East and Central Africa (Jama *et al.*, 2007; Ham and Akinifesi, 2006).

# CHAPTER THREE

## 3. MATERIALS AND METHODS

### 3.1 Description of the study area

#### 3.1.1 Location

The study was conducted in the woodlands of Iringa District covering six villages namely Kiwere, Mfyome, Migoli, Makuka, Mbweleli and Kinyali (Figure 3.1). The District has an area of 19,897 square kilometers of which only 9857.5 square kilometers are habitable and the rest are occupied by National Parks, Forests, Rock Mountain and water bodies (DANIDA, 2000). The district extend between latitudes $7.00^0$ – $8.30^0$ South and longitudes $34^0$ – $37^0$ East (Njau, 2005) and borders Mpwapwa District (Dodoma Region) to the North, Kilolo District to the North East, Mufindi District to the South, Chunya District (Mbeya Region) to the West and Manyoni District (Singida Region) to the North West.

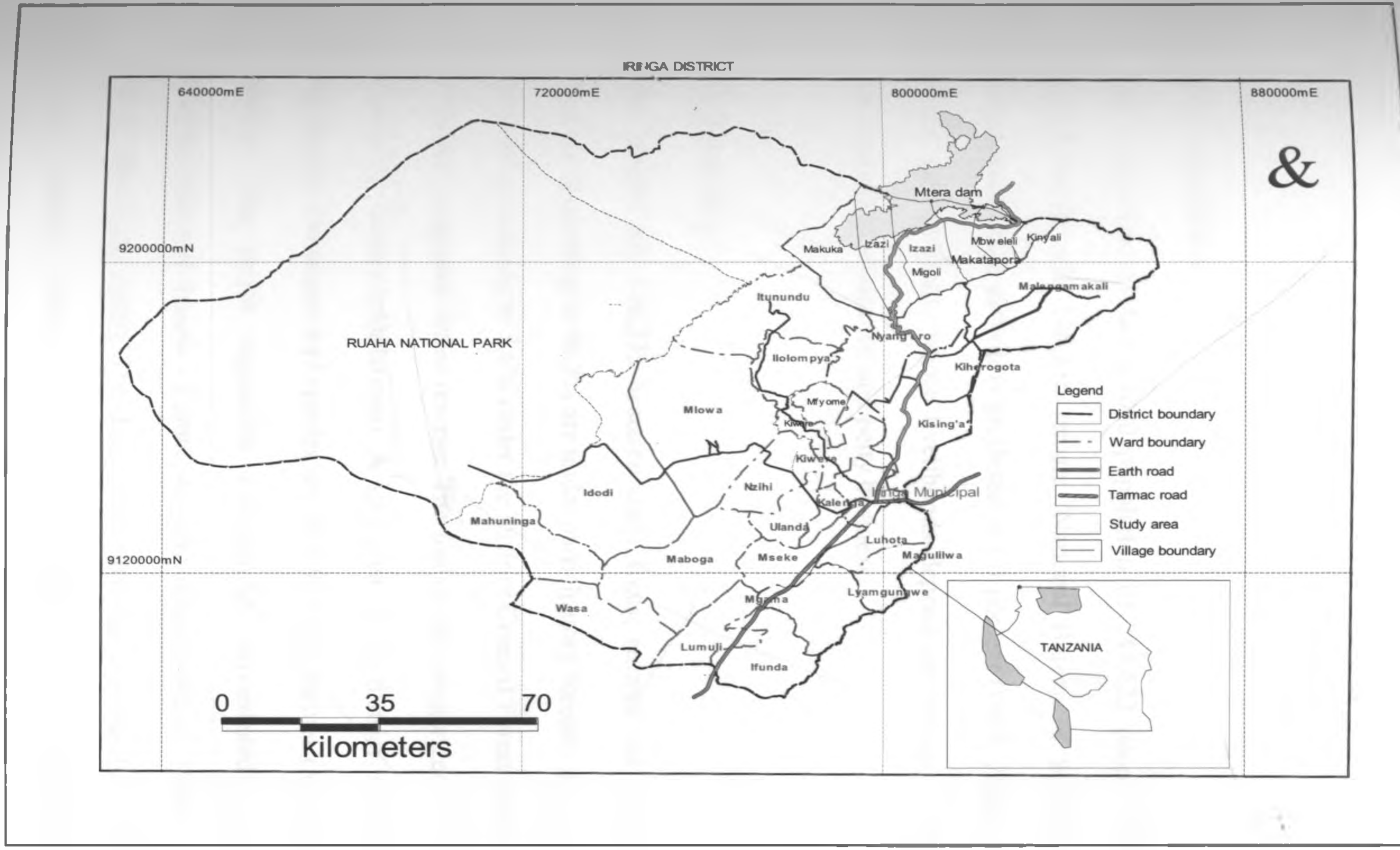


Figure 3.1. Map of Iringa District indicating six study sites

### 3.1.2 Population

The Iringa District has a total population of 245,623 people which comprises 119,487 male and 126,136 female (National Bureau of Statistics, 2002). The annual population growth is projected at 1.3 percent (URT, 2002). The main tribe of the area is Hehe, whose livelihoods depend on fishing, rainfed agriculture, forest products utilization and petty business.

### 3.1.3 Forestry

The District has 136,235 hectares under forest reserve out of which 131,253.7 hectares amounting to 96.3% are under participatory forestry management, 4,982.2 hectares accounting to 3.6% under the District Council Forest Reserve and the rest 0.1% are communal forest reserve. The forests are categorized into natural forests and exotic forests (plantations). A vast area of the district land is covered with woodlands. Dominant tree species are *Brachystegia* species (Miombo) and *Acacia* species. The major vegetation communities represented are *Julbernardia-Brachystegia* and *Acacia - Commiphora* woodland (White, 1993; Nahonyo *et al.*, 1998; DANIDA, 2000). The district has different woodlands namely Nyang'oro, Idodi, Pawaga, Mfyome, Kiwere, Makuka, Migoli, Mbweleli, Kinyali and Kitapilimwa; from which majority of the people depend on the existing forest resources during persistent drought. These forestlands are managed by the Central Government and Local Government Authorities.

### 3.1.4 Agriculture

Agriculture is the mainstay of the economy of Iringa District people with an approximately 95% of the rural population practicing mixed farming at subsistence level (IDI, 2008). The district has 480,158 hectares of arable land. Cultivated area is about 163,887 hectares (Nahonyo *et al.*, 1998). However, due to the aridity nature of some areas, agricultural production is not profitable and many families engage themselves in collecting forest product for their needs.

### 3.1.5 Soils

Soils are generally red brown lateritic, composed of loam, silt, sand and gravel in the Miombo woodlands which r are rocky outcrop. Alluvial black "cotton" soils are found in the flat lowlands (DANIDA, 2000). "*Mbugas*" (in Kiswahili) means areas where there is accumulation of fine sediment in poorly drained valley bottoms. Fine clay and silt cover the *mbuga* limestone.

### 3.1.6 Climate

Large area of Iringa District is located in the lowland which lies at an altitude of 900–1200m above sea level. This area forms part of Idodi, Mahuninga, Mlowa, Ilolompya, Itunundu, Izazi and Malengamakali wards. It experiences rainfall of between 500 and 600mm annually, and a mean temperature of between 20 and $30^0$C (IDI, 2008). Due to its topography and presence of Ruaha River and Mtera dam, the zone is more favorable for irrigation agriculture, fishing in Mtera dam and keeping of livestock mainly for indigenous cattle, sheep, goat and poultry. Despite the fact that the zone has very fertile land, agricultural production is low due to erratic rainfall.

### 3.1.7 Land use systems in the study sites

The land use systems were different in the study sites. However, other sites had the same land use systems since they are located in the same ecological zone. Makuka, Migoli, Mbweleli and Kinyali sites had similar land use systems such as livestock keeping, agriculture (sorghum, millet, maize and beans, sometimes irrigation agriculture is possible), forests from which products such as fuelwood, construction and food materials are derived; fishing activities from Mtera dam. In Kiwere and Mfyome the most important land use systems include agriculture and livestock keeping only. Generally, the land use systems in Makuka, Migoli, Mbweleli and Kinyali sites are more diverse but these areas are very dry in comparison with Kiwere and Mfyome sites. However, utilization of the forest products is common in all the study sites.

## 3.2 Methods

The study was carried out from November 2009 to December 2010. Methods of data collection consisted of a series of semi-structured and informal interviews to obtain information on plant uses, availability, preferences and conservation strategies. This information was obtained by interviewing different resource users and staff of the Ministry of Natural Resources and Tourism. Inventory-based and ethnobotanical resource assessment was used to determine the plant species composition and ecological data. The methodology employed was in accordance with the ethnobotanical methods used in other studies (Martin, 1995; Cotton, 1996).

### 3.2.1 Research design and sampling frame

A cross-sectional research design was used involving measurements of all variables for all cases within a narrow time span. Sampling was based on selection of 6 villages in proximity to the village forests. With assistance of village chairmen, a number of households were selected randomly using the village registers. From the register, names of 20 household heads were sampled per village using a random numbers and total number of 120 individuals were picked.

### 3.2.2 Assessment of edible woody plants and preferences

Participatory Rural Appraisal (PRA) was done in six villages boardering the forests to obtain information on woody plants used as food as suggested by Martin (1995), Alexiadess. and Shedon (1996) and Coe *et al.* (1999). A series of semi-structured interviews were employed in an open format that allows conversational, two-way communication in the communities around the village woodlands namely Kiwere, Mfyome, Mbweleli, Migoli, Kinyali and Makuka in which majority of the people depended on plant resources during persistent droughts. In every site, 20 people were selected randomly from the village register and interviewed. In each community, the interviews were conducted primarily with area resource users of key forest products from woody plants. The interview gathered information on edible woody plants frequently used by the local communities and their respective species names in local language. The species which were frequently used, their present trend of availability, and conservation status of shrubs and trees was also provided (Appendix 1).

A species preference of edible woody plants was done in the field following the technique reported by Martin (1995), Maundu (1995) and Cotton (1996). Preferred species for food including oils, fruits and vegetables were included. The respondents were asked to list the mostly preferred plants for oils, fruits and vegetables. From the list, two most used woody plants for vegetables, fruits and oils were selected and making a total of six most preferred plant species. The most preferred plants were valued by using a ranking value of one to five where the most preferred were given the highest value of five. This was done for five respondents from each village that was randomly encountered in the field and a total of 30 respondents were included in the study.

### 3.2.3 Inventory of forest resources

Selected woodlands were subjected to systematic assessment of the plants. A transect-based inventory was done in six woodlands managed by community, local and central government in Iringa District. The inventory methodologies included the following:

#### 3.2.3.1 Layout and enumeration

During sampling for vegetation data, a straight line method was used to achieve a systematic distribution of sample plots which were established along transects whose starting and ending points were selected randomly at each woodland site. Boundary points were avoided so as to reduce the marginal effects. The distance between the transects was 200m. Each transect was 1 km long and the orientation of each line was predefined by a compass bearing (North to South and East to West). Maintaining a constant and correct bearing along the transect, it is critical to ensure that all transects were parallel. Along each transect, 20 x 25 rectangular plots were laid at an interval of 100m. According to Lawton (1978) the 20 m x 25 m sample plots were adequate for plant composition studies of miombo woodlands and other woodlands in north-eastern Zambia. Greater sample sizes were found to result in few new species being recorded. McGregor (1994) also used plots of similar size in assessing the pattern and structure of miombo woodlands in peasant farming area of Zimbabwe.

During inventory phase a total of 120 rectangular plots of 20 x 25m were laid along the transects and assessed in six woodlands at which species names were identified by researcher and key informants for a comprehesive checklist at the University of Dar es Salaam herbarium and a voucher specimen deposited. During data collection all trees and shrubs wider than 10 cm in diameter at breast height (DBH) were measured for width by using 50cm caliper. Trees with diameter greater than 50cm, a measuring tape was used.

Within each 20 x 25 m plot, a 5 m x 15 m subplot was demarcated on the right hand side and the total number of saplings were counted and recorded. A 5 x 5m subplot was nested, in a similar manner, within each of the 5 x 15 m subplots for determining the number of seedlings. This nested vegetation sampling was done in accordance with Stohlgren *et al.* (1995).

Within the inner 5 x 15m subplot all seedlings and saplings of edible woody plants ($\leq$1cm and height $\leq$50cm) were assessed and enumerated to determine their regeneration potential. According to Sunderland (2000), any plant to be included in the regeneration potential should not exceed a height of 50cm. The recording sheets for the regeneration plots were separated from the recording sheets for the transect data.

The information was recorded on the field worksheets along with the location of the individuals along the transects (Appendix 2). In this study plants that were encountered in the field were collected and deposited as voucher specimens in the herbarium of the University of Dar es Salaam (UDSM). Other information collected included phenology, habitat, vernacular names, date, place of collection and uses of the species. In each plot of 20m x 25m, all woody plants were identified with the help of botanist and local informants. Wild food plants in each plot were also identified. Species that could not be identified in the field were collected and pressed for identification in the University of Dar es Salaam Herbarium

### 3.2.4 Sample collection and preparation for analysis

Six wild plant species were selected for study based on their performance in the preference ranking of the wild food plants from the study area. These were *Sterculia africana*, *Adansonia digitata*, *Vangueria infausta* fruits and *Opilia amentacea* and *Vitex mombassae* and *Maerua angolensis* leaves.

Parts of the identified plants were collected during the inventory survey from all woodland sites and temporarily stored in labeled polythene bags prior to being brought to the laboratory. *Sterculia africana* and *Adansonia digitata* were collected when dry while drupes of *Vangueria infausta* and *Vites mombassae* were collected when fleshy because the dried fruits are not consumable. The fleshy fruits were peeled off to get the edible part, dried at a room temperature, then oven dried. The dried fruits of *Adansonia digitata* and *Sterculia africana* were chopped then split open to free the seeds. The seeds were packed in 1 kg paper bag and oven dried. The vegetables were also collected, packed in paper bags and transported to the laboratory for further processing. In the oven, the leaves were dried at $105^0$C. for 48 hours. The dried samples were ground and sieved through 20 mm mesh sieve and stored in airtight containers prior to analysis at Sokoine University of Agriculture.

The preferred edible plant samples were analysed in triplicates for their moisture, crude protein, crude lipid, crude fibre and ash contents using standard methods as outlined by Association of Official Analytical Chemists (AOAC, 1995).

#### 3.2.4.1 Determination of moisture content of fruit, oil and vegetable samples

Moisture was determined by oven drying method. 1.5 g of well-mixed sample was accurately weighed in clean, dried crucible ($W_1$). The crucible oven dried at 105°C for 8 hours until a constant weight was obtained. Then the crucible was placed in the desiccator for 30 min to cool. After cooling it was weighed again ($W_2$). The percent moisture was calculated by following formula:

$$MC\% = W_1 - W_2 / \text{Wt of Sample} \times 100\%$$

Where

$W_1$ = Initial weight of crucible + Sample 1

$W_2$ = Final weight of crucible + Sample 1

### 3.2.4.2 Determination of ash in fruits, oils and vegetables

For determination of ash, a clean empty crucible was placed in a muffle furnace at 600°C for an hour, cooled in a desiccator and the weight of empty crucible recorded ($W_1$). One gram of each sample was put in the crucible and the weight recorded as ($W_2$). The sample was ignited over a burner with the help of blowpipe, until it was ashed. The crucible was placed in muffle furnace at 550°C for 2 hours. The appearances of grey white ash indicated complete oxidation of all organic matter in the sample. The crucible was cooled and weighed ($W_3$). Percent ash was calculated by following formula:

$$\%Ash = W_3 - W_1 / W_2 \times 100$$

### 3.2.4.3 Protein determination for fruits, oils and vegetables

The protein in the sample was determined by Kjeldahl method (AOAC, 1995). One gram of dried samples was put into digestion flask. 10mls of concentrated $H_2SO_4$ and 8 g of digestion mixture i.e. $K_2SO_4$ : $CuSO_4$ was added to the sample. The flask was swirled in order to mix the contents thoroughly and placed on a heater to start digestion till the mixture became clear (blue green in color). Two hours were required to complete the process. The digest was cooled and transferred to 100 ml volumetric flask and the volume was made up to mark by the addition of distilled water. Distillation of the digest was performed in Markam

Still Distillation Apparatus (Khalil and Manan, 1990). Ten (10) milliliters of digest was introduced in the distillation tube then 10 ml of 0.5 N NaOH was gradually added through the same way.

Distillation was continued for at least 10 min and $NH_3$ produced was collected as $NH_4$ OH in a conical flask containing 20 ml of 4% boric acid solution with few drops of modified methyl red indicator. During distillation process, yellowish colour appeared due to formation of $NH_4$ OH. The distillate was titrated against standard 0.1 N HCl solution till the appearance of pink color. A blank was also run through all steps as above. Percent crude protein content of the sample was calculated by using the following formula:

% Crude Protein = 6.25* x %N (*. Correction factor) (AOAC, 1995)

**3.2.4.4 Determination of crude fat in fruit, oil and vegetable samples**

Fat was determined by dry extraction method whereby the samples were put into a desiccator and weighed (W). It consisted of extracting dry sample with some QAORGANIC solvent, since all fat materials e.g. fats, phospholipids, sterols, fatty acids, carotenoids, pigments, chlorophyll etc. are extracted together therefore, the results are frequently referred to as crude fat. Crude fat was determined by ether extract method using Soxhlet apparatus as follows:

One gram of moisture free sample was wrapped in filter paper, placed in fat free thimble and then introduced in the extraction tube. Samples were weighed, cleaned and dried. The samples were filled with petroleum and then water was added and heated. After siphoning for five times, ether was allowed to evaporate and the beaker was disconnected before last siphoning. The extract was transferred into a clean glass dish with ether washing and evaporated ether on water bath. The dish was placed in an oven at 105°C for 2 hrs and cooled in a desiccator. The percent crude fat was determined by using the following formula:

% Crude Fat = Weight of ether extract/Weight of sample x100.

**3.2.4.5 Determination of crude fiber in fruits, oils and vegetables**

A moisture free and ether extracted sample of crude fiber made of cellulose was first digested with dilute $H_2SO_4$ and then with dilute KOH solution. The undigested residue collected was ignited and loss in weight after ignition was registered as crude fiber.

0.2g of the sample was weighed ($W_0$) and transferred to porous crucible. The crucible was placed into Dosi-fiber unit with the valve in "OFF" position. To this, 150 ml of preheated $H_2SO_4$ solution was added and some drops of foam-suppresser to each column. The cooling circuit was opened and turned on the heating elements (power at 90%). When it started boiling, the power was reduced by 30% and left for 30 min. The valves were opened for drainage of acid, followed by and rinsing with distilled water thrice to ensure complete removal of acid traces from the sample.

The same procedure was used for alkali digestion by using KOH instead of $H_2SO_4$. The sample was dried in an oven at $150^0C$ for 1 hour and allowed to cool in a desiccator and weighed ($W_1$). The sample crucibles were kept in muffle furnace at $55^oC$ for 4 hrs and cooled and weighed as $W_2$. Calculations were done by using the formula:

$$\% \text{ Crude fibre} = W_1 - W_{2/} Wo \times 100$$

### 3.2.4.6 Carbohydrates and nutrients determination in food samples

Carbohydrate content was obtained in accordance to methods outlined by Hassan and Umar (2006) by using the formula:

Carbohydrate content %= 100-(moisture + crude protein + crude lipid + crude fibre + ash content)

Potassium and sodium were determined by using flame emission spectrophotometer. Phosphorus was determined by vanado-molybdate colorimetric method. Calcium, iron, zinc and manganese were determined spectophotometrically using Buck 200 atomic absorption spectrophometer (Essien *et al.*, 1992), and these values compared with absorption of standards of these minerals.

### 3.2.4.7 Vitamin C determination in fruits, oils and vegetables

The determination of vitamic C content in each sample was carried out using the technique of Iodometric titration (AOAC, 1980; 1995). This involved adding 20ml of 0.5M $H_2SO_4$ solution to 50ml of each decolourized sample and followed by adding 2g of potassium iodide. Thereafter, 25ml of the standard potassium trioxoiodate solution was pipetted into each sample solution and a pale-yellow colour of the solution was observed. The ascorbic acid in the sample was analysed by generating excess water-iodine solution of potassium trioxoidate and potassium iodide. After the ascorbic acid has reacted the remainder was titrated with standard thiosulphate solution.

### 3.2.4.8 Determination of anti-nutrients in fruits, oils and vegetables

***Total Phenols***

Total phenols were extracted by heating a weighed portion of 500gm of dried sample with 5ml of 1.2M HCl in 50% aqueous methanol for 2h at 90°C and analyzed by Folin-Ciocalteau micro method (Slinkard and Singleton, 1977; Singleton *et al.*, 1999).

*Total Tannins*

Tannin was determined using the method of Trease and Evans (1978). 1 ml of the methanolic extract was treated with 5 ml Folin Dennis reagent in a basic medium and allowed to stand for colour development. The absorbance of the reaction mixture of each sample was measured at 760 nm spectrophotometrically.

### 3.2.5 Prioritization for conservation of edible woody plants

The edible wild food plants that were obtained from ethnobotanical survey were subjected to prioritization for conservation criteria as suggested by Kariuki and Simiyu (2005). A number of criteria were employed to prioritize the species for conservation to include:

i. Status: whether the species in question was threatened, endangered, vulnerable or least concern
ii. Uses: whether the species had single or multiple uses
iii. Distribution: the extent of occurrence of species in Tanzania in terms of floristic regions and coverage
iv. Endemism: whether the species was endemic, near endemic or widespread in its distribution across East Africa region
v. Regeneration: whether the species was propagated by one or several modes
vi. Life form: whether the species was herbaceous, woody shrub or trees, annual, biennial or perennial species
vii. Commercial value: whether the species had any commercial value outside

the area of occurrence or was only collected for subsistence use

viii. Cultural values

ix. Legislative values

If the criterion was applicable to any species it scored 1 and if the attribute did not apply, the species scored 0.

For example endangered species scored 1 and that of least concern 0. Species with multiple uses scored 1 and 0 for single use. A species that was found in all floristic regions of Tanzania scored 0 and one confined to very few floristic regions 1. If a species was endemic it scored 1 and wide spread distribution scored 0. A species with difficult propagation scored 1 and several propagation modes scored 0. Species with commeracial value scored 1 and non-commercial values 0. If species has cultural and legislative values scored 1 and low cultural and legislative protection scored 0.

The sources of the information were IUCN 2010, (the International Union for Conservation of Nature), CITES (the Convention on the International Trade on Endangered Species of Wild Fauna and Flora), EAPRLA (The East Africa Plants Red List Authority) and information obtained from the questionnaire survey. The scores were enumerated, summed up and ranked to obtain the species of high, intermediate and less conservation significance.

### 3.3 Data Analysis

The quantitative and qualitative methods were used to analyze the data from different sources. Ethnobotanical data were analyzed using descriptive statistics in SPSS Version 15 (Levesque, 2007). The results were presented in form of frequency distribution tables, cross tabulation and other graphical methods based on questionnaire variables. Qualitative methods were employed to analyze the data from field observations, organizational documents and literature studies.

Data which were recorded from the transect surveys were sorted to identify the key woody plants used as food into tables with the different diameter at breast height (DBH) values, DBH classes and number of seedlings and saplings for determining the population structure, density and frequency by using Pivot-Table merging technique in Microsoft Excel Version 11.

The diameter distribution classes were counted in relation to the number of individuals, converted into percentages and plotted on a bar graph to represent population structure. The data provided highlights on the population dynamics among the six forests of Iringa District. Proximate composition, minerals, vitamins, carbohydrates, anti-nutritional factors like free phenols and tannins were estimated in triplicates and the data were analyzed using statistical analysis system SPSS Version 15 (Levesque, 2007). Estimates of means and standard errors for all the parameters were calculated. Other inventory data were compared across the study sites using Analysis of Variance (ANOVA) in SPSS Software.

Density = Number of Individuals/Area surveyed

Relative density = number of individuals of a species/total number of individuals ×100%

Frequency= Number of quadrats in which species occur/Total number of quadrats sampled

Relative frequency = frequency of a species/sum frequencies of all species.

In addition the Law of Frequency was used to assess the rarity or commonness of the tree species (Pirie *et al.*, 2000; Hewit and Kellman, 2002). In this classification the percentage frequency of the species was classed as A, B, C, D and E; where A represents rare (0–20%), B is low frequency (20–40%), C is intermediate frequency (40–60%), D is moderately high frequency (60–80%) and E is high frequency or common (80–100%).

# CHAPTER FOUR

## 4. 0 RESULTS

### 4.1 Vegetation description composition of woody plants

#### 4.1.1 Composition of woody plants

The results indicated that a total of 204 species of woody plant species representing 39 families were identified (Table 4.1). As indicated in Table 4.1, Fabaceae, Rubiaceae, Anacardiaceae and Combretaceae were the most diverse families (in terms of species richness) of the woody species, contributing 49.5% of all the species in the study. Families Tiliaceae, Verbenaceae and Loganiaceae were moderately diverse with 7% each. Family Fabaceae had 62 species accounting to 30.4% of all the species.

The distribution of families in different study sites is indicated in Table 4.1 of which Kiwere and Mbweleli woodland sites had most number of families, followed by Mfyome and Migoli sites. As indicated in Table 4.1, 12 families were present in all six woodland sites, accounting for 35% of the total woody plants. The dominant families included Anacardiaceae, Apocynaceae, Boraginaceae, Burseraceae, Capparaceae, Euphorbiaceae, Fabaceae, Loganiaceae, Ochnaceae, Olacaceae, Opiliaceae, Rubiaceae, Sterculiaceae and Verbenaceae. The overall species encountered in the field are shown in Appendix 3.

Table 4.1. Composition of families of woody plants and their distribution in six woodland sites in Iringa District, Tanzania

KEY: (+) Presence of a family (-) Absence of family

| Family | Family Distribution in woodland sites | | | | | | Total Number of Species encountered in all sites | Percentage |
|---|---|---|---|---|---|---|---|---|
| | **Kiwere** | **Mfyome** | **Migoli** | **Mbweleli** | **Kinyali** | **Makuka** | | |
| Acanthaceae | + | - | - | + | - | - | 3 | 1.5 |
| Anacardiaceaae | + | + | + | + | + | + | 11 | 5.4 |
| Apocynaceae | + | + | + | + | + | + | 4 | 2.0 |
| Araliaceae | + | + | + | - | - | + | 1 | 0.5 |
| Asparagaceae | + | + | - | - | - | - | 2 | 1.0 |
| Balanitaceae | + | - | - | - | - | - | 1 | 0.5 |
| Bignoniaceae | + | + | + | - | + | + | 3 | 1.5 |
| Bombacaceae | - | + | + | + | + | + | 1 | 0.5 |
| Boraginaceae | + | + | + | + | + | + | 2 | 1.0 |
| Burseraceae | + | + | + | + | + | + | 5 | 2.5 |
| Combretaceae | + | + | - | - | - | + | 10 | 4.9 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Capparidaceae | + | + | + | + | + | + | 10 | 5.4 |
| Celastraceae | + | - | + | + | - | - | 2 | 1.0 |
| Chrysobalanaceae | - | - | + | + | - | + | 1 | 0.5 |
| Ebenaceae | - | + | + | + | - | + | 1 | 0.5 |
| Euphorbiaceae | + | + | + | + | + | + | 9 | 4.4 |
| Flacourtiaceae | - | - | - | + | + | - | 1 | 0.5 |
| Lamiaceae | + | + | - | + | - | - | 4 | 2.0 |
| Fabaceae | + | + | + | + | + | + | 62 | 30.4 |
| Loganiaceae | + | + | + | + | + | + | 7 | 3.4 |
| Meliaceae | - | - | + | - | - | + | 4 | 2.0 |
| Malvaceae | + | + | + | + | + | + | 1 | 0.5 |
| Moraceae | - | + | + | + | + | - | 1 | 0.5 |
| Myrtaceae | + | - | - | - | - | - | 1 | 0.5 |
| Ochnaceae | + | + | + | + | + | + | 2 | 1.0 |
| Olacaceae | + | + | + | + | + | + | 2 | 1.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Oleaceae | + | + | + | - | + | + | 1 | 0.5 |
| Opiliaceae | + | + | + | + | + | + | 2 | 1.0 |
| Polygalaceae | + | + | - | + | - | - | 1 | 0.5 |
| Rhamnaceae | + | + | + | - | + | - | 3 | 1.5 |
| Rubiaceae | + | + | + | + | + | + | 18 | 8.8 |
| Santalaceae | + | + | + | - | - | - | 1 | 0.5 |
| Sapindaceae | - | + | + | + | + | - | 4 | 2.0 |
| Smilacaceae | - | - | + | + | - | - | 3 | 1.5 |
| Sterculiaceae | + | + | + | + | + | + | 3 | 1.5 |
| Tiliaceae | + | + | + | + | + | + | 7 | 3.4 |
| Verbenaceae | + | + | + | + | + | + | 7 | 3.4 |
| Violaceae | - | - | - | + | - | - | 1 | 0.5 |
| Vitaceae | - | - | - | + | - | - | 1 | 0.5 |
| | | | **Total** | | | | 204 | 100.0 |

Among the studied woody plants the results revealed that 49.5% of the studied woody plants were shrubs while trees accounted for 50.5%. The compostion of trees and shrubs in all the study sites are shown in Figure 4.2. As shown in the figure, among the identified plant species, Makuka, Migoli and Kiwere woodlands had the highest number of trees, which accounted for 64.2%, 64.3% and 60% respectively. In Mbweleli woodland, the number of trees was also lower (38.7%) than the number of shrubs that amounted to 61.3%. Kinyali woodland site had 54.3% and 45.7% of trees and shrubs were recorded respectively.

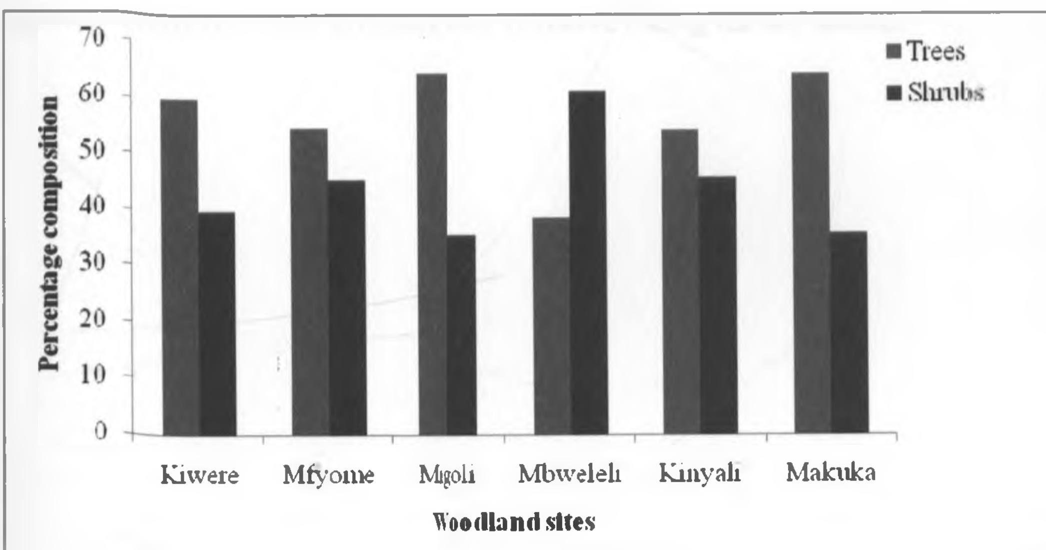


Figure 4.2. Composition of trees and shrubs in six woodland sites of Iringa District, Tanzania.

### 4.2 Edible woody plants

#### 4.2.1. Commonly used edible woody plants

Results recorded from questionnaire and key informants revealed that among the studied woody plants, 66 species were used as food and were distributed in 28 families (Table 4.2). This corresponded to about 32.4% of the studied woody plant species. Among the edible woody plants, 77.2% were commonly used as fruits and only1.4% as vegetables. The rest were used in form of resins, rootstock and seeds are mostly available in the woodland sites in the mid or end of rainy seasons. However, other products were available during the dry season.

Table 4.2. Edible woody plants identified from six woodland sites in Iringa District, Tanzania

| S/N | Species | Family | Edible parts | When available | LRS-Long Rain Season SRS-Short Rain Season DS-Dry Season |
|---|---|---|---|---|---|
| 1 | *Acacia senegal* | Fabaceae | Resins from bark | July-September | DS |
| 2 | *Acanthopale laxiflora* | Acanthaceae | fruits | December-April | LRS |
| 3 | *Acokanthera schimperi* | Apocynaceae | fruits | April-July | LRS |
| 4 | *Adansonia digitata* | Bombacaceae | leaves, fruits and seeds | All year round | LRS, SRS and DS |
| 5 | *Asparagus asparagoides* | Asparagaceae | Fruits | June-July | DS |
| 6 | *Azanza garckeana* | Malvaceae | fruits | May-November | DS |
| 7 | *Balanites aegyptiaca* | Balanitaceae | Fruits, seeds as oil | April-June | LRS |
| 8 | *Bauhinia kalantha* | Fabaceae | Leaves | November-April | SRS and LRS |
| 9 | *Berchemia discolor* | Rhamnaceae | fruits | March-April | LRS |
| 10 | *Bridelia cathartica* | Euphorbiaceae | fruits | February-June | LRS |
| 11 | *Bridelia micrantha* | Euphorbiaceae | fruits | January-April | LRS |
| 12 | *Canthium bibracteatum* | Rubiaceae | fruits | April-June | LRS |
| 13 | *Canthium burtii* | Rubiaceae | fruits | February-April | LRS and SRS |

| | | | | | |
|---|---|---|---|---|---|
| 14 | *Canthium crassum* | Rubiaceae | fruits | February-April | LRS and SRS |
| 15 | *Coffea eugenioides* | Rubiaceae | fruits | December-March | SRS |
| 16 | *Commiphora africana* | Burseraceae | rootstock | March-May | LRS |
| 17 | *Cordia africana* | Boraginaceae | fruits | July-November | DS |
| 18 | *Cordia sinensis* | Boraginaceae | fruits | July-November | DS |
| 19 | *Cordyla africana* | Fabaceae | fruits | November-December | SRS |
| 20 | *Crotalaria agatiflora* | Fabaceae | Leaves | December-April | LRS and SRS |
| 21 | *Crotalaria spartea* | Fabaceae | Leaves | December-April | LRS and SRS |
| 22 | *Ficus glumosa* | Moraceae | fruits | June-September | DS |
| 23 | *Grewia bicolor* | Tiliaceae | fruits | April-June | LRS |
| 24 | *Grewia hexamina* | Tiliaceae | fruits | April-June | LRS |
| 25 | *Grewia platyclada* | Tiliaceae | fruits | April-June | LRS |
| 26 | *Grewia similis* | Tiliaceae | fruits | April-June | LRS |
| 27 | *Grewia sinensis* | Tiliaceae | fruits | April-June | LRS |
| 28 | *Isoglossa lactea* | Acanthaceae | Leaves | January-April | SRS and LRS |
| 29 | *Kigelia africana* | Bignoniaceae | fruits | June-December | DS and Early SRS |

| | | | | | |
|---|---|---|---|---|---|
| 30 | *Lannea stuhlmannii* | Anacardiaceae | fruits | January-April | LRS and SRS |
| 31 | *Lannea fulva* | Anacardiaceae | fruits | February-March | SRS |
| 32 | *Lannea humilis* | Anacardiaceae | fruits | November-January | SRS |
| 33 | *Lannea schimperi* | Anacardiaceae | fruits | March-June | LRS |
| 34 | *Lannea schweinfurthii* | Anacardiaceae | fruits | May-June | LRS |
| 35 | *Maerua angolensis* | Capparidaceae | fruits, leaves | January-March | SRS |
| 36 | *Maerua parvifolia* | Capparidaceae | leaves | February-May | SRS and LRS |
| 37 | *Maerua prittwitzii* | Capparidaceae | fruits | February-May | LRS and SRS |
| 38 | *Maerua triphyla* | Capparidaceae | Roots/tubers | February-May | LRS and SRS |
| 39 | *Ochna holstii* | Ochnaceae | fruits | April-November | LRS and DS |
| 40 | *Opilia amentacea* | Opiliaceae | Leaves, fruits | April-November | LRS and DS |
| 41 | *Opilia celtidifolia* | Opiliaceae | leaves/ fruits | April-November | LRS and DS |
| 42 | *Ormocarpum trachycarpum* | Fabaceae | leaves | November-April | LRS and SRS |
| 43 | *Osyris lanceolata* | Santalaceae | Fruits, bark, roots | July-December | DS and SRS |
| 44 | *Parinari excelsa* | Chrysobalanaceae | Fruits, seeds | November-December | SRS |
| 45 | *Piliostigma thonningii* | Fabaceae | Fruits | May-August | LRS and DS |

| | | |
|---|---|---|
| 46 | *Rhus natalensis* | Anacardiaceae |
| 47 | *Sterculia africana* | Sterculiaceae |
| 48 | *Strychnos cocculoides* | Loganiaceae |
| 49 | *Strychnos innocua* | Loganiaceae |
| 50 | *Strychnos madagascariensis* | Loganiaceae |
| 51 | *Strychnos pungens* | Loganiaceae |
| 52 | *Strychnos spinosa* | Loganiaceae |
| 53 | *Syzygium guineense* | Myrtaceae |
| 54 | *Tamarindus indica* | Fabaceae |
| 55 | *Uapaca kirkiana* | Euphorbiaceae |
| 56 | *Uapaca kirkii* | Euphorbiaceae |
| 57 | *Vanguelia tomentosa* | Rubiaceae |
| 58 | *Vangueria infausta* | Rubiaceae |
| 59 | *Vitex doniana* | Verbenaceae |
| 60 | *Vitex iringensis* | Verbenaceae |
| 61 | *Vitex mombassae* | Verbenaceae |

| | | |
|---|---|---|
| fruits | May-November | LRS and DS |
| Seeds as Oil | July-December | DS and SRS |
| Fruits and seeds | July-December | DS and SRS |
| fruits | August-December | DS and SRS |
| fruits | January-April | SRS |
| fruits | January-March | SRS |
| fruits | May-June/Nov-December | LRS and SRS |
| fruits | February- June | SRS and LRS |
| fruits | June-November | DS and SRS |
| fruits | October-January | SRS |
| fruits | December-March | SRS |
| fruits | December-April | SRS and LRS |
| fruits | November-July | SRS and LRS |
| Fruits, seeds | April-July | LRS |
| Fruits, seeds | December-May | SRS and LRS |
| Fruits, seeds | April-September | LRS and SRS |

| | | | | | |
|---|---|---|---|---|---|
| 62 | *Ximenia caffra* | Olecaceae | fruits | November-January | SRS |
| 63 | *Zantha africana* | Sapindaceae | fruits | November-January | SRS |
| 64 | *Zanthoxylum chalybeum* | Rutaceae | Leaves, bark | January-April | SRS and LRS |
| 65 | *Ziziphus mauritania* | Rhamnaceae | Fruits, seeds | April-June | LRS |
| 66 | *Ziziphus mucronata* | Rhamnaceae | Fruits | May-August | LRS and DS |

KEY: Long rain season: March-June    Short rain season: November-February    Dry season: July-September

### 4.2.2 Preferred woody food plants

Among the studied edible woody plants, the most commonly preferred species as source of edible oils were *Adansonia digitata* and *Sterculia africana* in all villages. A*dansonia digitata* scored 311 out of 842 scores accounting for 37% followed by *Sterculia africana* with 29%. The lowest values were recorded from *Parinari excelsa* and *Balanites aegyptiaca* with 19% and 15% of the total scores respectively. Species preference in different villages are indicated in Table 43a whereby Mbweleli showed high preference of *Adansonia digitata* with 65%, followed by 47% at Migoli and less preference of 3.7% was recorded at Kiwere site. *Sterculia africana* was most preferred at Mfyome village by 40% followed by Makuka and Migoli villages with 36.6% and 33.3% respectively. However, *Balanites aegyptiaca* and *Parinari excelsa* were less common oil plants and most preferred at Kiwere village with 36.5% and 36.8% respectively.

Preferred species for vegetables are indicated in Table 4.3b, of which *Maerua angolensis, Adansonia digitata* and *Opilia amentacea* had the highest preference scores of 265, 270, and 265 respectively out of 928 total scores obtained during preference ranking process in all villages. These scores show that each preferred species account for about 29%. *Zanthoxylum chalybeum* had the lowest scores of 128 (14%). From the preference scores two species namely *Opilia amentacea* and *Maerua angolensis* were picked as the mostly preferred woody plants for vegetables. Although *A. digitata* had the same percentage contribution with other species like *Opilia amentacea* and *Maerua angolensis*, it was not considered for vegetables but rather for oils. Village preferences are indicated in Table 4.3b whereby Migoli and Kinyali villages showed a high preference for *Adansonia digitata* but low preference of this species was recorded at Kiwere village. *Opilia amentacea* was most preferred in all the villages whereby Mfyome village had the highest percentage (53%), followed by 33% at Kiwere, while 28% and 20% were recorded at Kinyali and Migoli respectively. *Maerua angolensis* was also preferred mostly at Mfyome village with 46% followed by Makuka with 37% and Migoli and Kiwere villages showed 25% and 24% respectively.

The edible woody plants that were preferred as source of fruits are indicated in Table 4.3c. During the preference ranking process, 8 species were identified by the local communities and results further showed that *Vangueria infausta*, *Vitex mombassae*, *Azanza garckeana* scored 290 (17.4%), 270 (16.2%) and 257 (15.4%) respectively out of 1664 total preference scores. Therefore, the two species i.e. *Vangueria infausta* and *Vitex mombassae* were selected as key species preferred for fruits in the study sites. Different villages showed varying preferences of fruit producing plants as indicated in Table 4.3c. *Vangueria infusta* was preferred mostly at Migoli, Mfyome and Makuka villages at 21% each, whereas 19% was recorded at Kinyali village. *Vitex mombassae* was the most preferred species at Kiwere, Migoli and Makuka villages at 18% each. *Azanza garckeana* and *Vitex* *doniana* showed preferences of 15.6% and 18% respectively. However, high preference of *Azanza garckeana* was recorded at Kiwere with 19% while *V. doniana* was highly preferred in Mbweleli village with 20.9%.

Table 4.3a. Most preferred species for oils in Iringa District, Tanzania

| | | Preferred Species for oils | | | | |
|---|---|---|---|---|---|---|
| Village | | *Adansonia digitata* | *Balanites aegyptiaca* | *Sterculia africana* | *Parinari excelsa* | **Total** |
| Makuka | Scores | 64.0 | 20.0 | 60.0 | 20.0 | |
| | % | 39.0 | 12.2 | 36.6 | 12.2 | |
| Migoli | Scores | 100.0 | 10.0 | 70.0 | 30.0 | |
| | % | 47.6 | 4.8 | 33.3 | 14.3 | |
| Kinyali | Scores | 72.0 | 30.0 | 55.0 | 50.0 | |
| | % | 34.8 | 14.5 | 26.6 | 24.2 | |
| Kiwere | Scores | 5.0 | 50.0 | 45.0 | 36.0 | |
| | % | 3.7 | 36.8 | 33.1 | 26.5 | |
| Mbweleli | Scores | 65.0 | 15.0 | 5.0 | 15.0 | |
| | % | 65.0 | 15.0 | 5.0 | 15.0 | |
| Mfyome | Scores | 5.0 | 5.0 | 10.0 | 5.0 | |
| | % | 20.0 | 20.0 | 40.0 | 20.0 | |
| **Total** | Scores | **311.0** | **130.0** | **245.0** | **156.0** | **842.0** |
| | % | **37** | **15** | **29** | **19** | **100** |

**Note:** Scores were determined by valuing most preferred plants by using a ranking value of one to five. First rank was given the highest value of five.

Table 4.3b. Preference scores of most preferred species for vegetables in Iringa District, Tanzania

| Village | | Preferred Species for vegetables | | | | |
|---|---|---|---|---|---|---|
| | | *Adansonia digitata* | *Zanthoxylum chalybeum* | *Opilia amentacea* | *Maerua angolensis* | Total |
| Makuka | Scores | 70.0 | 13.0 | 45.0 | 75.0 | |
| | % | 34.5 | 6.4 | 22.2 | 36.9 | |
| Migoli | Scores | 65.0 | 0.0 | 25.0 | 30.0 | |
| | % | 54.2 | 0.0 | 20.8 | 25.0 | |
| Kinyali | Scores | 55.0 | 0.0 | 30.0 | 20.0 | |
| | % | 52.4 | 0.0 | 28.6 | 19.0 | |
| Kiwere | Scores | 45.0 | 70.0 | 90.0 | 65.0 | |
| | % | 16.7 | 25.9 | 33.3 | 24.1 | |
| Mbweleli | Scores | 35.0 | 45.0 | 40.0 | 45.0 | |
| | % | 21.2 | 27.3 | 24.2 | 27.3 | |
| Mfyome | Scores | 0.0 | 0.0 | 35.0 | 30.0 | |
| | % | 0.0 | 0.0 | 53.8 | 46.2 | |
| **Total** | Scores | **270.0** | **128.0** | **265.0** | **265.0** | **928.0** |
| | % | **29** | **13.8** | **28.6** | **28.6** | **100** |

**Note:** Scores were determined by valuing most preferred plants by using a ranking value of one to five. First rank was given the highest value of five.

Table 4.3c. Preference scores of most preferred species for fruits in Iringa District, Tanzania

| | | Preferred Species for fruits | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Village | | *Adansonia digitata* | *Tamarindus indica* | *Cordyla africana* | *Grewia bicolar* | *Vitex doniana* | *Azanza garckeana* | *Vitex mombassae* * | *Vangueria infausta* * | **Total** |
| Makuka | Scores | 15.0 | 32.0 | 35.0 | 25.0 | 35.0 | 50.0 | 55.0 | 65.0 | |
| | % | 4.8 | 10.3 | 11.2 | 8.0 | 11.2 | 16.0 | 17.6 | 20.8 | |
| Migoli | Scores | 20.0 | 4.0 | 49.0 | 20.0 | 55.0 | 65.0 | 65.0 | 75.0 | |
| | % | 5.7 | 1.1 | 13.9 | 5.7 | 15.6 | 18.4 | 18.4 | 21.2 | |
| Kinyali | Scores | 50.0 | 30.0 | 22.0 | 50.0 | 30.0 | 35.0 | 45.0 | 60.0 | |
| | % | 15.5 | 9.3 | 6.8 | 15.5 | 9.3 | 10.9 | 14.0 | 18.6 | |
| Kiwere | Scores | 30.0 | 50.0 | 20.0 | 30.0 | 20.0 | 52.0 | 50.0 | 20.0 | |
| | % | 11.0 | 18.4 | 7.4 | 11.0 | 7.4 | 19.1 | 18.4 | 7.4 | |
| Mbweleli | Scores | 5.0 | | 45.0 | 35.0 | 45.0 | 25.0 | 30.0 | 30.0 | |
| | % | 2.3 | 0.0 | 20.9 | 16.3 | 20.9 | 11.6 | 14.0 | 14.0 | |
| Mfyome | Scores | 0.0 | 35.0 | 20.0 | 20.0 | 20.0 | 30.0 | 25.0 | 40.0 | |
| | % | 0.0 | 18.4 | 10.5 | 10.5 | 10.5 | 15.8 | 13.2 | 21.1 | |
| **Total** | **Scores** | **120.0** | **151.0** | **191.0** | **180.0** | **205.0** | **257.0** | **270.0** | **290.0** | **1664 16** |
| | **%** | **7.2** | **9.1** | **11.5** | **10.8** | **12.3** | **15.4** | **16.2** | **17.4** | **100.0** |

*-Indicate the selected species for fruits

**Note:** Scores were determined by valuing most preferred plants by using a ranking value of one to five. First rank was given the highest value of five.

### 4.3. Ecological parameters of most preferred edible woody plants

#### 4.3.1 Density

In all studied forest sites, *Opilia amentacea* had the highest average number of individuals per ha accounting for 28.6% of all individuals followed by *Vangueria infausta* with 26% (Table 4.4). *Maerua angolensis* had the lowest number of individuals. The results revealed that Mbweleli forest site had the highest number of individuals of *Opilia amentacea* (520 individuals/ha) followed by *Adansonia digitata* with 480 individuals per ha than any other site. Also *Sterculia africana* (380 trees/ha) and *Vangueria infausta* (320 trees/ ha) were higher in Mbweleli than other sites.

**Table 4.4. Density of highly preferred edible woody plants in six woodland sites of Iringa District, Tanzania**

| Preferred species | Product | Forest Sites (Number of Individual/ha) | | | | | | Average |
|---|---|---|---|---|---|---|---|---|
| | | Kiwere | Mfyome | Migoli | Mbweleli | Kinyali | Makuka | |
| *Adansonia digitata* | Oil | 20 | 140 | 20 | 480 | 180 | 100 | 156.7 |
| *Sterculia africana* | Oil | 40 | 100 | 120 | 380 | 140 | 160 | 156.7 |
| *Vangueria infausta* | Fruit | 260 | 60 | 180 | 320 | 260 | 340 | 236.7 |
| *Vitex mombassae* | Fruit | 20 | 20 | 40 | 20 | 100 | 240 | 73.3 |
| *Opilia amentacea* | Vegetable | 160 | 180 | 120 | 520 | 260 | 320 | 260.0 |
| *Maerua angolensis* | Vegetable | 20 | 20 | 20 | 20 | 60 | 20 | 26.7 |

### 4.3.2 Percentage frequency of preferred woody plants

Six preferred species from the study area had a wide range of occurrence, with percentage frequency from 5-50 % (Table 4.5). There was a high number of preferred woody plants that occurred only once that is a frequency of 0-20%. The distribution of six most preferred species into frequency classes showed that almost all species encountered were rare and had low frequency ranging from 0-40%. Only *A. digitata* and *O. amentacea* found from Mbweleli woodland site had intermediate frequency of between 40-60% and none of the species among the six preferred species were found with the other classes that is above 60%.

Table 4.5. Percentage frequency of highly preferred edible woody plants in six woodland sites of Iringa District, Tanzania

| | | Forest Sites (Percentage Relative frequency) | | | | | | Average |
|---|---|---|---|---|---|---|---|---|
| **Preferred species** | **Product** | **Kiwere** | **Mfyome** | **Migoli** | **Mbweleli** | **Kinyali** | **Makuka** | **%** |
| *Adansonia digitata* | Oil | 5 | 25 | 10 | 45 | 10 | 10 | 17.5 |
| *Sterculia africana* | Oil | 5 | 20 | 5 | 25 | 10 | 10 | 12.5 |
| *Vangueria infausta* | Fruit | 35 | 15 | 20 | 35 | 25 | 25 | 25.8 |
| *Vitex mombassae* | Fruit | 5 | 5 | 5 | 5 | 10 | 10 | 6.7 |
| *Opilia amentacea* | Vegetable | 30 | 45 | 15 | 50 | 25 | 25 | 31.7 |
| *Maerua angolensis* | Vegetable | 5 | 5 | 5 | 20 | 5 | 5 | 7.5 |

### 4.3.3 Seedlings and saplings

The results indicated that there was considerable variation in regeneration of seedlings (young plants already germinated from seeds < 15 cm) as indicated in Table 4.6. Mbweleli woodland had highest level of seedlings regeneration of 35,066 individuals/ha which is 33% of the total regeneration in the area followed by Makuka forest site with 17% of all seedlings. Saplings (young tree of less than 50 cm however, in montane forests it can even be 200 cm) were higher also at Mbweleli accounting to 6,134 saplings per ha followed by 3,866 saplings per ha at Makuka forest site.

Also, regeneration of the most preferred woody plants in the study area is indicated in Table 4.6. As indicated in the table *Opilia amentacea* had 10,800 seedlings per ha, followed by *Adansonia digitata* with 10,000 seedlings per ha at Mbweleli woodland. Likewise, Mbweleli woodland site showed higher regeneration than other sites. For example *Sterculia africana* had 5,333 seedlings while 5466 seedlings per ha was recorded for *Vangueria infausta* and 2667 seedling per ha for *Maerua angolensis*. Sapling number enumerated for *Opilia amentacea* (4,788 saplings per ha) was higher than those of other preferred species for example *Adansonia digitata* with 4667 saplings and 466 saplings per ha for *Vitex mombassae* (Table 4.6).

Table 4.6. Seedlings and sapling density of most preferred edible woody plants in Iringa District, Tanzania

| | | Woodland sites | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Preferred wood plant | | **Kiwere** | | **Mfyome** | | **Migoli** | | **Mbweleli** | | **Kinyali** | | **Makuka** | |
| | Product | Seedlings | Saplings | Seedlings | Saplings | Seedlings | Saplings | Seedlings | Saplings | Seedlings | Saplings | Seedlings | Saplings |
| *Adansonia digitata* | Oil | 0 | 0 | 2533 | 533 | 133 | 0 | 10000 | 0 | 5333 | 800 | 10000. | 0 |
| *Sterculia africana* | Oil | 1467 | 400 | 1867 | 133 | 1600 | 667 | 5333 | 1067 | 933 | 0 | 2267 | 400 |
| *Vangueria infausta* | Fruit | 3867 | 800 | 1200 | 0 | 6800 | 667 | 5466 | 1200 | 1457 | 267 | 200 | 1333 |
| *Vitex mombassae* | Fruit | 0 | 0 | 800 | 0 | 0 | 0 | 0 | 0 | 667 | 667 | 1333 | 2133 |
| *Opilia amentacea* | Vegetable | 8933 | 1066 | 4667 | 2400 | 333 | 533 | 10800 | 2667 | 1600 | 267 | 2400 | 0 |
| *Maerua angolensis* | vegetable | 533 | 0 | 667 | 0 | 267 | 0 | 3467 | 1200 | 533 | 0 | 400. | 0 |
| **Total** | | 14800 | 2266 | 11734 | 3066 | 9133 | 1867 | 35066 | 6134 | 10523 | 2001 | 16600 | 3866 |
| **Percentage** | | 15 | 11.80 | 12 | 15.96 | 9 | 9.72 | 35.8 | 31.94 | 10.75 | 10.42 | 16.96 | 20.13 |

### 4.3.4 Stem diameter size (DBH) class distribution

Diameter class distribution of all most preferred species is shown in Figure 4.3. The figure showed that there was high decline in the number of preferred species with increasing diameter size classes in all the study sites. The results revealed that 89.5% of all trees in Kiwere forest site were within DBH class of 10-20 cm of which *V. infausta* had more individuals within the class followed by *Opilia amentacea*. *Adansonia digitata* was within the DBH class of > 70 cm and had very few individuals. In the other woodland sites most of individuals were within the diameter class of 10-20 cm in the proportions of 47.6%, 69.2%, 49%, 61.5% and 80.7% respectively. In general, *A. digitata* had more number of individuals in all sites at DBH size class of >60cm and none of the individuals were recorded in a DBH of < 40 cm. The results revealed that the decline in number of individuals with increasing diameter size class occurred in all the forest sites investigated.

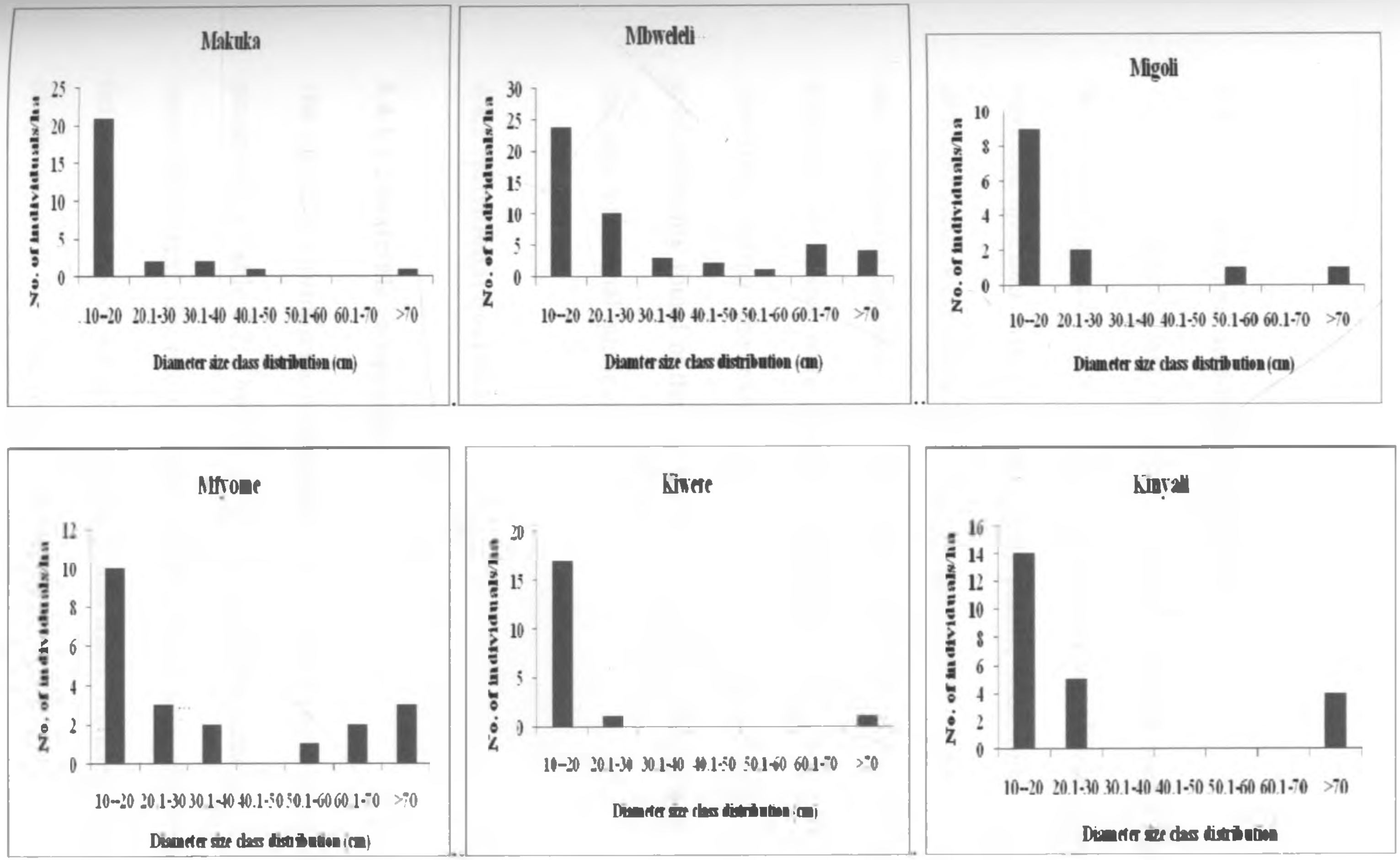


Figure 4.3. Diameter size class distribution of most preferred edible woody plants in six woodlands of Iringa District, Tanzania

### 4.4 Nutritional and anti-nutritional factors

The study showed that the most preferred species were *Vangueria infausta*, *Adansonia digitata*, *Opilia amentacea*, *Maerua angolensis, Vitex mombassae* and *Sterculia africana*. Among these woody plants, *Adansonia digitata* and *Sterculia africana* seeds were commonly used as a source of oil whereas *Vitex mombassae* and *Vangueria infausta* were commonly used as fruits. *Opilia amentacea* and *Maerua angolensis* were used as vegetables. The above named species were identified during the earlier preference ranking process. These species are predominantly found in the drylands of Iringa District and have varied nutritional and anti-nutritional qualities.

#### 4.4.1 Nutritional qualities

##### 4.4.1.1 Proximate composition

The results for proximate composition of six most preferred species for food are presented in Table 4.7. There were significant differences ($p < 0.05$) in percentage moisture content, dry matter, crude protein, crude fibre and carbohydrates among the preferred species for oils, vegetables and fruits. Generally the moisture content of species used for oils, vegetables and fruits was < 13% indicating that species had low moisture content.

The percentage ash contents of the species preferred for vegetables and fruits were significantly different ($F=9$, $p<0.05$). As indicated in Table 4.7, *Opilia amentacea* and *Maerua angolensis* which are commonly used as vegetables had the highest values ranging from 12-21% while the other species that were used as fruits and oils had the lowest values ranging from 3-6%. Results further revealed that *Sterculia africana* which is one of the oil producing plants had higher protein content of 24.9% which was higher than *Adansonia digitata* that had 2.45%. *Maerua angolensis* as a leafy vegetable had higher crude protein of 33.21% than *Opilia amentacea* of 14.8%. The fruits of *Vitex mombassae* and *Vangueria infausta* had lowest crude protein ranging from 3-5%.

Species used for oil i.e. *Adansonia digitata* and *Sterculia africana* and vegetables had the highest crude protein ranging from 23-34%. Other species such as *Vangueria infausta* and *Vitex mombassae* had low value of less than 2.4% crude protein.

Crude fiber in fruits, vegetables and oils from the species studied ranged from 9-27.6% on dry weight basis, of which *Sterculia africana* seeds which are a source of oil had high value of 27.60% followed by *Opilia amentacea* which had 16.06% and the rest had low crude fibre of less than 10%.

Crude lipid/oil content of the species studied was within the range of 1.2 % for *Vangueria infausta* to 6.80% for *Sterculia africana*. *Adansonia digitata* had 3.88%

crude oil and was lower than that of *S. africana*.

Highest percentage of carbohydrates, 77.07% was found in *Vangueria infausta* fruits, followed by *Adansonia digitata* (71%). All other species had values of less than 35% (see Table 4.7). Hence, *Vangueria infausta* and *Adansonia digitata* are potential source of carbohydrates.

Table 4.7. Proximate composition of the most preferred edible woody plants in Iringa District, Tanzania

| Preference: | Oil- producing | | Fruit-producing | | Vegetable-producing | |
|---|---|---|---|---|---|---|
| Parameters (%) | *Adansonia digitata* | *Sterculia africana* | *Vangueria infausta* | *Vitex mombassae* | *Opilia amentacea* | *Maerua angolensis* |
| Moisture Content | 9.62 ± 0.67 | 4.3 ± 0.18 | 4.16 ± 0.65 | 12.11 ± 0.32 | 9.21 ± 0.27 | 7.90 ± 0.77 |
| Dry matter | 88.3 ± 2.27 | 95.36 ± 0.25 | 93.65 ± 3.02 | 88.43 ± 0.29 | 91.4 ± 0.77 | 91.77 ± 0.33 |
| Ash | 5.43 ± 0.79 | 5.69 ± 0.28 | 3.37 ± 0.54 | 5.75 ± 0.26 | 21.09 ± 0.45 | 12.9 ± 0.09 |
| Crude protein | 2.4 ± 0.11 | 24.9 ± 0.63 | 3.01 ± 0.61 | 4.94 ± 0.26 | 14.80 ± 0.11 | 33.21 ± 0.63 |
| Crude fiber | 9.9 ± 0.18 | 27.55 ± 0.34 | 10.29 ± 1.04 | 11.39 ± 0.34 | 16.06 ± 0.17 | 14.98 ± 0.48 |
| Crude oil | 3.88 ± 0.13 | 6.84 ± 0.33 | 1.15 ± 0.23 | 2.97 ± 0.29 | 2.45 ± 0.40 | 3. 12 ± 0.29 |
| Carbohydrate | 70.74 ± 0.79 | 34.82 ± 0.21 | 77.07 ± 259 | 61.25 ± 0.46 | 34.94 ± 0.53 | 28.43 ± 0.34 |

#### 4.4.1.2 Mineral nutrients composition

The results on mineral nutrients composition of the most preferred species are provided in Table 4.8. There was a significant difference ($p<0.05$) in mineral nutrients composition of the preferred edible woody plants. As indicated, all edible plants that are commonly used as fruits, vegetables and sources of oil had higher levels of Potassium. For example *Vangueria infausta* had 749.3 mg/100g, *Adansonia digitata* 1013.41mg/100g, *Opilia amentacea* 3590.51mg/100g while *Sterculia africana* had 1842.93mg/100. However, copper, zinc, iron and manganese were very low in all species, amounting to less than 25g/100g.

As indicated in Table 4.8 mineral nutrients including sodium, magnesium, phosphorus and calcium were slightly higher in all species. For example *Opilia amentacea* and *Maerua angolensis* that are used as vegetables had highest values of calcium and magnesium that ranged between 3500-4800mg/100g and 464.43 - 675.62mg/100g respectively. The other preferred species had calcium values of about 100mg/100g and magnesium less than 180mg/100g. Sodium content in all studied edible woody plants ranged from 96 to 243mg/100g.

Table 4.8. Mineral nutrients composition of most preferred edible plant species in Iringa District, Tanzania

| Parameters Mg/100g dry wt. | **Oil- producing** | | **Fruit- producing** | | **Vegetable-producing** | |
|---|---|---|---|---|---|---|
| | *Adansonia digitata* | *Sterculia africana* | *Vangueria infausta* | *Vitex mombassae* | *Opilia amentacea* | *Maerua angolensis* |
| Iron | 21.67 ± 0.76 | 13.25 ± 0.30 | 24.43 ± 1.24 | 13.99 ± 0.37 | 15.65 ± 0.36 | 23.24 ± 0.28 |
| Calcium | 677.23± 0.47 | 101.59± 0.48 | 186.33± 3.99 | 603.52 ± 785.34 | 3559.27 ± 1.03 | 4785.97 ± 0.23 |
| Magnesium | 66.49 ± 0.46 | 180.53± 0.92 | 18.62 ± 0.41 | 34.61 ± 0.41 | 675.62 ± 0.37 | 464.43 ± 0.57 |
| Manganese | 0.78 ± 0.25 | 7.06 ± 0.26 | 2.91 ± 0.26 | 7.09 ± 0.32 | 10.05 ± 0.45 | 1.88 ± 0.35 |
| Phosphorus | 53.59 ± 0.38 | 532 ± 1.24 | 86.86 ± 1.45 | 103.22 ± 1.26 | 163.02 ± 0.76 | 205.10 ± 0.48 |
| Potassium | 1013 ± 0.78 | 1842.93± 1.25 | 747.26 ± 7.2 | 1382.68 ± 0.5 | 3590.51 ± 1.08 | 832.19 ± 0.78 |
| Sodium | 127.35± 0.75 | 167.27 ± 0.71 | 160.81± 0.71 | 96.08 ± 0.28 | 243.02 ± 0.31 | 96.11 ± 0.75 |
| Zinc | 3.99 ± 0.44 | 5.75 ± 0.47 | 7.05 ± 0.33 | 6.50 ± 0.37 | 3.47 ± 0.44 | 3.22 ± 0.21 |
| Copper | 6.25 ± 0.48 | 6.34 ± 0.56 | 5.91 ± 0. 60 | 5.28 ± 0.18 | 6.33 ± 0.56 | 4.73 ± 0.43 |

### 4.4.1.3 Vitamin C (Ascorbic acid)

Levels of vitamin C of all plant species tested are provided in Figure 4.4. There was a significant difference ($p<0.05$) in Vitamin C content among the species studied. The results indicated that *Adansonia digitata* seeds, most preferred for oils had the highest value of Vitamin C content of 57.31mg/100g, dry weight followed *Vitex mombassae* fruits with 40.95mg/100, dry weight.

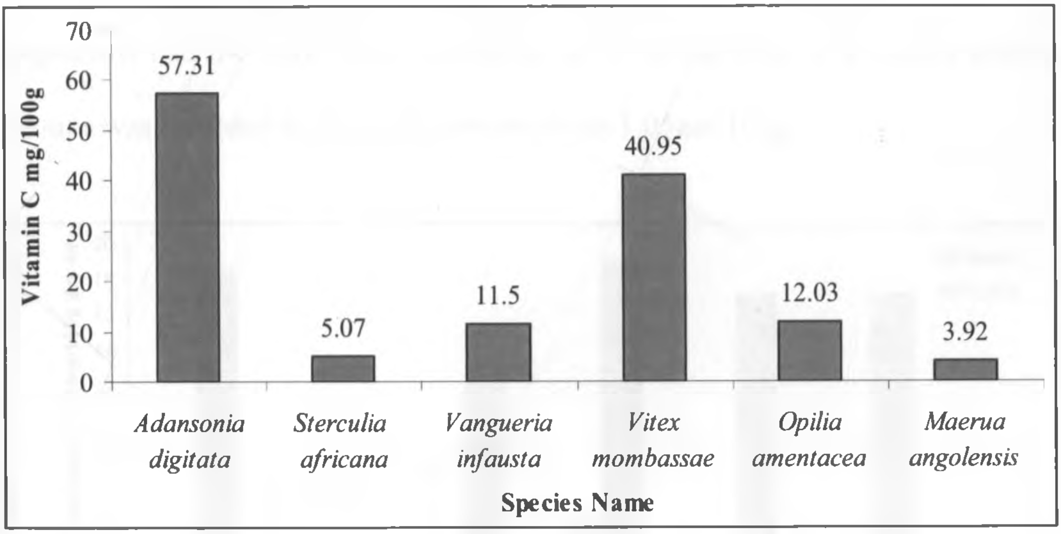


Figure 4.4. Vitamin C content of the most used plant species in the Drylands of Iringa District, Tanzania.

### 4.4.1.4 Anti-nutritional levels of the studied edible woody plants

Levels of the anti-nutritional factors are shown in Figure 4.5. The results showed that tannin levels were highest in all species studied compared to phenols. *Adansonia digitata* seeds had tannin content not exceeding 19 mg/100 g and also phenol levels were very low and less than 2mg/100g whereas *Sterculia africana* seeds had almost the same levels of tannins and phenols (Figure 4.5). The fruit and vegetable plant species had the highest levels of tannins ranging from 12.6-19.02 mg/100g dry weight whereas the phenols were less than 5mg/100g. As shown in the figure, *Vangueria mombassae* had high levels of phenols amounting to 4.33mg/100g while *Vangueria infausta* had the lowest level of 0.95mg/100g. *Vitex mombassae* had highest level of tannins of 19.02mg/100g followed by *Adansonia digitata* with 18.54mg/100g. Vegetable species i.e *Opilia amentacea* and *Maerua angolensis* had the same level of tannins of 17.05mg/100g. The lowest level of tannins was recorded in *Sterculia africana* with 1.05gm/100g.

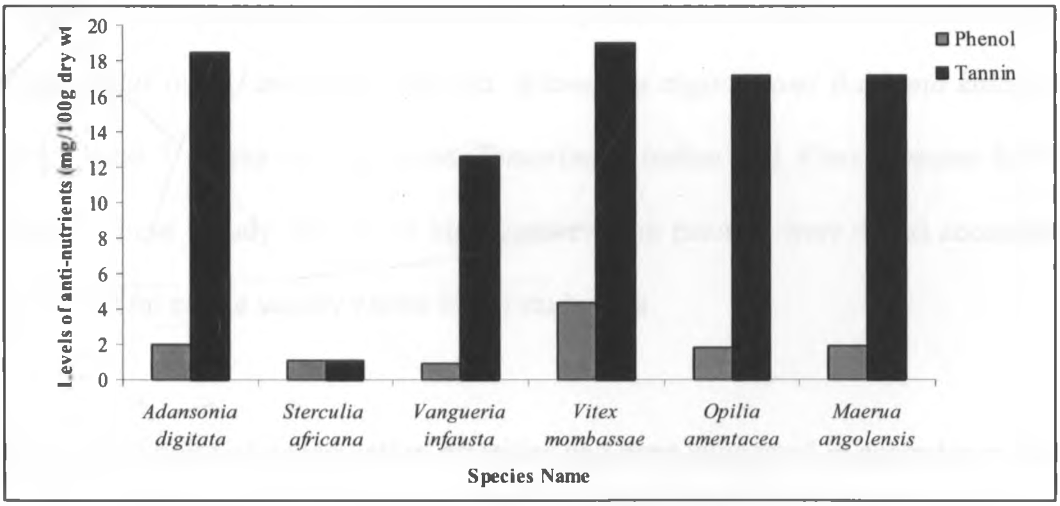


**Figure 4.5. Some of anti-nutritional compounds of the woody plant species studied from Iringa District, Tanzania.**

### 4.5. Prioritization for conservation of edible woody plants in Iringa District

A total of 66 woody plant species were ranked based on nine conservation priority criteria and their respective scores are indicated in Table 4.9. Generally, the highest ranking species, *Adansonia digitata* scored 7 points and the lowest ranking species was *Uapaca kirkiana* that scored 1 point. According to Ham and Akinnifesi (2006); Jama *et al.* (2007), any species that scored more of the priority criteria should be given high conservation priority. In this study the plants species that should be given high conservation priority had 6-7 scores.

As indicated in Table 4.9, edible woody plant species that are of high conservation value are unfortunately the ones that are heavily exploited by local community in Iringa District. As an example, the species ranked number 1 for conservation prioritization was *Adansonia digitata* followed by *Bauhinia kalantha*, *Tamarindus indica* and *Vitex doniana. Adansonia digitata and Bauhinia kalantha* had a total 7 scores each whereas *Tamarindus indica* and *Vitex doniana* had 6 scores. These woody species of high conservation priority were 4 and accounted for 6% of 66 edible woody plants in the study area.

The cut-off point of conservation priorities had been suggested in accordance with Ham and Akinnifesi (2006) and Jama *et al.* (2007) that for the priority species to be given priority interms of intermediate and high priority ranks should score more than half of the criteria i.e more than 50% of the set criteria. Based on the set of conservation criteria scores should be more than 5.

Therefore, edible woody plant species that have intermediate conservation priority are indicated also in Table 4.9. As indicated in the table, 10 species with 5 scores each were grouped into species of intermediate conservation priority.

Species that have less conservation priority are provided in Table 4.9. These species had scores ranging from 1 to 4 and are considered to be of least concern. The results showed that 41 edible woody plants of less conservation priority were recorded and these accounted for 62% of all studied edible woody plants. As indicated in the table, the first 5 species with least conservation priority had scores of 1 to 2 include *Uapaca kirkiana*, *Strychnos cocculoides*, *Vangueria tomentosa*, *Bridelia micrantha* and *Ochna holstii*.

Table 4.9. Prioritization scores for edible woody plants in Iringa District, Tanzania.

**KEY**

| **Status** | **Uses** | **Distribution** | **Endemism** | **Propagation** | **Commercial value** | **Legislative** | **Cultural Values** |
|---|---|---|---|---|---|---|---|
| **Th**-Threatened | **S**-Single use | **Ldistr**-Local distribution | **End**-Endemic | **Eprop**-Easy propagation | **Sub**-Subsistance | **LPF**-Lagislative provision in force | **HG**-High cultural values |
| **NTh**-Not threatened | **M**-Multiple use | **Rdist**-Regional distribution | **Nend**-Not endemic | **Dprop**-Difficult propagation | **Comm**-Commercial | **NLPF**-No lagislative provision in force | **LW**-low cultural values |

**High priority**

| | **Status** | | **Uses** | | **Distribution** | | **Endemism** | | **Part used** | | **Propagation** | | **Comm. value** | | **Legislative** | | **Cultural value** | | **Total Score** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Th | NTh | S | M | Ldist | RDist | End | NEnd | Few | many | Eprop | Dprop | Sub | Comm | LPF | NLPF | HG | LW | |
| *Adonsonia digitata* | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 7 |
| *Bauhinia kalantha* | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 7 |
| *Tamarindus indica* | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 6 |
| *Vitex doniana* | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 6 |

**Intermediate priority**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Opilia amentacea* | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 5 |
| *Azanza garckeana* | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 5 |
| *Ormocarpum trachycarpum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 5 |
| *Osyris lanceolata* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 5 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cordyla Africana* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 5 |
| *Cordia Africana* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 5 |
| *Ficus glumosa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 5 |
| *Grewia bicolor* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 5 |
| *Grewia similis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 5 |
| *Acanthopale laxiflora* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 5 |
| *Opilia celtidifolia* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 5 |
| *Parinari excels* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 5 |
| *Strychnos innocua* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 5 |
| *Vitex iringensis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 5 |
| *Vitex mombassae* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 5 |
| *Isoglossa lacteal* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 5 |
| *Crotalaria agatiflora* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 5 |
| *Crotalaria spartea* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 5 |
| Canthium burtii | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 5 |
| Asparagus asparagoides | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 5 |

**Low conservation priority**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Uapaka kirkiana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| *Strychnos cocculoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 |
| *Vanguelia tomentosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Bridelia cathartica* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Bridelia micrantha* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Ochna holstii* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 3 |
| *Zanthoxylum chalybeum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 |
| *Ziziphus mauritania* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 |
| *Ziziphus mucronata* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 |
| *Piliostigma thonningii* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 |
| *Acacia senegal* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 |
| *Berchemia discolor* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 4 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cordia sinensis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| *Grewia hexamina* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 4 |
| *Grewia platyclada* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 4 |
| *Grewia sinensis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 4 |
| *Kigelia africana* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 4 |
| *Lannea stulhmannii* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 4 |
| *Lannea fulva* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 4 |
| *Lannea humilis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 4 |
| *Lannea schimperi* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 4 |
| *Lannea schweinfurthii* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| *Maerua angolensis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| *Maerua parvifolia* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| *Maerua prittwitzii* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| *Maerua triphyla* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| *Sterculia africana* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| *Strychnos popatorum* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| *Strychnos pungens* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 4 |
| *Strychnos spinosa* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 4 |
| *Ximenia caffra* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| *Zantha africana* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| *Syzygium guineense* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| *Rhus natalensis* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| *Canthium bibracteatum* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| *Commiphora africana* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| *Coffea eugenioides* | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 4 |
| *Balanites aegyptiaca* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |
| *Acokanthera schimperi* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 4 |

# CHAPTER FIVE

## 5.0 DISCUSSION

### 5.1 Vegetation description

#### 5.1.1 Composition of woody plants

Studies on species composition in forests or woodlands are useful in the sustainability of forest resources since species composition plays a major role in the conservation of plant species and management of the ecosystem. In this study a total of 204 woody plant species were recorded and thus indicating that the species richness was higher in the studied woodlands compared with the 170 species reported by Isango (2007) at Nyang'olo site in 2005. Thus, species richness observed in this study may be attributed to the introduction of participatory forest management regime in the late 1990's coupled by burning of /and illegal logging operations and poor agricultural practices (DANIDA, 2000). Backeus (2006) recorded 86 tree species in the woodland of Kilosa District while Malimbwi *et al.* (1998) and Luoga (2000) documented 95 and 79 tree and shrub species respectively in Kitulanghalo Forest Reserve. Tairo (2007) reported low value of 62 tree and shrub species in Chinene Miombo Woodland in Dodoma District.

In all the study sites, the distribution of families was different. Some areas had higher species richness than others due to microclimatic variations of the areas. It was noted that, there are some groups of families, which are restricted in a specific forest due to niche differentiation of the species and associated families of Vitaceae and Violaceae at Mbweleli. These results concur with the earlier study by Obiri *et al.* (2002) which indicated that species restriction in an area suggests some degree of niche differentiation based on the site environment or disturbance tolerance within the miombo woodland community.

The results implied that the trees layer was almost by far the most species rich in different sites. Moreover, trees contributed less in Mbweleli site in relation to other sites. These results suggest that trees layer was an indicator of diversity in the studied sites. Contrary to this, Obiri *et al.* (2002) revealed that tree layers alone may not be a good indicator for the diversity of species and any assessment of plant diversity need to consider plant/species growth form such as shrubs, climbers and herbs. The presence and diversity of growth forms is dependent on species diversity. As a principle, therefore, tree species diversity mirrors the diversity of life forms or strata.

### 5.2 Commonly used edible woody plants in the miombo woodland

Utilization of woody plants as a source of food has been practiced for decades and this entirely depends on richness and diversity of species (Simitu, 2005). In this study, a significant number of woody species amounting to 66 that are used as food were recorded. However the value is lower than in the previous study by Temu and Chihongo (1997) that reported 83 indigenous tree species, which bear fruits and nuts throughout in the miombo woodland in Ruvuma region. Njau (2005) however, recorded a lower value of 49 species edible trees and shrubs in Nyangoro forest site. In northern Nigeria, Harris and Mohammed (2003) recorded 53 plant species in the semi-arid forests. For all recorded plants, different parts are used as food and these include fruits, leaves (vegetables), roots, tubers and gums. Results in this project are in agreement with the previous study by FAO (1992) that reported that fruits are used as food, beverages, and sources of essential oils for cooking. Typical examples include *Adansonia digitata* (beverage, oils and food), *Parinari spp.* (oils, beverages), *Cordia sinensis* (food), *Azanza garckeana* (food), *Uapaca kirkiana* (food, beverage), *Rhus vulgaris* (food), *Vitex spp* (food), *Strychnos cocculoides* (food, beverage) and *Tamarindus indica* (beverage).

Experience has shown that in the drylands leaves of wild plants are good sources of food in semi- arid areas (Njau, 2005). This is in line with the previous report by FAO (1992) which revealed that wild vegetables serve as buffer food supplies during the recycling periods of food shortage especially where extreme drought occurs usually around the months of November through February. Simitu (2005) has also highlighted that during heightened drought, wild food plants act as major components of daily food diet mixed with staples such as maize flour or millet.

Generally, use of edible woody plants had been practiced for many decades in the drylands. However, the frequency and extent of using woody plants as food are determined mainly by diversity of species and occasionally availability and preferences of the plant products. Therefore, diversity of edible plants in miombo woodland is critical for community food security during critical season of food shortages.

**5.3 Commonly preferred edible species in the study site**

Several edible plants have been documented from Iringa District, including *A. digitata*, *Grewia bicolar*, *Azanza garckeana* and *Ficus vallis-choudae*. Nevertheless, their utilization has been influenced by several factors such as the knowledge of the local people, the plant availability and perceived preferences in that particular area. In this study, differences in preference have been revealed in the study sites based on their availability, taste and socio-cultural value of the area. Some species for instance had wide distribution pattern and were most preferred in all the study sites because of being multipurpose in nature as a source of fruits, oils and vegetables such as *Adansonia digitata.* Other species like *Sterculia africana* were highly preferred in very dry areas as a source of oils. This observation is in line with the earlier study by Mengistu and Hager (2008) that reported that species preference varies from one area to another due to the community interest depending on the species distribution, the indigenous knowledge, economic status and climate variability.

In this study variations among ethnic groups was recorded and concur with the earlier studies by Maundu *et al.* (1999) and Harris and Mohammed (2003) which revealed that knowledge of wild foods varied according to the ethnic groups and gender. Therefore, different species may become highly preferred in one area and may be of less utility in another area. For example Mengistu and Hager (2008) revealed that *Tamarindus indica* and *Ximenia americana* are located in the same area but may be rated differently at two sites of Dejen District. Also, Mengistu and Hager (2008) concluded that *Ziziphus spina-christi, Carrissa spinarum* and *Diospyros mespiliformis* at Adiarkay site as most preferred species and influenced by the cultural domains. Thus the results obtained in this study may suggest that species preference depend predominantly on socio-cultural aspects rather than on change of climate or availability of a certain species in the area. Due to cultural preferences, Feyssa (2011) identified three wild edible fruit species namely *Ziziphus spina-christi* (L.) Desf., *Balanites aegyptiaca* (L.) Del. *and Grewia flavescens* A. Juss. as predominantly preferred in seei-arid East Shewa, Ethiopia.

Therefore, determination of most preferred edible plants in the drylands is centered on the community interest, taste and preference and all of them are depending on the species distribution, the indigenous knowledge, economic status and food availability. Consequently, it is important that knowledge of most preferred edible plants be documented to add to the whole body of knowledge needed in designing species conservation targets especially in food insecure areas.

## 5.4 Ecological parameters of most preferred edible woody plants

### 5.4.1 Density

There was considerable variation in stem density of the commonly harvested species in all sites and a range of 320 to 520 individuals per ha were recorded of which *Opilia amentacea* and *Adansonia digitata* were dominant. The density of species in different areas show variation and the species that have high density in one area may have lower density in the other area. For example, *Sterculia africana* had the low density of 40 stems/ha at Kiwere but were high at Mbweleli site with 380 stems/ha. This variation in density and distribution of the species might be associated with the impacts of abiotic factors like soil type which affect the distribution of a particular species (Blay *et al.* 2004). For example the highest density of *Adansonia digitata* and *Opilia amentacea* in Mbweleli site was dominated by black vertisol and water logging areas.

Different species behave differently to various environmental and disturbance factors, such as harvesting regime, fire and grazing. In order to achieve sustainable management of most commonly harvested tree species their silviculture and ecology must be studied (Blay *et al.* 2004).

The low density of trees per hectare of *Maerua angolensis* and *Vitex mombassae* implies that more time will be required to search for the preferred edible woody species. Given that livelihood strategies for the rural communities need to be diverse, less time could be available for other important strategies while household members spend more time searching for edible woody plants consumed by the households. Nevertheless, low densities of some commonly used species were influenced by the level of anthropogenic disturbances caused by differential land use system in the study sites. Therefore, the number of individuals in woodland ecosystem could be restored if the anthropogenic disturbances are minimized and hence increasing new recruitments (Simitu, 2005).

### 5.4.2. Percentage frequency

The frequency of most preferred species ranged from 0-40% indicating that all the species encountered had rare with range of 0-20% and low frequency (20-40%). The rarity of species may be attributed to the occurrence of abundant sporadic species with low frequency in the stands (Oyun *et al.*, 2009). The high percentage of more than 50% of rare species observed in this study confirms the notion that most of the species in an ecological community are rare, rather than common (Magurran, 1998; Magurran and Henderson, 2003). Their low to moderate frequency values show that the most preferred plants are not widely distributed through the study area. Therefore, *Sterculia africana*, *Maerua angolensis* and *Vitex mombassae* are common in the studied sites.

The results of this study further imply that preferred species were poorly dispersed in the area and the small size species such *Opilia amentacea* had high frequency than big tress such as *Adansonia digitata.* On the other the results suggest that most of the preferred woody plants identified in the study sites, have low to moderate frequency which inturn may have generally decreased in abundance in the woodland. Thus, conservation management aiming at increasing the population of most preferred species in the woodland over the long-term basis is of vital importance.

### 5.4.3 Seedlings and saplings

The study revealed a considerable variation of seedlings and saplings density and it is vividly known that this variation may be caused by several biotic and abiotic factors. Therefore high seedlings density in the studied forest sites was manifested by a successful seed germination and establishment, and in response to factors such as fruit produced every season and site qualities. Uma *et al.* (1998) reported that high seedling density is generally regarded as an indicator of adequate regeneration and population maintenance. For some species such *Vitex mombassae* and *Vitex doniana*, the seedlings and saplings density were very low and this might be caused by the fact that the fruits tend to loose their viability within a very short time. In some areas such as Kiwere, Migoli and Mbweleli sites the sapling densities of *Adansonia digitata* were very low or completely absent due to the fact they were severely consumed by human being and animals before transiting to trees. Likewise high value seedlings per ha reflect that the seed dormancy was broken by passage through digestive system of large animals and thus increasing seed germination capacity. Von Maydell (1990) showed that *A. digitata* seeds have very hard seed coats and germination is less than 20%. Hence mechanical, chemical or biological treatments are important. This was observed in areas of Mbweleli, Kinyali and Makuka whereby many people are keeping many animals including cattle and thus might have contributed to high seedling number.

Likewise, high seedling densities imply the existence of a good potential for the restoration of woody communities, and also low proportion of seedling density indicates the impact from human and animal interference on their regeneration. On the other hand low values of seedlings density per ha suggest that there was a declining level of protection and consequently increase severe human disturbance such as charcoal burning to the sites.

The saplings recorded in this study varied between the sites and ranged from 3866 to 6134 saplings per ha. The variation between seedling and sapling densities per ha is quite substantial in both sites. However, the fewer numbers of saplings in relation to seedlings reported in this study implies there is high mortality of seedlings and thus not transiting the saplings. Weidelt (1988) suggested that it could also mean that most of the seedlings probably die due to intense competition for available resources before they reach the sapling stage. Nevertheless, Mishra *et al.* (2005) revealed that in high saplings and seedlings in any forest site reflects on its high recruitment in the area.

On the other hand, low proportions of seedlings and saplings per ha could possibly be aggravated by high intensity of disturbance caused by animals or human beings. Human disturbances have caused many forests to become secondary forests and therefore regeneration dynamics are influenced by this agent. The findings obtained from this study are now a prerequisite to formulating management strategies needed to conserve biodiversity in the area. These results concur with those reported by Hall and Biwa (1993) that the regeneration status of species is a useful indicator and needs to be assessed through monitoring seedlings and saplings that provide information on the succession of forest ecosystems and also identifies any problems in tree regeneration. Therefore, regeneration of the most preferred species is a good indicator for the realization of more conservation practices which are vital in forest conservation in the area.

### 5.4.4 Diameter size class Distribution

Most plant species were distributed into different diameter size classes in all the study sites, of which the tree species of low DBH classes were more than fourfold compared with other classes. The diameter size class distribution of the species and individuals revealed that the percentage of individuals decreased with increase in diameter size classes.

On the other hand the diameter class distribution of trees and shrubs revealed that with an increase of diameter classes, the total number of species decreased. *Adansonia digitata* had the highest DBH which was one of the dominant tree species dry areas of Makuka, Migoli, Mbweleli and Kinyali. Nevertheless, increase in number of classes with low DBH size suggest that the species recruitment has started recently in an vigorous encouraging manner in both woodland sites but due to disturbances, lower species number are available with high diameter ranges in most of the sites. *Vangueria infausta* and *Opilia amentacea* were most abundant compared with *Sterculia africana* and *Maerua angolensis* which are less abundant and thus adequate protection is necessary to maintain an adequate number of species in each diameter class. A s indicated in Appendix 4, the recruitment level is high, however the number of individuals with diameter class greater than 10 were very minimal and this reflects that the population is dwindling. Therefore more conservation efforts are needed to counteract the abrupt decline of mature population through protecting seedlings to transit into trees.

The findings obtained in this study seem to agree with findings of Geldenhuys (1993) that showed the existence of small individuals in the miombo species due to periodic fires that occur throughout a miombo community.

In general, these results imply that selective management system based on DBH distribution can be practiced in the study area because it favours the sustained production of commercially valuable species while ensuring the overall species diversity. This management system may be applied in the study area to maintain its species diversity and sustainable productivity of valuable multipurpose species such *A. digitata*. The findings of this study concur with earlier reports by Agarwal *et al.* (1996) and Manilal (1997) that ecological parameters including regeneration and diameter size class distribution may be used as management system in the diversity most preferred species.

### 5.5 Nutritional and anti-nutritional qualities

#### 5. 5.1 Proximate composition

Moisture content was low for all species and this is a reflection of increased shelf life. These results are different from those reported by Mahammad *et al.* (2010) on seeds, pulp and peel of pear fruits to be 52.3 ±1.5%. On the other hand, the values reported in this study concur with those reported by Bamigboye *et al.*, (2010) which were 6.4±0.04 and 5.2±0.35 percent for the whole seed and dehulled, respectively. Low moisture content signifies the higher dry matter yield as reported by Bamigboye *et al.* (2010). Low moisture content also reflects their long storage because low moisture content does not favour growth and increase of pathogenicity.

A range of 3-21% of ash for all plant species is contrary to the those reported by Olaposi and Adunni (2010) that vegetables of *Cnidoscolus chayamansa, Solanum nodiflorum* and *Senecio biafrae* had percent ash contents of 1.57, 2.67 and 2.01 respectively. The high values of crude protein reported in this study suggests that crude protein levels of some plant species are closer to that of soybean which is over 36.6%. These results are in agreement with those reported by Jambunathan (1991) that oily seeds such as groundnuts have crude protein more than 25.2%. Therefore, seeds of *S. africana* and *M. angolensis* are good sources of proteins for human body.

High values of crude protein of most preferred vegetables are not far from 20.27 ± 0.17 and 17.24 ± 0.71% for *F. asperifolia* and *F. sycomorus* respectively reported by Nkafamiya (2010). However, Olaposi and Adunni (2010) reported very low values of crude protein not exceeding 3.1% in *Solanum nodiflorum*, a common leafy vegetable of the area. Kuti and Torres (1996) reported crude protein content of 5.71% (wet basis) for *Cnidoscolus chayamansa* vegetable and 11.6-12.3% (dry basis) for two varieties of *Senecio biafrae* vegetables (Adebooye, 2000).

The crude fiber content in fruits, vegetables and oils from most preferred species recorded in this study were lower than that of 28.68% in *F. asperfolia* and 31.54% as reported for *F. sycomorus* respectively (Nkafamiya *et al.*, 2010).

The crude lipid content of most preferred species was lower than that reported by Osman (2004) of 18.4% of *Adansonia digitata.* However the values were higher than those reported for Iranian vegetables of 3.44% (Aberoumand, 2008). Also Aberoumand (2008) reported very low values crude lipid of 5.28% in *Portulaca oleracea.* On the other hand Ekop (2007) reported crude lipid of *Gentum africanum* seeds of 3.15% which is in line with the oily plants recorded in this study. Hassan *et al.* (2009) reported that the crude lipid content of 12% found in seeds was significantly higher ($p<0.05$) than that of the peels. Dreon *et al.* (1990) concluded that lipids are essential because they provide the body with maximum energy.

The highest percentage of carbohydrates recorded in *V. infausta* fruits and *A. digitata* suggest that they are potential sources of carbohydrates. Carbohydrate contents of the two preferred woody plants in this study fall within the range expected of other renowned staples. Cassava has been reported to have contents ranging from 41.67 ± 4.4 (Sop *et al.,* 2008) to 86.3% (Charles, 2005). Sop *et al.* (2008) and Charles (2005) reported carbohydrate content of different sorghum varieties to vary from 23.55% to 69.96% the amount which are lower than the values recorded in this study. Also Sop *et al.* (2008) reported a low amount of carbohydrates in potato puree of 38.78 ± 1.62%. These results suggest that *V. infausta* and *A. digitata* had higher amount of carbohydrates compared to other conventional staples.

**5. 5.2 Mineral nutrients composition**

All the edible plants that are commonly used as fruits, vegetables and crude oil had high values of Potassium, Calcium, Magnesium and Phosphorus whereas copper, zinc, iron and manganese were very low amounting to less than 25 mg/100g for all species, but higher than the amount reported by Hassan and Umar (2006). Iron and zinc are among the essential elements for humans and their daily requiremraents for adult are 15 and 18 mg respectively (Hassan and Umar, 2006). A study by Nkafamiya *et al.* (2010) indicated that the level of iron in *Ficus asperifolia* was 14.56 ± 0.22 mg/100g whereas *F. sycomorus* had 11.65 ± 0.15 0.67 mg/100 g. Therefore, the values reported in this study are within the acceptable range.

Specifically values of Potassium in wild food plants were found to be higher than in the domesticated vegetables (Nkafamiya, 2010). According FNIC (2011), the domesticated vegetables had the following levels of K: cabbage 147mg/100g, broccoli 229 mg/100g, carrot 183mg/100g, Chinese cabbage 268 mg/100g and spinach 167 mg/100g. Also potassium and calcium were higher in *A. digitata* [K (1013.41 mg/100g) and Ca (677 mg/100g)]. Osman (2004) recorded minimum and maximum values of 726 and 3272 mg/100g of K, respectively in *A. digitata* which is within the range of values recorded in this study. On the other hand, Osman (2004) reported an average of 302 mg/100g K in *A. digitata* pulp which is similar to values reported in this study. FNIC (2011) have documented foods with highest levels of K to be watermelon (320mg/100g), pineapples (180mg/100g), papaya (360mg/100g) and orange (237mg/100g). Also in line with this study, K was the most abundant mineral in most of the samples. These results are in agreement with those reported by Ilelaboye and Pikuda (2009) that potassium dominates in seeds of lesser- known crops. Also Olaofe and Sanni (1980) reported that potassium is the predominant nutrient in Nigeria agricultural products.

### 5. 5.3 Vitamin C (Ascorbic acid)

Vitamin C or L-ascorbic acid or L-ascorbate is an essential nutrient for humans and certain other animal species, in which it functions as a vitamin. For all the studied plants, vitamin C was moderately high. However, Abitogun (2010) reported an average of 110±0.01 mg/100g of dry weight in ripe fruits of *Vitex grandiflora* which is higher than values reported in this study. Vitamin C is important as it acts as an anti-oxidant (Barminas *et al.*, 1998). FNIC (2011) reported higher values of vitamin C in commonly used fruits such as mango (57.3 mg/100g), pineapple (78.9mg/100), orange (69.7mg/100g), papaya (86.5mg/100g) and strawberry (84.7mg/100). However, FNIC (2011) reported low values of other fruits including tomato (15.6mg/100g), watermelon (23.2 mg/100g) and olives (0.1mg/100g).

### 5. 5.4 Anti-nutritional levels of mostly preferred woody plants

The commonly used edible woody plants had phenols ranging from 0.95 to 1.95 mg/100g and tannins ranged from 1.05 to 19.2mg/100g. These results suggest that all levels of anti-nutritional factors determined in the samples are below the recommended toxic levels threshold (Birgitta and Caroline, 2000). According to AOAC (1980; 1995), oral human toxic dose of phenols is from 200 mg to 300 mg/100g and lethal dose is from 3g/100g to 30 g/100g whereas the toxic level of tannins exceeds 65,000mg/kg. On the other hand Andy and Eka (1985), reported phenols and tannin levels in baobab amounting to 17.8mg/100g and 19.8 mg/100g respectively which were less than the toxic levels. Hossain and Becker (2001) reported values of phenols of between 2.96 and 5.95% and 1.97-2.25% of tannins in *Sesbania* seeds, *S. aculeate*, *S. rostrata* and *S. sesban*. Rathod and Valvi (2011) reported low values of tannin less than 2mg/100g in wild edible plants in India. In line with this study, Umaru *et al.* (2007) reported tannin levels of various wild fruits to range from 5.9-7.4 %. These values are below the permissible threshold toxic levels but may interfere with other nutrients and possibly decrease their availability. However, even the slightly inflated tannins levels of 17-19mg/100g in the preferred species was probably caused by analysis of the raw samples and can be reduced when treated for example in cooking processes. Similar results were obtained by Vijayakumari *et al.* (1998) for *Vigna aconitifolia* and *Vigna sinensis*. Soaking and cooking processes were applied to reduce phenols and tannins.

**5.6 Prioritization for conservation of edible woody plants**

Prioritizing indigenous species is a very difficult exercise since there are many edible tree species in Iringa District. However, for the sake of this study, some criteria were developed such as the use value, current socio-economic importance, local and regional distribution, commercialization, cultural value, and endemism. Based on the above criteria the maximum possible total prioritization score attainable was 7. *Adansonia digitata*, *Bauhinia kalantha*, *Tamarindus indica* and *Vitex doniana* had the highest prioritization scores of 6-7. These species are ranked 1, 2, 3 and 4, respectively. Earlier study by Robertson *et al.* (2003) it was reported that *Lantana camara, Chromolaena odorata* and *Opuntia ficus-indica* had high prioritization of scores 3.33, 3.06 and 2.96 respectively.

Results of this study may suggest that the species which have high conservation value are the ones that are heavily exploited by the local community. Therefore, these species which were ranked highest in the prioritization exercise require immediate and urgent need for conservation. Also, the importance of different wild food plants and consequently their depletion in the wild has called for urgent need for conservation (UNEP, 1995). According to Ruffo *et al.* (2002) plants such as *Habenaria* and *Satyrium* spp are among orchid species that have become endangered because of massive utilization in the southern Highlands of Tanzania. Jama *et al.* (2005) reported almost similar results where *Adansonia digitata* and *Tamarindus indica* were among the top five most promising species after a priority setting exercise within the East and Central African region. Prioritization of indigenous fruit species in Tanzania was based on taste, multiple uses, marketability and food security in famine/hunger. Yield potential and priority species that were recommended for conservation included *Parinari curatellifonia*, *Strychnos coccoloides*, *Uapaca kirkiana*, *Vitex mombassae* and *Vitex doniana* (Ramadhani *et al.*, 1998). Kariuki and Simiyu (2005) revealed that prioritization for conservation of wild edible plant species is meant for conservation of endangered, endemic and economically important plant species.

Based on priority by use value and cultural role criteria, Jama *et al.* (2005) also reported *Vitex mombassae, Strychnos cocculoides, Vitex doniana, Berchemia discolor, Adansonia digitata* and *Tamarindus indica* as species prioritized for conservation. Therefore, as an initial step and for domestication purposes in the Miombo woodlands, top 5 priority indigenous fruit species were selected. These included *Parinari curatellifolia, Strychnos cocculoides, Uapaca kirkiana, Vitex mombassae* and *Vitex doniana*. Criteria for selection of the priority species was based on their taste, multiple uses and duration of availability (ICRAF, 1992).

Species with intermediate or low prioritization are likely to be abundant by 94% compared with species of high priority. In this study it is suggested that the species of less or intermediate priority are also very important in an ecosystem. Therefore, the prioritization system presented here is a useful decision support tool for some edible woody plants in Iringa District and can also be used in other parts of Tanzania.

# CHAPTER SIX

# 6. CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Conclusions

i. Based on the results and subsequent discussion, it can be concluded that edible wild plants make a major contribution to dietary intake of rural people in the drylands of Iringa District during times of food shortage. Hence, the consumption of wild plants is a necessary part of the strategies adopted by dryland dwellers to survive in a harsh and unforgiving environment. In the results, a total of 204 woody plants representing 39 families were identified of which 49.5% of the studied woody plants were shrubs while trees accounted for 50.5%.

ii. Furthermore the vegetation data indicated that a total of 66 edible woody plants were identified and this shows a good diversity of edible woody plants in the drylands.

iii. Among the identified edible woody plants, *Adansonia digitata* and *Sterculia africana* were most preferred by the local communities as a source of oils. *Opilia amentacea* and *Maerua angolensis* were preferred woody plants for vegetables whereas *Vangueria infausta* and *Vitex mombasase* were preferred as fruits. Nonetheless, species preference varies from one area to another due to the community interest including species distribution, the indigenous knowledge, economic status and climate variability.

iv. On the other hand, the ecological importance of the trees was low, which reflected rarity of most of the species. However, the abundance of small trees coupled with high number of saplings and seedlings reflects a high regeneration potential of the forest. Ecological parameters of most preferred woody plants relate to the density of trees, their diameter classes, frequency and densities of regeneration pattern which vary from one woodland site to another. The study of ecological parameters can provide information on plant species distribution in different areas and woody plants utilization pattern.

v. The wild edible woody plants contain many essential nutrients like carbohydrate, protein, ash, crude fibre and low moisture content which make them a good source of energy and other body building blocks for human nutrition. Additionally, wild food plants contain anti-nutritive factors including tannins and phenols which are toxic and interfere with digestion and absorption. In the present study, all analyzed samples were below the toxic levels acceptable for daily intake.

vi. Since demand of most preferred species is high, there is a need to prioritize the species for conservation to include *Adansonia digitata*, *Bauhinia* *kalantha*, *Tamarindus indica* and *Vitex doniana*. Therefore, these species with high prioritization scores require an urgent need for conservation

## 6.2. Recommendations

i. The amount of information documented on the silvicultural management practices of indigenous food plant species is limited.

ii. There is scarcity of information on the cultivation and cultural requirements of indigenous food plants including germplasm development, propagation, establishment and their management in the field.

iii. Although some field appraisal revealed existence of field trials on indigenous food plants, there was little or no information generated from them. It is therefore, important that efforts be made to generate silvicultural information on the individual species.

iv. More treatments could be superimposed in the existing field trials to generate the information on growth characteristics and responses of interactions with crops.

v. There is need to identify the current and potential pests and diseases and establish ways of managing them.

vi. The food plants that are most preferred need to be conserved either in their natural habitats or farmlands. Therefore both *in situ* and *ex situ* conservation are of vital importance in this scenario.

vii. Most of the highly preferred species have low anti-nutritional factors and could serve as potential source in food formulation. In some cases where the toxic levels are high, pre-treatment either through soaking, germination and cooking will reduce the high levels of anti-nutritional factors.

viii. There is a clear need to incorporate nutritional and dietary concerns into forestry and agricultural plans. Linkages in studies could be established between the nutrient content of wild foods, dietary surveys of their consumption and anthropometric assessments.

ix. Wild foods often provide key supplements to the main diet and are of great nutritional importance. Without understanding the complementarities between staple food crops and wild food intake, agricultural planning will continue to be dominated by major crops and exclusion of the nutritionally very important, wild products.

x. More research is needed on the germination and viability capacities of most preferred woody plants.

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## APPENDICES

Appendix 1. Questionnaires template for interview schedule

**A: Interview guide for the household head**

i. Village name------

ii. Occupation-----

iii. Are you collecting NTFPs from wood plants (shrubs and trees) (Yes/No)

iv. If yes, which products are being collected? (i) fruits ii) vegetables iii) stapes iv) Oils v) any other specify……………

v. **Products from woody plants**

| SN | Species Used | Part used | seasonality | How often harvested | Amount collected | Amount stored | Species mostly prefered |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |

vi. Availability (increasing/decreasing/why)?

vii. Do you domesticate woody plants? Which wood species and what is the source of seeds/seedlings?

viii. How much are you harvesting from the cultivated plants?

ix. What are other practices for conservation? Which trees are conserved in each practice

x. Which one do you prefer and why?

**B: CHECKLIST (Village Leaders and Collectors)**

i. What is the trend of resource?

ii. Why the trend

iii. Which type of products from wood plants?

iv. Which species are involved?

v. Which species are used for domestication? How many do you have?

vi. How suitable are they?

vii. How do you conserve food plants (practices) and which one is good practice?

Appendix 2: Inventory form template

| Transect | Plot No | Species encountered | Dbh | Seedlings | Saplings | Diameter (DBH) | Disturbance | Phenology | Food type produced |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |

Appendix 3. List of woody plants and life forms in six woodland sites of Iringa District, Tanzania

| S/N | Scientifica name | Local Name (Hehe/Gogo) | Family | Life form |
|---|---|---|---|---|
| 1 | *Acacia albida* Del. | Mpogolo | Fabaceae | *T* |
| 2 | *Acacia mellifera* (Vahl) Benth. | Mkambala | Fabaceae | *T* |
| 3 | *Acacia nigrescens* Oliv. | Mkambala | Fabaceae | *T* |
| 4 | *Acacia nilotica* (L.) Willd. ex Del. | Muvulagavega | Fabaceae | *T* |
| 5 | *Acacia polyacantha* Willd. | Msukanzi | Fabaceae | *T* |
| 6 | *Acacia senegal* (L.) Willd. | Mzasa | Fabaceae | *T* |
| 7 | *Acacia seyal* Del. | Mbata | Fabaceae | *T* |
| 8 | *Acacia sieberiana* DC. | Mgunga | Fabaceae | *T* |
| 9 | *Acacia tortilis* (Forssk.) Hayne | Mkungugu | Fabaceae | *T* |
| 10 | *Acokanthera schimperi* (A.D.C) Schweinf. | Msungusungu | Apocynaceae | *S* |
| 11 | *Acanthopale laxiflora* C.B. Clarke. | Msungusungu | Acanthaceae | *S* |
| 12 | *Adansonia digitata* L. | Mbuyu | Bombacaceae | *T* |
| 13 | *Albizia petersiana* (Bolle) Oliv. | Muhogolo | Fabaceae | *T* |
| 14 | *Albizia anthelmintica* Brongn. | Msanze | Fabaceae | *T* |
| 15 | *Albizia gummifera* (JF Gmel. C.A. Sm. | Msisina | Fabaceae | *T* |
| 16 | *Albizia harveyi* Fourn. | Mtema | Fabaceae | *T* |
| 17 | *Albizia amara* (Roxb.) Boiv. | n/a | Fabaceae | *T* |
| 18 | *Albizia* sp | Msisina | Fabaceae | *T* |
| 19 | *Allophylus macrostachys* Radlk. | Sambu | Fabaceae | *S* |
| 20 | *Allophylus rubifolius* (A. Rich.) Engl. | Sambu | Fabaceae | *S* |
| 21 | *Anisotes bracteatus* Milne-Redh. | n/a | Acanthaceae | *S* |
| 22 | *Asparagus asparagoides* (L.) | Madang'anga | Asparagaceae | *S* |

| | | | | |
|---|---|---|---|---|
| | Druce. | | | |
| 23 | *Asparagus* sp | Madang'anga | Asparagaceae | *S* |
| 24 | *Azanza garckeana* (F. Hoffm.) Exell & Hillcoat. | Mtowo | Malvaceae | *T* |
| 25 | *Balanites aegyptiaca* (L.) Del. | Muvambanus | Balanitaceae | *T* |
| 26 | *Bauhinia kalantha* Harms. | Mhavava | Fabaceae | *S* |
| 27 | *Bauhinia kalantha* Harms. | Mhavava | Fabaceae | *S* |
| 28 | *Bauhinia* sp | n/a | Fabaceae | *S* |
| 29 | *Berchemia discolor* (Klotzsch) Hemsl. | Mgandu | Rhamnaceae | *T* |
| 30 | *Boscia angolensis Engl* | Muwisa | Capparaceae | *S* |
| 31 | *Boscia angustifolia* A.Rich. | Mpapala | Capparaceae | *S* |
| 32 | *Boscia mossambicensis* Klotzsch | Mpapala | Capparaceae | *S* |
| 33 | *Boscia salicifolia* Oliv. | Muwisa | Capparaceae | *S* |
| 34 | *Boscia* sp | Mpapala | Capparaceae | *S* |
| 35 | *Brachystegia boehmii* Taub. | Myombo | Fabaceae | *T* |
| 36 | *Brachystegia longifolia* Benth. | Mtanganidu | Fabaceae | *T* |
| 37 | *Brachystegia bussei* Harms. | Mtelela | Fabaceae | *T* |
| 38 | *Brachystegia speciformis* Benth. | Mkata | Fabaceae | *T* |
| 39 | *Bridelia cathartica Burtol* | Kitungilamela | Euphorbiaceae | *S* |
| 40 | *Bridelia micrantha* (Hochst.) Baill | Kitungilamela | Euphorbiaceae | *S* |
| 41 | *Combretum zeyheri* (Sond.) | Mlama | Combretaceae | *S* |
| 42 | *Canthium burtii* Bullock sensu R. B. Drumm | Mnyalupuko | Rubiaceae | *S* |
| 43 | *Canthium crassum* Hien. | Mbwewe | Rubiaceae | *S* |
| 44 | *Cassia abbreviate* Oliv. | Mmulimuli | Fabaceae | *S* |
| 45 | *Cassia singuena* Del. | Mmulimuli | Fabaceae | *T* |
| 46 | *Cassia* sp | Mmulimuli | Fabaceae | *T* |
| 47 | *Canthium oligocarpum* Hiern. | Mbwewe | Rubiaceae | *T* |
| 48 | *Catunaregam nilotica* (Stapf) Tirveng | Mpongolo | Rubiaceae | *S* |

| | | | | |
|---|---|---|---|---|
| 49 | *Catunaregam sp* | Mpongolo | Rubiaceae | *S* |
| 50 | *Catunaregam spinosa* (Stapf) Tirveng | Mpongolo | Rubiaceae | *S* |
| 51 | *Caturnaregam pygmaea* Vollesen | Mpongolo | Rubiaceae | *S* |
| 52 | *Cissus trothae* Gilg & M.Brandt | n/a | Vitaceae | *S* |
| 53 | *Clerodendrum paniculatum* L. | Mtandaduma | Verbenaceae | *S* |
| 54 | *Clerodendrum trichotomum* Thunb. | Mtandaduma | Verbenaceae | *S* |
| 55 | *Clorodendrum* sp | Mtandaduma | Verbenaceae | *S* |
| 56 | *Cordyla Africana* Lour. | Mkwata | Fabaceae | *S* |
| 57 | *Coffea eugenioides* S. Moore | Mtabagila | Rubiaceae | *T* |
| 58 | *Combretum collinum* Fresen. | Mlama | Combretaceae | *T* |
| 59 | *Combretum exalatum* Engl. | Mlama | Combretaceae | *T* |
| 60 | *Combretum molle* R.Br. ex G.Don. | Mlama | Combretaceae | *T* |
| 61 | *Combretum paniculatum* Vent. | Mlama | Combretaceae | *T* |
| 62 | *Combretum sericea* Burch. ex DC. | Mlama | Combretaceae | *T* |
| 63 | *Combretum* sp | Mlama | Combretaceae | ***T*** |
| 64 | *Combretum zeyheri* Sond. | Mlama | Combretaceae | ***T*** |
| 65 | *Commiphora africana* (A. Rich.) Engl. | Mtono | Burseraceae | *T* |
| 66 | *Commiphora* sp | Mtono | Burseraceae | *T* |
| 67 | *Commiphora boiviana* | Mtono | Burseraceae | *T* |
| 68 | *Commiphora mollis* (Oliv.) Engl. | Mtono | Burseraceae | *T* |
| 69 | *Commiphora myrrha* (Nees) Engl. | Mtono | Burseraceae | *T* |
| 70 | *Commiphora ugogensis* Engl. | Mtono | Burseraceae | *T* |
| 71 | *Commiphora mossambicensis* (Oliv.) Engl. | Mtono | Burseraceae | *T* |
| 72 | *Corchorus fascicularis* Lam. | Nyaluhanga | Tiliaceae | *S* |
| 73 | *Cordia Africana* Lam. | Mdawisowi | Boraginaceae | *T* |
| 74 | *Cordia sinensis* Lam. | Mdawisowi | Boraginaceae | *T* |
| 75 | *Cordia monoica* Roxb. | Mdawisowi | Boraginaceae | *T* |

| | | | | |
|---|---|---|---|---|
| 76 | *Crotalaria agatiflora* Schweinf. | Mnyaluhanga | Fabaceae | *T* |
| 77 | *Crotalaria spartea* Baker. | Mnyaluhanga | Fabaceae | *S* |
| 78 | *Croton* sp | Mweza | Euphorbiaceae | *S* |
| 79 | *Croton macrostachys* Hochst. ex Delile. | Mulungu | Euphorbiaceae | *T* |
| 80 | *Croton megalocarpus* Hutch. | Mulungu | Euphorbiaceae | *T* |
| 81 | *Dalbegia sissoo* Roxb. ex DC | Mitudula | Fabaceae | *T* |
| 82 | *Dalbergia melanoxylon* Guill. & Perr. | mpingo | Fabaceae | *T* |
| 83 | *Dalbergia nitidula* Welw. ex Baker | Mgiha | Fabaceae | *T* |
| 84 | *Dichrostachys cinerea* (L. Wight &Arn. | Mgegele | Fabaceae | *T* |
| 85 | *Diplorhynchus condylocarpon* (Muell. Arg.) Pichon | Mgegele | Apocynaceae | *S* |
| 86 | *Diplorhynchus* sp | Mgegele | Apocynaceae | *S* |
| 87 | *Dombeya rotundifolia* (Hochst. Planch.) | Mkangatowo | Sterculiaceae | *S* |
| 88 | *Ekebergia benguelensis* C. DC. | Kivangadume | Meliaceae | *S* |
| 89 | *Ekebergia capensis* Sparrm. | Kivangadume | Meliaceae | *T* |
| 90 | *Entada abyssinica* A. Rich | Mugelagela | Fabaceae | *T* |
| 91 | *Erythrina abyssinica* DC | Mkalala | Fabaceae | *T* |
| 92 | *Euclea divinorum* Hiern | Mdaha | Ebenaceae | *T* |
| 93 | *Euphorbia candelabrum* Kotschy | Mlangali | Euphorbiaceae | *S* |
| 94 | *Euphorbia cunadeuni* | Mlangali | Euphorbiaceae | *S* |
| 95 | *Euphorbia matabelensis* Pax | Mlangali | Euphorbiaceae | *S* |
| 96 | *Euphorbia* sp | Mlangali | Euphorbiaceae | *S* |
| 97 | *Excoecaria bussei* (Pax) Pax | Msegesege | Euphorbiaceae | *S* |
| 98 | *Faidhebia albida* (Del.) A. Chev. | Mpongolo | Fabaceae | *S* |
| 99 | *Ficus glumosa* Del. | Mkuyu | Moraceae | *T* |

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|---|---|---|---|---|
| 100 | *Gardenia transvenulosa* Verdc. | Mbamilamise | Rubiaceae | *T* |
| 101 | *Gardenia ternifolia* Schum. & Thonn. | Mbamilamise | Rubiaceae | *S* |
| 102 | *Gardenia posoquerioides* S. Moore | Mbamilamise | Rubiaceae | *S* |
| 103 | *Grewia bicolor* Juss. | Mperemehe | Tiliaceae | *S* |
| 104 | *Grewia hexamine* Burret. | Mperemehe | Tiliaceae | *S* |
| 105 | *Grewia platyclada* K. Schum. | Mperemehe | Tiliaceae | *S* |
| 106 | *Grewia similis* K. Schum. | Mperemehe | Tiliaceae | *S* |
| 107 | *Grewia mollis* Juss. | Mperemehe | Tiliaceae | *S* |
| 108 | *Hoslundia opposita* Vahl. | Mkulete | Lamiaceae | *S* |
| 109 | *Indigofera rhynchocarpa* Welw. ex Baker | Mlandala | Fabaceae | *T* |
| 110 | *Indigofera hirsuta* L. | Mlandala | Fabaceae | *S* |
| 111 | *Isoglossa lacteal* Lindau ex Engl. | Mfuto | Acanthaceae | *S* |
| 112 | *Jasminum polyanthum* Franch. | Mfuto | Oleaceae | *S* |
| 113 | *Julbernardia globiflora* (Benth.) Troupin | Mpinati | Fabaceae | *S* |
| 114 | *Kigelia Africana* (Lam.) Benth. | Mtalawanda | Bignoniaceae | *S* |
| 115 | *Lannea stuhlmannii* (Engl.) Engl. | Mgulumo | Anacardiaceae | *T* |
| 116 | *Lannea fulva* (Engl.) Engl. | Mgulumo | Anacardiaceae | *T* |
| 117 | *Lannea humilis* (Oliv.) Engl. | Mgulumo | Anacardiaceae | *S* |
| 118 | *Lannea schimperi* (A. Rich.) Engl. | Mgulumo | Anacardiaceae | *S* |
| 119 | *Lannea schweinfurthii* (Engl.) Engl. | Mgulumo | Anacardiaceae | *S* |
| 120 | *Lonchocarpus bussei* Harms | Mkware | Fabaceae | *S* |
| 121 | *Lonchocarpus capassa* Rolfe | Mkware | Fabaceae | *S* |
| 122 | *Macaranga capensis* Baill. Benth. ex Sim | Mpalala | Euphorbiaceae | *S* |
| 123 | *Maerua angolensis* DC | Mtosi | Capparidaceae | *S* |
| 124 | *Maerua edulis* (Gilg & Benedict) | n/a | Capparidaceae | *T* |

| | | | | |
|---|---|---|---|---|
| | DeWolf | | | |
| 125 | *Maerua parvifolia* Pax | n/a | Capparidaceae | *T* |
| 126 | *Maerua prittwitzii* Gilg & Gilg-Ben. | n/a | Capparidaceae | *S* |
| 127 | *Maerua triphylla* A. Rich. | n/a | Capparidaceae | *S* |
| 128 | *Macaranga kilimandscharica* Pax | Mpalala | Euphorbiaceae | *S* |
| 129 | *Margaritaria discoidea* (Baill.) G.L.Webster | Mkwambe | Euphorbiaceae | *S* |
| 130 | *Markhamia obtusifolia* (Bak.) Sprague | Mguvani | Bignoniaceae | *S* |
| 131 | *Markhamia* sp | Mguvani | Bignoniaceae | *T* |
| 132 | *Maytenus senegalensis* (Lam.) Exell | Mkelemembe | Celastraceae | *T* |
| 133 | *Mystroxylon aethiopicum* (Thumb.) Loes. | Mwambi | Celastraceae | *T* |
| 134 | *Ocimum gratissimum* Willd. | Kivumbavu | Lamiaceae | *S* |
| 135 | *Ochna holstii* Engl. | Mbumila | Ochnaceae | *T* |
| 136 | *Ochna* sp | Mbumila | Ochnaceae | *S* |
| 137 | *Ormocarpum kirkii* S. Moore | Kitimbwi | Fabaceae | *S* |
| 138 | *Opilia amentaceae* Roxb. | Lukokonza | Opiliaceae | *T* |
| 139 | *Opilia celtidifolia* (Guill. & Perr.) Walp. | Lukokonza | Opiliaceae | *S* |
| 140 | *Ormocarpum trachycarpum* (Taub.) Harms | Kitimbwi | Fabaceae | *S* |
| 141 | *Osyris lanceolata* (Hochst. & Steudel | Musakasaka | Santalaceae | *S* |
| 142 | *Ozoroa insignis* Del. | Mwataponzi | Anacardiaceae | *S* |
| 143 | *Ozoroa mucronata* (Bernh.) R.Fern. & A.Fern. | Mwataponzi | Anacardiaceae | *S* |
| 144 | *Ozoroa reticulata* (Bak.f.) Gillett | Mwataponzi | Anacardiaceae | *S* |
| 145 | *Parinari excels* Sab. | Msaula | Chrysobalanaceae | *S* |
| 146 | *Pavetta schumaniana* F. Hoffm. ex | Mnywaugimbi | Rubiaceae | *S* |

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|---|---|---|---|---|
| | K. Schum | | | |
| 147 | *Pentanisia schweinfurthii* Hiern. | n/a | Rubiaceae | *T* |
| 148 | *Peterodendron ovatum* (Sleumer) Sleumer | n/a | Flacourtraceae | *S* |
| 149 | *Phyllanthus eugleri* Pax | n/a | Euphorbiaceae | *S* |
| 150 | *Piliostigma thonningii* (Schumach.) Milne-Redh. | Mkombivavo | Fabaceae | *T* |
| 151 | *Polyscias fulva* (Hiern) Harms | Mdekedeke | Araliaceae | *S* |
| 152 | *Pseudolachnostylis* sp | Mnyaluhanga | Euphorbiaceae | *S* |
| 153 | *Pseudolachnostylis maprouneifolia* Pax | Mnyaluhanga | Euphorbiaceae | *T* |
| 154 | *Psychotria* sp | Mmenamena | Rubiaceae | *T* |
| 155 | *Pterocarpus angolensis* DC | Mninga | Fabaceae | *T* |
| 156 | *Pterocarpus chrysotherix* Taub. | Mvembadanda | Fabaceae | *T* |
| 157 | *Pavetta holstii* K.Schum. ex Engl. | Mnywaugimbi | Rubiaceae | *S* |
| 158 | *Canthium bibracteatum* (Baker) Hiern. | Mmenamena | Rubiaceae | *T* |
| 159 | *Rhus natalensis* Krauss | Mtigala | Anacardiaceae | *T* |
| 160 | *Rinorea ilicifolia* (Welw. ex Oliv.) Kuntze | Mgonilinde | Violaceae | *S* |
| 161 | *Rytiginia* sp | Mgombwe | Rubiaceae | *S* |
| 162 | *Schrebera trichoclada* Welw. | Mwahama | Oleaceae | *T* |
| 163 | *Sclerocarya birrea* (A. Rich.) Hochst. | Mtavaranda | Anacardiaceae | *S* |
| 164 | *Securidaca longipedunculata* Fres. | Mgulukanziva | Polygalaceae | *T* |
| 165 | *Senna singueana* (Del.) Lock | Muhanza | Fabaceae | *T* |
| 166 | *Sterculia Africana* (Lour.) Fiori | Mlutze | Sterculiaceae | *T* |
| 167 | *Strophanthus cournmontii* Franch. | Mwelewehe | Apocynaceae | *T* |
| 168 | *Strychnos cocculoides* Bak. | Mtangadasi | Loganiaceae | *S* |
| 169 | *Strychnos innocua* Del. | Mtangadasi | Loganiaceae | *T* |
| 170 | *Strychnos popatorum* Linn. | Mtangadasi | Loganiaceae | *T* |

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|---|---|---|---|---|
| 171 | *Strychnos pungens* Soler. | Mtangadasi | Loganiaceae | *T* |
| 172 | *Strychnos spinosa* Lam. | Mtangadasi | Loganiaceae | *T* |
| 173 | *Synadenium grantii* Hook. F. | Mlangali | Euphorbiaceae | *T* |
| 174 | *Syzigium guinense* (Willd.) DC. | Mvenge | Myrtaceae | *S* |
| 175 | *Tamarindus indica* L. | Mkwaju | Fabaceae | *T* |
| 176 | *Terminalia sericea* Burch. Ex. DC | Mpululu | Combretaceae | *T* |
| 177 | *Terminalia sp.* | Mpululu | Combretaceae | *T* |
| 178 | *Terminalia brownie* Fres. | Mpululu | Combretaceae | *T* |
| 179 | *Terminalia spinosa* Engl. | Mpululu | Combretaceae | *T* |
| 180 | *Terminalia stuhlmannii* Engl. | Mpululu | Combretaceae | *T* |
| 181 | *Thylachium africanum* Lour. | Mtambasi | Capparidaceae | *T* |
| 182 | *Thylachium* sp | Mtambasi | Capparidaceae | *S* |
| 183 | *Tinnea gracilis* Garcke. | n/a | Lamiaceae | *S* |
| 184 | *Turraea floribunda* Hochst. | Mkobola | Meliaceae | *S* |
| 185 | *Uapaca kirkiana* (Muell. Arg.) | Mikusu | Euphorbiaceae | *S* |
| 186 | *Uapaca* sp | Mikusu | Euphorbiaceae | *T* |
| 187 | *Vangueria tomentosa* Hochst. | Msada | Rubiaceae | *T* |
| 188 | *Vangueria infausta* Burch. | Msada | Rubiaceae | *T* |
| 189 | *Vangueria* sp | Msada | Rubiaceae | *T* |
| 190 | *Vitex doniana* Sweet | Mfudu | Verbenaceae | *T* |
| 191 | *Vitex iringensis* Gürke | Mfudu | Verbenaceae | *T* |
| 192 | *Vitex mombassae* Vatke | Mfudu | Verbenaceae | *T* |
| 193 | *Vitex keniensis* Turril | Mfudu | Verbenaceae | *T* |
| 194 | *Waltheria indica* L. | Mhangadasi | Sterculiaceae | *T* |
| 195 | *Xeroderris stuhlmanni* (Taub.) Mendonça & Sousa | n/a | Fabaceae | *S* |
| 196 | *Ximenia Americana* L. | Mtundwahavi | Olacaceae | *T* |
| 197 | *Ximenia caffra* Sond. | Mtundwahavi | Olacaceae | *S* |
| 198 | *Zanha Africana* (Radlk.) Exell | Kivangaduma | Sapindaceae | *S* |
| 199 | *Zanthoxylum chalybeum* Engl. | Mkunungu | Rutaceae | *T* |

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| 200 | *Zanthoxylum* sp | Mkunungu | Rutaceae | *S* |
| 201 | *Heisteria acuminate* Humb. & Bonpl.) Engl. | n/a | Olacaceae | *S* |
| 202 | *Ziziphus Mauritiania* Lam. | Mtanula | Rhamnaceae | *S* |
| 203 | *Ziziphus* sp | Mtanula | Rhamnaceae | *S* |
| 204 | *Ziziphus mucronata* Willd. | Mtanula | Rhamnaceae | *S* |

Appendix 4. Diameter class distribution of most preferred edible woody plants in Iringa District, Tanzania

| **Forest Site** | | | **Diameter Class (cm)** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Kilwere** | | Recruitment | 10-20 | 20.1-30 | 30.1-40 | 40.1-50 | 50.1-60 | 60.1-70 | > 70 |
| | *Vangueria infausta* | 4667 | 9 | | | | | | |
| | *Vitex mombacea* | 0 | 1 | | | | | | |
| | *Adansonia digitata* | 0 | | | | | | | 1 |
| | *opilia amentacea* | 9999 | 6 | | | | | | |
| | *Sterculia africana* | 1867 | | 1 | | | | | |
| | *Maerua angolensis* | 533 | 1 | | | | | | |
| Mfyome | *Vangueria infausta* | 1200 | 2 | | | | | | |
| | *Vitex mombacea* | 800 | 1 | | | | | | |
| | *Adansonia digitata* | 3066 | | | | | 1 | 2 | 3 |
| | *opilia amentacea* | 7067 | 6 | | | | | | |
| | *Sterculia africana* | 2000 | | 3 | 2 | | | | |
| | *Maerua angolensis* | 667 | 1 | | | | | | |
| Migoli | *Vangueria infausta* | 7467 | 2 | | | | | | |
| | *Vitex mombacea* | 0 | 1 | | | | | | |
| | *Adansonia digitata* | | 133 | | | | 1 | | 1 |
| | *opilia amentacea* | 866 | 4 | | | | | | |
| | *Sterculia africana* | 2267 | 1 | 2 | | | | | |
| | *Maerua angolensis* | 267 | 1 | | | | | | |
| Mbweleli | *Vangueria infausta* | 6666 | 7 | | | | | | |
| | *Vitex mombacea* | 0 | 1 | | | | | | |
| | *Adansonia digitata* | 10,000 | | | | 2 | 1 | 5 | 4 |
| | *opilia amentacea* | 13467 | 13 | | | | | | |
| | *Sterculia africana* | 6400 | | 10 | 3 | | | | |
| | *Maerua angolensis* | 4667 | 3 | | | | | | |

| | | | | |
|---|---|---|---|---|
| Kinyali | *Vangueria infausta* | 1724 | 5 | |
| | *Vitex mombacea* | 1334 | 3 | |
| | *Adansonia digitata* | 6133 | | 1 |
| | *opilia amentacea* | 1867 | 5 | |
| | *Sterculia africana* | 933 | | 4 |
| | *Maerua angolensis* | 533 | 1 | |
| Makuka | *Vangueria infausta* | 1533 | 7 | |
| | *Vitex mombacea* | 3466 | 8 | |
| | *Adansonia digitata* | 10000 | | |
| | *opilia amentacea* | 2400 | 4 | |
| | *Sterculia africana* | 2667 | 1 | 2 |
| | *Maerua angolensis* | 400 | 1 | |

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| 1 | | | |