CODESRIA

Dissertation By

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# ARBORESCENT SPECIES DIVERSITY AND STOCKING IN MIOMBO WOODLAND OF URUMWA FOREST RESERVE AND THEIR CONTRIBUTION TO LIVELIHOODS, TABORA, TANZANIAStatus

2008

# ARBORESCENT SPECIES DIVERSITY AND STOCKING IN MIOMBO WOODLAND OF URUMWA FOREST RESERVE AND THEIR CONTRIBUTION TO LIVELIHOODS, TABORA, TANZANIA



BY

MARCO ANDREW NJANA



A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN THE MANAGEMENT OF NATURAL RESOURCES FOR SUSTAINABLE AGRICULTURE OF SOKOINE UNIVERSITY OF AGRICULTURE, MOROGORO, TANZANIA.

2008

## ABSTRACT

Despite the fact that miombo woodlands are rich in species and offer extensive products and services, there is meager knowledge on the link between miombo woodlands and livelihood of local communities. This study assessed arborescent (tree and shrub) species diversity and stocking in the miombo woodland of Urumwa Forest Reserve (UFR) and their contribution to livelihoods of local communities. Four data sets were collected including: ecological, socio-economic, livelihood and institutional data. Ecological data were collected through forest inventory while socio-economic, livelihood and institutional data were collected through household questionnaire survey, Participatory Rural Appraisal (PRA) and checklist. Supplementary secondary data were obtained through literature survey and internet search. Analysis of inventory data was done by using Microsoft excel while other data sets were analysed by using Statistical Package for Social Sciences (SPSS). Content and Structural-Functional analyses were used for qualitative data. This study showed Shannon-Wiener Index of Diversity of 3.40 for the miombo woodland of UFR. Furthermore, logistic regression analysis showed that, increase in species diversity of the miombo woodland increased chances of the miombo woodland's contribution to livelihoods of local communities. Thus, the null hypothesis was rejected and alternative hypothesis was adopted. The findings in this study show mean stems density, basal area and volume of $583 \pm 49$ SPH, $8.54 \pm 0.51$ $m^2/ha$ and $58.41 \pm 4.09$ $m^3/ha$ respectively for UFR. Results show that, the miombo woodland contributes 59% to total household annual income. Similarly, results indicate that, to meet the wood resource requirements about 2 $m^3$ per hectare of wood resources is extracted annually from UFR. The study revealed both socio-economic and institutional factors which enable or constrain contribution of UFR to livelihoods in which the null hypothesis was rejected in favour of the alternative hypothesis. The study concludes that, despite the miombo woodland providing products and services to the surrounding communities the woodland is still fairly stocked with high tree and shrub species diversity. The study recommends in-depth forest inventory, preparation of management plan and promotion of good governance in management of UFR.

## DECLARATION

I, Marco Andrew Njana, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has not been submitted for any degree award at any other university.

26 Nov. 2009

Marco Andrew Njana
(MSc. MNRSA)

Date

The above declaration is confirmed by

27/11/09.

Prof. G. C. Kajembe
(Supervisor)

Date

27/11/2009

Prof. R. E. Malimbwi
(Supervisor)

Date

## COPYRIGHTS

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**DEDICATION**

This work is dedicated to my parents; Andrew Njana and Gaudensia Raphael who due to their love for me, formed me into whom I am; to my late brother Raphael N Njana who valued education and sent me to school, the fruit of which is this work so dearly completed.

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## LIST OF ABBREVIATIONS AND ACRONYMS

| | | |
|---|---|---|
| DFID | = | Department for International Development |
| DFO | = | District Forest Officer |
| DRC | = | Democratic Republic of Congo |
| FAO | = | Food and Agriculture Organisation of the United Nations |
| FBD | = | Forestry and Beekeeping Division |
| FRMP | = | Forest Resources Management Project |
| GPS | = | Geographical Positioning System |
| H' | = | Shannon-Wiener Index of species diversity |
| Ha | = | Hectare |
| ID | = | Index of Dominance |
| IVI | = | Important Value Index |
| JFM | = | Joint Forest Management |
| JMA | = | Joint Management Agreement |
| JWTZ | = | Jeshi la Wananchi Tanzania |
| MNRT | = | Ministry of Natural Resources and Tourism |
| PRA | = | Participatory Rural Appraisal |
| SE | = | Standard Error |
| SLF | = | Sustainable Livelihoods Framework |
| Sp./SPP | = | Species |
| SPSS | = | Statistical Package for Social Sciences |
| SPH | = | Stems per hectare |
| SUA | = | Sokoine University of Agriculture |

| | | |
|---|---|---|
| TAS | = | Tanzania Shilling |
| TTC | = | Teachers Teaching College |
| TTSA | = | Tanzania Tree Seed Agency |
| UFR | = | Urumwa Forest Reserve |
| URT | = | United Republic of Tanzania |
| US$ | = | United States Dollar |
| WCED | = | World Commission on Environment and Development |
| WWF-SARPO | = | World Wide Fund for Nature Southern Africa Regional Programme Office |

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background information

Miombo woodlands form an integral part of the rural landscape in Tanzania and play crucial role in providing rural communities with a wide range of products and services (Kajembe *et al.*, 2002). According to the national land covers and land use reconnaissance carried out in 1996, miombo woodlands cover 374,356 $km^2$ or about 93.2 % of total forest area of Tanzania (Mnangwone, 1999) (Table 1).

**Table 1: Forested area of Tanzania mainland**

| Forest type | Area ($km^2$) | % |
|---|---|---|
| Closed forests | 24 313.00 | 6.1 |
| Miombo woodlands | 374 356.00 | 93.2 |
| Mangroves | 1 569.00 | 0.4 |
| Plantations | 1 349.00 | 0.3 |
| **Total** | **401 587.00** | **100.00** |

Source: Mnangwone (1999)

Generally speaking, biodiversity can be considered at different levels: genetic diversity, species diversity as well as ecosystem diversity (Norse *et al.*, 1986). Huston (1994) defined diversity as the structural and functional variety of plants and animals at genetic, species and community levels. Thus, tree and shrub species diversity is the total number of species present in a community, likewise, the scope of species diversity tells the spread of individuals between species contained in a community. It is important however, when measuring diversity to take into account both species number and abundance (Kent and Coker, 1992). According to Narayan *et al.* (1994) in Kohli *et al.* (1996), the higher the value of species diversity the greater the stability of community structure and hence more and sustained supply of products and services on which livelihoods of communities depend. Kremen (2005) further noted that, greater species diversity increase the odds that the ecosystem has functional redundancy by containing species that are capable of functionally replacing other important species.



Miombo woodland ecosystem varies greatly both spatially and temporally due to complex interaction of a range of influences including climatic, edaphic, fire and anthropogenic factors (Maliondo *et al.*, 2005). Frost (1996) ascertained that, the miombo vegetation is extremely rich in plant species, many of which are endemic. Frost (1996) reported that, about 175 tree species most of which belong to the legume sub-families of *Caesalpinioideae* and *Papilionoideae* are indigenous to the Tanzania's miombo woodlands. Nduwamungu (1997) studied a total of 99 tree and shrub species in miombo woodlands of Kitulangalo forest reserve. *Mimosoideae, Papilionoideae* and *Caesalpinioideae* were dominant representing 2%, 13% and 21% respectively of total recorded individuals. Similarly, Malimbwi *et al.* (1998) enumerated 95 and Luoga (2000) enumerated 79 species in Kitulanghalo Forest Reserve while Backeus (2006) found 86 species around Ihombwa village in Mikumi Division, Kilosa District. However, drawing from these studies, there is high variation in stem density, basal area and standing volume per hectare. This may be attributed to environmental, socio-economic and institutional factors among others. Institutions may be regarded as shared rules regarding what actions individuals must take, must not take or are permitted to take in particular settings (Menard and Shirley, 2005).

Miombo woodlands are central to the livelihood systems of millions of rural and urban dwellers in Tanzania. Livelihood comprises of capabilities, assets and activities required to make a living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in future, while not undermining the natural resources base (DFID, 1999). Analysing livelihood systems entails examining factors involved in the manner in which people make a living. Livelihood system is a set of activities aimed at making a living. They include: food processing, livestock production, cultivation or use of natural or common property resources, labour exchange among family or neighbours, contracted "home work," borrowing, scavenging and begging.



Goods and services provided by miombo woodlands which contribute to livelihoods of local communities include: medicines, charcoal, firewood, food (game, meat, fruits, honey etc.), withies, fibers, and construction and craft materials. Miombo woodlands also support agricultural production (e.g. tobacco growers use energy from miombo woodlands for processing their tobacco). The services include cultural and spiritual values, climate amelioration, erosion and hydrological control (Luoga, 2000; Abdallah, 2001). Interspersed within the miombo woodlands are broad, grassy depressions called 'mbuga' which are seasonally waterlogged, support cultivation and livestock grazing (McFarlane and Whitlow, 1990).

The majority of rural inhabitants are poverty stricken and natural resources out skirting them act as safety net for their well-being most of the time. Forests and woodlands are not only the source of a variety of food that supplement what rural communities obtain from agriculture, but also supplement household income (Monela *et al.*, 2000). A significant element of the 'safety net' for many rural people in times of 'famine foods' which has been gathered from woodlands and fallow-lands (Norton *et al.*, 1994).

The loss of forests and woodlands certainly goes hand in hand with the loss of forest and woodland products (Munyanziza, 1994). Accordingly, in order for the management of forests and woodlands to be sustainable in Tanzania and else where, it is important to understand multiple livelihood activities. This will enhance our understanding of the multiple sources of vulnerability faced by the poor, the multiple ways in which their lives are affected by structures and institutions, and the varied ways in which development interventions may strengthen or weaken these livelihood activities.



## 1.2 Problem statement and study justification

Despite the fact that miombo woodlands are rich in species, well stocked and offer extensive products and services, there is meager knowledge on the link between miombo woodlands and livelihood of local communities. Few studies relate diversity of miombo woodlands to livelihoods; similarly, there is scanty information which relate socio-economic factors and institutional set-ups underlying miombo woodlands' contribution to livelihoods. Thus, this study contributes to this knowledge gap.

Urumwa Forest Reserve (UFR) is Central Government owned forest, located in Tabora region. The woodland was gazetted in 1953 in Government Notice No. 50 covering an area of 12,800 hectares. UFR has been managed through Joint Forest Management (JFM) setting since 1996. Joint Forest Management (JFM) is an institutional arrangement which divides forests and woodland management responsibilities and returns between the owner (usually central, local government or private individual) and adjacent communities. It is formalized through the signing of a Joint Forest Management Agreement between village representatives and the owner. About 61% of all vegetation types in Tabora region is miombo woodlands, it is against this background that the area was selected for this study since it is a good representative of miombo woodlands in Tanzania and as such it is worthy assessing for the contribution of miombo woodlands to local communities' livelihoods.



Literature shows that, tree and shrub species diversity in miombo woodlands have been studied in Tanzania. These include: Tuite (1992), Nduwamungu (1997, 2001), Malimbwi *et al.* (1998), Zahabu (2001), Mbwambo (2000), Luoga (2000), Backeus *et al.* (2006), Mohamed (2006) to name just a few. However, most of these studies have been done on eastern Tanzania. Hence, this study intended to examine tree and shrub species diversity and stocking in the miombo woodland of western Tanzania.

Forest Policy (URT, 1998), Forest Act No. 14 (URT, 2002) and National Forest Programme (URT, 2001) are the paramount tools for the management of forests and woodlands in Tanzania. Two broad objectives stipulated in the National Forest Policy are: (i) rehabilitation and maintenance of forest resources and (ii) improving livelihoods of forests and woodlands dependant communities (URT, 1998). FAO (2000) argued that, prerequisites for achieving broad goals highlighted in the National Forest Policy include: improved local governance through more effective and accountable institutions, reduced vulnerability through a sustainable supply of forest and woodland products and services. The growing concern about miombo woodlands management in recent years is rooted in the perception of their importance to the physical environment and livelihoods of local communities (Dewees, 1994). This clearly shows a growing anxiety on the subject 'Contribution of miombo woodland to livelihoods' and review of literature reveal that, the products and services derived from miombo woodlands address basic human needs i.e. food, shelter, health and spiritual well being. It is against this background, this study assessed products and services accrued by local communities from the miombo woodland of UFR and their contribution to local communities' livelihoods.



Institutions can be seen as sets of formal and informal rules that shape interactions between humans and nature. They constrain some activities and facilitate others (North, 1990). Moreover, institutions play a central role in facilitation of livelihood outcomes which include: more income, improved well-being, reduced vulnerability, improved food security and more sustainable use of natural resources (Carney, 1998). Restricted access to forests and woodlands has been reported to affect forest users, especially those who rely on them for their livelihoods (Malla, 2000). A people-centered management of forests and woodlands can increase the contribution of forests and woodlands in reducing poverty. According to FAO (2000), benefits to local livelihoods from people-centered forestry include: right to access, reduced vulnerability income from forest goods and services, improved governance and direct benefits from environmental services among others. According to Kjaer (2004), governance is the setting, application and the enforcement of rules. It is worthy noting that, such institutional and socio-economic factors are likely to influence contribution of miombo woodlands such as UFR to local communities' livelihood. This is the essence that, this study assessed institutional and socio-economic factors enabling or constraining contribution of the miombo woodland to livelihoods of local communities.



### 1.3 Study objectives

#### 1.3.1 Overall objective

The overall objective of this study was to assess arborescent (tree and shrub) species diversity and stocking in the miombo woodland of Urumwa Forest Reserve (UFR) and their contribution to livelihoods of local communities.

#### 1.3.2 Specific objectives

Specific objectives of the study include:

(i) Examining tree and shrub species diversity and stocking in the miombo woodland of UFR;

(ii) Assessing products and services accrued by local communities from the miombo woodland and their contribution to their livelihoods;

(iii) Assessing wood products out–take from UFR and its implication on woodland stock;

(iv) Assessing socio-economic and institutional factors enabling or constraining contribution of the miombo woodland resources to livelihoods of local communities.

### 1.3.4 Research questions

(i) What is the tree and shrub species diversity in terms of species richness, abundance, composition and diversity indices (Shannon-Wiener Index of Species Diversity, Index of Dominance and Importance Value Index) in the miombo woodland of UFR?

(ii) What is the stocking (Stem density, basal area and standing volume) in the miombo woodland of UFR?

(iii) What is the regeneration status of tree and shrub species in the woodland? What are the regenerating species?

(iv) What are livelihood activities undertaken in the study area? What among these are miombo woodland dependent livelihoods?

(v) What are products and services derived by local communities from the miombo woodland?

(vi) What is the contribution of the miombo woodland to livelihoods of local communities?

(vii) What is the estimated annual cut of tree and shrub species ($m^3$)?

(viii) Which are tree and shrub species used? Which specific use(s)?

(ix) What socio-economic and institutional factors which enable or constrain the contribution of the miombo woodland resources to livelihoods of local communities?

**1.4 Hypotheses**

(i) $H_0$: Tree and shrub species diversity in the miombo woodland of UFR has no significant contribution to livelihoods of the local communities;

$H_1$: Tree and shrub species diversity in the miombo woodland of UFR has significant contribution to livelihoods of the local communities.

(ii) $H_0$: Socio-economic and institutional factors significantly constrain the contribution of miombo woodland to local communities' livelihood;

$H_1$: Socio-economic and institutional factors significantly enable the contribution of miombo woodland to local communities' livelihood.

**1.5 Conceptual framework**

A conceptual framework is schematic representation of the study and it provides guidance in data collection. The conceptual framework in figure 1 shows that, surrounding communities interact with the miombo woodland stock through institutions, formal and informal. The interaction takes place in the form of livelihood strategies which are shaped by institutions, formal and/or informal.

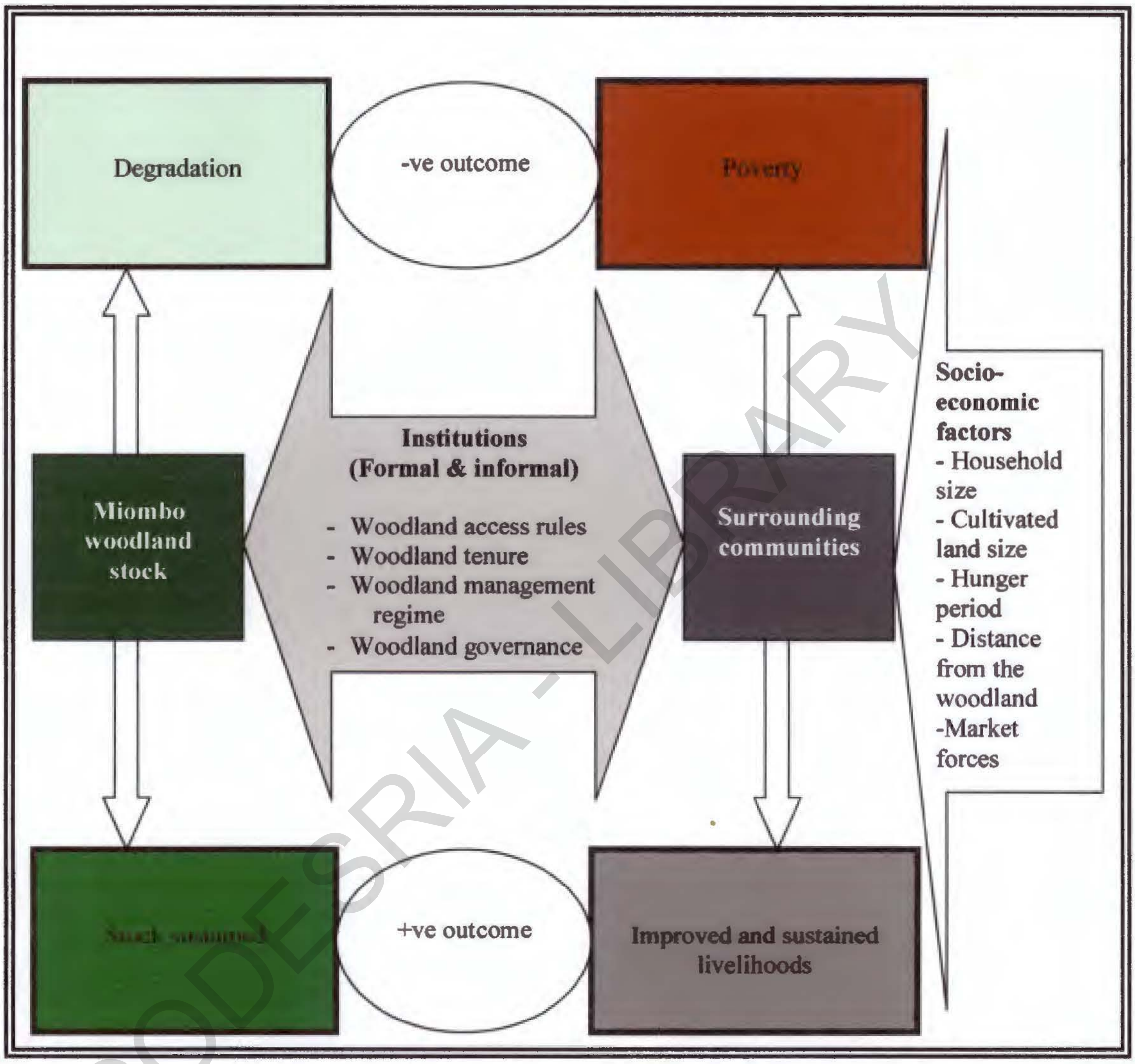


**Figure 1: Conceptual framework of the study**

The various livelihood strategies in the miombo woodlands are geared towards attainment of livelihood outcomes which according to Carney (1998) include: more income, improved well-being, reduced vulnerability, improved food security and more sustainable use of natural resources. Accordingly it suggests that, if institutions play well their roles, the miombo woodland stock will be sustained and hence improved and sustained livelihoods through sustained supply of products and services. The reverse is true.

**1.6 Limitations of the study**

- Financial and time resources for conducting this study were limited. This was sorted out by extra working hard within the bounded time frame;

- Most interviewed heads of households were reluctant to disclose their undertakings and income there off. The plausible reason for this could be, they would bear responsibilities if activities undertaken are illegal. This is supported by the fact that, respondents felt unease at the initial stage of the interview process by perceiving that the researcher was on investigation rather than research mission. Likewise, respondents tended to underestimate household annual income and crop harvest. The plausible reason could be rooted in the perception that, the researcher was carrying out inventory to identify the vulnerables so that they may be supported. This was overcome by making the respondents understand clearly the objective of the research and that; the researcher was neither in investigation mission nor identification of the vulnerables.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 The miombo ecoregion

Miombo woodlands, a specific type of savanna characterized by deciduous arborescent species dominated by the genera *Brachystegia* and *Julbernadia* and grasses. The miombo ecoregion is the most extensive vegetation type in Africa south of the equator (Campbell *et al.*, 1996). This miombo woodland ecosystem extends across about 2.8 million km$^2$ of the southern sub-humid tropical zone from Tanzania and Democratic Republic of Congo (DRC) in the north, through Zambia, Malawi and eastern Angola, to Zimbabwe and Mozambique in the south (Desanker *et al.*, 1997). The ecoregion constitute the largest more-or-less contiguous block of deciduous tropical woodlands and dry forests in the world and is a home to over 40 million people and the source of products and services which cover the basic human needs (Campbell *et al.*, 1996). Besides local interest, the woodlands also have global significance with respect to environmental and biodiversity conservation. About half of the elephants and rhinos left in Africa are found in miombo ecoregion. Nature and wildlife tourism is one of the main economic sectors in the region, with considerable potential for growth (Maliondo *et al.*, 2005; Byers, 2001). The ecological dynamics of the miombo ecoregion have been shaped in many ways by human beings, and it is believed no part of it remains absent of human influence (WWF-SARPO, 2001). Survival of people in this ecoregion has always depended on natural resources drawn from ecosystem. Many people may even become more dependent on this natural asset as poverty and human population increase (WWF-SARPO, 2001).

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Two categories of miombo woodlands are known in the miombo ecoregion and both exist in Tanzania. White (1983) divided miombo woodlands into dry and wet. The dry miombo woodlands occur in areas receiving less than 1000 mm rainfall annually. They occur in Zimbabwe, central Tanzania, southern areas of Mozambique, Malawi and Zambia. Their canopy height is less than 15 m and the vegetation is floristically impoverished. The wet miombo woodlands occur in areas receiving more than 1000 m rainfall per year and these are found in eastern Angola, northern Zambia, south – western Tanzania and central Malawi. Canopy height is usually greater than 15 m reflecting general deeper and moister soils, which create favourable conditions for growth. Besides, the vegetation is floristically rich (Frost, 1996).



**2.2 Miombo woodlands in Tanzania**

Miombo constitutes the largest single vegetation type in the country (93.2 %). In Tanzania, the relatively dry miombo woodlands cover extensive areas of Shinyanga, Kigoma, Tabora, Rukwa, Mbeya and Iringa regions and wet miombo occupies the south-eastern regions namely: Lindi, Mtwara, Songea, Mbeya, Iringa and Morogoro (Millington *et al.*, 1994). It occurs at altitudes from near sea level to about 1,600 m, with annual rainfall ranging from 500 mm to 1,200 mm (Jeffers and Boaler, 1966). Miombo in Tanzania consists of two main layers, the tree canopy and the herb or ground layer, plus an under-wood layer of smaller trees. In some places a shrub layer also exists (Jeffers and Boaler, 1966; Acres *et al.*, 1984). According to Jeffers and Boaler (1966), the canopy of mature miombo stands in Tanzania reach a height of 10 to 20 m. Although slightly open in some areas, the ground layer is dominated by *Hyperrhenia* grasses with saplings of the main canopy species and they are often subject to burning (Jeffers and Boaler, 1966; Lawton, 1982; Tuite and Gardiner, 1990). These woodlands differ in the degree of canopy closure and in species composition (White, 1983). Where canopy cover is complete, the ground layer often includes a large proportion of herbs and grasses and the height reaches 50 cm (Jeffers and Boaler, 1966). Growth ring counts of *Pterocarpus angolensis* stems in Tanzania by Boaler and Sciwale (1966) suggested that miombo trees can live up to about 100 years.

Miombo woodlands in Tanzania and else where in the region are highly depended as source of livelihoods of local inhabitants although uses are believed to be inefficient. For example, it is estimated that humans use only 10% of the fruits potential and the rest are wasted, due to poor markets and rudimentary processing technologies in the country (Nsubemuki *et al.*, 1997).



## 2.3 Ecology of Miombo woodlands

### 2.3.1 Tree and shrub species diversity in miombo woodlands

The knowledge of species diversity is particularly useful in understanding the importance of tree species to peoples' livelihoods. Chidumayo *et al.* (1996) stressed that, the diverse uses of miombo woodlands and the need to optimize the sustainable flow of benefits to communities living in the miombo environment pose a challenge.

Species diversity refers to the number of different species in a particular area and their relative frequencies (Wilson, 2006; Harrison *et al.*, 2007). Species richness may be defined as the actual number of different species in a community rather than the number of individuals contained therein (Harrison *et al.*, 2007). The same author defined species evenness as the relative abundance with which each species is represented in a community while composition is the assemblage of plant species that characterize the vegetation (Martin, 1996). The most common measure of species composition is richness (number of different species) and abundance (number of individuals per species found in a given area). Therefore, as species richness and evenness increases, so is the species diversity.

Miombo woodlands are extremely rich in plant species in spite of their apparent uniformity in structure and composition over large areas. The number of higher plant species in the miombo ecoregion is estimated to be 8 500 species, out of which 334 are trees (Frost, 1996; Rodgers *et al.*, 1996). In another study, Malaisse (1978) reported at least 480 flowering plant species from miombo woodlands of Katanga (Democratic Republic of Congo) while Nduwamungu (1997) documented a total of 99 tree and shrub species in miombo woodlands of Kitulangalo, Tanzania. Dominant tree species in miombo are those in the family *Fabaceae*, sub-family *Caesalpinioideae* in the genera *Brachystegia, Julbernadia* and *Isoberlinia.* Others include *Pterocarpus angolensis, Parinari curatellifolia, Afzelia quanzensis* and *Erythrophloem africanum* (Chidumayo and Frost, 1996).



A number of indices are known for measuring species diversity in communities. A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide information about community composition and take the relative abundances of different species into account (Magurran, 1988). There are many indices used to measure species diversity. However, for the purpose of this study, Shannon-Wiener index of species diversity, Index of Dominance (ID) and Important Value Index (IVI) were used in assessing tree and shrub species diversity in miombo woodlands of UFR.

**Shannon-Wiener Index of species diversity (H')**

This index considers species richness (number of species) and evenness (species distribution) (Magurran, 1988). The larger the value of H' the greater the species diversity and vice versa, though in practice, for biological communities it does not exceed 5.0 (Krebs, 1989). Shannon-Wiener Index of species diversity is mathematically represented as follows:

$$H' = -\sum_{i=1}^{s} P_i \ln P_i \quad \text{..........} (1)$$

Source (Kent and Coker, 1992)

Where;

H' = the Shannon index of diversity;

$\sum$ = the summation symbol;

s = the number of species;

$p_i$ = the proportion of individuals or the abundance of species i in the sample;

ln = the logarithm to base e;

- = the negative sign multiplied with the rest of variables in order to make H' Positive.

Studying miombo woodlands of Kitulangalo forest reserve in Morogoro, Tanzania, Zahabu (2001) reported H' value of 3.13. Similar results were reported in previous study in the same forest reserve by Nduwamungu (1997). Other studies in miombo woodlands of Igombe river forest reserve, Tabora, Tanzania by Mafupa (2006) and Handeni Hill forest reserve, Tanga, Tanzania by Mohamed (2006) reported H' values of 2.90 and 3.10 respectively while Silayo *et al.* (2006) reported a relatively close value of 2.86 for Uzigua Forest Reserve.

**Index of Dominance (ID)**

Index of dominance also known as Simpson's index; measures the probability that, two individuals randomly selected from a sample will belong to the same species. In other words it is a measure of distribution of individuals among species in a community. The value of ID ranges between 0 and 1. The value '0' represents infinity diversity and '1' represents no diversity. Thus, the greater the value of ID the lower the species diversity and vice versa (Misra, 1989; CHAPOSA, 2002). ID is computed by using the following model:

$$ID = \sum \left[ \frac{n_i}{N} \right]^2 \qquad (2)$$

Source (Misra, 1989)

Where;

ID = the index of dominance;

$n_i$ = the number of individuals of species i in the sample;

N = the total number of individuals (all species) in the sample;

$\sum$ = the summation symbol.

Malimbwi and Mugasha (2002) and Mohamed (2006) recorded ID values of 0.073 and 0.063 respectively in miombo woodlands of Handeni Hill forest reserve, Tanga, Tanzania. Mafupa (2006) studying miombo woodlands of Igombe river forest reserve, Tabora, Tanzania presented ID value of 0.088 and 0.135 in undisturbed and disturbed strata respectively.

**Importance Value Index (IVI)**

Importance value index is a composite index made up of sum of Relative Frequency (RF), Relative Density (RD) and Relative Dominance (RDo) of species. This index is useful in evaluating the importance of a given species in a given plant community (Kent and Coker, 1992). The maximum value of IVI is 300. It is calculated as follows (Ambasht, 1990):

$$RF = \frac{Number\ of\ occurance\ of\ the\ species}{Number\ of\ occurances\ of\ all\ species} \times 100$$

$$RD = \frac{Number\ of\ individuals\ of\ the\ species}{Number\ of\ individuals\ of\ all\ species} \times 100$$

$$RDo = \frac{Total\ basal\ area\ of\ the\ species}{Total\ basal\ area\ of\ all\ species} \times 100$$

$$IVI = RF + RD + RDo \quad \text{.......... (3)}$$

### 2.3.2 Stocking in miombo woodlands

Stocking generally include: number of stems, basal area and volume of standing trees and shrubs in a given area. Regeneration is as well included in the scope of stocking since today's regenerants are tomorrow's trees and shrubs.

**Stem density (Number of stems per hectare) (N)**

Stem density indicates the degree of rowdiness of stems in a given area (Husch *et al.*, 1982). Studies show that, stem density in miombo woodlands varies widely. However, it ranges from 380 to 1400 SPH (Trapnell, 1959; Boaler and Sciwale, 1966; Strang, 1974; Ek, 1994; Nduwamungu and Malimbwi, 1997; Mafupa, 2006; Mohamed, 2006).

Results of a study conducted by Nduwamungu (1997) in miombo woodlands of Kitulangalo, Morogoro, Tanzania found stem density of 691 SPH. This result is comparable with results obtained by Malaisse (1978) in miombo woodlands of Katanga, DRC which ranges from 520 to 645 SPH. Similarly, Malimbwi and Mugasha (2002) and Mohamed (2006) reported 355 and 817 SPH respectively in miombo woodlands of Handeni Hill forest reserve.



**Basal area ($m^2$ per hectare) (G)**

Tree basal area ($g_i$) is the cross-sectional area of a tree or shrub at breast height whereas stand basal area (G) is the total basal area of all trees or of specified classes of trees per hectare (Hush *et al.*, 1982; Philip and Gentry, 1993). According to Philip (1994), in natural forests, basal area is a good measure of the potential of a site. In most miombo woodlands, the basal area range between 7 and 25 $m^2$ per hectare

(Strang, 1974; Chidumayo, 1987; Lowore *et al.*, 1994; Nduwamungu and Malimbwi, 1997; Zahabu, 2001; Mafupa, 2006; Mohamed, 2006).

**Standing volume ($m^3$ per hectare) (V)**

Basal area is linearly related to volume (Lowore *et al.*, 1994). The mean harvestable volume in miombo woodlands range between 14 $m^3$ per hectare in dry miombo woodlands of Malawi (Lowore *et al.*, 1994) and 117 $m^3$ per hectare in Zambian wet miombo woodlands (Chidumayo, 1988). Luoga *et al.* (2002) while studying miombo woodlands of eastern Tanzania found standing volume of 47 $\pm$ 3.38 (S.E) $m^3$ per hectare in reserved miombo woodland which was contrary to standing volume of 16.7 $\pm$ 2.26 $m^3$ per hectare in miombo woodlands which fall under general land. Nduwamungu (1997) reported mean standing volume of 71 $m^3$ per hectare at Kitulangalo forest reserve, Morogoro, Tanzania while Mafupa (2006) recorded mean standing volume of 87.14 $m^3$ per hectare in undisturbed strata and 21.09 $m^3$ per hectare in disturbed strata in Igombe river forest reserve, Tabora, Tanzania.

**Regeneration potential**

Regeneration in miombo ecosystems consists mainly of stump/root coppices. The greater the height at which the stem is cut, the greater the number of resultant coppice shoots (Chidumayo *et al.*, 1996; Shackleton, 2001; Luoga *et al.* 2004). Subsequent to cutting, the coppice re-growth can be managed according to conventional silvicultural practices, although rarely is the case.

The remarkable regenerating capacity of miombo is key to ongoing productivity of miombo. After tree cutting there is rapid regeneration from coppice, root suckering and the large bank of suppressed saplings, known as suffructices (Boaler, 1966; Strang, 1974; Chidumayo, 1993). These forms of regeneration allow for much faster reestablishment than regeneration from seed, and provide a degree of protection from fire and grazing (White 1976, cited in Piearce, 1993) which are common in most miombo woodlands.



## 2.4 Miombo woodlands and livelihoods

### 2.4.1 The concept of livelihood

Livelihood means the whole complex of factors that allow families to sustain themselves materially, emotionally, spiritually and socially. Central to this is income, whether in the form of cash or natural products directly consumed for subsistence such as food, fuel or building materials (Chambers and Conway, 1992).

Terms related to livelihoods include asset, shock, stress, vulnerability and resilience. Assets are referred to as the resources used for gaining a livelihood (Satge *et al.*, 2000). 'Shocks' are sudden events which undermine household livelihoods. These include: retrenchment, death of economically active member, drought, floods or extreme weather events. 'Stresses' are ongoing pressure which face households and individuals. They include: long-term food insecurity and limited access to essential services such as health or water supplies. Other stresses include: degrading natural resource base, this may force people to travel further and further for natural resource products. 'Vulnerability' is regarded as characteristics that limit an individual, a household, a community, a city or even an ecosystem's capacity to anticipate, manage, resist or recover from the impact of natural or other threats. 'Resilience' is a measure of the household's ability to absorb shocks and stresses. A household with well diversified assets and livelihood activities can cope better with shocks and stresses and stresses than one with a more limited asset base and few livelihood resources.

### 2.4.2 Contribution of miombo woodland resources to livelihoods of local communities

The miombo woodlands provide a wide range of wood and Non-wood products which are important to the livelihoods of adjacent communities (Monela *et al.*, 2000). For example the miombo woodlands of Malawi are known to have over 75 indigenous fruit trees, which bear edible fruits. The fruits are rich in minerals and vitamins, sold for cash income and constitute important food sources during famines and or emergencies (Akinnifesi, *et al.*, 2006; Saka and Msonthi, 1994). Utilization and trade of fruits are integral components of local economies and culture and play important roles in household welfare. Economic activities and population densities are the main determinants of demand of goods and services from the miombo woodlands (FAO, 2000).

The miombo woodlands environment has a characteristic of fluctuating rainfall patterns and the frequency of draughts which make it possible for most of people out skirting 'miombo' to rely on their products (Campbell, 1996). In times of draughts as is in the time of hardship and hunger, rural households turn to miombo products as source of sustenance and cash income. Moreover, miombo woodlands have been an emergency resource and a buffer, providing a livelihood of the last resort when other options retreat (Campbell, 1996).

Charcoal is the preferred form of wood energy among the urban households, and serves mainly as a source of income for the rural households who mainly use firewood for energy requirements. In Zimbabwe, Wood fuel accounts for about 52% of the total energy consumption (Gwaze and Marunda, 1998). About 80% of the rural households depend on Wood fuel as source of energy for cooking, brick making, beer brewing, tobacco curing and hearting. In Swaziland, over 75% of the population in the rural areas uses firewood for cooking and warming house (Dlamini, 1998). All these energy materials are sourced from miombo woodlands.



### 2.4.3 Products and services derived by local communities from miombo woodlands

Miombo woodlands have for a long time been a useful source of various forest products and services for the subsistence needs of rural communities which cover the basic requirements for human life: food, shelter and energy. The current challenge in the miombo region however, is to assess the resource and quantify the value of these products, and to transform their use from subsistence to commercial products through processing and marketing (commercialization) so that the local people also benefit.

Service role of miombo woodlands include: soil erosion control, protection of water catchments, providing shade, modifying hydrological cycles and maintaining soil fertility and biodiversity conservation. Religious and cultural customs practiced in miombo woodland areas are vital to the spiritual well-being and effective functioning of rural communities (Clarke *et al.*, 1996; Monela *et al.*, 2000).

**Wood fuel**

Wood fuel represents a source of cash income for many, and consequently, proximity to markets and transport routes is a significant factor in the harvesting levels (Chidumayo, 2002; Luoga *et al.*, 2002; Malimbwi *et al.*, 2005). Malimbwi *et al.* (2005) reported on potential charcoal yield along a harvesting gradient between a major transport route and protected miombo woodlands. Adjacent to the road the estimated yield was 1 bag (56 kg charcoal) per hectare, whereas 10 – 15 km away from the road the yield was 125 bags per hectare. They concluded that miombo woodlands in Kitulangalo forest reserve could be harvested for charcoal approximately every eight years (cutting cycles).

Clarke *et al.* (1996) noted that women are the principal collectors and consumers of firewood for domestic use, and are highly selective in the species used. Luoga *et al.* (2002) observed a range of species used for firewood in Kitulangalo forest reserve and surrounding public land forests in Morogoro, Tanzania. The most common species collected are *Combretum spp.* followed by *Julbernardia globiflora* (Benth.).

Typical attributes of a species regarded as good for Wood fuel or charcoal are medium to high wood density, low moisture content, long-lasting, low smoke yield, absence of thorns and absence of unusual fumes or smells (Abbot and Lowore, 1999; Luoga *et al.*, 2002). Highly used for this purpose include those in genera *Acacia, Brachystegia, Combretum* and *Julbernardia.*

Selectivity for size is also marked, but it is influenced by the end purpose for the wood. Collectors of Wood fuel for household fires typically target branches and stems 3 – 8 cm diameter (Abbot and Lowore, 1999). For example, charcoal makers include larger stems and branches (Abbot and Lowore, 1999; Abbot and Homewood, 1998). Smaller diameters of < 2 cm are collected opportunistically.



**Timber**

Most households use construction timber to some degree, for housing and/or fencing. There is marked selectivity regarding the size and species used (Vermeulen, 1996; Luoga *et al.*, 2002), which imposes a degree of area selection regarding where best to harvest the right size and species. Different species are required for different components of the construction. For example, Luoga *et al.* (2002) reported the key differences in species used as poles for wall, beam and roofing as well as withies.

There are both competition and complementarities in use of miombo trees for fuelwood and construction. Typically construction needs require thicker and longer poles than what is preferred for fuelwood (Luoga *et al.*, 2002). Consequently, the bulk of construction timber is obtained via felling of the main stem, rather than lopping of branches or collection of deadwood as is the case for fuelwood. Felling of these larger pieces produces off-cuts that can be used for fuelwood (Abbot and Lowore, 1999). Because construction timber is of larger diameters, if off-take is significant it can alter the size-class profile of the standing stock in favour of smaller stems (Abott and Homewood, 1998; Backéus *et al.*, 2006), which if sustained over long periods would reduce the overall sustainable yield of fuelwood into the future.

**Medicinal plants**

The demand and use of plants for medicinal purposes by both the population at large and the traditional healers are well recognised. Mander *et al.* (2006) estimated that there may be up to 70 000 traditional healers in Malawi while Urio *et al.* (1996) estimated about 30 000 traditional healers in Tanzania. Considering the population of Tanzania, Ishengoma and Gillah (2002) reported that, at least one traditional healer serves 750 people where as 50 000 people are served by one medical doctor. In rural communities throughout Africa, medicinal plants constitute a fundamental component of traditional healthcare systems (Gari, 2002) which demonstrates their contribution to reduction of excessive mortality and disability due to diseases such as HIV/AIDS, malaria, tuberculosis, sickle-cell, anaemia, diabetes and mental disorders and mitigate poverty through increased economic well-being of communities (Elujoba *et al.*, 2005). It is estimated that, about 80% of the rural population in Tanzania depends on herbalists who handle their medical problems (FAO, 1986). This shows that medicinal plants in Tanzania play an important role in primary health care, both in rural and urban areas. Luoga *et al.* (2002) recorded a total of 35 plant tree species from eastern Tanzania miombo woodlands in which 83% were harvested from roots. The rapid rise in price of industrial medicine coupled with the removal of Tanzania's free medical services in 1993 compelled many people to use local medicine made from medicinal plants (Crafter and Awimbo, 1998). Use of plant material for physical and psychological ailments and spiritual rituals and observances is common (Brigham, 1994; Cunningham, 1996; Luoga *et al.*, 2002), both through self-collection and use, as well as via traditional healers. In some areas there is also significant trade in medicinal plants, with rural collectors supplying traditional healers and markets serving urban areas. A variety of plants parts are used, including leaves, roots and barks.

According to Mbwambo (2000) miombo species with medicinal properties found in the central western Tanzania include: *Afzelia quanzensis, Cassipourea insignis, Combretum collium, C. molle, C. zeyheri, Dichrostachys cinerea, Erythrina abyssinica, Fagara mekeri, Ozoroa insignis, Popowia obovata, Pterocarpus angolensis, P. tinctorius, Schrebera koiloneura, Tamarindus indica, Vitex mombassae* and *Xylopia antunesii.* Tree species preferences for medicinal use depend on the knowledge of the user and the number of cures each species offers. Mbwambo (2000) found that, some tree species serve more than one purpose thus their promotion must take into consideration their multiple uses.

Medicinal plants provide up to 80% of the world population's primary health care products while at the same time form a basis for cultural identity and heritage, income generation and are an important resource base for new drug products (Mander and Breton, 2006). In Malawi, the predominant medical system in use is that of traditional medicine, especially in the rural areas (Maliwich, 1997). Earlier studies done in

Malawi indicate that the miombo woodlands are an important source of medicinal plants with local communities using over 20 different species for medicinal purposes (Ngulube *et al.*, 2006).

**Beehives and other products from bark**

Lynam *et al.* (2003) describe how bark is much sought after as a resource for making bee hives. However, they comment that usually harvesting is destructive, resulting in the death of the tree due to the removal of a large ring of bark from the central trunk. In contrast, Smith *et al.* (1996) describe the use of hollowed out logs for beehives in Tanzania. Dovie (2003) summarises a number of reports on the use of bark from *Adansonia digitata* as a fibre for mats and ropes.

**Wild fruits**

Miombo woodlands are known for their richness of tree species with edible fruits (Clarke *et al.*, 1996). These represent a significant source of nutrition even in the non-agricultural period. Indeed, peak consumption is during the dry season (Campbell, 1987; Wilson, 1990). This is particularly important for poor households (Wilson, 1990; Abbot, 1997; Mithöfer and Waibel, 2003; Cunningham and Shackleton; 2004) and children (Campbell, 1987; Wilson, 1990). Additionally, greater proportions of poor households engage in selling wild fruits than do wealthier households (McGregor, 1995; Mithöfer and Waibel, 2003; Shackleton and Shackleton, 2006).

Campbell (1987) noted that, miombo woodlands are rich in variety and quantities of fruit trees. Luoga *et al.* (2002) identified nine tree species which bear edible fruits including: *Flueggea virosa, Allophylus, Heinsia crinita, Diospyros zombensis, Grewia bicolor, Vangueria infausta, Annona senegalensis, Tamarindus indica* and *Ximenia cafra. Grewia flavescens* fruits are grounded and made into porridge; it is mostly used as food stuff during dry seasons. In Tanzania, a total of 83 species have been recorded as wild fruits and most of them are harvested from miombo woodlands (Temu and Msanga, 1994). *Tamarindus indica, Sclerocarya birrea sub sp. cafra, Kigelia africana, Adansonia digitata, Syzygium spp.* and *Brachystegia microphylla* are some of the potential edible wild fruits from miombo woodlands (Monela *et al.*, 2000). *Tamarindus indica* and *Adansonia digitata* fruits are used for making juices and flavouring ice creams. In rural areas, fruits drawn from miombo woodlands play a very important part in complementing diet with vitamin C content. Indigenous fruit tree species from miombo woodlands are also used to generate income (both cash and barter) through sales of fruits. Wild fruits have long been valued as buffer food resources in periods of famine and food shortage (FAO, 2000).



**Wild vegetables**

Wild leafy vegetables are a significant component of rural peoples' diet throughout Africa, including the miombo region (Fleuret, 1979; Malaisse and Parent, 1985; Zinyama *et al.*, 1990; McGregor, 1995). Dozens of species are harvested, with marked regional variations. As a food source they are richer in minerals and vitamins than domesticated crops, such that their role in food security and combating mineral deficiencies is beginning to be recognised (FAO, 1988; Frison *et al.*, 2006). For example, Amaranthus typically has 200 % more vitamin A and carotenoids than cabbage and ten times more iron (Schippers, 2000). Moreover, they are relatively high yielding without much care and are better able than domesticated crops to survive periods of low rainfall. These advantages have also resulted in them being regarded as important safety-nets for times of household stress caused by unfavourable climate, economic or illness (Shiundu, 2002; Barany *et al.*, 2004).

Luoga *et al.* (2002) found three arborescent species which serve as vegetable in miombo woodlands of eastern Tanzania. They include: *Zanthoxylum chalybeum, Ormocarpum kirkii* and *Zahna Africana.* The common leaves consumed in Mozambique sourced from miombo woodlands include: *Adeinia gummifera, Amaranthus sp., Corchorus tridense, Ipomea lapatifolia* and *Momordica balsamica* (FAO, 2000). *Ormocarpum sp* is used as wild vegetable from miombo woodlands of Malawi (Lowore *et al.*, 1995) while ten species are recorded as wild vegetable in central Zambia (Campbell *et al.*, 1996).



**Mushroom**

Miombo woodlands are a home for over 30 edible mushroom species and are an important source of food and income for rural communities throughout Malawi (Ngulube *et al.*, 2006). These are collected before the first crops mature in the rain season. Once collected, they are frequently sold fresh but may also be processed and stored for future use. Similarly Lowore *et al.* (1995) stressed that; the season for mushroom is usually from November to April which is normally rain season, this coincides with the time when agricultural food stocks from are low. Mushrooms are mostly consumed fresh, but a portion of the harvest may be preserved and stored for future use.

Mushrooms are also widely relished throughout the miombo region (Wilson, 1990; Clarke *et al.*, 1996). In Tanzania, the highest diversity of edible mushrooms exists in southern and western parts of the country, most of which are found in miombo woodlands. Mushrooms make a remarkable addition to the daily diet of Tanzanians and serve as supplementary food (Harkonen *et al.*, 2003). FAO (2000) argued that, mushroom are the most sought-after wild food in natural ecosystem especially the miombo ecosystems. In Malawi, 60 species of edible mushrooms have been recorded and are widely sold on roadsides during the rain season. A study carried out in Zimbabwe identified 21 species of edible mushrooms which are consumed by both rich and poor people (Campbell *et al.*, 1996).

**Edible insects**

Edible insects are another important source of nutrition from miombo woodlands and the rest of sub-Saharan Africa (van Huis, 2003). The review by DeFoliart (1999) mentioned that, 65 species of insects are consumed throughout the DRC, 60 in Zambia and 40 in Zimbabwe. As with wild leafy vegetables, the consumption of insects has been undermined by western society's distaste and thus it is probably a declining practice (DeFoliart, 1999).

**Wild meat**

Another source of wild protein is obtained through hunting of small mammals, ranging from small rodents to small antelope (Wilson, 1990; McGregor, 1995). Larger species may also be trapped or hunted, but populations are very low in regions with high human population densities, and so the smaller species comprise the bulk of the bush meat intake. In some sub-Saharan countries wild animals constitute over 50 % of all animal protein consumed (Panayotou and Ashton, 1992). In many countries it is also a form of recreation with young adolescents hunting small birds and rodents, before graduating to larger game as they mature into adulthood.

**Cultural and spiritual benefits**

Most focus on use and management of miombo species has been on the utilitarian aspects, which belie the significant spiritual and cultural dimensions associated with particular species, places and vegetation types (Mandondo, 1997). Some of these may be of significance to single households or clans, often differentiated by status within traditional structures. Others may be recognized and revered by communities. The maintenance and respect for burial sites and sacred areas can result in markedly lower rates of transformation than adjacent non-sacred areas (Byers *et al.*, 2001), and presumably has biodiversity and ecosystem services benefits which spill out into neighbouring transformed landscapes (e.g. pollination services). However, there is some suggestion that these belief systems and values are being eroded with modernization and migration of people into areas with which they have no ancestral ties (Byers *et al.*, 2001).



**Gums**

According to Kagya (2002) Gum Arabic from *Acacia Senegal* and *Acacia seyal* tree species are of great importance in Tanzania. It is traditionally an important food for pastoralists, farmers and hunters (Becker, 1983). Nomads from Mauritania use it for making 'N'dadzalla' a mixture of fried gum, butter and sugar (FAO, 1991). It is also used as milk when mixed with sugared water (Giffard, 1975). Makonda (1997) recorded seven species which produce gums and latex, including: *Ficus spp., Commiphora Africana* and *Euphorbia tirucalli*.

**Agriculture and pasture for livestock**

Miombo woodlands are acknowledged for their service in supporting agriculture. Miombo of western Tanzania, where more than 60% of the country's tobacco is produced have shown increase in area for cultivation from 228 000 hectares in 1985/86 to 1 374 000 hectares in 1991/92 (Misana, 1988). Tobacco farmers use miombo as source of energy for curing tobacco. Interspersed within the miombo woodlands are broad, grassy depreciations called 'mbuga' which are seasonally waterlogged, support cultivation and livestock grazing (McFarlane and Whitlow, 1990).



**Others**

Additionally, miombo woodlands play an important role in controlling soil erosion; provide shade and modifying hydrological cycles. Miombo also provide watershed protection to areas prone to erosion by heavy seasonal rains (Clarke *et al.*, 1996). Fibre is another important use of miombo. Bark fibre is obtained by stripping the bark from young saplings, shoots or branches of miombo tree and shrub species. The study by Ngulube *et al.* (2006) showed that the most commonly used species included *Brachystegia boehmii, B. longifolia, B. spiciformis, B. utilis* and *Bauhinia petersiana* with *B. beohmii* as the most preferred tree species because of their fibre strength and ease of peeling. Williamson (1975) lists over 50 species used for making strings and ropes, mats and baskets, for stuffing pillows and in construction work around the homestead.

## 2.5 Socio-economic and institutional factors influencing the contribution of miombo woodland resources to livelihoods of local communities

Households in rural areas depend on a mix of activities to meet livelihood needs including off-farm activities, harvesting products from woodlands and crop and livestock production (Bradley and Dewees, 1993). The actual mixture of local community activities in miombo woodlands depends on a variety of factors ranging from socio-economic (e.g. distance to market and population densities) to bio-physical (e.g. crop production potential) (Clarke *et al.*, 1996). Driving variables in woodland resource use include: institutional (tenure and local and state authority), degree of commercialization, features of household (wealth status and labour availability) and features of the resource (distances to resources, existence of substitutions and backstops) (Matose and Wily, 1996).



### 2.5.1 Socio-economic factors

Socio-economic factors may constraint or enable contribution of miombo woodland resources to livelihoods of the local communities. They include: household size, gender, age, education status, household income, and distance from homestead to the woodlands, cultivated land size and hunger period. Selected socio-economic factors are discussed in the following section:

**Family size**

Family size determines per capita collection and utilization of miombo woodland products. According to Nyingili (2003), the number of members in the household has an important implication in household ability to access enough food. A large number imply more mouths to feed and more people to share household budget.

**Gender**

According to Fernandez (1994) gender is a cultural construct related to the behaviour learned by men and women; it affects what they do and how they do within a specific social setting. Gender differentiation comes about as a result of the specific experiences, knowledge and skill, women and men develop as they carry out the productive and reproductive responsibilities assigned to them (Fernandez, 1994). As a result of gender specialization, the local knowledge and skills held by women often differ from those held by men.

Yadama *et al.* (2001) revealed that, the primary players in the collection, processing, and marketing of edible wild plants from miombo are women. Men are mainly responsible for construction timber, poles and some collection of medicinal plants which are also gathered by women. On the other hand Guinand *et al.* (2001) noted that, mostly children collect and consume fruits of wild plants. Women frequently collect wild foods when they are on their way to fetch water, to collect firewood, on their way to the market and when walking back home from the fields. Therefore, women and children are the main actors concerning the collection, preparation and consumption of wild-food plants. Children forage and climb trees for collection while women do the preparation and the cooking (Guinand *et al.*, 2001). Monela *et al.* (2000) reported that economic hardships in Tanzania led to a breakdown in traditional gender roles particularly in peri-urban and intermediate sites, rather than remote sites Women are increasingly expanding their roles, away from traditional domestic activities to income generating activities such as collection and sale of forest and woodland product, casual labor and petty business. On the other hand men are gradually taking up activities which have traditionally been in the domain of women, especially those that are lucrative.

**Distance from homestead to the woodlands**

Distance is the prime determinant when it comes to collection of products from miombo woodlands. Communities located much close to a given miombo woodland will tend to collect and use more than those located at a distance. McGregor (1995) in his study conducted in Shirungwi, Zimbabwe noted that, rising scarcities of woodland resource caused increase in distance to woodland food resources. As a result, households tended to shift their consumption of once depended woodland resource to alternatives which could offer similar use.

**Hunger period**

Miombo woodland areas are characterized by fluctuating weather, thus communities in miombo woodlands become vulnerable through occasional hunger periods as a result of rain shortage or dynamics. Accordingly, the longer the hunger periods the more dependency on miombo woodland resources as safety net. Malaisse and Parent (1995) identified several plants which are used as famine foods. They found that, *Encephalartos poggei* is among them; its stems are steeped in running water for three days, then sun-dried and crushed into a fine powder. The stem is an extreme good source of energy. Similarly Backer (1983) identified several wild plant species used only in times of scarcity and famine; among them are fibers of *Grewia bicolar* and the seeds of *Combretum aculeatum* and *Dioscorea* sp. The tubers and other underground parts of plants like *Arisaema concinnum, Dioscorea* spp. easily take the place of potatoes and tuberous crops. The grain of several species of grasses particularly bamboos contribute to the bulk of the food in such periods of scarcity (FAO, 1984). This therefore shows that, edible wild food plants are able to fill a variety of food gaps.

**Household income**

Low-income in the household contributes to the increased dependency on edible wild plants from forests and woodlands. Tanzania being one of the worlds poorest countries with an estimated 65% of her population living on less than US$ 0.5 per day (Msuya *et al.,* 2004), indigenous forest and woodland foods have played a role in poverty alleviation through their big contribution to food security (Kajembe *et al.,* 2000). Reliance on indigenous forest products for food depends on the degree of poverty in the society. A study conducted by Hamza *et al.* (2004) on the contribution of medicinal plants to the health of communities living around Miombo woodlands of Nachingwea district, Tanzania, found that about 94% of the population using plant medicines had income levels below TAS 200,000 per year.

Miombo woodland resources are renewable, widespread, and they are often found in common property regimes where the poor can access them without owning the land (Cavendish, 2000). In addition, exploiting natural systems often can be done with little need for investment or expensive equipment, making the cost of entry low, an important consideration for poor families with limited assets. Woodland income deserves special attention, since it is often the element that is not accurately accounted for in most considerations of rural livelihoods (Cavendish, 2000). Where markets exist, goods harvested from woodlands, such as wild food plants, herbs fruits and medicinal plants, can be sold for cash or exchanged for services like school fees. Subsistence use represents the greater part of the value of these natural products to household's livelihood. Besides, wild products bring a reduction in cash expenditures of households, a form of income that is essential to the survival of the very poor. Estimated cash equivalents for subsistence use of wild products range between US$ 194 and US$1,114 per year over a series of seven studies in South Africa, a significant income fraction (Shackleton *et al.,* 2000).



**Occupation**

Nduwamungu (2001) studying the dynamics of deforestation of miombo woodlands of Kilosa district, Tanzania found that, the main occupation of the majority of people is peasantry farming (97%). Farming continues to play a critical role in household's livelihood and food security. As natural asset, the use of miombo woodland resources is determined by occupation. For example, large proportions of communities in miombo woodlands in Tabora region, Tanzania are tobacco farmers and pastoralists. Tobacco farmers depend on miombo woodlands as source of material for tobacco curing while pastoralists esteem miombo woodlands as grazing area for their livestock (Kajembe and Kessy, 2000; Abdallah, 2001).

### 2.5.2 Institutional factors

Institutions can be defined as norms, rules of behaviour and accepted ways of doing things, they can be formal or informal. Uphoff (1986) uses the term 'institution' to refer to a set of shared norms and behaviour. Institutions relevant to natural resource use and management include: rules governing access to resources (e.g. tenure), government laws and policies that are intended to determine the way resources are managed, arrangements for decision-making about resource use and distribution of benefits.

Common property is an example of the way in which appropriate institutional arrangements can shape resource use. The theory of 'the tragedy of the commons' Hardin (1968) suggested that, resources without clear ownership would be degraded because individuals would have no incentive to reduce their level of resource use if others continued their use at unsustainable levels. Everyone would attempt to maximize use in the short term even when they could see long-term availability declining.



**Tenure**

Tenure encompasses the right to secure long-term access to land and resources, their benefits and the responsibilities related to these rights. Security of tenure is a critical yet often under acknowledged component in determining how rural people can improve their livelihoods and reduce poverty. Tenure, if clearly defined enables local communities to protect forests and woodlands from encroachment so as to increase their benefits (FAO, 2001). In Tanzania, land belongs to the state and is divided into three tenurial categories: reserved, village, and general land. Since all the land belongs to the state, it is the responsibility of the government to direct land development efforts. Likewise, it is the responsibility of the government to protect land resources on behalf of land users by formulating policies to guide both resource utilization and conservation (Kajembe *et al.*, 2003). Miombo woodlands in Tanzania fall broadly into two categories: those in reserved land managed by central and local governments, and those in general land (Luoga *et al.*, 2002).

**Institutional arrangement**

Joint Forest Management (JFM) is an institutional arrangement that can affect livelihoods outcomes since it aims at enhancing natural resources, building local institutional capacity and sustaining livelihoods through equitable and productive natural resources management. JFM is a result of institutional rearrangement following recognition that sustainable natural resources management can never be independent of sustainability of collective human institutions that frame resource governance and local users usually have great stake in sustainability of resources and institutions (Agrawal, 2001).

JFM takes place on reserved land where a legally binding Joint Management Agreement (JMA) spells out how the forest management rights and responsibilities and associated costs and benefits are shared between the forest owner (central or local governments or even private owner) and the partner communities (URT, 2002; Blomley, 2006; Lund and Nielsen, 2006).

In JFM, it is important to distinguish between managers and forest users, since for managers, costs are imposed in the form of management responsibilities while for forest users, costs appear in the form of regulations i.e. taxation and use restrictions (Agrawal and Gbson, 1999).

**Policies**

National forest Policy (1998), Forest Act (2002) and National Forest Programme (2001) are the paramount tools for management of forests and woodlands in Tanzania. They play an important role in the management of forest and woodland resources which cater for improved resource base and livelihoods. Policies, institutions and processes affect how people use their assets in pursuit of different livelihood strategies. A simple example of transforming process might be National Forest Policy (1998), the policy advocates involvement of adjacent communities in the management of forests and woodlands. Through such settings, communities are entitled to derive benefits (products and services) from forests and woodlands and transform them into something useful for livelihoods.



**Local authority**

Indigenous management practices depend on the ability of communities to make and defend management rules. Having effective and credible local authorities is one such requirement. This will ensure that, natural resources are well managed through observation of rules and regulations. In this regard, resources will be sustained and hence livelihoods. However, in most countries, traditional leaders no longer have any legal power to enforce natural resources management regulations though in some areas they are reported to exist. For example in northern Zimbabwe, a local chief authority still effectively enforces the full spectrum of traditional miombo woodlands management rules (Clarke, 1995). Continued effectiveness of traditional authorities in protecting woodland resources is reported in Tanzania (Gerden and Mtallo, 1990) and Zambia (Sørensen, 1993). Mukamuri (1995) and McGregor (1991) provide evidence of almost total breakdown of local authority in areas of southern Zimbabwe.

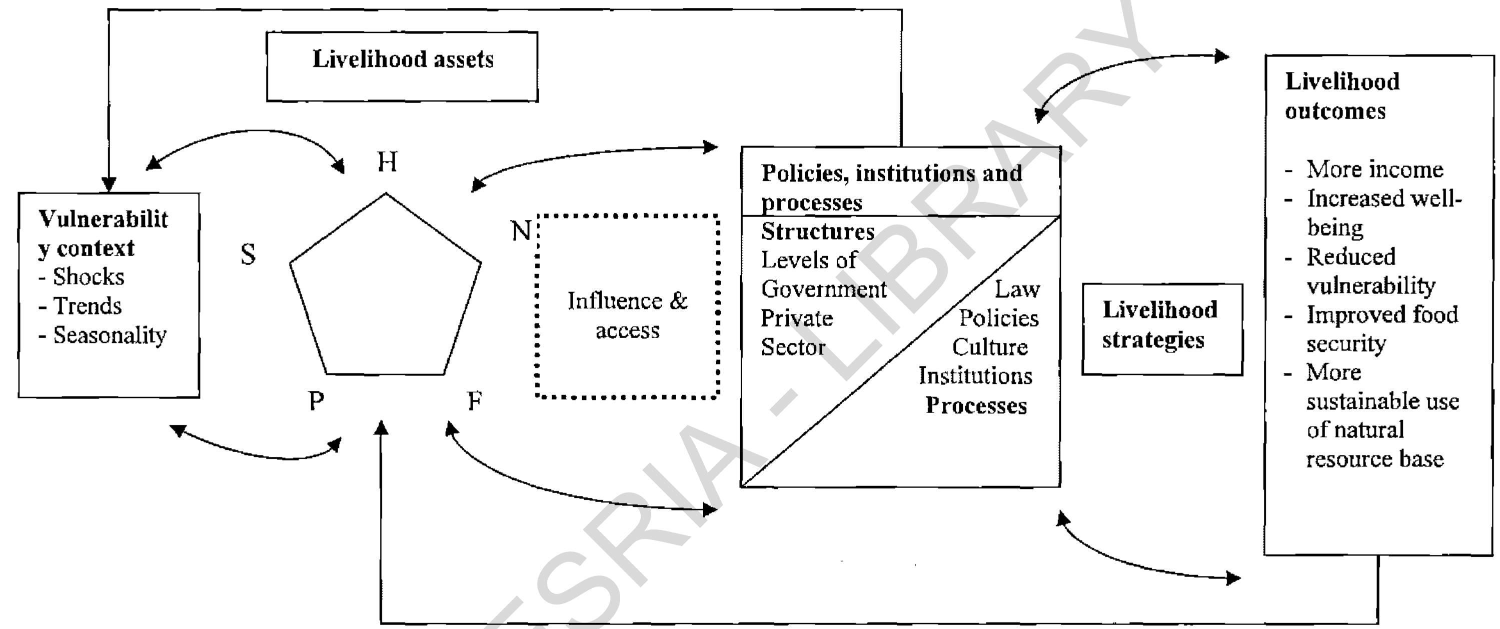
### 2.6 Sustainable management of miombo woodlands and sustainable livelihoods

Sustainable forest management may be defined as management aimed at maintaining and enhancing the long-term health of the forest ecosystems while providing ecological, economic, social and cultural opportunities for the present and future generations (FAO, 1999). According to Sayer *et al.* (1997) Forest sustainability involves maintaining and enhancing the contribution of forests to human well-being, both of present and future generations, without compromising their ecosystem integrity, i.e., their resilience, function and biological diversity. Currently, ecological sustainability is a major concern since it is believed to take care of livelihood sustenance of forest and woodland dependants. Accordingly, livelihoods sustenance should relate to sustainable use of forest and woodland products that ensure negligible impact on the structure and dynamics of plant populations (Mallik, 2000). According to Chambers (1995), 'sustainability' in livelihood context is achieved by helping people to build resistance to external shocks and stresses, maintain the long-term productivity of natural resources, move away from dependence on unsustainable outside support and avoid undermining the livelihood options of others. Sustainability seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future (WCED, 1987).

Sustainable Livelihoods Framework (SLF) provides a way of thinking about the linkages between the context, vulnerability, and access to natural resources (Baumann, 2006). The framework is useful for looking at the contribution of forests/trees to people's livelihoods as well as for enabling an understanding of rights, access and the influences in broader context (Shimizu, 2006). SLF view people as operating in a context of vulnerability. It examines how different people pursue a range and combination of livelihood strategies given particular context, combination of assets and set of opportunities and constraints presented by institutional structures and processes (Shimizu, 2006). The asset pentagon includes five assets which through structures and processes may be transformed into livelihood outcomes (Figure 2).

Vulnerability refers to trends, shocks and seasonality that people generally have little or no control over and that often have adverse effects on their livelihoods and whose outcome can make a difference between survival and starvation. It is common for people living in poor conditions to be vulnerable to vicious circle of poverty (DFID, 2003). In this context, elements of vulnerability relevant to inhabitants in miombo woodlands include: drought, demand market fluctuations (woodlands and farm products), soil fertility and diseases (both human and livestock) among others. For example, simple logic suggest that farmers out skirting miombo are vulnerable to market of farm crops due to the fact that, prices of farm crops at the time of sale are not known when decision to produce are made. Assets or capital are the heart of sustainable livelihood framework. Institutions, organizations, policies and legislation are the ones which shape livelihoods (Figure 2). These structures can help people to improve their livelihoods by controlling the context of vulnerability or by helping people to accumulate assets.

They can however make people more vulnerable by creating shocks through transforming structures. Accordingly, vulnerability, structures and processes affect the choice of people's livelihood strategies which create livelihood outcomes. These in turn affect assets through positive or negative outcomes. For Scoones (1998), sustainable livelihoods are all about getting institutional and organizational settings 'right'. And for many scholars, getting institutional right will be achieved by improving governance through decentralization of state power and institutional and organizational change to increase accountability and transparency (DFID, 1999; Goldman, 1998; Hobley, 2001). However, concern with only formal institutions can be too narrow. There is a need therefore to broaden institutional analysis beyond formal governance, to include community and familial structures and norms, through which new institutions evolve using elements of existing social and cultural arrangements (Cleaver, 2001; Fox, 1997). Therefore, seeking to get institutional 'right' based on simplistic institutional model, may be undermined by actual complexities involved in broader institutional reform.




**KEY:**
H = Human capital, S = Social capital, P = Physical capital, F = Financial capital, N = Natural capital

**Figure 2: Sustainable Livelihood Framework; Source: DFID (2001)**

## 2.7 Poverty as a cross cutting issue

Over 75% of the Tanzania's population resides in rural areas where people rely upon agriculture and natural resources. The link between rural livelihoods and natural resource management is of fundamental importance to effective poverty reduction strategies (Kallonga *et al.*, 2003). Management of natural resources in the new paradigm focuses on improving livelihoods and uplifting the livelihoods of the poor. The overall goal of Tanzania National Forest Policy is: *"to enhance the contribution of the forest sector to sustainable development of Tanzania and the conservation and management of her natural resources for the benefit of present and future generations"* (URT, 1998). However, policies, laws and institutions relevant to crosscutting issues have rarely been coordinated. Most policies and strategies in the ground are sectoral in vision. Coordination modalities are absent or inadequate at all levels and even more at village level where the actual implementation of programmes takes place. Clear arrangement need be worked out including interactive consultations at all levels from policy formulation to planning of implementation interventions (Mariki, 2002).



Poverty reduction efforts in Tanzania must be considered within the context of three fundamental realities. Firstly, over 75% of the country's population lives in rural areas (World Bank, 2002). Secondly, in rural areas people overwhelmingly depend on agriculture and other natural resource uses for their livelihoods and survival. For example, approximately 92% of Tanzanians rely on Wood fuel from trees and other vegetation for their domestic energy supplies (URT, 1998). Rural economies are therefore largely a product of the use and management of land and natural resources. Thirdly, Tanzania possesses a wealth and abundance of natural resources to employ in the battle against poverty and improved livelihoods. Thus, strategies and practices which ensure sustainable use and conservation of natural resources must become central elements of successful national poverty reduction efforts and improved peoples' livelihoods.

# CHAPTER THREE

## 3.0 MATERIAL AND METHODS

## 3.1 Study area

### 3.1.1 Geographical location

The study was conducted in Urumwa Forest Reserve, Uyui district, Tabora, Tanzania. Tabora Region is located in mid-western part of Tanzania on the central plateau between latitude 40° - 70° South and longitude 31° - 34° East. The region shares a border with Shinyanga region in the North, Singida region in the East, Mbeya and Rukwa regions in the South while the Western border is shared with Kigoma region. Tabora region has an area of 76 151 $km^2$ representing 9% of the land area of Mainland Tanzania. A total of 34 698 $km^2$ are Forest Reserves and 17 122 $km^2$ are Game Reserves.

The miombo woodland of Urumwa Forest Reserve covers an area of 12 800 ha. The region is endowed with substantial woodland estate of nearly three and a half million hectares. These are within 33 forest reserves, which together embrace two-thirds of the regional total area and represent more than one-quarter of national forest resources (Wily and Monela, 1999). UFR located about 15 km south of Tabora is owned by Central Government and managed under JFM setting. Its status is a production forest. There are eight villages involved in JFM arrangements including: Kasisi, Igombabilo, Isukamahela and Mtakuja. Others are Masimba, Kikungu, Ntalikwa and Kipalapala.

Specifically, the study was conducted in Isukamahela, Kipalapala, Masimba and Mtakuja villages (Figure 3). This was the basis for selection of study villages.

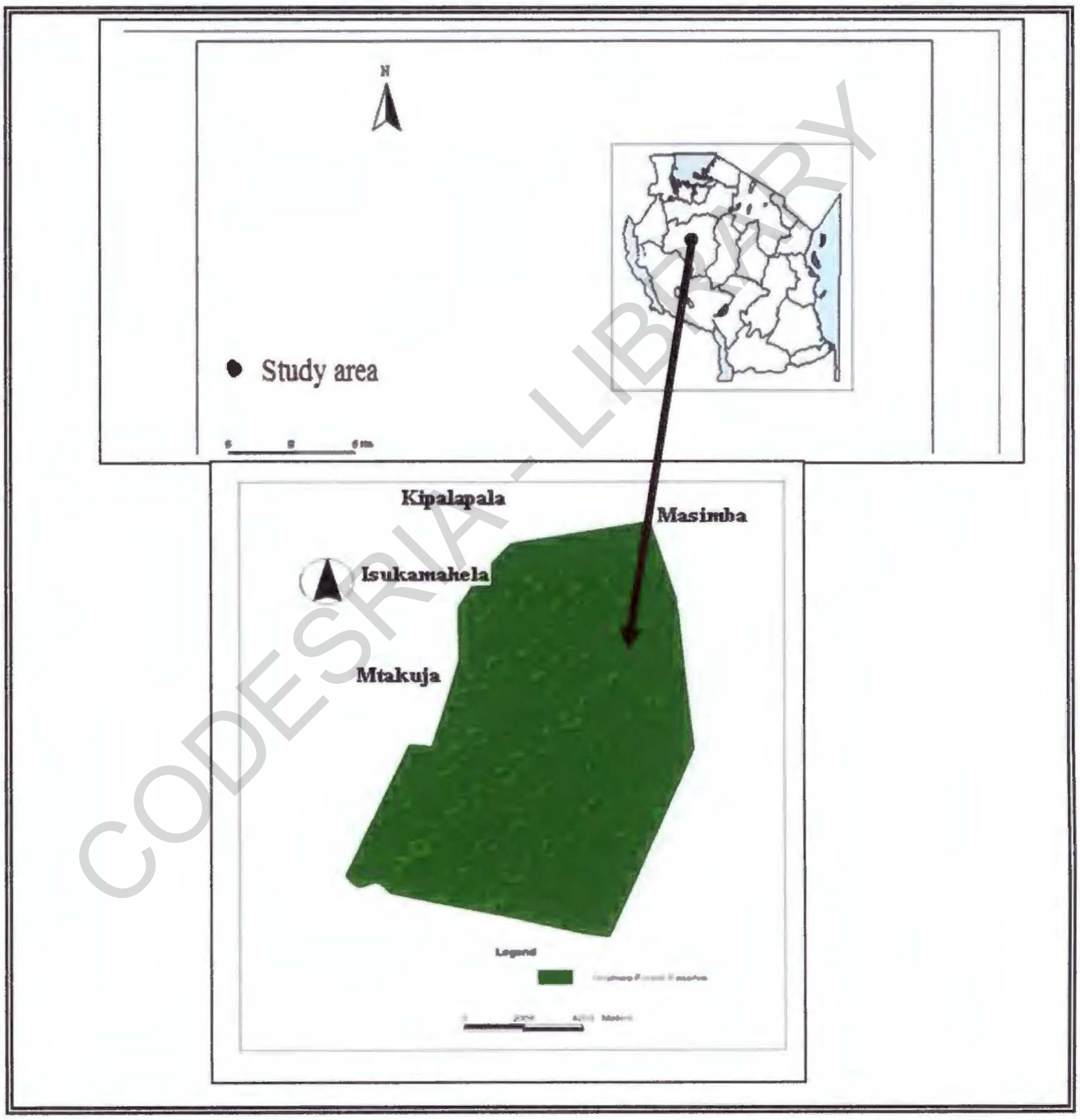



**Figure 3: Geographical location of UFR, Tabora, Tanzania**

### 3.1.2 Climate

Temperature in the study area is generally warm. Temperatures reach their peak in September and October just before the onset of the rainy season. The maximum monthly temperature varies between 27.6 °C and 30 °C while the minimum monthly temperature varies from 15 °C to 18 °C (Acres *et al*., 1984).

Rainfall is markedly seasonal and ranges between 700 mm in the northeast and 1,000 mm in the western part. The rainfall pattern is characteristically variable and unpredictable both spatially and temporarily, with a risk of dry long spells at any time during the rainy season, and incidences of long droughts are a common phenomenon (Simon, 1998). Rains normally start in October or November, reaching a peak in December after which a slightly dry spell follows in January or February. A second lower peak occurs in February to March and the rains tail off in April, sometimes extending into May (Acres *et al*., 1984).

### 3.1.3 Soils and Geology

The study area is gently undulating with few granite hills emerging from the ridges, and low swampy depressions forming the drainage lines between the ridges. The soils on the upper slopes are mainly red brown sandy loams underlain by light sandy clays while soils in the lower slopes are drained dark gray sandy loams with black clays in the depressions. These soils are of medium fertility with low contents of total nitrogen, available phosphorus, exchangeable potassium and other cat-ions (Acres *et al*., 1984).

### 3.1.4 Vegetation

Vegetation consists of upland vegetation which includes woodland, bush land thicket, grassland; lowland or wetland vegetation consisting of wooded grassland and swamps. Woodland is the natural vegetation over most of the region and can be divided into two main groups: Miombo and *Acacia*; *Combretum* and *Albizia* woodlands. The main vegetation found in the study area is miombo woodland with other vegetation communities interspersed within including *Acacia/Combretum* woodlands, and mbuga wooded grasslands. These miombo woodlands contain the majority of the commercially exploitable timber species including *Pterocarpus angolensis, Afzelia quanzensis, Dalbergia melanoxylon, Burkea africana, Pterocarpus tinctorius, Swartzia madagascariensis and Pericopsis angolensis.* The *Acacia/combretum* woodland is comprised of *Acacia, Commiphora* and *Combretum* species. Many other species also occur. The mbuga wooded grasslands comprise the grasses with scattering trees occurring on valley floors and floodplains (Acres *et al*., 1984).

### 3.1.5 Socio-economic activities

The main socio-economic activities of the people in Tabora region include agricultural production and livestock keeping (about 90%). Other activities include: beekeeping, fishing and lumbering. Cultivated food crops include: maize, cassava, sweet potatoes, paddy and groundnuts. Cash crops which are given high priority in the area include: tobacco and cotton. Communities adjacent to UFR are mostly farmers, pastoralists or agro-pastoralists with their livelihood activities such as firewood collection and charcoal making undertaken in the miombo woodland of Urumwa.

## 3.2 Methods

### 3.2.1 Data collection

Four data sets were collected for the purpose of this study; ecological, socio-economic, livelihood and institutional data. Ecological data were collected through forest inventory. Household questionnaire, Participatory Rural Appraisal (PRA) and checklist are tools used to collect socio-economic, livelihood and institutional data. Besides, participant observation approach was used as a means of triangulation of the data. All data categories were supplemented by secondary data obtained through literature survey (e.g. research reports, published and unpublished works, government reports etc) and internet search.



#### 3.2.1.1 Ecological data

Forest inventory is defined as the procedure for obtaining information on the quantity and quality of the woodland resources and other characteristics of the land on which the trees and shrubs are growing (Malimbwi, 1997). Forest inventory was important in order to estimate the available stock in the woodland, understand tree and shrub species diversity, their distribution and quantify annual out-take. The actual inventory was preceded by a reconnaissance survey which involved establishing transects and plot laying-out on the map of the forest reserve.

##### 3.2.1.1.1 Sampling design

In order to cover the whole woodland area and variation between vegetation cover, systematic sampling design was adopted in this study. In this study, systematic sampling design ensured an even spread of the samples throughout the woodland area and thus increased the chances of including all vegetation types in the woodland (De Vries, 1986; Philip, 1994).

**3.2.1.1.2 Sampling intensity, shape and size of the plots**

Synnot (1979) recommended sampling intensity within a range of 0.5% to 0.7% for tropical natural forest inventories. This is equivalent to 772 sample plots for this particular forest; however, according to Malimbwi and Mugasha (2002) and Malimbwi *et al.* (2005), financial and time constraints and purpose of the forest inventory may dictate the sampling unit to be as low as 0.01%. Thus, in this study a sampling intensity of 0.045% which is equivalent to 70 sample plots was adopted. Reasons behind this include limited finances and time constraint. As such, the woodland was therefore divided into seven transect lines that were 1 352 m apart and the interval between sample plots was also 1 352 m. Figure 4 demonstrates transect alignment and plot layout.

Circular shaped sample plots were adopted which have an advantage of reducing edge effects in the samples. The edge effects may lead to possible counting errors. The effects are less on the circle plots than in square and rectangular plots (Krebs, 1989).

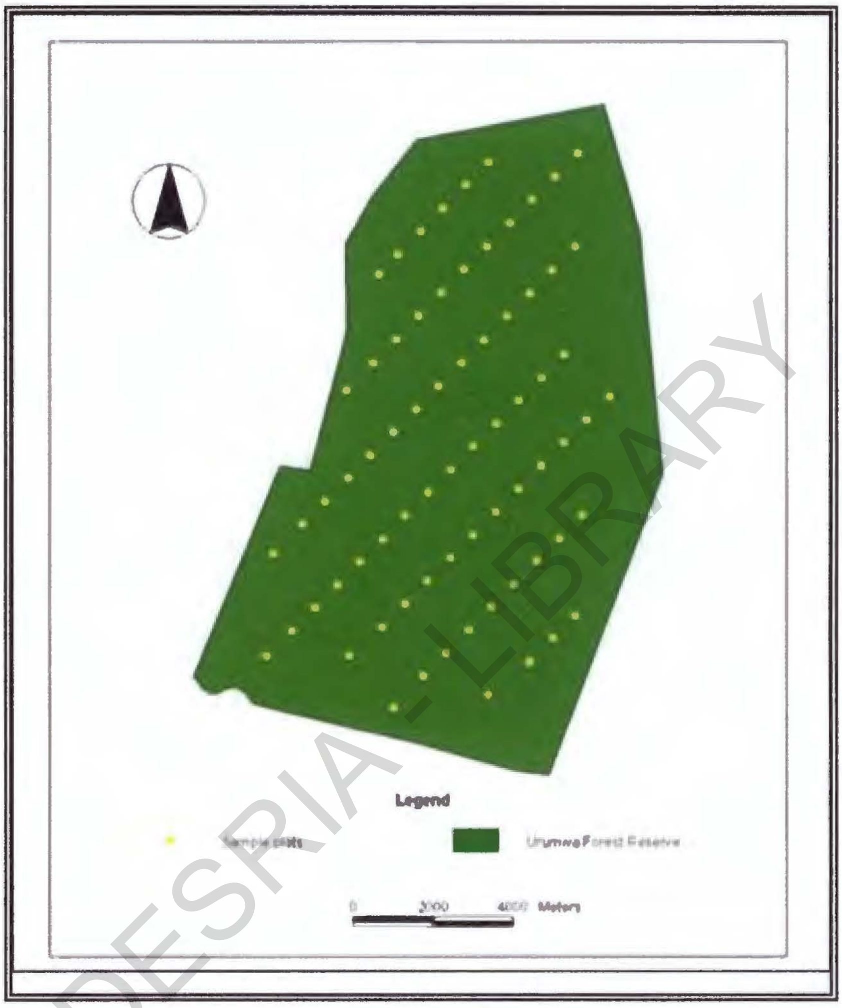





**Figure 4: Map of UFR showing transect alignment and plot layout**

To ease the counting, each sample plot was sub-divided into five sub-plots (concentric plots) of 2 m (0.0013 ha), 5 m (0.0079 ha), 10 m (0.031 ha), 15 m (0.07 ha) and 20 m (0.126 ha). Data recollected within each specified circle included:

- Within 2 m radius, all regenerants were recorded
- Within 5 m radius, all trees and shrubs with dbh $\geq$ 4 cm were recorded
- Within 10 m radius, all trees and shrubs with dbh > 10 cm were recorded
- Within 15 m radius, all trees with dbh > 20 cm were recorded

- Within 20 m radius, all stumps were recorded.

Data recorded include: tree and shrub (and stump) species names (trees, shrubs and stumps), count (regenerants and stumps), diameter at breast height (dbh) (all trees and shrubs), basal diameter (stumps and sample trees) and stem height (sample trees). Uses (harvested tree and standing tree and shrub species), age (stump) and Geographical Positioning System (GPS) readings are other documented information. The field form used for inventory data collection is attached as Appendix 1. Stump age was subjectively decided with the help of field assistants based on their personal experience and knowledge of miombo trees and shrubs. This was triangulated with a researcher looking at the freshness, stump colour and ring counts where conspicuous. Tree and shrub species names were locally named; botanical identification of these trees and shrubs was done with the aid of experienced botanist from Tanzania Tree Seed Agency (TTSA), *Mzee* Christopher K. Ruffo. The choice of minimum dbh of 4 m for assessing trees and shrubs was based on Kielland-Lund (1982)'s suggestion that, this diameter which correspond roughly to the minimum dbh needed for a trees or shrub to survive grass fires, a common phenomenon in most miombo woodlands.



**3.2.1.2 Socio-economic, livelihood and institutional data**

Household questionnaire was the main tool for socio-economic, livelihood and institutional data collection. Data collected using this method were supplemented and or triangulated with data collected by using PRA, checklist, participant observation and literature review. These data aided in assessing the contribution of the miombo woodland to local communities' livelihoods and understanding enabling and constraining factors.

#### 3.2.1.2.1 Participatory Rural Appraisal (PRA)

Chambers (1997) described PRA as "a growing family of approaches and methods which enable local people to share, enhance and analyse their knowledge of life and conditions, plan, act, monitor and evaluate". The outsiders should play a facilitative role while insiders (local people) are invited to participate in all stages from diagnosing to analysing the constraints and opportunities of their livelihood systems (Bhatia and Ringia, 1996).

In this study, PRA meetings were held in two randomly selected villages of Isukamahela and Mtakuja. Participants of these meetings included village government officials, key informants and lay people. Some of the PRA techniques used included: resource mapping, transect walk, matrix scoring, wealth ranking, local histories, ven-diagrams and time lines. Through this approach, socio-economic, livelihood and institutional data were acquired. Generally, the research approach aided in understanding essentials of UFR to local communities in the livelihood context, constraints and/ favouring factors on the road to exploring the essentials.

#### 3.2.1.2.2 Household questionnaire

The structured and semi-structured questionnaire containing open and close–ended questions were designed based on the specific objectives, research questions and hypotheses (Appendix 2). Pre-testing of the questionnaire was done during reconnaissance survey in order to check reliability and validity of the questionnaire items. This is in accordance with Mettrick (1993) who argued that, pre-testing is essential before beginning any survey. In each household, the head of the household were interviewed, but other members were encouraged to attend and supplement information.

In this study, household questionnaire survey focused on four villages out skirting miombo woodland of UFR namely: Isukamahela, Kipalapala, Masimba and Mtakuja. Households were visited only once. The study regarded household as a sampling unit. Representative sample of respondents were selected from each village based on random sampling procedures. A village register was used as sampling frame and households were randomly picked. A household is defined as the number of people who dwell or live under the same roof and share the same bowl. They also recognize the authority of a household head as ultimate decision-maker for the household. Boyd *et al.* (1981) recommended a sampling intensity of 5% of total number of households in a study site. For the purpose of this study a sampling intensity of 10% was adopted. This is equivalent to 84 households (Table 2).

**Table 2: Number of sampled households in the study area**

| S/N | Study village | Population | | Number of households | Sample households |
|---|---|---|---|---|---|
| | | ME | KE | | |
| 1 | Isukamahela | 331 | 281 | 119 | 12 |
| 2 | Kipalapala | 1049 | 1077 | 481 | 49 |
| 3 | Masimba | 244 | 208 | 88 | 9 |
| 4 | Mtakuja | 281 | 306 | 134 | 14 |
| **Total** | | | | | **84** |

Source: Planning Commission (2002)



#### 3.2.1.2.3 Participant observation

Participant observer is described as the one who seeks to go beyond outward appearances and probe the perceptions, motives, beliefs, values and attitudes of the people studied (Casley and Kumar, 1988). As a data acquisition tool in this study, participant observation was used in such a way that the researcher assumed the place of a community member. The method greatly helped in consolidation and triangulation of information acquired through other methods. Likewise, the method was instrumental as it reduced the number of questions that needed to be asked and aided in overcoming some of the encountered study limitations including alienation.

#### 3.2.1.2.4 Checklist

Checklist is among the data collection tools used in this study which was addressed to institutions responsible with the management of UFR. This included local government

(Uyui District Forest Officer) and central government (Tabora Regional Catchment Forest Officer). The checklist served as a guide to the entire discussion.

#### 3.2.1.3 Literature survey and internet search

Secondary data for all data sets were collected through literature search from reports at the district and regional offices, libraries and from websites.

### 3.2.2 Data analyses

#### 3.2.2.1 Ecological data

Analysis of ecological data to examine tree and shrub species diversity and stocking of the woodland resources involved computation of such parameters as species diversity indices (H', ID and IVI), stem density (N), basal area (N) and standing volume (V). All parameters assessed for standing crop were similarly done for cut-wood so as to quantify out-take. Quantification of wood out-take was aimed at understanding the main livelihood activity (wood-based) and see if the livelihood in question is friendly to other livelihoods. The analysis was done by using Microsoft excel spreadsheet package. Before the computation of various parameters, a checklist of tree and shrub species was developed. Botanical names were matched with local names in the checklist. Each tree was then given a code number for subsequent analysis.

#### 3.2.2.1.1 Tree and shrub species diversity indices

This study used Shannon-Wiener Index (H'), Index of Dominance (ID) and Importance Value Index (IVI) indices to assess tree and shrub species diversity in the miombo woodland of UFR. Indices with their respective models have been presented in section 2.3.2.

Communities were asked to identify the species mostly used and which bears multiple uses collected from the woodland. The hypothesis was tested by using logistic regression which is discussed in section 3.2.2.2. H' value of the identified species was regarded as independent variable against a dependent variable 'contribution of miombo woodlands to local communities' livelihoods' in the model.

#### 3.2.2.1.2 Stocking parameters

As discussed in section 2.3.3, for the purpose of this study stocking parameters include: stem density (N) (trees and shrubs, cut-wood and regenerants), basal area (G) (trees and shrubs; and cut-wood) and volume (V) for standing crop (trees and shrubs; and cut-wood). Computation of stocking parameters proceeded as follows:

**Stem density (N) (stem count per hectare)**

This was computed by using the following formula;

$$N = \frac{i}{A} \quad \text{.......................................................................} (4)$$

Where;

N = Stem density (stem count/ha);

i = Stem count;

A = Plot area (ha).

**Basal area (G) ($m^2$ per hectare)**

This was calculated by using the following formula;

$$g_i = \frac{\pi dbh^2}{4}$$

$$G = \sum\left(\frac{g_i}{A*n}\right) \quad \text{.......... (5)}$$

Where;

dbh = Diameter at breast height (cm);

Π = Pie;

A = Plot area (ha);

n = Number of plots;

$g_i$ = Basal area of a tree/shrub ($m^2$).

**Volume**

The total tree volume was calculated by using the following formula developed by Malimbwi *et al.* (1994).

$$V = 0.0001 \; d_i^{2.032} \; h_i^{0.66} \quad \text{.......... (6)}$$

Where:

V = Total volume ($m^3$);

$d_i$ = Diameter at breast height (1.3m) for the $i^{th}$ tree (m);

$h_i$ = Total height of the $i^{th}$ tree (m).

Height of trees and shrubs; and cut-wood were estimated by using model which was fitted by using sample trees and shrubs (7).

$$Ht = 1.113478(dbh)^{0.7334627} \qquad (7)$$

($R^2$ = 93%; SE = 1.35; Observation = 180)

Where:

Ht = Tree/shrub height (m);

dbh = Diameter at breast height (cm).

Diameter at breast height of cut-wood was estimated from the measured basal diameter (bd) of stumps. Model (9) was used to estimate dbh of cut-wood which was developed by using dbh – bd regression relationship. Both models (8 and 9) were highly significant, despite that; model (9) depicted lower standard error compared to model (8). Similar method was used by Luoga *et al.* (2002) and Mafupa (2006).

$$dbh = -2.04429 + 0.93544(bd) \qquad (8)$$

($R^2$ = 98%; SE = 2.41; F-Value = $1.0241X10^{-129}$; Observation = 180)

$$dbh = 0.553058(bd)^{1.127354} \qquad (9)$$

($R^2$ = 98%; SE = 0.13; F-Value = $2.297X10^{-127}$; Observation = 180)

Where:

bd = Basal diameter (cm)

#### 3.2.2.2 Socio-economic, livelihood and institutional data analysis

In this study, both qualitative and quantitative socio-economic, livelihood and institutional data were analysed.

Qualitative data were subjected into content and structural-functional analyses. Prior to content and structural analyses, qualitative data acquired through PRA were analysed with the help of the local communities. Content analysis is a set of methods for analysing the symbolic content of any communication. The basic idea is to reduce the total content of communication to some set of categories that represent some characteristics of research interest (Singleton *et al.*, 1993) cited by Mayeta, (2004). Through this method, the data collected through verbal discussions with key informants were analysed in details whereby the recorded dialogues were individually broken down into smallest meaningful units of information or themes and tendencies. According to Kajembe and Luoga (1996), the technique helps the researcher in ascertaining values and attitudes of the respondents thereby generating themes and tendencies. Qualitative data results were used along with the output generated from quantitative data (descriptive and inferential statistical analyses) to triangulate and enrich the understanding on the contribution of the miombo woodland resources to local communities' livelihoods.

The Statistical Package for Social Sciences (SPSS version 15.0) was the main tool for quantitative data analysis. Formal data analyses were preceded by cleaning up of the data and coding that facilitated further analysis. Descriptive statistical analysis included: frequency distribution tables, cross – tabulations, histograms, pie - charts and percentages where as descriptive statistical analysis included measures of central tendencies (means) and variability (standard deviation and standard error). Inferential data analysis was carried out by using logistic regression. The logistic regression model (10) was used to analyse binary dependent variables. The binary dependent variable used in this study was 'Contribution of the miombo woodland resources of UFR to livelihoods of the local communities' which was assigned value '1' if it contributes to livelihoods of local communities and '0' if it does not. Using the logistic model, probability of events to occur or not to occur i.e. odds ratio (β), prediction equations were then developed. In this study independent variables were household size, cultivated land size, food security, hunger periods, income generating activities, distance from the woodland; and market and demand of miombo woodland resources (socio-economic factors). Other factors include: woodland access rules, woodland tenure, institutional arrangement, user rights (institutional factors) and tree and shrub species diversity. These factors may in one way or another enable or constrain the contribution of miombo woodland resources to livelihoods of local communities. Logistic regression model is presented in equation (10).

$$Y_i = \frac{1}{1+e-^{z}}$$ (Prance *et al.*, 1987) .................................................. (10)

i.e. $Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ........ + \beta_n X_n$

Where;

$Y_i$ = is a binary variable with the value of 1 if the response is that, miombo woodland resources contribute to livelihoods of local communities and 0 if otherwise;

$\beta_0, \beta_1$ to $\beta_n$ = coefficients of independent variables showing marginal effects (positive or negative) of the unit change in the independent variables on the dependent variable;

e = natural logarithm base (2.718);

i = 1, 2 ....n; where n is the total number of variables;

$X_1$ to $X_n$ = independent variables;

$X_1$ = Household size;

$X_2$ = Cultivated land size;

$X_3$ = Hunger periods;

$X_4$ = Livelihood activities;

$X_5$ = Distance from the miombo woodland;

$X_6$ = Market and demand of miombo woodland resources;

$X_7$ = Woodland access rules;

$X_8$ = Miombo woodland tenure;

$X_9$ = Institutional arrangements;

$X_{10}$ = Tree and shrub species diversity of the miombo woodland.

For proper interpretation of logistic regression results, the researcher looked carefully at the following:

- ❖ The wald statistics to see whether the increase in the independent variable is statistically significant or not;
- ❖ The sign of effect (β) to see whether the increase in the independent variable increased or decreased the probability of success (contribution of miombo woodland to livelihoods of local communities);
- ❖ Magnitude of similarly measured variables to determine which of the independent variables seem to have greater effect on contribution of miombo woodland to local communities' livelihoods;
- ❖ The Exp (β) to see how much a unit increase in $X_k$ changes the odds of success (contribution of miombo woodland to livelihoods of local communities);
- ❖ Lastly, assessed the results of different values of independent variables and made mathematical calculations to see how changes in the value of a particular independent variable affect the probability of success.



To asses the goodness of fit of the regression model to the data, three methods were used namely the model chi-square, the log likelihood ratio-test denoted by –2LL and the classification tables. By using the model Chi-square test, the significance level of the model was tested at 0.05 probability level. The magnitude of the –2LL value also determined the goodness of fit of the model to the given data set, the smaller value of –2LL, the goodness of fit of the model.

Likewise, the study compared quantities of resources extracted from the miombo woodland between the study villages. This was used as a proxy in understanding if miombo woodland resources significantly contribute to livelihoods of communities in a given study village with respect to the others. A two tailed t – test at 0.05 probability levels of significance was used in this case. Jayaraman (2000) argued that, the t – test is often desired in comparing means of two groups of observations representing different populations to find out whether populations differ with respect to their locations.

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSIONS

### 4.1 Tree and shrub species diversity in the miombo woodland of UFR

#### 4.1.1 Tree and shrub species composition and richness in the miombo woodland

A total of 835 trees and shrubs were measured. The trees and shrubs were distributed in 82 species, out of these; tree species constituted 73% while shrub species were 27%. Appendix 5 shows classification of species into trees and shrubs. Table 3 shows a list of tree and shrub species found in UFR. The following genera were dominant: *Caesalpinioideae* (30%), *Combretaceae* (29%), *Papilionoideae* (10%), *Apocynaceae* (7%), *Minosoideae* (5%) and *Rubiaceae* (5%). Figure 5 shows dominant species by stems per hectare in UFR which include: *Combretum zeyheri* (15%), *Diplorhynchus condylocarpon* (9%), *Jubernadia globiflora* (7%), *Combretum molle* (6%), *Combretum adenogonium* (5%), *Brachystegia spiciformis* (4%), *Terminalia sericea* (4%) and *Brachystegia boehmii* (4%). Similar results were reported by Mbwambo (2000) and Mafupa (2006) in miombo woodlands of Handeni Hill Forest Reserve, Tanga, Tanzania and Igombe Forest Reserve, Tabora, Tanzania.

**Table 3: Tree and shrub species identified in sample plots in UFR**

| S/N | Spp code | Botanical name | S/N | Spp code | Botanical name |
|---|---|---|---|---|---|
| 1 | 82 | *Acacia drepanolobium* | 42 | 74 | *Jubernadia globiflora* |
| 2 | 83 | *Afzelia quanzensis* | 43 | 11 | *Kigelia africana* |
| 3 | 43 | *Albizia antunesiana* | 44 | 65 | *Lannea humilis* |
| 4 | 44 | *Albizia harveyi* | 45 | 19 | *Lannea schiniperi* |
| 5 | 68 | *Annona senegalensis* | 46 | 75 | *Lonchocarpus capassa* |
| 6 | 69 | *Azanza garckeana* | 47 | 4 | *Maerua parvifolia* |
| 7 | 30 | *Berchemia discolor* | 48 | 25 | *Manilkara mochisia* |
| 8 | 77 | *Brachystegia boehmii* | 49 | 8 | *Markhamuia obtusifolia* |
| 9 | 71 | *Brachystegia spiciformis* | 50 | 26 | *Monotes adenophyllus* |
| 10 | 16 | *Brychystegia microphylla* | 51 | 61 | *Mundudea sericea* |
| 11 | 55 | *Brychystegia wangermeana* | 52 | 76 | *Mutidentia crassa* |
| 12 | 22 | *Burkea africana* | 53 | 34 | *Oldfieldia dactylophylla* |
| 13 | 48 | *Calotropis procera* | 54 | 6 | *Ormocarpum trachycarpum* |
| 14 | 36 | *Cassia abbreviata* | 55 | 79 | *Ozoroa insignis* |
| 15 | 35 | *Cassipourea mollis* | 56 | 9 | *Parinari curatellifolia* |
| 16 | 80 | *Catunaregamspinosa* | 57 | 21 | *Pavetta schumanniana* |
| 17 | 53 | *Chrysophyllum bengweolense* | 58 | 7 | *Pericopsis angolensis* |
| 18 | 67 | *Cissus cornifolia* | 59 | 18 | *Phyllanthus engleri* |
| 19 | 47 | *Clerodendrum myricoides* | 60 | 64 | *Piliostigma thonningii* |
| 20 | 37 | *Combretum adenogonium* | 61 | 72 | *Pseudolachnostylis maprouneifolia* |
| 21 | 33 | *Combretum collinum* | 62 | 40 | *Pterocarpus angolensis* |
| 22 | 32 | *Combretum molle* | 63 | 27 | *Pterocarpus tinctorius* |
| 23 | 1 | *Combretum obovatum* | 64 | 49 | *Schrebera trichoclada* |
| 24 | 51 | *Combretum zeyheri* | 65 | 63 | *Securidaca longipedunculata* |
| 25 | 45 | *Commiphora africana* | 66 | 70 | *Solanum incanum* |
| 26 | 46 | *Commiphora mossambicensis* | 67 | 29 | *Sterculia quinqueloba* |
| 27 | 52 | *Crosspteryx febrifuga* | 68 | 66 | *Strychnos cocculoidos* |
| 28 | 17 | *Dalbegia melanoxylon* | 69 | 28 | *Strychnos innocua* |
| 29 | 2 | *Dalbergia nitidula* | 70 | 20 | *Strychnos potatorum* |
| 30 | 13 | *Diospyros fischieri* | 71 | 78 | *Strychnos spinosa* |
| 31 | 56 | *Diospyros mespiliformis* | 72 | 57 | *Tamarindus indica* |
| 32 | 58 | *Diplorhynchus condylocarpon* | 73 | 5 | *Tapiphyllum floribunda* |
| 33 | 73 | *Ekebergia benguelensis* | 74 | 24 | *Terminalia mollis* |
| 34 | 15 | *Erythrophleum africanum* | 75 | 81 | *Terminalia sericea* |
| 35 | 31 | *Ficus sycomorus* | 76 | 39 | *Vangueriopsis lanciflora* |
| 36 | 59 | *Flacourtia indica* | 77 | 14 | *Vitex doniana* |
| 37 | 50 | *Friesodielsia lanciflora* | 78 | 60 | *Vitex mombassae* |
| 38 | 12 | *Garcinia livingstonei* | 79 | 41 | *Xeroderris stunmannii* |
| 39 | 10 | *Grewia conocarpoides* | 80 | 54 | *Xylopia antunesii* |
| 40 | 42 | *Hymenocardia acida* | 81 | 23 | *Zanha africana* |
| 41 | 38 | *Isoberlinia angolensis* | 82 | 3 | *Ziphus mucronata* |

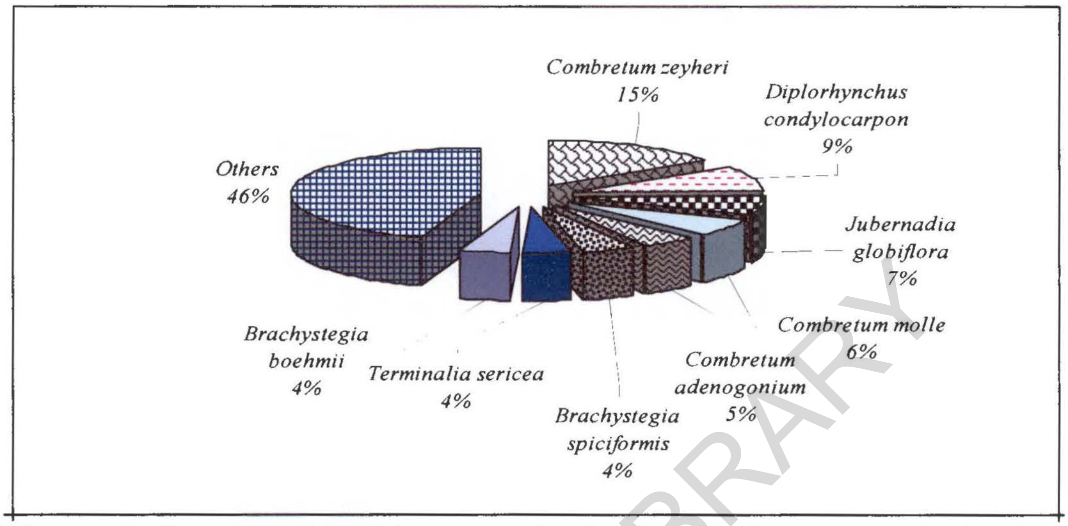



**Figure: 5: Species richness by stems density in miombo woodland (Number of species = 80)**



### 4.1.2 Tree and shrub species diversity indices in the miombo woodland

#### 4.1.2.1 Shannon-Wiener Index (H') of tree and shrub species in miombo woodland

The study revealed Shannon-Wiener Index of Diversity of 3.40 for the miombo woodland (Appendix 8). This index tells about species richness (number of species) and evenness (species distribution) (Magurran, 1988), the larger the value of H' the greater the species diversity and vice versa. An ecosystem with H' value > 2 has been regarded as medium to high diverse in terms of species (Barbour *et al.*, 1999). Thus, miombo woodland has reasonably high tree and species diversity. Species noted to have contribution to high species diversity include: *Combretum zeyheri* (0.29), *Diplorhynchus condylocarpon* (0.21), *Jubernadia globiflora* (0.19), *Combretum molle* (0.17), *Combretum adenogonium* (0.15), *Brachystegia spiciformis* (0.14), *Terminalia* *sericea* (0.14) and *Brachystegia boehmii* (0.13). *Others are Friesodielsia lanciflora* (0.12), *Albizia harveyi* (0.11), *Crosspteryx febrifuga* (0.11), *Combretum collinum* (0.10) and *Pterocarpus angolensis* (0.09) (Appendix 8).

Comparative studies elsewhere in miombo woodlands by a number of scholars have shown consistently more or less the same value. Nduwamungu (1997) and Zahabu (2001) reported H' value of 3.79 and 3.13 respectively in miombo woodlands of Kitulangalo forest reserve in Morogoro, Tanzania. Recent studies in miombo woodlands of Igombe river forest reserve, Tabora, Tanzania by Mafupa (2006) and Handeni Hill forest reserve, Tanga, Tanzania by Mohamed (2006) reported H' values of 2.90 and 3.10 respectively.



#### 4.1.2.2 Index of Dominance (ID) of tree and shrub species in miombo woodland

According to Misra (1989), the greater the value of ID the lower the species diversity and vice versa (in the scale of 0 to 1). The study came up with ID of 0.056 for miombo woodland. This result indicates that there is higher species richness in that miombo woodland. The ID value in this study is comparable to what has been found other studies in miombo woodlands. Malimbwi and Mugasha (2002) and Mohamed recorded ID values of 0.073 and 0.063 respectively in miombo woodlands of Handeni Hill forest reserve, Tanga, Tanzania while Mafupa (2006) reported ID value of 0.088 and 0.135 in undisturbed and disturbed strata of miombo woodlands of Igombe river forest reserve, Tabora, Tanzania respectively.

### 4.1.2.3 Importance Value Index (IVI) of tree and shrub species in miombo woodland

IVI is useful since it provides knowledge on important tree species of a plant community. This study found IVI of 300 for miombo woodland. Figure 6 and appendix 8 shows the distribution of important tree and shrub species in the woodland. These results reveal that, the most important species in UFR have high diversity in the scale of Shannon-Weiner Index of Diversity.

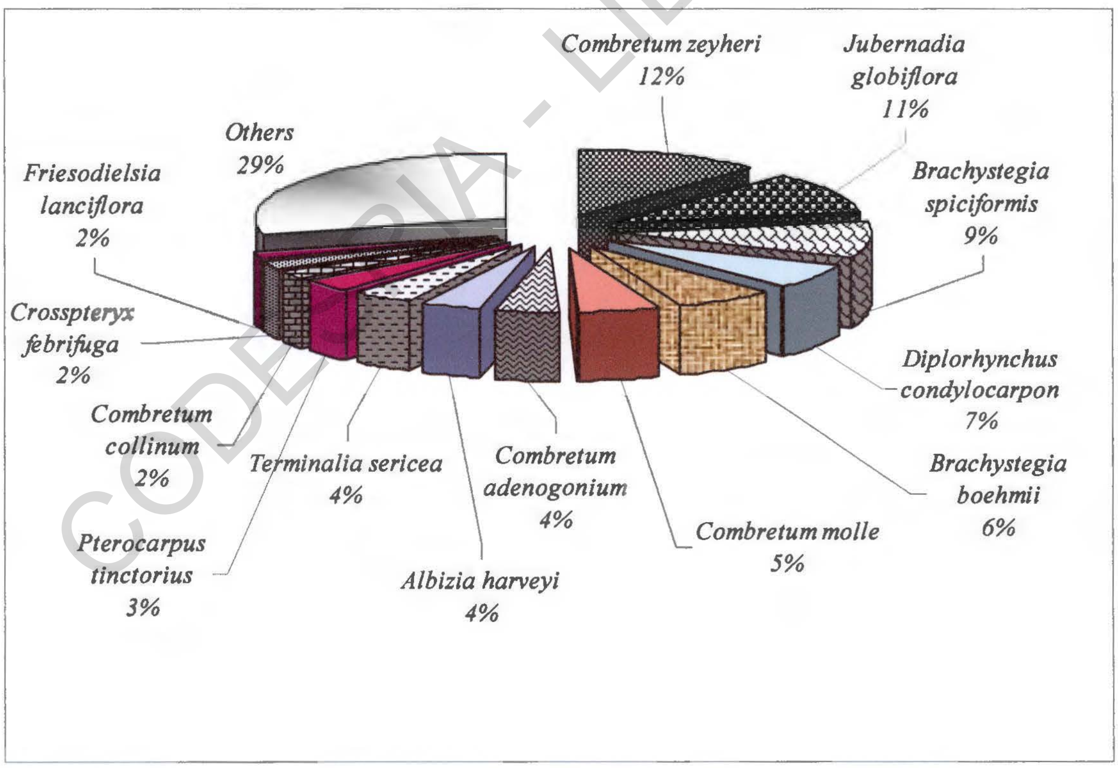



**Figure 6: Tree and shrub species richness according to IVI in UFR (Number of species = 80)**

Logistic regression results show that, tree and shrub species diversity in the miombo woodland had positive relationship ($\beta = 5.440$) with contribution of the woodland to livelihoods of local communities and that an increase in one unit of species diversity in the woodland increases the odds ratio by a factor 23.65. This implies that, increase in species diversity of the miombo woodland increased chances of the miombo woodland's contribution to livelihoods of local communities. Kremen (2005) asserted that, greater diversity increased the odds that the ecosystem had functional redundancy by containing species that are capable of functionally replacing other important species. Conclusively, the null hypothesis (i) was rejected and alternative hypothesis (i) was adopted that is, tree and shrub species diversity in the miombo woodland contribute significantly to livelihoods of the local communities at 5% probability level ($p = 0.036$). This implies that, the greater the diversity of species in the woodland increased rooms of options in livelihoods and vice versa.



## 4.2 Stocking of standing crop in the miombo woodland of UFR

### 4.2.1 Stem density (N)

#### 4.2.1.1 Stem density of standing trees and shrubs (N)

The total mean stems density in UFR was found to be 583 $\pm$ 49 for trees and shrubs with $\geq$ 4 cm dbh (Figure 7 and Appendix 6). Figure 7 shows an inverted 'J' shape which is common for natural forests with active regeneration (Phillip, 1983) and recruitment. Accordingly, active regeneration and recruitment in miombo woodland of UFR as depicted in this study is a good sign of sustainability of the woodland stock which has chances of insuring sustainable supply of products and services; and hence sustained livelihoods of the woodland dependants.

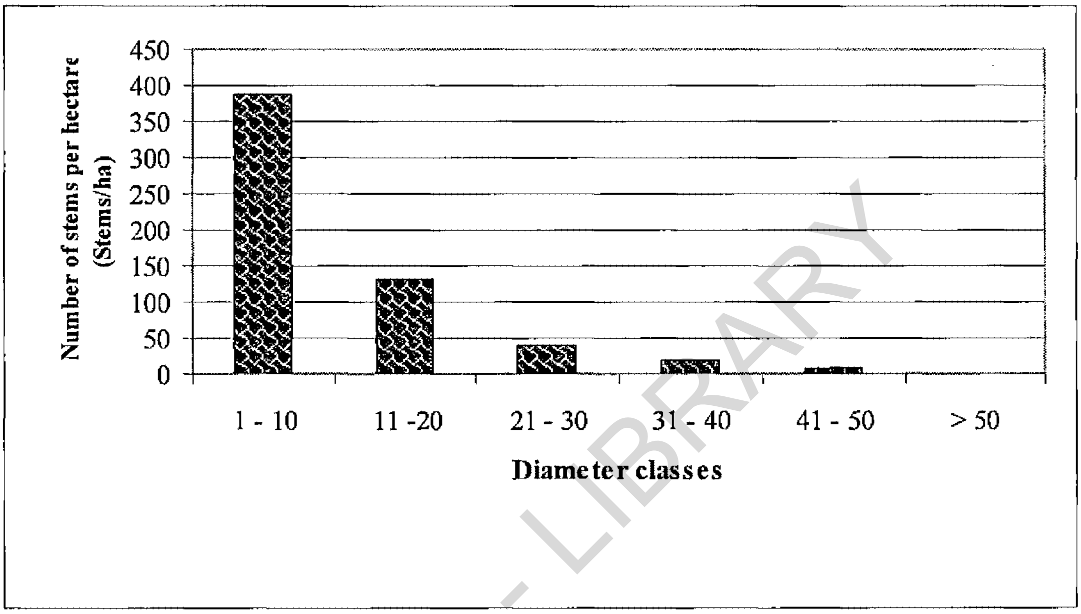



**Figure 7: Distribution of number of stems per hectare of standing crop by diameter classes in UFR (Sample plots = 70)**



The results on stem density in this study are in line with results reported elsewhere in miombo woodlands. Malaisse (1978) reported 520 – 645 stems per hectare in miombo woodlands of Katanga (DRC), Rees (1974) and Chidumayo (1993) recorded SPH of 762 and 750 respectively in miombo woodlands of Zambia while Nduwamungu and Malimbwi (1997) and Mafupa (2006) reported SPH of 691 and 722 in miombo woodlands of Kitulangalo and Igombe, Tanzania respectively.

**4.2.1.2 Stem density of regenerants (N)**

The results show that, mean total density of regenerants was 5 967 ± 699 stems per hectare (Appendix 7). Figure 8 shows the distribution of regenerants in the miombo woodland. It shows that, *Combretum collinum* (13%), *Brachystegia spiciformis* (8%), *Combretum zeyheri* (8%), *Comtretum molle* (8%), *Jubernadia globiflora* (8%), *Crosspteryx febrifuga* (7%), *Pterocarpus tinctorius* (6%) and *Terminalia sericea* (6%) are among the most regenerating species in UFR (Appendix 7). From these results it suffices to conclude that, the most regenerating species are plausibly the most exploited species by local communities in their daily livelihood activities. Regeneration in miombo is mainly from stump coppices, stump/root sucker shoots and recruitment from old stunted seedlings already present in grass layer at the time of tree cut, fall or death (Boaler and Sciwale, 1966; Strang, 1974; Chidumayo, 1989; 1993; 1997).



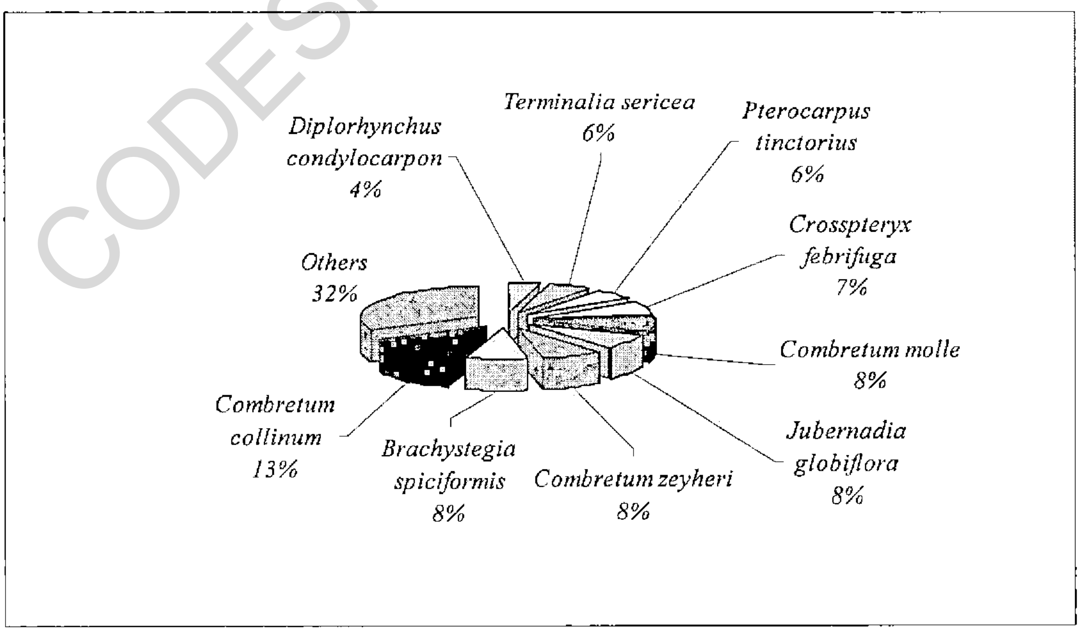



**Figure 8: Distribution of regenerant species in UFR (Number of species = 40)**

### 4.2.2 Basal area (G) and volume (V) of standing crop

According to Philip (1994), in natural forests, basal area is a good measure of the potential of a site. The study depicted mean basal area and volume of 8.54 $\pm$ 0.51 (SE) $m^2$/ha and 58.41 $\pm$ 4.09 (SE) $m^3$/ha respectively for miombo woodland of UFR (Appendix 6). According to Lowore *et al.* (1994) basal area is linearly related to volume. This is confirmed by findings of this study that, basal area and standing volume manifest linear relationship with the increase in diameter classes (Figures 9 and 10). In most miombo woodlands, the basal area range from 7 to 25 $m^2$ per hectare (Strang, 1974; Chidumayo, 1987; Lowore *et al.*, 1994; Nduwamungu and Malimbwi, 1997; Zahabu, 2001; Mafupa, 2006; Mohamed, 2006) while the mean harvestable volumes in miombo woodlands range between 14 $m^3$ per hectare in dry miombo woodlands of Malawi (Lowore *et al.*, 1994) and 117 $m^3$ per hectare in Zambian wet miombo woodlands (Chidumayo, 1988). This shows that, basal area and standing volume for miombo woodland of UFR lies within ranges of stocking in the miombo ecoregion.



Figure 11 shows the distribution and contribution of species to mean total volume per hectare. Species which contribute more to volume are similar to species manifesting high diversity indices and are well distributed across diameter classes (Appendix 6).

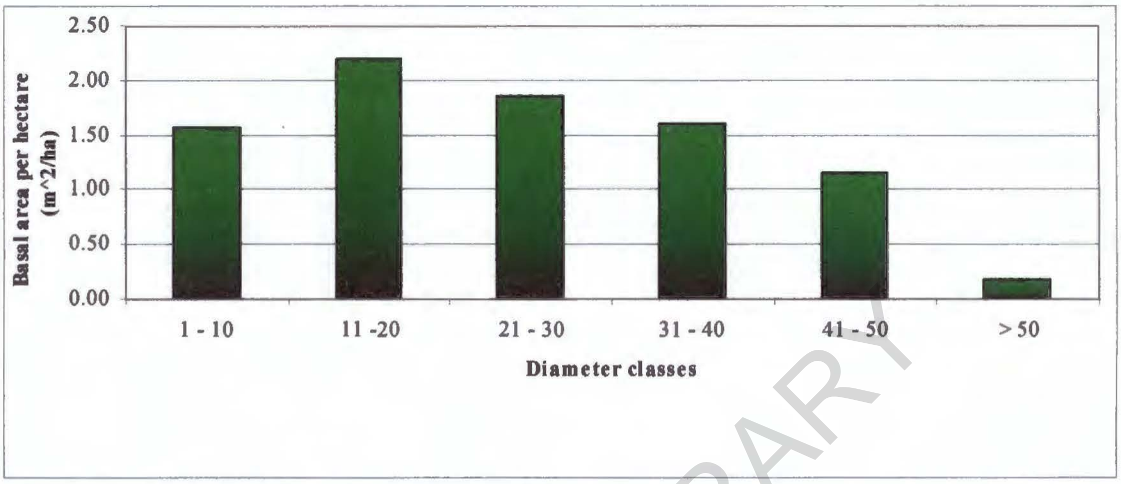



**Figure 9: Distribution of basal area of standing crop by diameter classes in UFR (Sample plots = 70)**

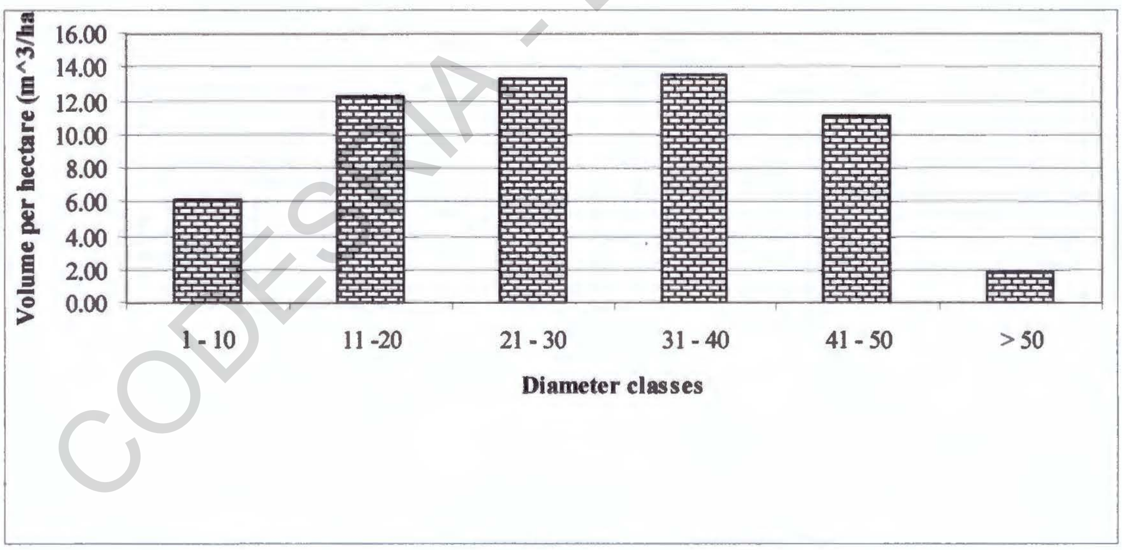



**Figure 10: Distribution of volume of standing crop by diameter classes in UFR (Sample plots = 70)**

Findings of other scholars in miombo woodlands include: Strang (1974) recorded mean basal area of 10 – 11m$^2$ per hectare in Miombo woodlands of Zimbabwe, Endean (1968) reported 10.9 m$^2$ per hectare in mature miombo woodlands of Zambia while

Malimbwi and Mugasha (2002) and Mohamed (2006) reported mean basal area of 11.21 $\pm$ 3.38 $m^2$ per hectare and 12.7 $\pm$ 1.55 $m^2$ per hectare respectively in the miombo woodland of Handeni Hill Forest Reserve, Tanga, Tanzania. Nduwamungu (1997) and Zahabu (2001) reported mean standing volume of 71 $m^3$ per hectare and 78.8 $m^3$ per hectare at Kitulangalo forest reserve, Morogoro, Tanzania while Mafupa (2006) recorded mean standing volume of 87.14 $m^3$ per hectare in undisturbed strata and 21.09 $m^3$ per hectare in disturbed strata in Igombe river forest reserve, Tabora, Tanzania.

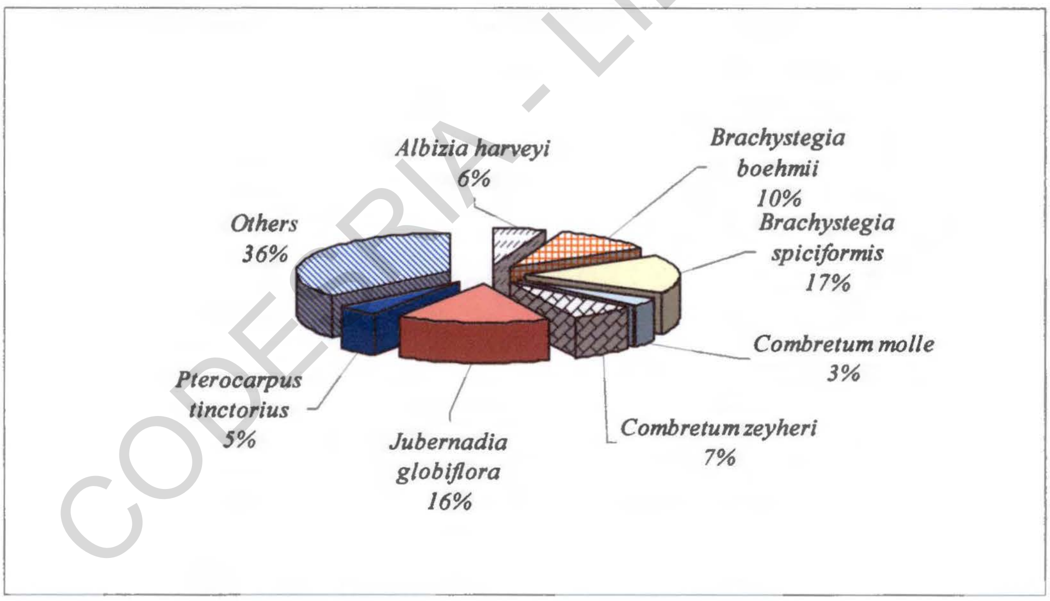



**Figure 11: Distribution of volume of standing crop by species in UFR (Number of species = 80)**

These results suggest that, although the miombo woodland has portrayed a reasonably good regeneration potential, it is not well stocked. The values of basal area and standing volume of UFR are lower than those presented in various studies in the region. Figures 9 and 10 do not display well the usual 'J' shape common for natural forests, basal area and standing volume increases from diameter class I to II then slightly start decreasing from diameter class III to V. Thereafter there is a sharp fall-off. The plausible reason for this could be the livelihood activities undertaken in the woodland which are mostly charcoal production and other forms of wood out – take consume tree and shrub species of higher diameter classes (> 30 cm dbh). This is supported by what is seen in Plate 1 which shows wood cutting activities in the miombo woodland, this suggest the absence of trees and shrubs of higher dbh classes.

**Plate 1: Wood cutting for charcoal making in UFR**

## 4.3 Miombo woodland of UFR and livelihoods of local communities

### 4.3.1 Products and services derived from UFR

Table 4 shows a list of 16 products and 2 services derived by local communities from the miombo woodland. They cover basic household needs which include: firewood, charcoal, construction materials, food, medicines and assets that may be transformed into cash and supplement other necessities. At least five tree/shrub species offers a single use of products derived from the miombo woodland (Table 4; Appendix 5). This means that, communities have alternative species for a given miombo woodland product as such, communities become 'less vulnerable' in case a particular species is out or under-stocked. For example, during PRA exercises, communities in the study area pointed out about the scarcity of some tree/shrub species which once were highly abundant e.g. *Pterocarpus angolensis* a valuable and preferred timber tree species which is currently rare in the woodland. Despite that, communities have alternative species which offer them sustained livelihoods, they include: *Afzelia quanzensis, Albizia antunesiana, Brachystegia spiciformis, Pterocarpus tinctorius* and *Jubernadia globiflora* which are present in a reasonable stock and offer the same purpose as *Pterocarpus angolensis*.

**Table 4: Products and services derived from UFR**

| Products and services | Number of species used | Mtakuja N = 14 f (%) | Isukamahela N = 12 f (%) | Masimba N = 9 f (%) | Kipalapala N = 49 f (%) | Overall Collect and / use f (%) | Overall Don't collect nor use f (%) |
|---|---|---|---|---|---|---|---|
| Firewood | 76 | 14 (17) | 12 (14) | 9 (11) | 45 (54) | 80 (95) | 4 (5) |
| Charcoal | 70 | 1 (1) | 2 (2) | 1 (1) | 6 (7) | 10 (15) | 74(85) |
| Pole | 47 | 9 (11) | 11 (13) | 9 (11) | 16 (19) | 45 (65) | 39 (35) |
| Timber | 19 | 2 (2) | 4 (5) | 0 (0) | 1 (1) | 7 (10) | 77 (90) |
| Medicinal plant | 61 | 6 (7) | 7 (8) | 9 (11) | 2 (2) | 24 (35) | 60 (65) |
| Edible wild vegetable | Na* | 6 (7) | 2 (2) | 7 (8) | 0 (0) | 15 (22) | 69 (78) |
| Edible wild fruit | 31 | 6 (7) | 4 (5) | 8 (10) | 2 (2) | 20 (29) | 64 (71) |
| Edible mushroom | Na* | 3 (4) | 3 (4) | 9 (11) | 0 (0) | 15 (22) | 69 (78) |
| Edible insect | Na* | 2 (2) | 3 (4) | 9 (12) | 0 (0) | 9 (12) | 75 (88) |
| Wild meat | Na* | 0 (0) | 1 (1) | 2 (2) | 0 (0) | 3 (4) | 81 (96) |
| Honey | 76 | 5 (6) | 8 (10) | 0 (0) | 2 (2) | 15 (22) | 69 (78) |
| Beehive | 8 | 5 (6) | 8 (10) | 2 (0) | 0 (0) | 15(22) | 69 (78) |
| Beeswax | 40 | 4 (5) | 6 (7) | 5 (6) | 0 (0) | 10 (12) | 74 (88) |
| Fodder/Pasture | Na* | 6 (7) | 7 (8) | 7 (8) | 0 (0) | 20 (29) | 64 (71) |
| Rope | 5 | 8 (10) | 9 (11) | 8 (10) | 15 (18) | 40 (58) | 44 (42) |
| Thatching grass | Na* | 10 (12) | 10 (12) | 9 (11) | 19 (23) | 48 (57) | 36 (43) |
| Attract rain | Na* | 2 (2) | 1 (1) | 1 (1) | 1 (1) | 5 (7) | 79 (93) |
| Support of agriculture | Na* | 0 (0) | 0 (0) | 3 (4) | 0 (0) | 3 (4) | 81 (96) |

* = Not applicable

#### 4.3.1.1 Firewood and charcoal

Firewood is the main source of energy both in rural and urban area. In the study area all surveyed households use firewood as the main form of wood fuel; out of these 95% households depend on the miombo woodland as a source of firewood (Table 5). Wood fuel is used for cooking, brick making, local brew making, tobacco curing and heating.

**Table 5: Quantities of woodland products derived from UFR annually**

| Woodland product | Mtakuja N=14 | Isukamahela N=12 | Masimba N=9 | Kipalapala N=49 | Overall N=84 |
|---|---|---|---|---|---|
| Firewood (Headload/year) | 59.79±2.49(SE) | 81.58±.98(SE) | 128.44 ± 16.06(SE) | 82.08±6.54(SE) | 83.26±5.17(SE) |
| Charcoal (Bag/year) | 20.50±2.0(SE) | 19±4.41(SE) | 26.00±3.44(SE) | 39.23±49(SE) | 28.69±2.96(SE) |
| Pole (No./year) | 32.85±9.09(SE) | 40.42±7.03(SE) | 47.00±3.70(SE) | 10.83±2.97(SE) | 22.61±3.24(SE) |
| Timber (Plank/year) | 13.86±2.63(SE) | 15.92±2.78(SE) | 0.00±00(SE) | 8.00±2.80(SE) | 11.93±3.21(SE) |
| Medicinal plant (Kg/year) | 4.80±0.51(SE) | 8.10±2.2(SE) | 11.85±2.87(SE) | 1.50±0.26(SE) | 4.92±1.63(SE) |
| Edible wild vegetable (Kg/year) | 17.86±7.19(SE) | 4.33±0.33(SE) | 67.56±15.56(SE) | 0.00±0.00(SE) | 10.83±3.03(SE) |
| Edible wild fruit (Kg/year) | 9.14±3.08(SE) | 10.67±4.15(SE) | 35.11±5.53(SE) | 0.10±0.07(SE) | 6.87±1.51(SE) |
| Edible mushroom (Kg/year) | 2.78±0.55(SE) | 2.23±0.45(SE) | 6.00±0.71(SE) | 0.00±0.00(SE) | 3.09±0.91(SE) |
| Edible insects (Kg/year) | 1.08±0.01(SE) | 0.00±00(SE) | 4.50±1.38(SE) | 0.00±0.00(SE) | 0.43±0.19(SE) |
| Honey (Kg/year) | 17.00±7.25(SE) | 53.50±11.99(SE) | 0.00±0.00(SE) | 12.24±1.6(SE) | 11.79±2.97(SE) |
| Rope (Kg/year) | 2.20±0.59(SE) | 2.34.00±0.62(SE) | 4.00±1.32(SE) | 1.10±0.26(SE) | 2.07±0.30(SE) |
| Thatching grass (Headload/year) | 4.64±1.46(SE) | 4.25±0.83(SE) | 8.88±1.24(SE) | 2.05±0.42(SE) | 3.52±0.44(SE) |



Most households collect firewood on weekly basis. Table 5 presents quantity of firewood collected annually per household from the woodland. Comparing differences between study villages in amount of firewood collected from the woodland, results show that, Masimba village significantly depend on miombo woodland as a source of firewood at probability level of 0.05 ($p = 0.03$) than the rest of the study villages. This could be because Masimba is located much close to the woodland compared to other villages (Plate 2). The mean gross monetary value of firewood collected annually from the woodland is TSHs. 87 425 ± 4 998 (SE) per household. Firewood is sold at TSHs. 1 000 ± 100 (SE) per head load in the study area. Species preferred for firewood include: *Jubernadia globiflora, Brachystegia spiciformis, Afzelia quanzensis, Azanza garckeana, Berchemia discolor, Brachystegia boehmii, Combretum collinum,* *Combretum molle, Combretum zeyheri, Commiphora Africana, Diplorhynchus condylocarpon, Erythrophleum africanum, Pericopsis angolensis, Pterocarpus tinctorius* and *Zanha Africana* (Appendix 5). Attributes of a species regarded as good for Wood fuel are medium to high wood density, low moisture content, long-lasting coals, low smoke yield, absence of thorns and absence of unusual fumes or smells (Abbot and Lowore 1999; Luoga *et al*., 2002). Selectivity for size is also marked in collection of firewood, but it is influenced by the end purpose. Collectors of Wood fuel for household fires typically target branches and stems of 3 – 8 cm diameter (Abbot and Lowore, 1999). Mean diameter of trees and shrubs used for firewood from UFR is 12.6 + 2.7 (SE) cm (diameter class II).

Very few (15%) households in the study area claimed involvement in charcoal making in the miombo woodland. However, the researcher's eye witness showed that, charcoal making is the leading livelihood activity in the woodland (Plates 4 and 5). As pointed out earlier, charcoal making by local communities is mainly used for income generation that supplements household total income. Table 5 shows quantity of charcoal collected from the woodland annually per household. Kipalapala study village was observed to be highly involved in charcoal making in the woodland compared to Mtakuja study village ($p = 0.02$).

**Plate 2: A bunch of firewood for home use at Masimba village, Tabora, Tanzania**

**Plate 3: Firewood for brick making in the periphery of UFR at Isukamahela, Tabora, Tanzania**

**Plate 4: Charcoal kiln in in UFR**

**Plate 5: Charcoal bags being transported from UFR to Tabora town**

Kipalapala compared to Isukamahela and Masimba villages showed no any significant difference in charcoal making activities. The plausible reason for households at Kipalapala village being mainly involved in charcoal making in the woodland is that, the village is much close to Tabora town which suggest availability of market from the nearby town. In the study area charcoal is sold TSHs. 4 500 $\pm$ 450 (SE) per bag.

Species preferred for charcoal include: *Brachystegia spiciformis, Azanza garckeana, Annona senegalensis, Albizia harveyi, Albizia antunesiana, Afzelia quanzensis, Berchemia discolor, Brachystegia boehmii, Brychystegia microphylla* and *Terminalia sericea* (Appendix 5). During inventory in the woodland the researcher observed a wide range of tree and shrub sizes that were cut for charcoal making, stump diameter of trees and shrubs cut for this purpose ranged from 15 cm to 40 cm.



#### 4.3.1.2 Construction materials

Shelter is one of the basic needs of human being. Most households use locally available materials for construction purposes such as house, fence or cage. Construction materials identified by households in the study area include timber, pole, rope and thatching grass (Table 4). All of these materials are collected from UFR. Table 5 shows quantity of various construction materials collected by households from the miombo woodland annually. Results in table 4 show that, very few households are involved in lumbering (10%) while many households plainly admitted the use of the miombo woodland as a source of poles, rope and thatching grass. During PRA exercises however, local people disclosed the truth that lumbering is an activity undertaken illegally by a good number of local inhabitants. Construction materials derived from miombo woodlands in the study area are exploited subsistently but also commercialized. In local markets construction materials are sold as follows: timber (TSHs. 4 000 $\pm$ 400 (SE) per plank), pole (TSHs. 1 000 $\pm$ 100 (SE) per pole), rope (TSHs. 1 000 $\pm$ 216 (SE) per Kg) and thatching grass (TSHs. 800 $\pm$ 50 (SE) per head load). Consequently, monetary value of construction materials presented in table 5 is as follows: pole (TSHs. 35 870 ± 3 629 (SE)), rope (4 520 ± 315 (SE)) and thatching grass (TSHs. 1 455 ± 126 (SE)). These results imply that, the miombo woodland contribute highly to livelihoods of local communities in terms of construction materials. Accordingly, results show that, there is no significant difference in extraction of construction materials from the woodland between study villages. This implies that, all villages have the same level of construction material extraction from the miombo woodland. Plates 6, 7 and 8 shows various construction materials collected from the miombo woodland. However, households involved in lumbering were not ready to disclose quantities of construction materials collected from the woodland, the plausible reason for this could be a fear that the researcher was on investigation. This is among the study limitations.

**Plate 6: Confiscated timber from UFR at Uyui District Forest Office, Tabora, Tanzania**

**Plate 7: Poles used for fencing at Masimba village, Tabora, Tanzania**

This study observed selectivity and preference of species for construction materials derived from the miombo woodland. Further more, construction needs require thicker and longer poles than what is preferred for Wood fuel (Luoga *et al.*, 2002). A total of

19 preferable timber species, 47 species for poles and 5 species for rope have been identified in this study, commonly used species include: *Pterocarpus angolensis, Afzelia quanzensis, Brachystegia boehmii, Brachystegia spiciformis,* and *Jubernadia globiflora* with mean dbh of 44.7 $\pm$ 5.9 cm (SD = 9.5) for timber; *Brachystegia spiciformis, Combretum collinum, Combretum zeyheri, Diplorhynchus condylocarpon, Jubernadia globiflora, Pterocarpus angolensis, Pterocarpus tinctorius* and *Terminalia sericea* with mean dbh of 24.3 $\pm$ 5.3 cm (SD= 11.9) for pole and *Brachystegia boehmii, Brachystegia spiciformis, Brychystegia microphylla, Jubernadia globiflora* and *Lannea schiniperi* for rope (Appendix 5).



**Plate 8: Thatching grass collected from UFR, Tabora, Tanzania**

Clarke *et al.* (1996) noted that, house and barn construction requires many poles of many different dimensions, weight and durability. The same author argued that, these materials as well as rope for tying them together and grass for thatching, need to be replaced at frequent intervals.

**4.3.1.3 Wild food**

Food is an important ingredient in human life. Miombo woodlands have proved to be important in life of communities living adjacent to miombo woodlands. Six types of wild food from the miombo woodland were identified in this study. They include: wild vegetable, wild fruit, mushroom, insect, wild meat and honey.

Wild vegetable and mushroom were individually mentioned by 22% of all respondents in the study area and the results showed significant difference in quantities of wild vegetables and mushroom collected from the miombo woodland when Masimba village was compared to Kipalapala village. However, there was no any significant difference between Mtakuja, Masimba and Isukamahela villages. This could be attributed to the fact that, Masimba is very close to the woodland compared to other study villages. Thus, communities at Masimba villages highly depend on the miombo woodland as a source of wild vegetable (Table 5). From table 5, monetary value of wild vegetables collected annually from the miombo woodland by households is about TSHs. 27 300 $\pm$ 4 230 (SE). Price of wild vegetable in local market in Tabora vary depending on the species however, the mean price is TSHs. 279 $\pm$ 9 (SE) while mushroom were sold at TSHs. 640 $\pm$ 50 (SE) per Kg. This implies that, the miombo woodland contribute about TSHs. 27 300 annually to households in the study area for vegetables alone. These results are comparable with other findings, Luoga *et al.* (2002) for example found three arborescent species which serves as vegetable in miombo woodlands of eastern Tanzania. They include: *Zanthoxylum chalybeum, Ormocarpum* *kirkii* and *Zahna Africana*. The common leaves consumed in Mozambique sourced from miombo woodlands include: *Adeinia gummifera, Amaranthus sp., Corchorus tridense, Ipomea lapatifolia* and *Momordica balsamica* (FAO, 2000). Harkonen *et al.* (2003) observed that, in Tanzania most people include mushrooms in their diets during rain seasons. For example, Bena, Hehe, Nyamwezi and Makua include mushrooms in their daily meal during rain seasons. These results reveal the essential role played by wild vegetables and mushrooms in household food security. The predominance of *ectomycorrhizae* in miombo woodland (largely a result of the poor soils), many of which produce mushrooms, making miombo woodlands one of the prime 'mushroom biomes of the world'. This has given rise to a culture of mushroom gathering which is widespread among people in miombo woodlands but largely absent in other tropical African dry woodlands (WWF-SARPO, 2001).



A total of 31 woodland species consumed as fruits have been identified in this study (Table 4 and Appendix 5). A few (29%) households in the study area admitted the use of wild fruits from the miombo woodland. It was observed that, households at Masimba village compared to other villages are significantly involved in collection of wild fruits from the miombo woodland (p = 5%). The reason behind could be that, Masimba village is closely bordered with UFR compared to other study villages. This finding is supported by researcher's observation; members of Masimba village which are mostly Sukuma pastoralists were visibly seen collecting wild fruits in the woodland during inventory work. Children who look after herds of cattle are the ones engaged in wild fruit collection, they do so while undertaking their day – day responsibilities as herd-men. The most common species of wild fruits enumerated in this study, include the following: *Adansonia digitata, Parinari curatellifolia, Flacourtia indica, Garcinia livingstonei, Azanza garckeana, Berchemia discolor, Cissus cornifolia, Strychnos cocculoidos, Strychnos innocua, Strychnos spinosa, Tamarindus indica, Vangueriopsis lanciflora, Vitex doniana* and *Vitex mombassae* (Appendix 5). Among these fruits *Adansonia digitata, Tamarindus indica, Parinari curatellifolia, Vitex doniana* and *Vitex mombassae* were found to be sold at the local market in Tabora town, a tin of *Vitex mombassae* and *Vitex doniana* fruits was sold TSHs. 300 respectively while fruits of *Parinari curatellifolia* were sold at TSHs. 500 a tin. Similar findings have been reported in other studies. A total of 83 indigenous tree species, which bear edible fruits and nuts through out the year, have been identified in miombo woodlands of Tanzania (Temu and Msanga, 1994), while more than 50 fruit trees were found in Miombo of Tabora, region (Temu and Chihongo, 1998; Ramadhani *et al.*, 1998). Wild fruits from miombo play important role in food security by serving as 'buffer foods' that contribute to dietary needs during periodic food shortages (Makonda, 1997; Lipper, 2000; Roe and Elliot, 2004). Wild fruits indigenous in the miombo ecoregion contain high level of vitamins and some minerals than domesticated species (Peters and O'Brien, 1981; Fox and Norword Young, 1982; Malaisse and Parent, 1985; Saka and Msothi, 1994).

Edible insect was mentioned by very few (12%) of all respondents in the study area (Table 4). It was observed that, Households at Kipalapala village due to the fact that the village is located a reasonable distance from the miombo woodland are not involved in collection of insects. However, results show that, though households from others villages mentioned 'edible insect' the proportion is unexpectedly too low. The plausible reason for this could be that, western society's distaste of edible insect consumption which has resulted into decline of the practice (DeFoliart, 1999) in most African societies. Edible insects from miombo woodlands are recognized as an important source of nutrition (van Huis, 2003). The review by DeFoliart (1999) mentioned that, 65 species of insects were consumed throughout the DRC, 60 in Zambia and 40 in Zimbabwe.

Wild meat is an important source of protein to communities living around miombo woodlands. As a product accrued from the miombo woodland, wild meat constitutes the category that received the least responses (4) among respondents in the study area (Table 4). During PRA exercises it was observed that, wild animals in the miombo woodland are amongst the scarce resources if not non-existent. This explains the reason why just a few mentioned access to wild meat from the miombo woodland.

Honey, a bee product is another vital product derived from miombo woodlands. Bee keeping is the central livelihood activity undertaken in miombo woodlands, worthy of special note in this respect is Tabora region, Tanzania. About 22% of respondents are involved in beekeeping in the study area (Table 4). In the study area, honey is used as sweetener, for brewing alcohol and medicine. As food, honey is mainly taken with sweet potatoes, cassava or used in the place of sugar for porridge. As ingredient in local brew making, honey is widely used in the study area. Table 5 shows quantities of honey collected by households from UFR on annual basis. It was observed that, honey is sold at TSHs. 2 800 ± 305 (SE) per litre in the study area. These results imply that, honey is quiet potential both as household food and reliable source of income. The miombo woodland contribute to livelihoods of local communities by supporting honey production through provision of bee hives, bee forages and trees on which bee hives are placed. Moreover, all these provisions of the miombo woodland depend on tree and shrub species diversity. A total of 76 tree and shrub species suitable for honey were enumerated in the study area, the most common species include: *Brychystegia microphylla, Burkea Africana, Berchemia discolor, Cassia abbreviate, Albizia antunesiana, Albizia harveyi, Combretum zeyheri, Brychystegia wangermeana, Diplorhynchus condylocarpon, Azanza garckeana, Brachystegia spiciformis, Brachystegia boehmii, Terminalia sericea* and *Acacia drepanolobium* (Appendix 5).



#### 4.3.1.4 Medicinal plants

About 61 species of medicinal plants have been identified in the study area (Table 4). The medicinal plant species identified in this study are used by local communities as a livelihood strategy for health care, diseases treated by these species include: coughs, headache, sores, diarrhea, hernia, asthma, snake-bite, fever, malaria, constipation and typhoid to name just a few. The most common medicinal plant species include: *Combretum molle. Combretum collinum, Cassia abbreviate, Isoberlinia angolensis, Albizia antunesiana, Albizia harveyi, Commiphora Africana, Calotropis procera, Combretum zeyheri, Brychystegia, wangermeana, Jubernadia globiflora, Strychnos* *spinosa, Catunaregam spinosa* and *Terminalia sericea* (Appendix 5). For example *Combretum zeyheri* treat typhoid, *Cassia abbreviata* is used for stomachache, headache, malaria and fever. Parts of plants utilized as medicine are roots, leaves, barks or stem wood. Table 5 shows quantities of medicinal plants collected by households in the study area annually. It was observed that, individuals knowledgeable with medicinal plant species are not the young generation, most of them are middle aged to elders who seem to have acquired such knowledge from their ancestors. These results show great dependence of the miombo woodland as a source of medicine for their health care which has implication on communities' livelihood status, since health members of households will engage in various livelihood activities than those with ill-health. These results are as well supported by the researcher's observation, no a single health center was observed in the study villages. This suggests that, communities in the study area satisfy their health needs from the nearby miombo woodland.



Findings of this study are in agreement with studies in Tanzania and elsewhere in the miombo ecoregion. Dery *et al.* (1999) noted that, about 80% of rural people in Tanzania depend on traditional healers and traditional herbs for their health care needs and over 300 medicinal trees in the Miombo woodlands have been identified to cure more than 100 human diseases in Tanzania. Use of plant material for physical and psychological ailments and spiritual rituals and observances is common (Brigham, 1994; Cunningham, 1996; Luoga *et al.*, 2002), both through self-collection and use, as well as via traditional healers. In some areas there is also significant trade in medicinal plants, with rural collectors supplying traditional healers and markets serving urban areas. According to Mbwambo (2000) miombo species with medicinal properties found in the central western Tanzania include: *Afzelia quanzensis, Cassipourea insignis, Combretum collium, C. molle, C. zeyheri, Dichrostachys cinerea, Erythrina abyssinica, Fagara mekeri, Ozoroa insignis, Popowia obovata, Pterocarpus angolensis, P. tinctorius, Schrebera koiloneura, Tamarindus indica, Vitex mombassae* and *Xylopia antunesii*.

#### 4.3.1.5 Other products and services

Other products and services enumerated in the study area include: beehive, beeswax, fodder/pasture, attraction of rainfall and support of agriculture (Table 4). Beehive and beeswax are related to beekeeping livelihood activities. Beehive and beeswax were mentioned by 22% while 12% respectively out of all respondents in the study area, it is the main investment in beekeeping whose products are honey and beeswax. This means that, beehives derived from the miombo woodland implies a notable contribution of the miombo woodland to beekeeping as a livelihood activity. The dominance of *Brachystegia, Julbernardia* in UFR provides the basis for beekeeping as a significant (culturally, socially and economically) form of land use in miombo woodland. About 8 species used for beehive were enumerated in the study area, they include the following: *Brachystegia spiciformis, Afzelia quanzensis, Pterocarpus angolensis, Pterocarpus tinctorius, Jubernadia globiflora, Brachystegia boehmii, Calotropis procera* and *Brychystegia microphylla* (Appendix 5). Participant observation during inventory work in the miombo woodland revealed that, most beehives are locally made. Beewax serves as an important source of household income in the study area, price of beeswax in Tabora region is about TSHs. 2 000 ± 185 (SE) per Kg.

This study also revealed fodder/pasture as an important product that supports livelihoods of local communities in the study area. About 29% of all respondents depend on the miombo woodland as source of fodder/pasture for their livestock. Cattle (49%), goat (38%) and sheep (13%) are the livestock kept in this study. Figure 12 shows the distribution of livestock keeping in the study villages. These results indicate that, Masimba village is prominent in livestock keeping. It was further observed that, free grazing is the mode of livestock feeding practiced in the study area. Grazing area include: the miombo woodland of UFR (34%), general land (46%) and own farm land (20%).



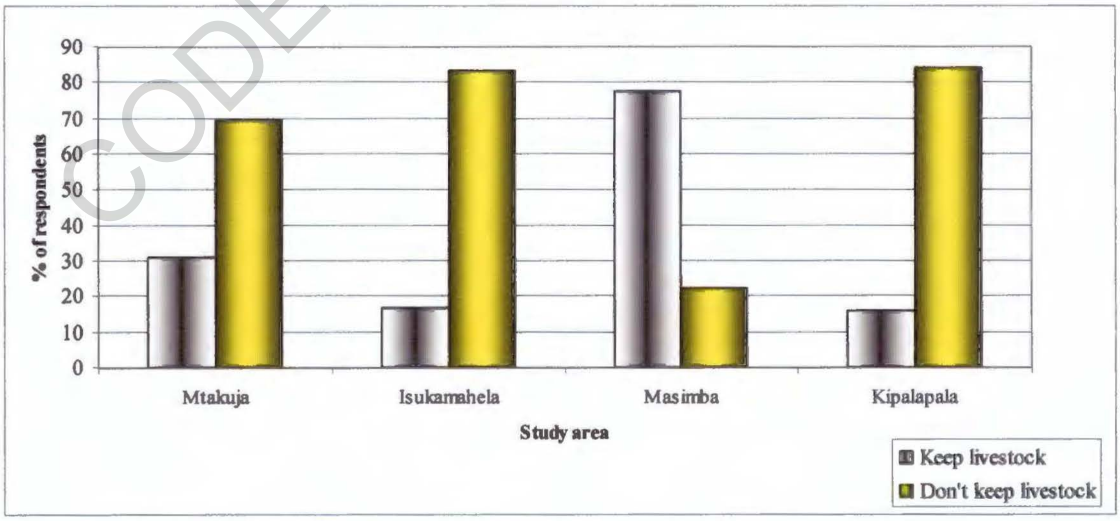



**Figure 12: Livestock keeping in the study area (N = 84)**

Only two services provided by the miombo woodlands were recognized by local communities in the study area; attraction of rainfall (7%) and support of agriculture (4%). This may be attributed to the fact that, most people tend to be short-sighted by realizing potential of tangible benefits alone and forget the non-tangible benefits like services. These results are comparable with other studies, miombo woodlands are acknowledged for their service in supporting agriculture. Miombo of western Tanzania, where more than 60% of the country's tobacco is produced have shown increase in area for cultivation from 228 000 hectares in 1985/86 to 1 374 000 hectares in 1991/92 (Misana, 1988). Tobacco farmers use miombo as source of energy for curing tobacco. Interspersed within the miombo woodlands are broad, grassy depreciations called 'mbuga' which are seasonally waterlogged, support cultivation and livestock grazing (McFarlane and Whitlow, 1990). Moreover, miombo woodlands play an important role in controlling soil erosion; provide shade and modifying hydrological cycles. Miombo also provide watershed protection to areas prone to erosion by heavy seasonal rains (Clarke *et al.*, 1996).



### 4.3.2 Contribution of the miombo of UFR to livelihoods of local communities

The miombo woodland contributes to livelihoods of local communities through the products and services accrued from the miombo woodland. Table 4 presents products and services derived by local communities from the miombo woodland which contribute both to household income as well as household consumable reap. Analysis of contribution of the miombo woodland to local communities' livelihoods shows that, miombo woodlands contribute 59% to total household annual income. The income is earned through livelihood activities which depend on the miombo woodland. These include: beekeeping, tobacco farming, brick making (burning), charcoal making, lumbering and healing by using medicinal plants. The rest (41%) come from cultivated agricultural crops (35%), livestock keeping (4%) and petty businesses (2%). The woodland products are not solely used for subsistence but also sold locally on roadside or through informal networks. In this way households depended on the woodland as source of supplementary income. Table 6 shows distribution of household income generated from various livelihood activities in the study area where beekeeping (TSHs. 81 244 per household per year) manifest prominent contribution to household income. Table 6 shows that, average household annual income of TSHs. 379 643 in the study area. Cavendish (2000) asserted that, exploiting natural systems often can be done with little need for investment or expensive equipment, making the cost of entry low, an important consideration for poor families with limited assets. Woodland income deserves special attention, since it is often the element that is not accurately accounted for in most considerations of rural livelihoods. Where markets exist, goods harvested from woodlands, such as wild food plants, herbs fruits and medicinal plants, can be sold for cash or exchanged for services like school tuition.

**Table 6: Distribution of households' annual income in the study area**

| | N Statistic | Minimum Statistic | Maximum Statistic | Mean Statistic | Std. Error | Std. Deviation Statistic |
|---|---|---|---|---|---|---|
| Income from farming (TSHs) | 84 | 0 | 292 000 | 53 286 | 8 587 | 78 705 |
| Income from livestock (TSHs) | 84 | 0 | 600 000 | 20 714 | 8 144 | 74 640 |
| Income from petty business (TSHs) | 84 | 0 | 2 800 000 | 78 726 | 35 465 | 325 044 |
| Income from beekeeping (TSHs) | 84 | 0 | 1 745 000 | 81 244 | 32 636 | 299 112 |
| Income from tobacco (TSHs) | 84 | 0 | 700 000 | 27 262 | 11 033 | 101 121 |
| Income from burnt bricks (TSHs) | 84 | 0 | 440 000 | 38 131 | 9 288 | 85 128 |
| Income from charcoal (TSHs) | 84 | 0 | 400 000 | 33 482 | 10 443 | 95 712 |
| Income from timber (TSHs) | 84 | 0 | 595 000 | 33 048 | 12 109 | 110 983 |
| Income from forest medicines (TSHs) | 84 | 0 | 350 000 | 9 583 | 4 994 | 45 775 |
| Household annual income(TSHs) | 84 | 22 000 | 3 388 000 | 379 643 | 49 904 | 457 381 |



Chambers and Leach (1987) noted that, forest products are important in rural livelihoods and serve as buffer against contingencies. Moreover, the authors argued that, forests and woodland products do not just provide subsistence needs, but also act as a source of income, type of savings and assets. Sunderlin *et al.* (2003) likewise argued that, woodlands resources can play a major role in bolstering livelihoods and in poverty mitigation. This is illustrated by Campbell *et al.* (2001) in Zimbabwe who demonstrated the role of miombo woodlands resources in livelihoods of local communities as it contributed nearly 30% of total household annual income. Similar conclusions have been reported by Fisher (2004) in Malawi. Thus, in many rural settings miombo woodlands serve as poverty-mitigating income source. Cultivated food crops in the study area include: maize, millet, sweet potatoes, cassava and groundnut. The crops are consumed at household level but also sold for income generation. Income from miombo woodlands compared to income generated from other sources were not statistically significantly different (p (t) = 0.26 and d.f = 3). Similarly, products accrued from miombo woodlands for household consumption accrued compared to other household consumable products were not statistically significantly different (p (t) = 0.48 and d.f = 3). Although the contribution of miombo woodlands to both household consumption and income were not significantly different it is worth acknowledging that, the miombo woodland contributes fairly well to livelihoods of local communities. These results are in line with findings by Monela *et al.* (2000) who argued that, the miombo woodlands provide a wide range of wood and Non-wood products which are important for the livelihoods of adjacent communities. Similarly, FAO (2000) argued that, utilization and trade of fruits from miombo are integral components of local economies and culture and play important roles in household welfare.

### 4.4 Wood resources out – take from UFR and its implication on woodland stock and local communities' livelihoods

In the context of sustainable livelihoods, it is important that stock and supply of products and services to local communities are sustained. Woodland inventory results show that the woodland is not well stocked. Stock extraction from the miombo woodland was as well checked during household survey and results are presented in table 7. Estimation of wood out-take involved assessment of cut stumps in sample plots during inventory of the woodland. Appendix 9 shows distribution of stem density, basal area and volume of cut wood from the miombo woodland. Results demonstrate that, about 2.00 $m^3$ per hectare of wood resources is extracted annually from UFR (Appendix 9). This is a function of various livelihood activities undertaken in the miombo woodland (Figure 19). Figures 13, 14 and 15 present distribution of cut wood for different stocking parameters (N, G and V) in the miombo woodland. Results in figure 13 shows that, most out-take of wood from the miombo woodland involve cutting trees and shrubs in II, III diameter classes followed by I, IV, V and VI diameter classes. Despite that little proportion of wood of diameter class classes IV, V and VI is cut but it contribute to reasonably higher basal area and volume (Figure 14 and 15). This explains why there is relatively poor stocking of standing crop in the miombo woodland. Figure 16 illustrate distribution of cut tree and shrub species in the miombo woodland. Results in figure 16 reveal that, *Brachystegia spiciformis, Jubernadia globiflora* and *Afzelia quanzensis* are the highly extracted species. These findings tally with results on preferred species for various uses in this study.



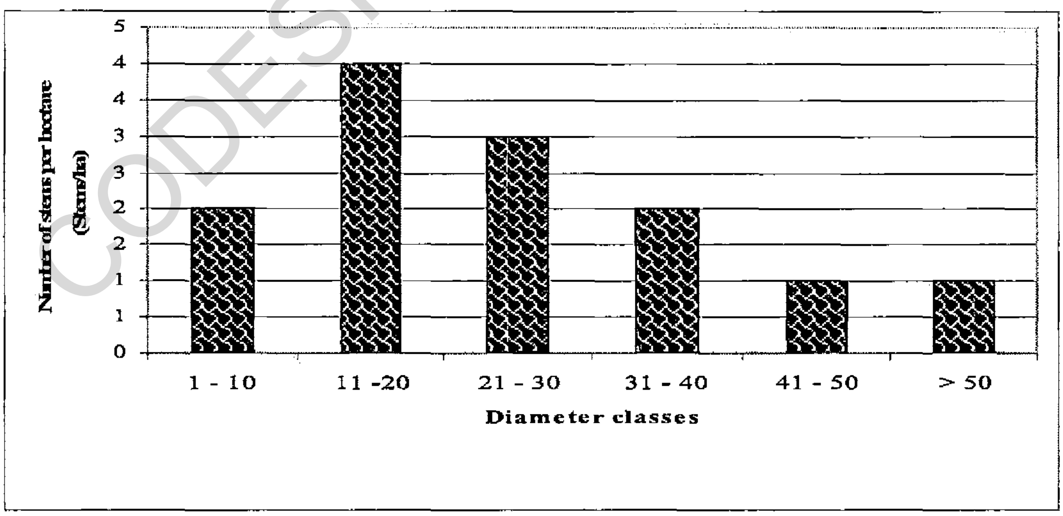



**Figure 13: Distribution of stems density of cut wood by diameter classes in UFR (Sample plots = 70)**

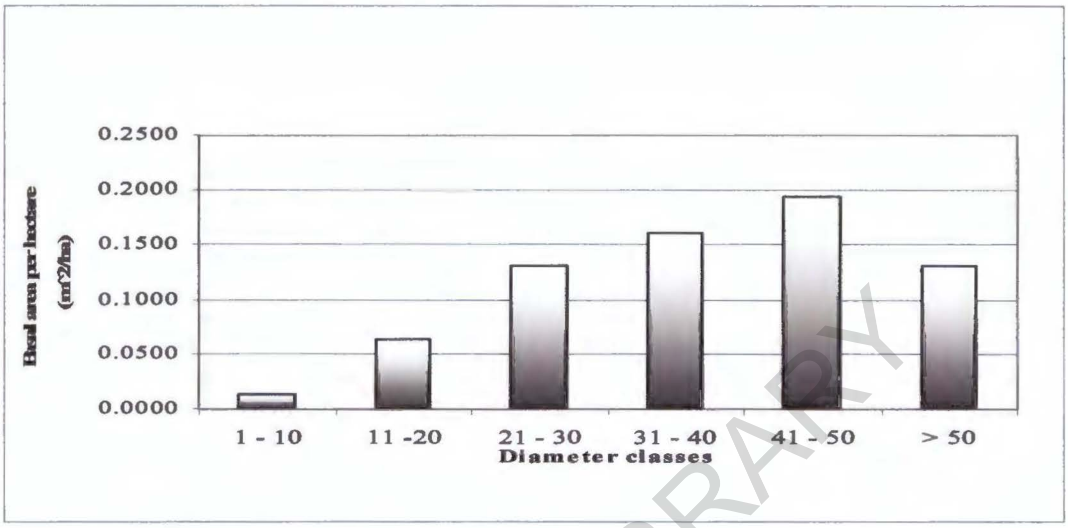



**Figure 14: Distribution of basal area of cut wood by diameter classes in UFR (Sample plots = 70)**

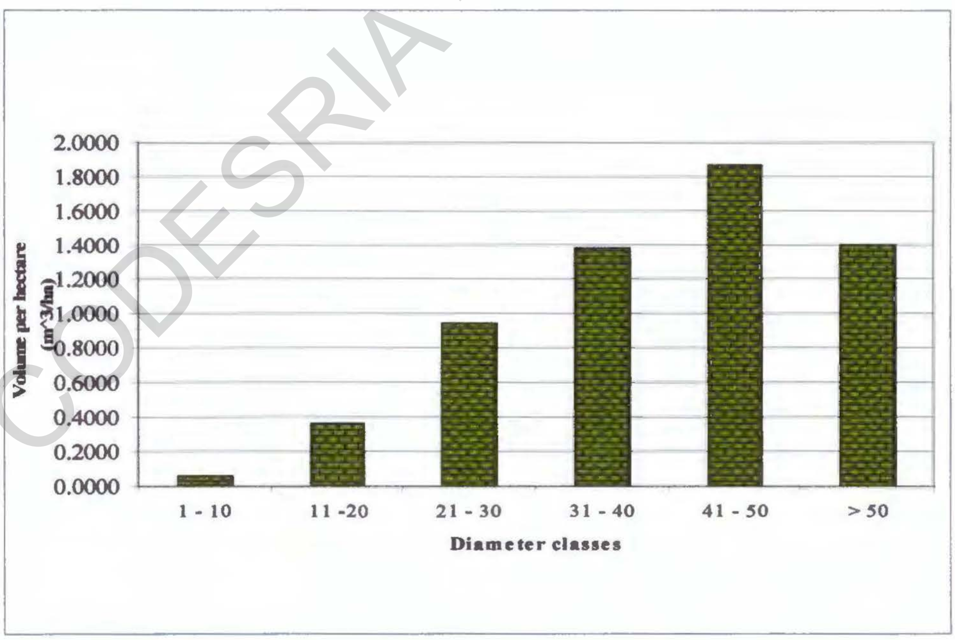



**Figure 15: Distribution of volume of cut wood by diameter classes in UFR (Sample plots = 70)**

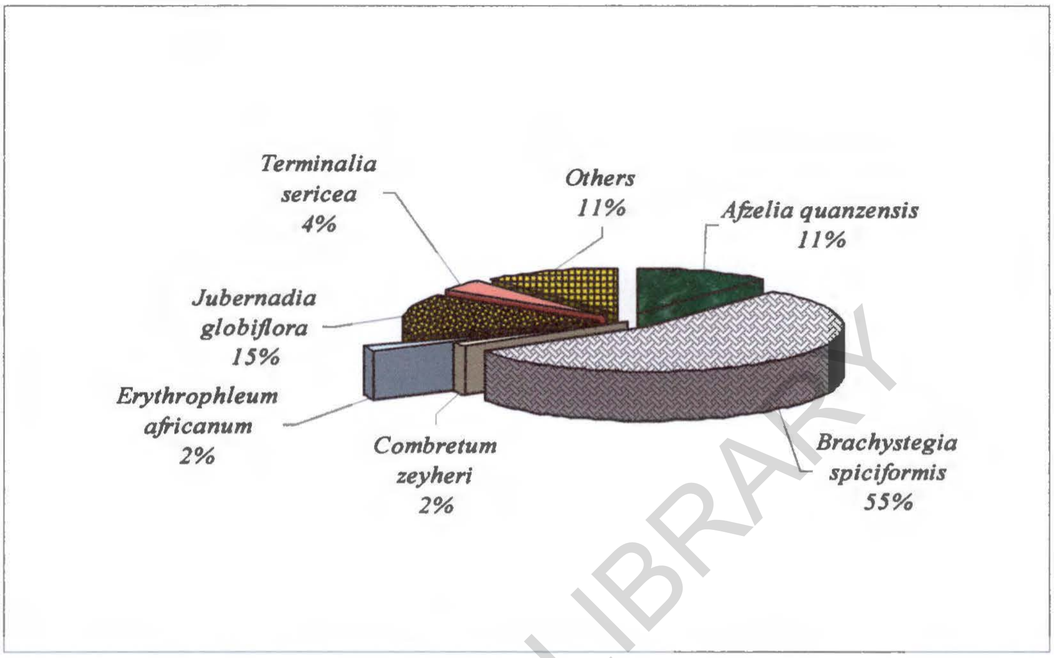



**Figure 16: Distribution of volume of cut wood by species in UFR (Number of species = 22)**

This study has identified charcoal making, firewood collection, pole cutting and lumbering as the prominent livelihood activities undertaken in the miombo woodland of UFR (Figure 17). Charcoal contributes to excessively high out-take volume of wood since charcoal making involves clear-cutting of trees and shrubs (Plates 1 and 5).

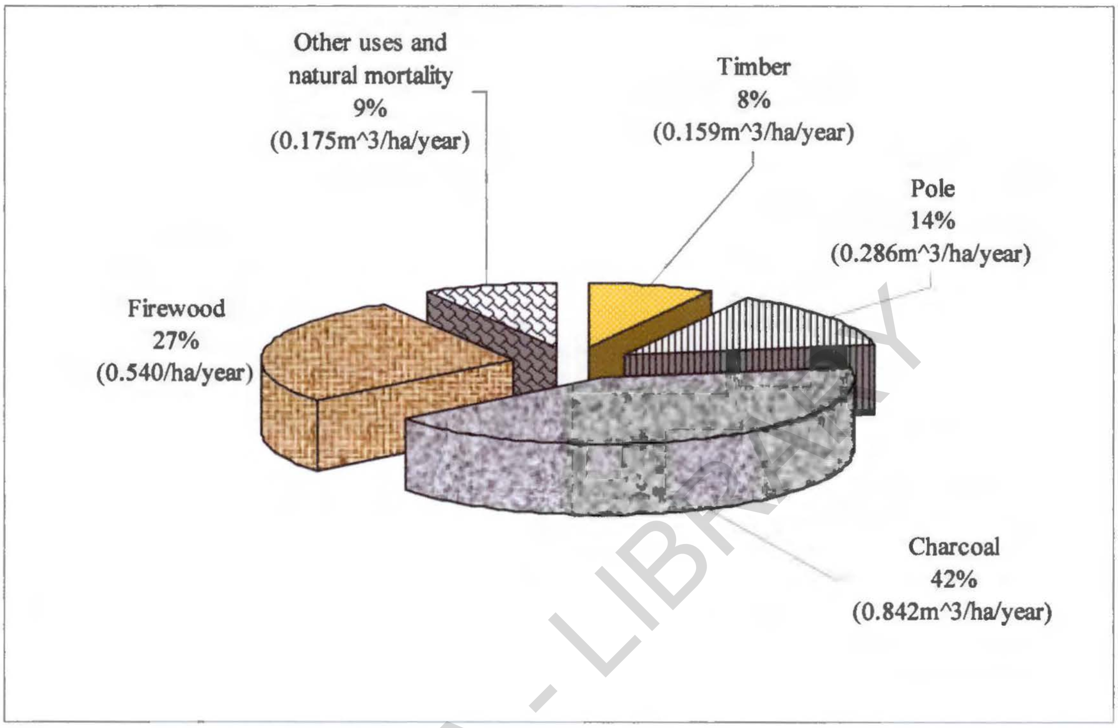



**Figure 17: Use distribution of harvested wood in UFR (Number of stumps = 126; Number of species = 22)**

Mean annual increment is important in deciding amount of wood out-take. Malimbwi *et al.* (2005) found mean annual increment (MAI) of 2.35 $m^3$ per ha per year in miombo woodlands of Kitulangalo, Tanzania. Similar results are recorded by Temu (1980) and Nilsson (1986) in studies done in miombo woodlands of Tanzania. This shows that, annual wood out-take in the study area almost equals the mean annual increment which means using nearly all profit made. The plausible reason for such use pattern is done without institutional control on species and sizes to remove. This may therefore lead to extinction of some species or overexploitation of some size classes hence eventually unsustainable. This observation is in line with Dewees (1994) who described that, miombo woodlands have been subjected to intensive use such that very few unmodified miombo woodlands remaining. Likewise other scholars who have worked in miombo woodlands have remarked that, utilization of miombo woodlands are unsustainable and inefficient (Nduwamungu, 2001; Maliondo *et al.*, 2005; Monela and Abdallah, 2007). Findings in this study have shown than UFR provide a range of products and services that support livelihoods of local communities in a number of dimensions, accordingly, this call for sustainability of the miombo woodland stock in order to sustain the many livelihoods supported by the woodland. This will be achieved through effective institutional framework for the management of the miombo woodland. An effective institutional framework is that which facilitate regulated miombo woodland resources geared towards achieving both sustained miombo woodland stock and improved livelihoods of the miombo woodland dependent communities. This will lead into a win-win situation. Otherwise if the prevailing situation persevere, communities around UFR are likely to be vulnerable in the near future when woodland stock will be depleted hence negatively affecting livelihoods of communities around UFR which are mostly woodland dependent. Such a situation will be a heavy blow to the communities which will be obliged to develop new livelihood strategies so as to cope and recover from shock and stress.

Table 7 shows availability of woodland resources in UFR, these results indicate that, most resources are fairly or scarcely available. Similar results were noted during PRA exercises that, woodland resources are growingly becoming rare over time. The plausible reason for this could be excessive and uninstitutionalised charcoal making which as said earlier though selective in species and size of trees and shrubs to be cut, involve clear-felling (Plates 1 and 4). This is a threatening trend which if continue in the same line is likely to lead into depletion of the miombo woodland a situation that will subject miombo woodland dependent communities into a vulnerable atmosphere and perhaps poverty trap.

**Table 7: Availability of resources in UFR**

| | Availability | | | |
|---|---|---|---|---|
| | Plenty | Fair | Scarce | Overall |
| Woodland resources | f (%) | f (%) | f (%) | f (%) |
| Firewood | 49 (34) | 14 (10) | 1 (1) | 64 (16) |
| Charcoal material | 5 (3) | 5 (4) | 0 (0) | 10 (3) |
| Pole | 18 (13) | 19 (14) | 9 (8) | 46 (12) |
| Timber | 0 (0) | 2 (1) | 12 (10) | 14 (4) |
| Medicinal plant | 8 (6) | 13 (9) | 3 (3) | 24 (6) |
| Wild vegetable | 2 (1) | 6 (4) | 7 (6) | 15 (4) |
| Bee forage | 1 (1) | 11 (8) | 15 (13) | 27 (7) |
| Wild fruit | 3 (2) | 14 (10) | 13 (11) | 30 (8) |
| Mushroom | 2 (1) | 2 (1) | 11 (9) | 15 (4) |
| Fodder/pasture | 23 (16) | 6 (4) | 1 (1) | 30 (8) |
| Thatching grass | 8 (6) | 25 (18) | 8 (7) | 41 (10) |
| Rope | 25 (17) | 12 (9) | 3 (3) | 40 (10) |
| Beehive material | 0 (0) | 6 (4) | 9 (8) | 15 (4) |
| Wildlife | 0 (0) | 0 (0) | 23 (20) | 23 (6) |
| **Total** | **144 (100)** | **138 (100)** | **117 (100)** | **399 (100)** |

It is said, sustainable livelihoods depend on environmental sustainability, but more specifically on the manner in which the natural resource stock is used (Foster *et al.*, 2001 cited in Fratkin *et al.*, 2006).

### 4.5 Socio – economic and institutional factors enabling or constraining contribution of the miombo woodland to local communities' livelihoods

Contribution of miombo woodland to local communities depends on a number of factors that may include socio-economic and institutional factors. Logistic regression model was employed in the assessment of socio-economic and institutional factors enabling or constraining the contribution of miombo woodland resources to local communities' livelihoods. The goodness of fit of the model was found to fit well with findings of this study (77%) (Table 8). A chi-square value of 35.64 with a degree of freedom of 10 was highly significant at 5% probability level (P=0.00), meaning that, the independent variables (socio-economic and institutional) affected very well the dependent variable. Likewise, the – log likelihood (-2LL) value of 66.65 indicated that, the model fitted the data well. Besides, the classification power of the model was able to accurately classify respondents by 80% into households which reported and those which did not report the contribution of miombo woodland resources to their livelihoods. Table 8 shows that Wald statistics are non-zero values, which implies that there is interaction between the dependent and independent variables. According to Norusis (1990) and Powers and Xie (2000) the non-zero Wald statistic values indicates the presence of relationships between the dependent and explanatory variables. Thus, with reference to the results revealed in this study the null hypothesis was rejected in favour of the alternative hypothesis that Socio-economic and institutional factors significantly enable contribution of the miombo woodland to local communities' livelihood at 5% level of significance.

**Table 8: Factors underlying the contribution of woodland resources to livelihoods of local communities in UFR**

| | β | S.E. | Wald | d.f | Sig. | Exp(β) |
|---|---|---|---|---|---|---|
| Household size | 0.137 | 0.158 | 0.743 | 1 | 0.389 ns | 1.146 |
| Cultivated land size | -1.127 | 0.420 | 7.191 | 1 | 0.007 * | 0.324 |
| Hunger period | 1.061 | 0.696 | 2.326 | 1 | 0.127 ns | 2.891 |
| Livelihood activities | 0.827 | 0.701 | 1.392 | 1 | 0.238 ns | 2.287 |
| Distance | -0.143 | 0.184 | 0.608 | 1 | 0.435 ns | 0.866 |
| Woodland access rules | 1.374 | 0.682 | 4.052 | 1 | 0.044 * | 3.950 |
| Woodland tenure | -0.136 | 0.711 | 0.037 | 1 | 0.068ns | 0.872 |
| Market and demand of woodland resources | 0.656 | 0.747 | 0.770 | 1 | 0. 083 ns | 1.927 |
| Constant | 2.812 | 1.763 | 2.542 | 1 | 0.111 ns | 16.637 |

Number of cases = 84, Exp (ß) = odds ratio (probability of success/probability of failure), SE= standard error of the estimate, *Statistically significant at 0.05 level of significance, ns = statistically non significant at 0.05 level of significance, Sig = significance, ß = regression coefficients which stand for the odds ratio of probability of success to the probability of failure and Wald statistics = $ß/(SE)^2$, d.f = degree of freedom.

These findings are in line with the study conducted in miombo woodlands in Tanzania by Monela *et al.* (2000) who argued that, production and marketing of timber, wildlife and honey harvested from the miombo woodlands contribute significantly to the income of local communities and individuals through local and overseas trading.

This study came up with the following socio-economic factors: Ethnicity, household size, age, education, hunger periods, livelihood activities, market and demand of miombo woodland resources, cultivated land size and distance. Institutional factors include: Institutional arrangement in the miombo woodland, woodland access rules, miombo woodland tenure and miombo woodland governance (Table 8). These factors are discussed in the subsequent sub-section:

### 4.5.1 Enabling socio-economic factors

#### 4.5.1.1 Ethnicity

Table 9 shows that, majority of interviewed households belonged to Nyamwezi ethnic tribe (62%) followed by Sukuma (24%). Others constitute minority ethnic tribes which include: Konongo (4%), Fipa (2%), Nyaturu (4%) and Sumbwa (4%). It was observed that, the Nyamwezi tend to settle in village centers while the Sukuma tend to confine themselves in the periphery of the villages. It is plausibly due to structural arrangement so as to allow free grazing of livestock since the Sukuma are characterized as agro-pastoralists.

**Table 9: Ethnic diversity in UFR**

| Characteristics | Mtakuja f (%) N = 14 | Isukamahela f (%) N = 12 | Masimba f (%) N = 9 | Kipalapala f (%) N = 49 | Overall f (%) N = 84 |
|---|---|---|---|---|---|
| **Ethnic diversity** | | | | | |
| Nyamwezi | 8 (57) | 10 (84) | 1 (11) | 34 (69) | 53 (62) |
| Sukuma | 4 (28) | 1 (8) | 7 (78) | 8 (16) | 20 (24) |
| Konongo | 0 (0) | 0 (0) | 0 (0) | 3 (6) | 3 (4) |
| Fipa | 1 (7) | 0 (0) | 0 (0) | 1 (2) | 2 (2) |
| Nyaturu | 0 (0) | 1 (8) | 0 (0) | 2 (4) | 3 (4) |
| Sumbwa | 1 (7) | 0 (0) | 1 (11) | 1 (2) | 3 (4) |
| **Total** | **14 (100)** | **12 (00)** | **9 (100)** | **49 (100)** | **84 (100)** |

According to Abdallah (2001), the Nyamwezi are mostly farmers, beekeepers or both. Accordingly, it shows that different ethnic communities perceive miombo woodlands differently (Kajembe and Kessy, 2000). Perception is subject to the derived livelihoods, the Sukuma as agro-pastoralist communities look mainly at the miombo woodlands as grazing areas while Nyamwezi as farmers define miombo woodlands as a source of charcoal, firewood for cooking and tobacco curing and timber among others. It is therefore evident that ethnicity promote contribution of the miombo woodlands to livelihoods of local communities. Kajembe and Kessy (2000) and Abdallah (2001) reported similar findings.

#### 4.5.1.2 Household size

Household size determines per capita collection and utilization of miombo woodland products hence contribution to communities' livelihoods. Household size has positive regression coefficient (β) of 0.137 and the odds ratio (Exp β) of 1.146 (Table 8), this suggest that household size in the study area enables the contribution of miombo woodlands to livelihoods of local communities. This means that, since the regression coefficient is positive the unit change in this variable will increase the likelihood of the miombo woodland's contribution to household hence livelihood by a factor 1.146. In other words, given most household members in the study area lie in the working class (31 – 51 years old), the larger the household size the higher the chances that members of households will be involved in various livelihood strategies as diverse as including collection of miombo woodland resources geared towards contribution to households' livelihood. However, the effect of household size on odds of contribution of the miombo woodland was not statistically significant (Table 8) yet the variable very important in livelihood context. This study found mean household size of 6 individuals.

#### 4.5.1.3 Age

In this study, age ranged between 31 and 51 years with mean age of 43 $\pm$ 4 (SE) years. Individuals in such age class are involved actively in diverse livelihood activities both farm and off-farm. These results suggest that, age of respondents in the study area enables contribution of the miombo woodland to livelihoods of local communities since there are chances of households being involved in livelihood activities which in one way or another depend on miombo woodlands.

#### 4.5.1.4 Education

Education is an important item in development of livelihood strategies, it determine which livelihood activities a household is involved. In the study area, 82% of respondents have received at least primary school (Table 10). This means that very few are illiterate; thus, results suggest that, education is an enabling factor that shape households in the study area into various livelihood activities that include exploring miombo woodlands as a natural capital.

**Table 10: Education status of communities surrounding UFR**

| Characteristics | Mtakuja f (%) N = 14 | Isukamahela f (%) N = 12 | Masimba f (%) N = 9 | Kipalapala f (%) N = 49 | Overall f (%) N = 84 |
|---|---|---|---|---|---|
| **Education status** | | | | | |
| No formal education | 3 (21) | 0 (0) | 5 (56) | 7 (14) | 15 (18) |
| Primary school | 11 (79) | 11 (92) | 4 (44) | 39 (80) | 65 (77) |
| Secondary school | 0 (0) | 1 (8) | 0 (0) | 3 (6) | 4 (5) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |

#### 4.5.1.5 Hunger periods

Hunger periods experienced by households are determinant factors on dependence of miombo woodlands as source of livelihoods. Table 8 shows that, hunger periods has a positive regression coefficient ($\beta = 1.061$) with odds ratio of 2.891; that is an increase in hunger period increases the likelihood of the miombo woodland's contribution to local communities' livelihoods by a factor 2.891 and vice versa. This implies that, a unit increase in hunger period forces households to derive their livelihoods from miombo woodlands. Hunger period is statistically not significant at probability level of 5% ($p = 0.127$). The study indicates that, hunger period experienced by households in the study area range from 0 to 7 months with a mean of 4.3. Such hunger period is large enough to promote livelihood strategies.

Farming is among the major livelihood activities in the study area. Figure 18 shows type of crops grown in the study area, they include: maize (100%), millet (8%), sweet potatoes (82%), cassava (39%) and groundnut (58%). Results in Table 11 shows that, about half (56%) of all respondents are food secure. It was observed that, the use of poor agricultural implements and technology (11%), draught (51%), poor seed quality (4%), poor land fertility (21%) and inadequate land for agriculture are among the reasons which results into food shortage (11%) (Table 12). These results indicate that, households in the study area are highly affected by draught which results into poor harvest hence long hunger periods.

**Table 11: Status of food security in the study area**

| Food security | Mtakuja f (%) N = 14 | Isukamahela f (%) N = 12 | Masimba f (%) N = 9 | Kipalapala f (%) N = 49 | Overall f (%) N = 84 |
|---|---|---|---|---|---|
| Yes | 6 (43) | 7 (58) | 6 (67) | 28 (57) | 47 (56) |
| No | 8 (57) | 5 (42) | 3 (33) | 21 (43) | 37 (44) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |

**Table 12: Causes of food insecurity in the study area**

| Reasons | Mtakuja f (%) N = 14 | Isukamahela f (%) N = 12 | Masimba f (%) N = 9 | Kipalapala f (%) N = 49 | Overall f (%) N = 84 |
|---|---|---|---|---|---|
| Use of poor agricultural implements and technology | 3 (21) | 1 (10) | 1 (25) | 3 (7) | 8 (11) |
| Draught | 7 (50) | 5 (50) | 3 (75) | 21 (49) | 36 (51) |
| Poor seed quality | 0 (0) | 0 (0) | 0 (0) | 3 (7) | 3 (4) |
| Poor land fertility | 3 (21) | 4 (40) | 0 (0) | 8 (19) | 15 (21) |
| Inadequate land for agriculture | 1 (7) | 0 (0) | 0 (0) | 8 (19) | 8 (11) |
| **Total** | **14 (100)** | **10 (100)** | **4 (100)** | **43 (100)** | **71 (100)** |



Findings of this study reveals that, as a result of food insecurity and hunger periods, households have developed a number of livelihood strategies which include: purchase of food, use of miombo woodland resources, work as casual labour, selling of livestock, reduce number of meals and remittances (Table 13). The use of miombo woodlands as source of food and income generation scored higher (32%) compared to other livelihood strategies (Table 13). These results show that hunger periods promotes households to depend on miombo woodlands as source of their livelihoods.

**Table 13: Livelihood strategies to cope with inadequate crop harvest**

| Strategies | Mtakuja f (%) N = 14 | Isukamahela f (%) N = 12 | Masimba f (%) N = 9 | Kipalapala f (%) N = 49 | Overall f (%) N = 84 |
|---|---|---|---|---|---|
| Purchase food | 0 (0) | 0 (0) | 0 (0) | 1 (3) | 1 (2) |
| Use woodland resources (as food and or income generating source) | 3 (21) | 5 (63) | 1 (17) | 11 (35) | 19 (32) |
| Casual labour | 2 (21) | 0 (0) | 2 (33) | 9 (29) | 13 (22) |
| Selling livestock | 1 (7) | 3 (38) | 3 (50) | 1 (3) | 7 (12) |
| Reduce number of meals | 6 (43) | 0 (0) | 0 (0) | 4 (13) | 10 (17) |
| Remittances | 2 (140 | 0 (0) | 0 (0) | 5 (16) | 7 (12) |
| **Total** | **14 (100)** | **8 (100)** | **6 (100)** | **31 (100)** | **59 (100)** |

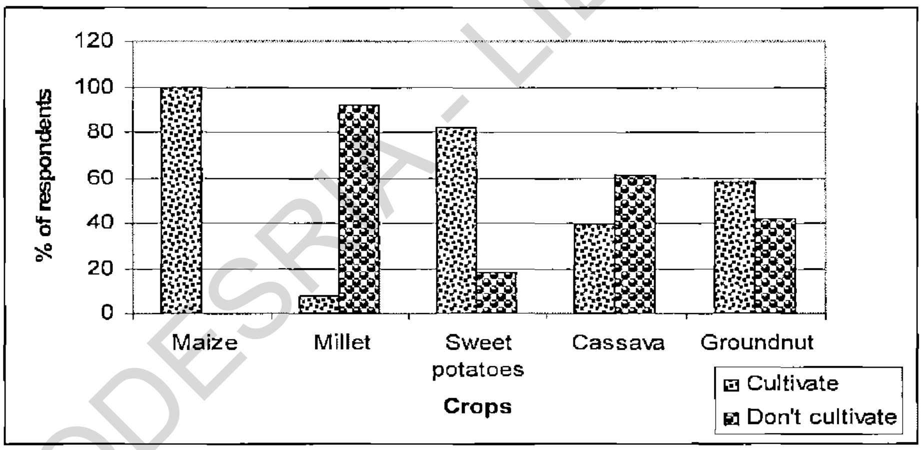



**Figure 18: Type of crops cultivated in the study area (N = 84)**



### 4.5.1.6 Livelihood activities

Livelihood activities practiced by households in the study area have a positive regression coefficient (β) of 0.827 with odds ratio (Exp β) of 2.287, meaning that, a unit increase in livelihood activity will increase the likelihood of miombo woodland's contribution to local communities' livelihood by a factor 2.287 and vice versa (Table

8). Figure 19 shows livelihood activities identified in the study area, like many places in rural areas, farming received 46% respondents among livelihood activities practiced in the study area. In this study, farming excluded an account of tobacco farming so as to capture miombo woodlands dependent livelihoods. About 3% of respondents are involved in tobacco in villages around. Tobacco farmers depend on the miombo woodlands as a source of firewood for tobacco curing. Other livelihood activities which depend on miombo woodlands include: livestock keeping (11%), beekeeping (8%), brick burning (10%), charcoal making (6%), lumbering (9%) and collection of medicinal plants (3%). These results indicate that, livelihood activities enable the contribution of miombo woodlands to local communities' livelihoods. However, Table 8 shows that, the effects of livelihood activities on the miombo woodland's contribution to livelihoods of local communities were not statistically significant at probability level of 5% (p = 0.238).



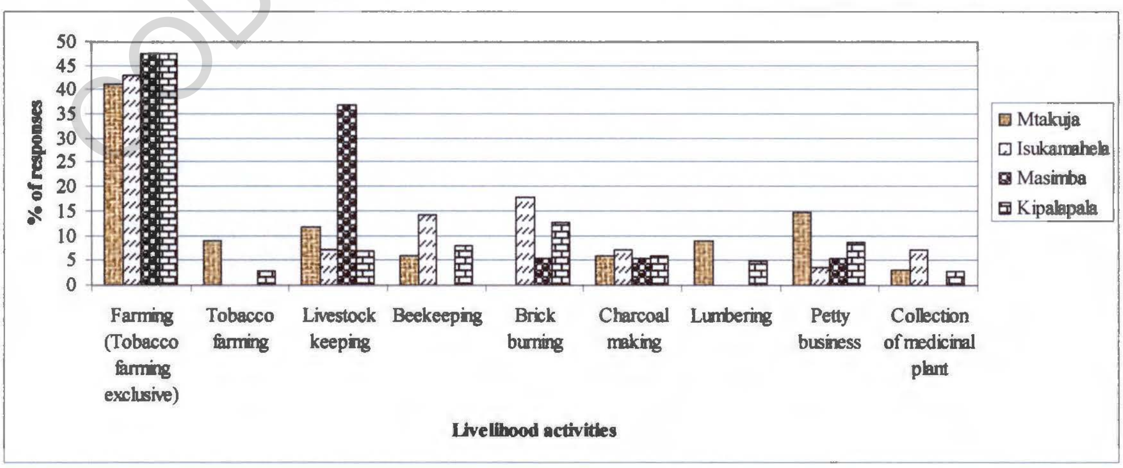



**Figure 19: Livelihood activities in the study area (N = 84)**

#### 4.5.1.7 Market and demand of miombo woodland resources

Market and demand of miombo woodland resources are important factors that determine contribution of the miombo woodland's contribution to local communities' livelihoods. Market and demand of miombo woodland resources have positive regression coefficient (β = 0.656) with odds ratio of 1.927 (Table 8). This implies that, a unit increase in market and demand of miombo woodland resources will enable the odds of miombo woodland's contribution to livelihoods of local communities by a factor 1.927. Majority (80%) of respondents in the study area claimed that, there is market for miombo woodland resources. Traded resources which are accrued from the miombo include: Firewood, charcoal, pole, timber, medicinal plant, edible wild fruit, edible mushroom, honey, beewax and thatching grass. However, there is variation in demand of these resources; timber, charcoal and firewood receive high demand (83%), medicinal plant, honey and beewax are fairly demanded (60%) while edible wild fruit, edible mushroom and thatching grass are poorly demanded. The plausible reason for resources identified as highly demanded could be high dependence of these resources e.g. charcoal and firewood are widely used as Wood fuel both in urban and rural areas in the country; likewise, timber is an important resources for various construction purposes and for furniture. However, demand and market of miombo woodland resources is not statistically significant at probability level of 5% (p = 0. 083). Despite that, the factors are quiet important as they determine chances of the miombo woodland's contribution to livelihoods of local communities. Market forces of miombo woodland resources in Tabora include: Bakeries, institutions (TTC, Prisons and

JWTZ), local people (rural and urban), carpentry workshops and Tabora Beekeepers' Association. UFR is the only miombo woodland closest from Tabora municipality compared to others in the region, thus it is highly depended as a source of various miombo woodland resources.

### 4.5.2 Enabling institutional factors

#### 4.5.2.1 Institutional arrangement in management of the miombo woodland

The miombo woodland is a Central Government forest reserve currently managed in what is known as 'Pilot JFM' since 1996. Uyui district office, Tabora, Tanzania represents the FBD in the management of UFR. During a discussion with Uyui DFO it was realized that, JFM in UFR was initiated following requests posed by villagers to be granted access to use the woodland resources. This is because villages around the woodland had high demand of wood and non-wood resources and none in the neighbouring except UFR. A total of eight villages surrounding the woodland were contracted, the contract stipulate user rights and responsibilities. Through such institutional arrangement, communities around UFR are able to derive their livelihoods. Similarly, the National Forest Act (2002) and National Forest Policy (1998) foster involvement of adjacent in management of forests and woodlands. Through such settings, communities are entitled to derive benefits (products and services) from forests and woodlands and transform them into livelihood outcomes.

Results in table 14 shows that, 46% of all respondents are aware of JFM practice in UFR. Others are either unaware of JFM existence in UFR, this signify that there is 'knowledge vacuum' and perhaps a governance issue. Accordingly, this may results into some communities being marginalized that is, some communities' members due to 'knowledge vacuum' may be constrained from access and hence derive their livelihoods from the woodland. Wily and Monela (1999) asserted that, JFM in the woodland is poorly planned and remains poorly grounded.

**Table 14: Awareness of management regime in management of UFR**

| | Mtakuja f (%) N = 14 | Isukamahela f (%) N = 12 | Masimba f (%) N = 9 | Kipalapala f (%) N = 49 | Overall f (%) N = 84 |
|---|---|---|---|---|---|
| **Management regime** | | | | | |
| Joint Forest Management | 5 (36) | 9 (75) | 4 (44) | 21 (43) | 39 (46) |
| Non-Joint Forest Management | 2 (14) | 0 (0) | 2 (22) | 9 (18) | 13 (15) |
| Don't know | 7 (50) | 3 (25) | 3 (33) | 19 (39) | 32 (38) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |



### 4.5.2.2 Miombo woodland access rules

Results in table 8 indicate that, miombo woodland access rules have a positive regression coefficient value of 1.374 and the odds ratio of 3.950. This implies that, an increase in woodland access rules significantly ($p = 0.044$) enables the miombo woodland's contribution to local communities' livelihoods by a factor 3.950 and vice versa. This is supported by results in Table 15 which reveal that, majority of respondents (74%) across study villages are not constrained by the miombo woodland access rules.

Discussions with Uyui DFO who is responsible for the management of UFR indicated that local communities' user rights of the miombo woodland include: collection of firewood, poles, thatching grass, timber, mushroom, gum, vegetables, honey and charcoal. Others are collection of medicinal plants, edible fruits, rope and insect. Charcoal making is among the user rights on condition that it is undertaken outside the forest reserve.

**Table 15: Woodland access mechanisms in UFR**

| | Mtakuja f (%) N = 14 | Isukamahela f (%) N = 12 | Masimba f (%) N = 9 | Kipalapala f (%) N = 49 | Overall f (%) N = 84 |
|---|---|---|---|---|---|
| **Woodland access rules** | | | | | |
| Doesn't constraint | 9 (64) | 8 (67) | 6 (67) | 39 (80) | 62 (74) |
| Constraint | 5 (36) | 4 (33) | 3 (33) | 10 (20) | 22 (26) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |
| **Woodland access** | | | | | |
| Permission | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Freely | 9 (64) | 12 (100) | 3 (33) | 42 (86) | 66 (79) |
| Illegally | 5 (36) | 0 (0) | 6 (67) | 7 (14) | 18 (21) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |

Livestock grazing and farming in the forest reserve are not listed among the user rights thus they are illegal livelihood activities. Each village was allocated a harvesting coupe that facilitated communities to derive their livelihoods through user rights in the miombo woodland. In this context, a coupe is defined as an area where clear-cutting/thinning operations are carried out by preserving designated seed trees and/ or other valuable trees as deemed necessary by the FBD which is the owner. From this it clearly shows that user rights enable the miombo woodland's contribution to local communities' livelihoods.

Table 16 shows that, 64% majority of communities in the study area are aware of their user rights in the miombo woodland. Communities' awareness on their user rights in the miombo woodland is important as it allows them to explore such opportunities in favour of their respective livelihoods. However, Table 16 shows that 36% of respondents in the study are unaware of their user rights as stipulated in the JFM arrangement. This may have been caused by ineffective awareness creation and extension services in the area.

**Table 16: Awareness of local communities on the miombo woodland user rights**

| User rights awareness | Mtakuja f (%) N = 14 | Isukamahela f (%) N = 12 | Masimba f (%) N = 9 | Kipalapala f (%) N = 49 | Overall f (%) N = 84 |
|---|---|---|---|---|---|
| Aware | 10 (71) | 9 (75) | 8 (89) | 27 (55) | 54 (64) |
| Unaware | 4 (29) | 3 (25) | 1 (11) | 22 (45) | 30 (36) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |



### 4.5.3 Constraining socio-economic factors

#### 4.5.3.1 Cultivated land size

Cultivated land size has negative regression coefficient (β) of -1.127 with odds ratio (Exp β) of 0.324 which was statistically significant ($p = 0.007$) (Table 8). This mean an increase in one unit of cultivated land size decrease chances of the miombo woodland's contribution to households' livelihood by a factor 0.324 and vice versa. This imply that, if a household have large land to cultivate will harvest more thus will become self sufficient in terms of food and income, as a result little or not involved very much in miombo woodland related livelihoods. Table 17 shows that, all interviewed households possess land for agriculture; further more, most households land is acquired through inheritance (61%).

This study found mean cultivated land size of 1.5 hectares per household. It was further observed that, such land size produces an average of 4.5 $\pm$ 0.5 (SE) bags of maize annually. Figure 18 shows that, maize is the main food crop cultivated in the study area.

**Table 17: Characteristics of respondents on farm-land in the study area**

| Characteristics | Mtakuja f (%) N = 14 | Isukamahela f (%) N = 12 | Masimba f (%) N = 9 | Kipalapala f (%) N = 49 | Overall f (%) N = 84 |
|---|---|---|---|---|---|
| **Land holding** | | | | | |
| Yes | 14 (100) | 12 (100) | 9 (100) | 49 (100) | 84 (100) |
| No | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |
| **Land acquisition** | | | | | |
| Inherited | 9 (64) | 11 (92) | 4 (44) | 27 (55) | 51 (61) |
| Bought | 5 (36) | 1 (8) | 5 (56) | 22 (45) | 33 (39) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |

Thus, considering cultivated land size and the level of productivity it shows that cultivated land size is not adequate to produce food required to feed a mean household size of 6 individuals, besides it was observed that land is infertile which gives very little harvest annually. Participant observation showed that, parts of the miombo woodland have been encroached especially the '*mbugas*' which are seasonally flooded. '*Mbuga*' support paddy farming in the study area. The plausible reason for inadequate cultivated land size in the study area is limited suitable land for farming and growing population given land is an inelastic resource, population density in Tabora has increased from 14 persons per $km^2$ in 1988 to 23 persons per $km^2$ in 2002 (Population and Housing Census, 2002). Inadequacy of suitable land for farming place communities in a relatively vulnerable situation, to combat such vulnerability households have developed livelihood strategies such as firewood collection, charcoal making and brick burning through which households earn supplementary income which mitigate their hardship. All these livelihood strategies are supported by the only nearby miombo woodland of UFR.

#### 4.5.3.2 Distance

Distance from homestead to the miombo woodland in the study area have a negative regression coefficient (β) of -0.143 with odds ratio (Exp β) of 0.866, this implies that, a unit increase in distance between homestead and the miombo woodland will constrain the likelihood of miombo woodland's contribution to local communities' livelihood by a factor 0.866 and vice versa (Table 8). The factor is not statistically significant at probability level of 5% ($p = 0.435$). The distance between homestead and UFR ranged from 0.5 to 5 km with a mean of 1.8. Similarly, Grundy *et al.* (1983) recorded spatial effects of miombo woodland resource use in Mutanda Resettlement area, Zimbabwe, noted that, increase in distance from homestead to the woodland raised costs of resource collection and vice versa. McGregor (1995) in his study conducted in Shirungwi, Zimbabwe argued that, rising scarcities of woodland resource caused increase in distance to woodland food resources.

### 4.5.4 Constraining institutional factors

#### 4.5.4.1 Miombo woodland tenure

Results presented in Table 8 indicate that, miombo woodland tenure has a negative regression coefficient value of -0.136 and the odds ratio 0.872. This shows that, the likelihood of the miombo woodland's contribution to local communities' livelihoods constrained by a factor 0.872 for every increase in this variable and vice versa. All respondents acknowledged that, the woodland is owned by the government, even though they generally expressed their opinion that, woodland tenure is a constraint to them in terms of the woodland's contribution their livelihoods. It was further noted that, communities in the study area are able to derive their livelihoods from the woodland as a result of JFM arrangement. However, the JFM arrangement is in the form of contract, the life span of the contract is two years. Currently, the contract has expired since 2002. The contract was not renewed after 2002 because JFM arrangement in UFR was mainly initiated by Forest Resources Management Project (FRMP), which was funded by World Bank and phased out in 1999. The emphasis of FRMP was a shift from state-driven regime of forest management to collaborative forest management (Wily and Monela, 1999). Despite that, contracts are not suspended and communities continue benefiting by depending on the woodland as a source of their livelihoods. The challenge to communities lie on 'tenure', they lack security with their user rights to the miombo woodland. Tenure includes the right to secure long-term access to land and resources, their benefits and the responsibilities related to these rights. Had it been that, the miombo woodland holding dwell in the hands of communities they would have livelihood security. Researcher's observation noticed that, due to lack tenure security livelihood activities in the miombo woodland are unsustainable and the pattern is likely to increase due to observed weak institutional arrangements at district and local levels. However, woodland tenure was not statistically significant at 5% probability level (p = 0.068). According to FAO (2001) security of tenure is a critical yet often under acknowledged component in determining how rural people can improve their livelihoods and reduce poverty. Tenure, if clearly defined enables local communities to protect forests and woodlands from encroachment so as to increase their benefits.



#### 4.5.4.2 Governance in the miombo woodland

Institution responsible for the management of UFR is FBD represented by Uyui District Forest Office, Forest Resources Management Project (FRMP) and village governments. The role of the Uyui DFO is to provide technical support and facilitate the implementation of JFM in UFR. FRMP a World Bank Funded Project operated since 1996 to 1999. Its main objective was to empower villagers to manage the woodland and enhance sustainable harvesting of resources from the woodland. The village governments catered their responsibilities of managing the woodland through village woodland management committees. Village woodland management committees were institutionalised with the main responsibilities of carrying out patrols in the woodland and implement woodland village by-laws on daily basis.

This study found that woodland management committees are no-more in all studied villages and that there is no any form miombo woodland governance at local level where by 87% said that there is no woodland management committee and 13% are not aware of its existence (Table 18). Furthermore, majority of respondents (72%) are not aware of their responsibilities in management of the miombo woodland, this finding concur with an observation that, no any role played by local communities in management of the miombo woodland (Table 18).

During PRA exercises results show that, institutions responsible for the management of UFR are not coordinated (Figure 20). This implies that, these institutions do not fulfill their responsibilities and are ineffective. Discussions with Uyui DFO explored that, their role in provision of technical support and implementation of JFM in UFR was lagging behind. Reasons behind are inadequate staff and funding from FBD.



**Table 18: Local authority and awareness in management of UFR**

| Existence of woodland management committee | Mtakuja f (%) N = 14 | Isukamahela f (%) N = 12 | Masimba f (%) N = 9 | Kipalapala f (%) N = 49 | Overall f (%) N = 84 |
|---|---|---|---|---|---|
| Yes | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| No | 11 (79) | 10 (83) | 7 (78) | 45 (92) | 73 (87) |
| Don't know | 3 (21) | 2 (17) | 2 (22) | 4 (8) | 11 (13) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |
| **Awareness of responsibilities** | | | | | |
| Aware | 3 (21) | 4 (33) | 2 (22) | 14 (29) | 23 (28) |
| Unaware | 11 (79) | 8 (67) | 7 (78) | 35 (71) | 61 (72) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |
| **Role played by communities in managing the woodland** | | | | | |
| Yes | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| No | 14 (100) | 12 (100) | 9 (100) | 49 (100) | 84 (100) |
| **Total** | **14 (100)** | **12 (100)** | **9 (100)** | **49 (100)** | **84 (100)** |

On the other hand village governments in the study area expressed their grievances that, they were not fostered in any way a situation that has led decline in local authority in management of the woodland which at the moment it is just a legend. Such institutional vacuum has certainly resulted into 'open access' situation whereby households carry out uninstitutionalised livelihood activities in the miombo woodland. This may be regarded as a constraint in sustaining both miombo woodland stock and livelihoods. Furthermore, during PRA villagers raised their voices saying that, during FRMP tenure JFM in UFR was really active and that they were well facilitated in term of frequent extension services and education. This implies that, FRMP a donor funded project was the main facilitator of JFM activities in the study area and that when it phased out all initiatives went in vain.



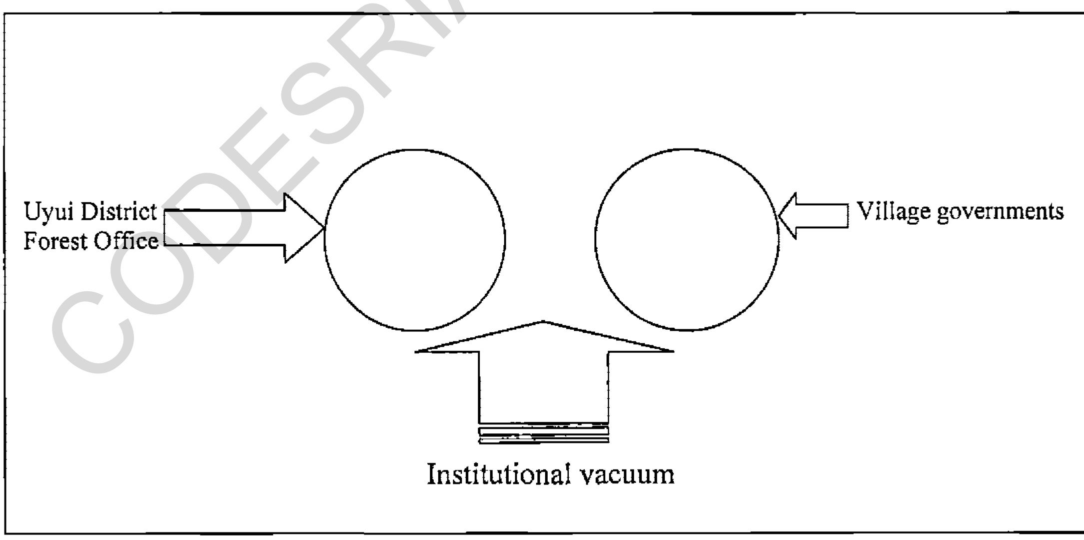



**Figure 20: Venn-diagram showing interaction of institutions responsible for management of UFR under JFM arrangements**

Results in Table 15 show that, communities in the study area access the woodland freely (79%) or illegally (21%). The plausible reason for this is weak or no institutions on the ground. Hardin (1968) suggested that, resources without clear ownership would be degraded because individuals would have no incentive to reduce their level of resource use if other people continued their use at unsustainable levels. Everyone would attempt to maximize use in the short term even when they could see long-term availability declining. The author further stressed that, indigenous management practices depend on the ability of communities to make and defend management rules. Having effective and credible local authorities is one such requirement.

# CHAPTER FIVE

## 5.0 CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

This study intended to assess tree and shrub species diversity and stocking in UFR and its contribution to livelihoods of surrounding communities. The study revealed that the miombo woodland of UFR has a reasonably good tree and shrub species composition and richness. Species noted to be both dominant and with high species diversity indices include: *Combretum zeyheri* (0.29), *Diplorhynchus condylocarpon* (0.21), *Jubernadia globiflora* (0.19), *Combretum molle* (0.17), *Combretum adenogonium* (0.15), *Brachystegia spiciformis* (0.14), *Terminalia sericea* (0.14) and *Brachystegia boehmii* (0.13). These dominant as well as highly diverse tree and shrub species fit quiet well within the general definition of miombo woodlands. Furthermore, logistic regression analysis employed in this study showed that, tree and shrub species diversity in the miombo woodland of UFR has positive relationship with contribution of the woodland to livelihood of local communities. This implies that, increase in species diversity of the miombo woodland increased chances of the miombo woodland's contribution to livelihoods of local communities. Thus, the null hypothesis was rejected and alternative hypothesis was adopted that is, tree and shrub species diversity in miombo woodlands contribute significantly on the livelihoods of the local communities at 5% probability level ($p = 0.036$). Generally speaking, the stocking of the miombo woodland was found to be good. Stem density of trees and shrubs depicted an inverted 'J' shape which is common shape for natural forests with active regeneration and recruitment; this indicates a good sign of sustainability of the woodland stock which has chances of insuring sustainable supply of products and services; and hence sustains livelihoods of the surrounding communities.

Findings of the study show that, miombo woodland of UFR contributes to livelihood of local communities through the products and services accrued by local communities from the miombo woodland. Products and services accrued from the miombo woodland by local communities include: firewood, charcoal, construction materials, wild food and medicinal plants. Other products and services include: beehive, beewax, fodder/pasture, attraction of rainfall and support of agriculture. Analysis of contribution of miombo woodlands to local communities' livelihoods shows that, miombo woodlands contribute 59% to total household annual income. However, income from miombo woodlands as compared to income generated from other sources were not statistically significantly different (p (t) = 0.26 and d.f = 3).



The study showed that, about 2.00 $m^3$ per hectare of wood resources is extracted annually from the miombo woodland. Wood resources in diameter classes II and III are the most extracted. Mean annual increment is important in deciding amount of wood out-take. Malimbwi *et al.* (2005) found mean annual increment (MAI) of 2.35 $m^3$ per ha per year in miombo woodlands of Kitulangalo, Tanzania. Similar results have been reported by Temu (1980) and Nilsson (1986) in studies done in miombo woodlands of Tanzania. This shows that, an estimated annual wood out-take of about 2.00 $m^3$ in the study area almost equals the mean annual increment (2.35 $m^3$). This may therefore lead to extinction of some species or overexploitation of some size classes hence eventually unsustainable.

Contribution of miombo woodlands to local communities depend on a number of socio-economic and institutional factors. Logistic regression model was employed in the assessment of socio-economic and institutional factors enabling or constraining the contribution of miombo woodland resources to local communities' livelihoods. The study shows that, enabling socio-economic factors are ethnicity, household size, age, education, hunger periods, livelihood activities and; market and demand of miombo woodland resources where as enabling institutional factors include: institutional arrangement in management of the miombo woodland, miombo woodland access rules. Similarly, the study reveal that, constraining socio-economic factors include: cultivated land size and distance while constraining institutional factors include: miombo woodland tenure and governance in the miombo woodland. The goodness of fit of the model was found to fit well with findings of this study (77%). A chi-square value of 35.64 with a degree of freedom of 10 was highly significant at 5% probability level (P=0.00), meaning that, the independent variables (socio-economic and institutional) affected very well the dependent variable. Likewise, the – log likelihood (-2LL) value of 66.65 indicated that, the model fitted the data well. Besides, the classification power of the model was able to accurately classify respondents by 80% into households reported and those which did not report the contribution of miombo woodland resources to their livelihoods. The study show that, wald statistics have non-zero values, which implies that there is interaction between dependent and independent variables. Thus, the null hypothesis was rejected in favour of the alternative hypothesis that Socio-economic and institutional factors significantly enable contribution of the miombo woodland to local communities' livelihood at 5% level of significance.

**5.2 Recommendations**

Findings of this study clearly manifest the contribution of the miombo woodland to local communities' livelihoods from the many products and services accrued. Thus it is urgent ensuring that the woodland stock is sustained so as to contribute to sustained livelihoods and make a 'win-win' or double victory a reality. Thus, this study recommends the following:

- For the purpose of sustainable management of the miombo woodland that caters for livelihoods of local communities it is essential that an in-depth forest inventory is conducted in the miombo woodland so as to quantify stocking of tree and shrub species. This will serve as baseline data for the development of management plan which is a central tool for management of forest and woodland resources.

- The study shows that, charcoal is the main form of wood out-take from the miombo woodland, the study recommend a detailed assessment to quantify wood out-take with keen emphasis on charcoal kilns survey. Furthermore, wood out-take should be related with mean annual increment in the miombo woodland so as to examine sustainability of the miombo woodland stock.

- Although the miombo woodland is managed under JFM arrangements, this study has revealed that, JFM is not fully operational other than that communities surrounding UFR enjoying the user rights granted under JFM set up. Therefore, there is a need to re-institute JFM in UFR. This should involve stakeholder analysis and identification of various user groups. Also, it is equally important to follow procedures as stipulated in the Community Based Forest Management Guidelines Hand Book which was not observed during the initiation of JFM in UFR.

- Integrity is a governance burning challenge. The National Forest Policy (URT, 1998), National Forestry Programme (URT, 2001) and National Forest Act No. 14 (URT, 2002) clearly stipulate and promote management of forests and woodlands and their contribution to livelihoods. However, there is mis-match' between what is stated in policies and actual practices in the ground in the study area. This study recommends the government through FBD which is responsible for the management of forests and woodlands to shift from rhetoric to action oriented policies as a means of promoting good governance in the miombo woodland which feature as a constraining institutional factor in contribution of the miombo woodland to livelihoods of local communities.

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# APPENDICES

## Appendix 1: Forest inventory form

Date: ___________; Transect no.: _________________; Plot no.: ___________

Plot area: ________ (ha); GPS readings: Easting __________; Northing _______

| Trees and shrubs | | | | | | |
|---|---|---|---|---|---|---|
| SN | Species name | | bd (cm) | dbh (cm) | Ht (m) | Remarks/uses |
| | Local name | Botanical name | | | | |
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Key:

bd = Basal diameter dbh = Diameter at breast height Ht = Height

Use codes: 1 = Timber; 2 = Poles; 3 = Firewood; 4 = Charcoal; 5 = Medicine; 6 = Edible fruit; 7 = Edible root; 8 = Fodder etc.

**Appendix 1 cont.**

| Stumps | | | | |
|---|---|---|---|---|
| SN | Species name | | Bd (cm) | Remark/uses |
| | Local name | Botanical name | | |
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| Regenerants | | | | |
|---|---|---|---|---|
| S/N | Species name | | No. of species | Remarks |
| | Local name | Botanical name | | |
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## Appendix 2: Household structured questionnaire

**A: Household identification variables** **Date: ___________**

| No. | Item | Name/Number |
|---|---|---|
| 1.0 | Name of interviewer | |
| 2.0 | Questionnaire number | |
| 3.0 | Village name | |
| 4.0 | Ward name | |
| 5.0 | Division name | |
| 6.0 | District name | |
| 8.0 | Region name | |

**B: Household baseline data**

1.0 Name of household head ________________________________

2.0 Gender of respondent
- (i) Male _______
- (ii) Female ______

3.0 Age of head of household[years] ________

4.0 Marital status
- (i) Single ________
- (ii) Married ______
- (iii) Divorced ______
- (iv) Widowed ______

5.0 Education status
- (i) None __________
- (ii) Primary school _____
- (iii) Secondary school ____
- (iv) College/ University ____
- (v) Others[Specify] _________________________

6.0 Household size ________

Household composition

| Age category | Male | Female |
|---|---|---|
| < 20 years | | |
| 20 – 40 years | | |
| 41 – 60 years | | |
| > 60 years | | |

## Appendix 2 cont.

7.0 Residence period of respondent in the area[years] ________

### C: Livelihood data

1.0 Main household income generating activities

| No. | Type of economic activity | Estimated annual income[TShs] |
|---|---|---|
| 1.0 | Agriculture | |
| 2.0 | Livestock keeping/Livestock | |
| 3.0 | Petty business | |
| 4.0 | Collection of miombo woodland products | |
| 5.0 | Beekeeping | |
| 6.0 | Tobacco farming | |
| 7.0 | Brick making[burning] | |
| 8.0 | Timber | |
| 9.0 | Herbalist | |
| 10.0 | | |

2.0 (a) Do you own land for agriculture?
(i) Yes ______
(ii) No _______

(b) If Yes in C: 2.0 (a), what is the land size cultivated ________ [ha].

(c) If Yes in C: 2.0 (a), how did you acquire the land?

(c) Type of crops cultivated

| No. | Type of crop | Amount harvested | Amount sold | Income generated out of crop sale (TSHs) |
|---|---|---|---|---|
| 1.0 | Maize | | | |
| 2.0 | Millet | | | |
| 3.0 | Sweet potatoes | | | |
| 4.0 | Cassava | | | |
| 5.0 | Groundnuts | | | |
| 6.0 | | | | |

## Appendix 2 cont.

3.0 Does the harvest satisfy your annual household food requirements?

(i) Yes
(i) No

4.0 Reasons for inadequate agricultural crop production if any?

(i) Use of poor agricultural tools and technology _______
(ii) Draught _______
(iii) Poor seed quality _______
(iv) No fertilisation/ infertile soil _______
(v) Inadequate land for agriculture _______

5.0 If No in 3.0, what do you do to fill the deficit?

(a)

(i) Purchase food
(ii) Collect products and services from UFR
(iii) Others, specify ____________________

(b) What is the distance from UFR to your residence (km) __________

(c) What is the hunger period (months) __________

6.0 (a) Do you collect and use products and services from UFR?

(i) Yes
(ii) No

(b) If No in 6.0 (a), why?

______________________________________________

______________________________________________

(c) For how long have you been engaged in collection and use woodland resources?

(i) Less than one year
(ii) 1 – 7 years
(iii) More than 7 years

(d) What are the objectives of collecting/using woodland resources from UFR?

(i) Secure food
(ii) Increase household income
(iii) Both (i) and (ii)
(iv) Others ______________________________

**Appendix 2 cont.**

7.0 (a) Do you keep livestock?
- (i) Yes
- (ii) No

(b) Type of livestock kept

- (I) Cattle
- (II) Goat
- (III) Sheep
- (IV) Others ______________________________

(c) What is the mode of grazing?

- (i) Zero grazing
- (ii) Free grazing

(d) What is the grazing area?

- (i) Urumwa forest reserve
- (ii) Areas other than Urumwa forest reserve

**Annendix 2 cont.**



| 7.0 Products and services derived from UFR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SN | Type product and/services | Source | Frequency | Harvest/month | Availability Plenty[1]/Fair[2]/ Very little[3] | Species preferred | Species heavily exploited | Household consumption[1], Commercialisation [2], both[1 and 2] |
| 1.0 | Firewood | | | | | | | |
| 2.0 | Charcoal | | | | | | | |
| 3.0 | Poles | | | | | | | |
| 4.0 | Timber | | | | | | | |
| 5.0 | Forest medicines | | | | | | | |
| 6.0 | Forest vegetables | | | | | | | |
| 7.0 | Honey | | | | | | | |
| 8.0 | Forest fruits | | | | | | | |
| 9.0 | Mushrooms | | | | | | | |
| 10.0 | Gums | | | | | | | |
| 11.0 | Weaving materials | | | | | | | |
| 12.0 | Insect | | | | | | | |
| 13.0 | Wild meat | | | | | | | |
| 14.0 | Fodder/ pasture | | | | | | | |
| 15.0 | Thatching grass | | | | | | | |
| 16.0 | Ritual/cultural ervices | | | | | | | |
| 17.0 | Others | | | | | | | |
| 18.0 | | | | | | | | |
| 19.0 | | | | | | | | |
| 20.0 | | | | | | | | |
| 21.0 | | | | | | | | |
| 22.0 | | | | | | | | |
| 23.0 | | | | | | | | |
| 24.0 | | | | | | | | |
| 25.0 | | | | | | | | |

## Appendix 2 cont.

**D: Institutions data**

1.0 (a) How do you access the woodland products and services from UFR?

(i) Freely
(ii) By permission
(iii) Illegally

(b) Are you constrained in any way by UFR access rules?

(iii) Yes
(iv) No

(c) Are there market opportunities for miombo woodland products and services from UFR?

(i) Yes
(ii) No

(d) Who is responsible for collection of woodland products?

(i) Male
(ii) Female

(e) Do you use miombo woodland resources for income generation?

Sale of miombo woodland products and services from UFR

| SN | Product and/service | Amount sold | Unit price (TSHs) | Total income per year (TSHs) | Species | Availability Plenty[1], Fair[2], Scarce[3] |
|---|---|---|---|---|---|---|
| 1.0 | | | | | | |
| 2.0 | | | | | | |
| 3.0 | | | | | | |
| 4.0 | | | | | | |

**Appendix 2 cont.**

(f) How do you rate the demand of miombo woodland products and/services?

(i) High
(ii) Average
(iii) Low

2.0 (a) Is there any institution(s) managing UFR?

(i) Yes
(ii) No

(b) If Yes in 2.0 (a), name the institution(s)

________________________________________

________________________________________

(c) Who own the forest?

(i) Central government
(ii) Local government
(iii) Village government
(iv) Don't know

(d) What is the type of management is applied?

(i) Government only
(ii) Community participation
(iii) Don't know

(e) Does your village have a woodland management committee?

(i) Yes
(ii) No
(iii) Don't know

(f) What is the role of villagers in the management of UFR?

________________________________________

________________________________________

**Appendix 2 cont.**

(g) If the type of management applied is 'participatory' in 2.0 (d) do you have user right? What resources?

(i) Yes

(ii) No

(iii) Don't know

______________________________________________

______________________________________________

3.0 (a) Do you have access to credits/loans?

(i) Yes

(ii) No

(b) If Yes in 3.0 (a), who/which institutions provide the credit/loans?

______________________________________________

______________________________________________

______________________________________________

(c) What is the status of access to credits/loans?

(i) Easy

(ii) Difficult

(iii) Very difficult

(d) What are reasons for your answer in 3.0 (c)?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

**Appendix 3: Checklist for institutions involved in management of Urumwa forest reserve**

1. Ownership of UFR?
2. How is Urumwa forest reserve managed?
3. Which institutions are involved in the management of Urumwa forest reserve?
4. What are the objectives and roles of institutions?
5. How do local communities meet their livelihood needs?
6. Do woodland resources in Urumwa forest reserve contribute to livelihoods of local communities in any way?
7. Who have/are use/user right in UFR? What resources?
8. How institutions facilitate the contribution of woodland resources to local communities' livelihoods?
9. Are there market forces which prompt communities' collection of woodland resources to meet their livelihood needs? What are they? How far are they located?
10. What are your responsibilities in the management of UFR?
11. What is the number and distribution of staff in the management of UFR? Is the number of staff adequate? If no why?
12. What are challenges in management of UFR? Way forward and strategies in improving management of UFR?

**Appendix 4: Checklist to village leaders**

1. What is the village population?
2. What is the population of pastoralists? What kinds of livestock are kept? Their population village wise?
3. Social services and infrastructure in the village [e.g how many hospitals each village has?
4. What are the main economic activities/income generating activities in the village?
5. What is the average household income per year?
6. What kind of resources derived by local communities from the woodland?
7. What is the availability of resources from UFR? [Plenty/fair/scarce] Which resources? Why?
8. Are there market opportunities for woodland resources? What are they? How far are they from UFR?
9. What services [e.g. catchment area] does UFR provide?
10. Are there any cultural and or ritual activities done in the UFR? Mention them? When are they done? Which tribe? For what purpose?
11. Do you have access to credits/loans?
12. How is the UFR managed?
13. Are there any institutions responsible for the management of UFR? What are their objectives?

**Appendix 4 cont.**

14. Do you have user rights in UFR? What are they?
15. What is the role of local communities in the management of UFR?
16. How do the institutions involved in the management of UFR facilitate the contribution of UFR to local communities' livelihoods?
17. Does the institutions enable or constraint contribution of woodland resources to local communities?

**Appendix 5: Master tree and shrub species checklist for UFR**

| S/N | Spp code | Botanical name | Local name(Nyamwezi) | Family name | Life form | USE/USES |
|---|---|---|---|---|---|---|
| 1 | 82 | *Acacia drepanolobium* | Ulula/Vulula | Minosoideae | T | 3,4,10,13,21,22 |
| 2 | 83 | *Afzelia quanzensis* | Mkola | Caesalpimoideae | T | 1,2,3,4,9,12 |
| 3 | 43 | *Albizia antunesiana* | Mpilipili/Mgando kaguva | Mimosoideae | T | 1,2,3,4,5,9,13,16 |
| 4 | 44 | *Albizia harveyi* | Mpogolo | Mimosoideae | T | 2,3,4,5,8,9,13,15,16,17 |
| 5 | 68 | *Annona senegalensis* | Mtopetope | Annonaceae | T | 2,3,4,5,6,8,9,13,15 |
| 6 | 69 | *Azanza garckeana* | Mtowo | Malvaceae | T | 2,3,4,6,8,9,13,15,16 |
| 7 | 30 | *Berchemia discolor* | Mkuni | Rhamnaceae | T | 1,2,3,4,6,9,13,15,16 |
| 8 | 77 | *Brachystegia boehmii* | Muyombo/Myenze | Caesalpimoideae | T | 3,4,9,10,11,12,13 |
| 9 | 71 | *Brachystegia spiciformis* | Mtundu | Caesalpimoideae | T | 1,2,3,4,5,9,10,11,12,13 |
| 10 | 16 | *Brychystegia microphylla* | Mgela | Caesalpimoideae | T | 1,2,3,4,9,10,11,12,13,15 |
| 11 | 55 | *Brychystegia wangermeana* | Msilanga | Caesalpimoideae | T | 1,3,4,5,9,10,11,12,13 |
| 12 | 22 | *Burkea africana* | Mkalati | Caesalpinioideae | T | 1,2,3,4,13,17 |
| 13 | 48 | *Calotropis procera* | Mpumbulya/Mpumbula | Asdepiadaceae | T | 3,5 |
| 14 | 36 | *Cassia abbreviata* | Mlundalunda/Mzoka | Caesalpimoideae | T | 2,3,4,5,13,15 |
| 15 | 35 | *Cassipourea mollis* | Mlugala | Rhizophoraceae | T | 2,3,4,5,13,15 |
| 16 | 80 | *Catunaregam spinosa* | Mwocha/Mochangoko | Rubiaceae | T | 2,3,4,5,15 |
| 17 | 53 | *Chrysophyllum bengweolense* | Mseveye | Sapotaceae | T | 2,3,4,5,9,13,14,15 |
| 18 | 67 | *Cissus cornifolia* | Mtongamwaka/Mtandamwaka | Vitaceae | T | 5,6,13 |
| 19 | 47 | *Clerodendrum myricoides* | Mpugambu | Verbenaceae | T | 3,16,20 |
| 20 | 37 | *Combretum adenogonium* | Mluzyaminzi | Combretaceae | T | 3,4,5,13 |
| 21 | 33 | *Combretum collinum* | Mlandala | Combretaceae | T | 2,3,4,5,9,13 |
| 22 | 32 | *Combretum molle* | Mlama | Combretaceae | T | 2,3,4,5,9,13 |
| 23 | 1 | *Combretum obovatum* | Igoveko/Vugoveko | Combretaceae | T | 3,11,13,21 |
| 24 | 51 | *Combretum zeyheri* | Msana | Combretaceae | T | 3,4,5,8,13 |
| 25 | 45 | *Commiphora africana* | Mponda/Msagari | Burseraceae | T | 5,7,8,19 |
| 26 | 46 | *Commiphora mossambicensis* | Mpondapanda | Burseraceae | T | 7,8,19 |
| 27 | 52 | *Crosspteryx febrifuga* | Msanzambeki | Rubiaceae | T | 3,4,5,16,15,16 |
| 28 | 17 | *Dalbegia melanoxylon* | Mgembe/Mpingo | Papilionoideae | T | 1,2,3,4,5,8,9,13,15,16,17 |

**Appendix 5 cont.**

| | | | | | | |
|---|---|---|---|---|---|---|
| 29 | 2 | *Dalbergia nitidula* | Kafinulampasa | Papilionoideae | T | 2, 3,4,5,9,13,17 |
| 30 | 13 | *Diospyros fischieri* | Mfubata/Mfuvata | Ebenaceae | T | 3,4,5,16,15 |
| 31 | 56 | *Diospyros mespiliformis* | Msinde | Ebenaceae | T | 1,2,3,4,5,6,8,9,12,13,15,16 |
| 32 | 58 | *Diplorhynchus condylocarpon* | Msonga | Apocynaceae | T | 3,4,13,14,15 |
| 33 | 73 | *Ekebergia benguelensis* | Mtuzigwa/Mtuzya | Meliaceae | T | 3,4,5,13,15 |
| 34 | 15 | *Erythrophleum africanum* | Mgando/Mgimbila | Caesalpimoideae | T | 1,2,3,4,5,13 |
| 35 | 31 | *Ficus sycomorus* | Mkuyu | Moraceae | T | 3,6,8 |
| 36 | 59 | *Flacourtia indica* | Msungu | Flacourtiaceae | T | 3,4,5,6,8,13 |
| 37 | 50 | *Friesodielsia lanciflora* | Msalansi | Rubiaceae | T | 2,3,4,5,6,9,13 |
| 38 | 12 | *Garcinia livingstonei* | Mfilafila | Clusiaceae | T | 2,3,4,5,6,9,13,15 |
| 39 | 10 | *Grewia conocarpoides* | Mdati | Tiliaceae | T | 2,3,4,6,8,9,13 |
| 40 | 42 | *Hymenocardia acida* | Mpala | Euphorbiaceae | T | 3,4,5,9,13,15 |
| 41 | 38 | *Isoberlinia angolensis* | Mnembela | Caesalpimoideae | T | 3,4,5,9,13,15 |
| 42 | 74 | *Jubernadia globiflora* | Muva | Caesalpimoideae | T | 1,3,4,5,9,10,11,12,13 |
| 43 | 11 | *Kigelia africana* | Mdungwa | Bignoniaceae | T | 3,5,6,13 |
| 44 | 65 | *Lannea humilis* | Mtinje | Anacardiaceae | T | 3,4,5,10,13,15,19 |
| 45 | 19 | *Lannea schiniperi* | Mgumbu | Anacardiaceae | T | 6,8,10,13 |
| 46 | 75 | *Lonchocarpus capassa* | Muvale | Papilionoideae | T | 2,3,4,5,8,9,13,16,17 |
| 47 | 4 | *Maerua parvifolia* | Kalilalila | Capparaceae | T | 3,4,5,13,21 |
| 48 | 25 | *Manilkara mochisia* | Mkonze | Sapotaceae | T | 1,2,3,4,5,9,13,15,16,17 |
| 49 | 8 | *Markhamuia obtusifolia* | Mbapa | Bignoniaceae | T | 3,4,9,13,15 |
| 50 | 26 | *Monotes adenophyllus* | Mkukuti | Dipterocarpaceae | T | 2,3,4,9,13,15 |
| 51 | 61 | *Mundudea sericea* | Mtandala | Papilionoideae | T | 2,3,4,5,9,13,18 |
| 52 | 76 | *Mutidentia crassa* | Muyogoyogo | Rubiaceae | T | 3,4,5,6,8,13,15 |
| 53 | 34 | *Oldfieldia dactylophylla* | Mliwafengi | Euphorbiaceae | T | 2,3,4,5,6,13,15 |
| 54 | 6 | *Ormocarpum trachycarpum* | Kapyapya/Kapyompyo | Papilionoideae | T | 3,4,5,13 |
| 55 | 79 | *Ozoroa insignis* | Mwembepori/Mkalakala | Anacardiaceae | T | 3,4,5,13,15,16 |
| 56 | 9 | *Parinari curatellifolia* | Mbula/Muvula | Chrysobalanaceae | T | 1,2,3,4,5,6,8,13,15 |
| 57 | 21 | *Pavetta schumanniana* | Mhihyavana | Rubiaceae | S | 3,5,13 |
| 58 | 7 | *Pericopsis angolensis* | Mbanga | Papilionoideae | T | 1,3,4,5,9,13,16,17 |
| 59 | 18 | *Phyllanthus engleri* | Mgogondi | Euphorbiaceae | T | 3,4,5,6,8,13,15 |

**Appendix 5 cont.**

| | | | | | | |
|---|---|---|---|---|---|---|
| 60 | 64 | *Piliostigma thonningii* | Mtindwambongo | Caesalpimoideae | S | 2,3,4,5,6,9,10,13,15 |
| 61 | 72 | *Pseudolachnostylis maprouneifolia* | Mtungulu | Euphorbiaceae | T | 2,3,4,5,8,13,15,19 |
| 62 | 40 | *Pterocarpus angolensis* | Mninga | Papilionoideae | T | 1,2,3,5,12,13,15,16 |
| 63 | 27 | *Pterocarpus tinctorius* | Mkulungu | Papilionoideae | T | 1,2,3,4,5,9,13,15,16,17,27 |
| 64 | 49 | *Schrebera trichoclada* | Mputika | Oleaceae | T | 2,3,4,5,13,15 |
| 65 | 63 | *Securidaca longipedunculata* | Mteyu | Polygalaceae | S | 2,3,4,5,13 |
| 66 | 70 | *Solanum incanum* | Mtula/Mdulanu | Solanaceae | S | 5,13 |
| 67 | 29 | *Sterculia quinqueloba* | Mkungulanga/Mguwa | Sterculiaceae | T | 1,3,6,13 |
| 68 | 66 | *Strychnos cocculoidos* | Mtonga/Mntonga | Loganiaceae | T | 2,3,4,6,13,15 |
| 69 | 28 | *Strychnos innocua* | Mkulwa | Loganiaceae | T | 3,4,6,13 |
| 70 | 20 | *Strychnos potatorum* | Mgwegwe/Mpandepande | Loganiaceae | T | 2,3,4,5,13,18 |
| 71 | 78 | *Strychnos spinosa* | Mwage | Loganiaceae | T | 2,3,4,6,9,13,15 |
| 72 | 57 | *Tamarindus indica* | Msisi | Caesalpimoideae | T | 1,2,3,4,5,6,9,12,13,15,16 |
| 73 | 5 | *Tapiphyllum floribunda* | Kambolambola | Rubiaceae | S | 5,6,13 |
| 74 | 24 | *Terminalia mollis* | Mkelenge | Combretaceae | T | 2,3,4,13,17 |
| 75 | 81 | *Terminalia sericea* | Mzima | Combretaceae | T | 2,3,4,5,15 |
| 76 | 39 | *Vangueriopsis lanciflora* | Mngelelya | Rubiaceae | T | 3,4,6,13,15 |
| 77 | 14 | *Vitex doniana* | Mfulu | Verbenaceae | T | 3,4,6,8,9,13,15,16 |
| 78 | 60 | *Vitex mombassae* | Mtalali | Verbenaceae | T | 3,4,5,6,8,13 |
| 79 | 41 | *Xeroderris stunmannii* | Mnyenye | Papilionoideae | T | 1,2,3,4,5,8,12,13,15,16 |
| 80 | 54 | *Xylopia antunesii* | Mshenene | Annonaceae | T | 3,4,5,9,13,15 |
| 81 | 23 | *Zanha africana* | Mkalya | Spapindaceae | S | 2,3,4,5,6,8,13,15 |
| 82 | 3 | *Ziphus mucronata* | Kagowole | Rhamnaceae | T | 2,3,4,5,6,13,18,21 |

**KEY:**

**1.0 Life form**
S = Shrub
ST = Small tree
T = Tree

**2.0 Uses**
1 = Timber
2 = Poles
3 = Firewood
4 = Charcoal
5 = Medicine
6 = Edible fruit
7 = Edible root
8 = Fodder
9 = Tool handle
10 = Fibre
11 = Storage pot
12 = Beehive
13 = Bee forage
14 = Birdlime
15 = Wooden spoon
16 = Carvings
17 = Pestles
18 = Fish poison(fishing)
19 = Live fence
20 = Insect repellant
21 = Hedge
22 = Gum

**Appendix 6: Distribution of N, G and V of standing crop by species and diameter classes in UFR**

| Spp code | Botanical name | DBH classes (cm) | | | | | | | | | | | | | | | | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | | | II | | | III | | | IV | | | V | | | VI | | | | | |
| | | 1 - 10 | | | 11 - 20 | | | 21 - 30 | | | 31 - 40 | | | 41 - 50 | | | > 50 | | | | | |
| | | N | G | V | N | G | V | N | G | V | N | G | V | N | G | V | N | G | V | N | G | V |
| 82 | *Acacia drepanolobium* | | | | 0 | 0.01 | 0.03 | 1 | 0.02 | 0.16 | | | | | | | | | | 1 | 0.03 | 0.19 |
| 83 | *Afzelia quanzensis* | | | | | | | 0 | 0.01 | 0.08 | 0 | 0.04 | 0.39 | | | | | | | 1 | 0.05 | 0.46 |
| 43 | *Albizia antunesiana* | | | | 0 | 0.01 | 0.03 | 0 | 0.01 | 0.07 | | | | | | | | | | 1 | 0.02 | 0.10 |
| 44 | *Albizia harveyi* | 11 | 0.04 | 0.15 | 4 | 0.06 | 0.35 | 3 | 0.12 | 0.88 | 0 | 0.04 | 0.34 | 1 | 0.16 | 1.55 | | | | 19 | 0.42 | 3.28 |
| 68 | *Annona senegalensis* | | | | 0 | 0.00 | 0.02 | | | | | | | | | | | | | 0 | 0.00 | 0.02 |
| 69 | *Azanza garckeana* | | | | 0 | 0.01 | 0.06 | | | | | | | | | | | | | 0 | 0.01 | 0.06 |
| 30 | *Berchemia discolor* | | | | 2 | 0.04 | 0.26 | 0 | 0.01 | 0.05 | | | | | | | | | | 2 | 0.05 | 0.32 |
| 77 | *Brachystegia boehmii* | 13 | 0.03 | 0.09 | 4 | 0.09 | 0.55 | 3 | 0.18 | 1.33 | 2 | 0.18 | 1.51 | 1 | 0.22 | 2.20 | 0 | 0.04 | 0.43 | 24 | 0.74 | 6.11 |
| 71 | *Brachystegia spiciformis* | 11 | 0.06 | 0.28 | 3 | 0.06 | 0.34 | 4 | 0.23 | 1.68 | 4 | 0.41 | 3.50 | 2 | 0.26 | 2.56 | 1 | 0.13 | 1.41 | 25 | 1.16 | 9.77 |
| 16 | *Brychystegia microphylla* | | | | 0 | 0.00 | 0.02 | | | | 1 | 0.06 | 0.48 | 1 | 0.12 | 1.16 | | | | 2 | 0.18 | 1.66 |
| 55 | *Brychystegia wangermeana* | 2 | 0.01 | 0.06 | | | | | | | | | | | | | | | | 2 | 0.01 | 0.06 |
| 22 | *Burkea africana* | 2 | 0.01 | 0.04 | | | | | | | | | | | | | | | | 2 | 0.01 | 0.04 |
| 48 | *Calotropis procera* | 4 | 0.02 | 0.07 | | | | | | | | | | | | | | | | 4 | 0.02 | 0.07 |
| 36 | *Cassia abbreviata* | | | | 0 | 0.00 | 0.02 | | | | | | | | | | | | | 0 | 0.00 | 0.02 |
| 35 | *Cassipourea mollis* | | | | 1 | 0.01 | 0.07 | | | | | | | | | | | | | 1 | 0.01 | 0.07 |
| 80 | *Catunaregamspinosa* | | | | 2 | 0.04 | 0.21 | | | | | | | | | | | | | 2 | 0.04 | 0.21 |
| 53 | *Chrysophyllum bengweolense* | 2 | 0.01 | 0.04 | | | | | | | | | | | | | | | | 2 | 0.01 | 0.04 |
| 67 | *Cissus cornifolia* | 2 | 0.01 | 0.04 | | | | | | | | | | | | | | | | 2 | 0.01 | 0.04 |
| 47 | *Clerodendrum myricoides* | | | | 0 | 0.00 | 0.02 | 0 | 0.01 | 0.04 | | | | | | | | | | 1 | 0.01 | 0.06 |
| 37 | *Combretum adenogonium* | 16 | 0.07 | 0.26 | 10 | 0.19 | 1.04 | 1 | 0.04 | 0.24 | | | | | | | | | | 28 | 0.29 | 1.54 |
| 33 | *Combretum collinum* | 9 | 0.04 | 0.16 | 6 | 0.10 | 0.59 | 1 | 0.02 | 0.15 | | | | | | | | | | 16 | 0.17 | 0.90 |
| 32 | *Combretum molle* | 25 | 0.12 | 0.47 | 11 | 0.21 | 1.16 | 1 | 0.05 | 0.37 | | | | | | | | | | 37 | 0.37 | 2.01 |
| 1 | *Combretum obovatum* | 9 | 0.03 | 0.09 | 0 | 0.00 | 0.02 | | | | | | | | | | | | | 10 | 0.03 | 0.12 |
| 51 | *Combretum zeyheri* | 66 | 0.32 | 1.31 | 20 | 0.31 | 1.71 | 2 | 0.11 | 0.78 | 0 | 0.02 | 0.17 | | | | | | | 89 | 0.76 | 3.96 |
| 45 | *Commiphora africana* | 6 | 0.04 | 0.19 | 4 | 0.06 | 0.35 | 0 | 0.02 | 0.12 | | | | | | | | | | 10 | 0.12 | 0.66 |

**Appendix 6 cont.**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | *Commiphora mossambicensis* | | | | 1 | 0.01 | 0.06 | | | | | | | | | | | | | 1 | 0.01 | 0.06 |
| 52 | *Crosspteryx febrifuga* | 15 | 0.05 | 0.18 | 3 | 0.07 | 0.40 | 0 | 0.01 | 0.10 | | | | | | | | | | 18 | 0.13 | 0.68 |
| 17 | *Dalbegia melanoxylon* | 0 | 0.00 | 0.02 | 0 | 0.01 | 0.04 | | | | | | | | | | | | | 1 | 0.01 | 0.05 |
| 2 | *Dalbergia nitidula* | | | | 1 | 0.02 | 0.14 | | | | | | | | | | | | | 1 | 0.02 | 0.14 |
| 13 | *Diospyros fischieri* | | | | 1 | 0.02 | 0.11 | | | | | | | | | | | | | 1 | 0.02 | 0.11 |
| 56 | *Diospyros mespiliformis* | | | | | | | 0 | 0.01 | 0.09 | | | | | | | | | | 0 | 0.01 | 0.09 |
| 58 | *Diplorhynchus condylocarpon* | 39 | 0.14 | 0.57 | 11 | 0.16 | 0.84 | 1 | 0.06 | 0.45 | 0 | 0.02 | 0.12 | | | | | | | 51 | 0.38 | 1.99 |
| 73 | *Ekebergia benguelensis* | | | | 0 | 0.01 | 0.05 | 0 | 0.01 | 0.10 | | | | | | | | | | 1 | 0.02 | 0.16 |
| 15 | *Erythrophleum africanum* | | | | 1 | 0.02 | 0.10 | 1 | 0.05 | 0.38 | 1 | 0.06 | 0.48 | 0 | 0.06 | 0.58 | | | | 3 | 0.19 | 1.53 |
| 31 | *Ficus sycomorus* | | | | | | | 0 | 0.01 | 0.10 | | | | | | | | | | 0 | 0.01 | 0.10 |
| 59 | *Flacourtia indica* | 2 | 0.01 | 0.03 | | | | | | | | | | | | | | | | 2 | 0.01 | 0.03 |
| 50 | *Friesodielsia lanciflora* | 20 | 0.07 | 0.26 | | | | | | | | | | | | | | | | 20 | 0.07 | 0.26 |
| 12 | *Garcinia livingstonei* | | | | 0 | 0.01 | 0.03 | | | | | | | | | | | | | 0 | 0.01 | 0.03 |
| 10 | *Grewia conocarpoides* | 4 | 0.03 | 0.12 | 0 | 0.01 | 0.05 | | | | | | | | | | | | | 5 | 0.04 | 0.16 |
| 42 | *Hymenocardia acida* | 5 | 0.03 | 0.13 | | | | | | | | | | | | | | | | 5 | 0.03 | 0.13 |
| 38 | *Isoberlinia angolensis* | | | | | | | 0 | 0.01 | 0.05 | | | | | | | | | | 0 | 0.01 | 0.05 |
| 74 | *Jubernadia globiflora* | 20 | 0.08 | 0.30 | 8 | 0.14 | 0.83 | 7 | 0.33 | 2.41 | 5 | 0.45 | 3.87 | 1 | 0.20 | 1.94 | | | | 41 | 1.21 | 9.35 |
| 11 | *Kigelia africana* | | | | | | | 0 | 0.01 | 0.09 | | | | | | | | | | 0 | 0.01 | 0.09 |
| 65 | *Lannea humilis* | 7 | 0.03 | 0.11 | 1 | 0.02 | 0.10 | 0 | 0.02 | 0.10 | | | | | | | | | | 9 | 0.06 | 0.32 |
| 19 | *Lannea schiniperi* | 5 | 0.03 | 0.11 | 2 | 0.04 | 0.23 | 2 | 0.07 | 0.53 | 0 | 0.02 | 0.14 | | | | | | | 10 | 0.16 | 1.01 |
| 75 | *Lonchocarpus capassa* | 7 | 0.04 | 0.15 | 1 | 0.01 | 0.05 | 0 | 0.01 | 0.05 | 0 | 0.01 | 0.11 | | | | | | | 9 | 0.07 | 0.37 |
| 25 | *Manilkara mochisia* | | | | 1 | 0.02 | 0.14 | | | | | | | | | | | | | 1 | 0.02 | 0.14 |
| 8 | *Markhamuia obtusifolia* | | | | 1 | 0.01 | 0.05 | 0 | 0.01 | 0.05 | | | | | | | | | | 1 | 0.02 | 0.10 |
| 26 | *Monotes adenophyllus* | | | | 0 | 0.01 | 0.03 | | | | | | | | | | | | | 0 | 0.01 | 0.03 |
| 61 | *Mundudea sericea* | | | | 0 | 0.01 | 0.03 | | | | | | | | | | | | | 0 | 0.01 | 0.03 |
| 76 | *Mutidentia crassa* | 2 | 0.00 | 0.00 | | | | | | | | | | | | | | | | 2 | 0.00 | 0.00 |
| 34 | *Oldfieldia dactylophylla* | 2 | 0.02 | 0.07 | 2 | 0.03 | 0.15 | | | | | | | | | | | | | 5 | 0.04 | 0.21 |
| 6 | *Ormocarpum trachycarpum* | 2 | 0.00 | 0.01 | | | | | | | | | | | | | | | | 2 | 0.00 | 0.01 |

**Appendix 6 cont.**

| | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79 | *Ozoroa insignis* | | | | | | | 0 | 0.01 | 0.09 | | | | | | | | | | 0 | 0.01 | 0.09 |
| 9 | *Parinari curatellifolia* | 7 | 0.00 | 0.01 | | | | | | | | | | 0 | 0.03 | 0.25 | | | | 7 | 0.03 | 0.26 |
| 21 | *Pavetta schumanniana* | 2 | 0.01 | 0.05 | | | | | | | | | | | | | | | | 2 | 0.01 | 0.05 |
| 7 | *Pericopsis angolensis* | 2 | 0.01 | 0.04 | 2 | 0.02 | 0.12 | 1 | 0.08 | 0.61 | 0 | 0.02 | 0.17 | 0 | 0.07 | 0.66 | | | | 6 | 0.20 | 1.59 |
| 18 | *Phyllanthus engleri* | | | | 0 | 0.00 | 0.02 | | | | | | | | | | | | | 0 | 0.00 | 0.02 |
| 64 | *Piliostigma thonningii* | | | | 0 | 0.00 | 0.02 | | | | | | | | | | | | | 0 | 0.00 | 0.02 |
| 72 | *Pseudolachnostylis maprouneifolia* | 7 | 0.02 | 0.06 | 0 | 0.01 | 0.08 | 0 | 0.02 | 0.12 | 0 | 0.01 | 0.12 | | | | | | | 8 | 0.06 | 0.38 |
| 40 | *Pterocarpus angolensis* | 13 | 0.03 | 0.10 | 1 | 0.01 | 0.06 | 0 | 0.01 | 0.05 | | | | | | | | | | 14 | 0.05 | 0.22 |
| 27 | *Pterocarpus tinctorius* | 5 | 0.02 | 0.08 | 2 | 0.04 | 0.22 | 2 | 0.09 | 0.68 | 2 | 0.18 | 1.52 | 0 | 0.03 | 0.26 | | | | 12 | 0.36 | 2.76 |
| 49 | *Schrebera trichoclada* | 2 | 0.00 | 0.01 | 2 | 0.03 | 0.14 | | | | | | | | | | | | | 4 | 0.03 | 0.16 |
| 63 | *Securidaca longipedunculata* | 2 | 0.01 | 0.05 | | | | | | | | | | | | | | | | 2 | 0.01 | 0.05 |
| 70 | *Solanum incanum* | | | | | | | 0 | 0.01 | 0.05 | | | | | | | | | | 0 | 0.01 | 0.05 |
| 66 | *Strychnos cocculoidos* | 9 | 0.03 | 0.11 | | | | | | | | | | | | | | | | 9 | 0.03 | 0.11 |
| 28 | *Strychnos innocua* | | | | 1 | 0.01 | 0.07 | | | | | | | | | | | | | 1 | 0.01 | 0.07 |
| 20 | *Strychnos potatorum* | 2 | 0.01 | 0.03 | | | | 0 | 0.01 | 0.11 | | | | | | | | | | 2 | 0.02 | 0.14 |
| 78 | *Strychnos spinosa* | | | | 0 | 0.01 | 0.04 | | | | | | | | | | | | | 0 | 0.01 | 0.04 |
| 57 | *Tamarindus indica* | | | | | | | 1 | 0.05 | 0.37 | | | | | | | | | | 1 | 0.05 | 0.37 |
| 5 | *Tapiphyllum floribunda* | 2 | 0.01 | 0.06 | 1 | 0.01 | 0.08 | | | | | | | | | | | | | 3 | 0.03 | 0.13 |
| 24 | *Terminalia mollis* | | | | 0 | 0.01 | 0.05 | 0 | 0.02 | 0.19 | | | | | | | | | | 1 | 0.03 | 0.24 |
| 81 | *Terminalia sericea* | 15 | 0.05 | 0.20 | 10 | 0.15 | 0.84 | 1 | 0.03 | 0.18 | 0 | 0.02 | 0.21 | | | | | | | 25 | 0.25 | 1.42 |
| 39 | *Vangueriopsis lanciflora* | | | | 0 | 0.00 | 0.02 | | | | 0 | 0.02 | 0.16 | | | | | | | 1 | 0.02 | 0.18 |
| 14 | *Vitex doniana* | | | | 0 | 0.01 | 0.03 | | | | | | | | | | | | | 0 | 0.01 | 0.03 |
| 60 | *Vitex mombassae* | 5 | 0.02 | 0.06 | | | | | | | | | | | | | | | | 5 | 0.02 | 0.06 |
| 41 | *Xeroderris stunmannii* | | | | 1 | 0.03 | 0.14 | 1 | 0.05 | 0.36 | | | | | | | | | | 3 | 0.08 | 0.50 |
| 54 | *Xylopia antunesii* | | | | 0 | 0.00 | 0.02 | | | | | | | | | | | | | 0 | 0.00 | 0.02 |
| 23 | *Zanha africana* | | | | | | | 0 | 0.01 | 0.10 | 0 | 0.04 | 0.33 | | | | | | | 1 | 0.05 | 0.42 |
| 3 | *Ziphus mucronata* | 5 | 0.01 | 0.02 | | | | | | | | | | | | | | | | 5 | 0.01 | 0.02 |
| **Grand Total** | | **386** | **1.56** | **6.18** | **133** | **2.20** | **12.24** | **38** | **1.85** | **13.38** | **17** | **1.60** | **13.62** | **7** | **1.15** | **11.15** | **1** | **0.17** | **1.84** | **583** | **8.54** | **58.41** |

**Appendix 7: Stems density of regenerants in UFR**

| S/N | Spp code | Botanical name | N | RD |
|---|---|---|---|---|
| 1 | 82 | *Acacia drepanolobium* | 22 | 0.37 |
| 2 | 83 | *Afzelia quanzensis* | 11 | 0.18 |
| 3 | 43 | *Albizia antunesiana* | 22 | 0.37 |
| 4 | 44 | *Albizia harveyi* | 66 | 1.10 |
| 5 | 30 | *Berchemia discolor* | 33 | 0.55 |
| 6 | 77 | *Brachystegia boehmii* | 231 | 3.86 |
| 7 | 71 | *Brachystegia spiciformis* | 505 | 8.46 |
| 8 | 35 | *Cassipourea mollis* | 88 | 1.47 |
| 9 | 80 | *Catunaregamspinosa* | 55 | 0.92 |
| 10 | 67 | *Cissus cornifolia* | 66 | 1.10 |
| 11 | 37 | *Combretum adenogonium* | 110 | 1.84 |
| 12 | 33 | *Combretum collinum* | 747 | 12.50 |
| 13 | 32 | *Combretum molle* | 462 | 7.72 |
| 14 | 1 | *Combretum obovatum* | 77 | 1.29 |
| 15 | 51 | *Combretum zeyheri* | 505 | 8.46 |
| 16 | 45 | *Commiphora africana* | 66 | 1.10 |
| 17 | 52 | *Crosspteryx febrifuga* | 407 | 6.80 |
| 18 | 17 | *Dalbegia melanoxylon* | 33 | 0.55 |
| 19 | 13 | *Diospyros fischieri* | 22 | 0.37 |
| 20 | 58 | *Diplorhynchus condylocarpon* | 253 | 4.23 |
| 21 | 50 | *Friesodielsia lanciflora* | 33 | 0.55 |
| 22 | 42 | *Hymenocardia acida* | 55 | 0.92 |
| 23 | 74 | *Jubernadia globiflora* | 473 | 7.90 |
| 24 | 65 | *Lannea humilis* | 33 | 0.55 |
| 25 | 8 | *Markhamuia obtusifolia* | 110 | 1.84 |
| 26 | 34 | *Oldfieldia dactylophylla* | 99 | 1.65 |
| 27 | 9 | *Parinari curatellifolia* | 198 | 3.31 |
| 28 | 7 | *Pericopsis angolensis* | 77 | 1.29 |
| 29 | 18 | *Phyllanthus engleri* | 88 | 1.47 |
| 30 | 40 | *Pterocarpus angolensis* | 77 | 1.29 |
| 31 | 27 | *Pterocarpus tinctorius* | 352 | 5.88 |
| 32 | 49 | *Schrebera trichoclada* | 11 | 0.18 |
| 33 | 66 | *Strychnos cocculoidos* | 11 | 0.18 |
| 34 | 28 | *Strychnos innocua* | 33 | 0.55 |
| 35 | 78 | *Strychnos spinosa* | 11 | 0.18 |
| 36 | 24 | *Terminalia mollis* | 77 | 1.29 |
| 37 | 81 | *Terminalia sericea* | 341 | 5.70 |
| 38 | 14 | *Vitex doniana* | 11 | 0.18 |
| 39 | 60 | *Vitex mombassae* | 99 | 1.65 |
| 40 | 41 | *Xeroderris stunmannii* | 11 | 0.18 |
| **Grand Total** | | | **5978** | **100.00** |

**Appendix 8: Tree and shrub species diversity indices for the miombo woodland of UFR**

| S/N | Spp code | Botanical name | H' | ID | IVI |
|---|---|---|---|---|---|
| 1 | 82 | *Acacia drepanolobium* | 0.0115 | 0.0000 | 1.00 |
| 2 | 83 | *Afzelia quanzensis* | 0.0071 | 0.0000 | 1.10 |
| 3 | 43 | *Albizia antunesiana* | 0.0077 | 0.0000 | 0.53 |
| 4 | 44 | *Albizia harveyi* | 0.1099 | 0.0010 | 12.21 |
| 5 | 68 | *Annona senegalensis* | 0.0056 | 0.0000 | 0.24 |
| 6 | 69 | *Azanza garckeana* | 0.0056 | 0.0000 | 0.32 |
| 7 | 30 | *Berchemia discolor* | 0.0196 | 0.0000 | 1.79 |
| 8 | 77 | *Brachystegia boehmii* | 0.1295 | 0.0016 | 18.48 |
| 9 | 71 | *Brachystegia spiciformis* | 0.1357 | 0.0019 | 26.22 |
| 10 | 16 | *Brychystegia microphylla* | 0.0184 | 0.0000 | 3.40 |
| 11 | 55 | *Brychystegia wangermeana* | 0.0180 | 0.0000 | 0.58 |
| 12 | 22 | *Burkea africana* | 0.0180 | 0.0000 | 0.54 |
| 13 | 48 | *Calotropis procera* | 0.0317 | 0.0000 | 1.06 |
| 14 | 36 | *Cassia abbreviata* | 0.0056 | 0.0000 | 0.24 |
| 15 | 35 | *Cassipourea mollis* | 0.0101 | 0.0000 | 0.54 |
| 16 | 80 | *Catunaregamspinosa* | 0.0180 | 0.0000 | 1.21 |
| 17 | 53 | *Chrysophyllum bengweolense* | 0.0180 | 0.0000 | 0.54 |
| 18 | 67 | *Cissus cornifolia* | 0.0180 | 0.0000 | 0.54 |
| 19 | 47 | *Clerodendrum myricoides* | 0.0077 | 0.0000 | 0.47 |
| 20 | 37 | *Combretum adenogonium* | 0.1453 | 0.0023 | 12.54 |
| 21 | 33 | *Combretum collinum* | 0.0970 | 0.0007 | 7.14 |
| 22 | 32 | *Combretum molle* | 0.1748 | 0.0040 | 16.06 |
| 23 | 1 | *Combretum obovatum* | 0.0674 | 0.0003 | 2.72 |
| 24 | 51 | *Combretum zeyheri* | 0.2876 | 0.0236 | 35.79 |
| 25 | 45 | *Commiphora africana* | 0.0695 | 0.0003 | 4.81 |
| 26 | 46 | *Commiphora mossambicensis* | 0.0101 | 0.0000 | 0.53 |
| 27 | 52 | *Crosspteryx febrifuga* | 0.1089 | 0.0010 | 6.84 |
| 28 | 17 | *Dalbegia melanoxylon* | 0.0101 | 0.0000 | 0.52 |
| 29 | 2 | *Dalbergia nitidula* | 0.0142 | 0.0000 | 0.88 |
| 30 | 13 | *Diospyros fischieri* | 0.0101 | 0.0000 | 0.61 |
| 31 | 56 | *Diospyros mespiliformis* | 0.0028 | 0.0000 | 0.29 |
| 32 | 58 | *Diplorhynchus condylocarpon* | 0.2141 | 0.0078 | 19.81 |
| 33 | 73 | *Ekebergia benguelensis* | 0.0077 | 0.0000 | 0.61 |
| 34 | 15 | *Erythrophleum africanum* | 0.0299 | 0.0000 | 4.32 |
| 35 | 31 | *Ficus sycomorus* | 0.0028 | 0.0000 | 0.30 |
| 36 | 59 | *Flacourtia indica* | 0.0180 | 0.0000 | 0.53 |
| 37 | 50 | *Friesodielsia lanciflora* | 0.1158 | 0.0012 | 5.57 |
| 38 | 12 | *Garcinia livingstonei* | 0.0056 | 0.0000 | 0.27 |
| 39 | 10 | *Grewia conocarpoides* | 0.0379 | 0.0001 | 1.67 |
| 40 | 42 | *Hymenocardia acida* | 0.0437 | 0.0001 | 1.67 |

**Appendix 6 cont.**

| | | | | | |
|---|---|---|---|---|---|
| 41 | 38 | *Isoberlinia angolensis* | 0.0028 | 0.0000 | 0.24 |
| 42 | 74 | *Jubernadia globiflora* | 0.1864 | 0.0049 | 32.27 |
| 43 | 11 | *Kigelia africana* | 0.0028 | 0.0000 | 0.29 |
| 44 | 65 | *Lannea humilis* | 0.0647 | 0.0002 | 3.38 |
| 45 | 19 | *Lannea schiniperi* | 0.0674 | 0.0003 | 5.53 |
| 46 | 75 | *Lonchocarpus capassa* | 0.0631 | 0.0002 | 3.44 |
| 47 | 25 | *Manilkara mochisia* | 0.0101 | 0.0000 | 0.67 |
| 48 | 8 | *Markhamuia obtusifolia* | 0.0119 | 0.0000 | 0.76 |
| 49 | 26 | *Monotes adenophyllus* | 0.0056 | 0.0000 | 0.27 |
| 50 | 61 | *Mundudea sericea* | 0.0056 | 0.0000 | 0.62 |
| 51 | 76 | *Mutidentia crassa* | 0.0180 | 0.0000 | 0.44 |
| 52 | 34 | *Oldfieldia dactylophylla* | 0.0379 | 0.0001 | 2.13 |
| 53 | 6 | *Ormocarpum trachycarpum* | 0.0180 | 0.0000 | 0.45 |
| 54 | 79 | *Ozoroa insignis* | 0.0028 | 0.0000 | 0.29 |
| 55 | 9 | *Parinari curatellifolia* | 0.0559 | 0.0002 | 2.25 |
| 56 | 21 | *Pavetta schumanniana* | 0.0180 | 0.0000 | 0.56 |
| 57 | 7 | *Pericopsis angolensis* | 0.0478 | 0.0001 | 5.31 |
| 58 | 18 | *Phyllanthus engleri* | 0.0056 | 0.0000 | 0.25 |
| 59 | 64 | *Piliostigma thonningii* | 0.0056 | 0.0000 | 0.24 |
| 60 | 72 | *Pseudolachnostylis maprouneifolia* | 0.0608 | 0.0002 | 3.09 |
| 61 | 40 | *Pterocarpus angolensis* | 0.0889 | 0.0006 | 4.14 |
| 62 | 27 | *Pterocarpus tinctorius* | 0.0776 | 0.0004 | 9.67 |
| 63 | 49 | *Schrebera trichoclada* | 0.0317 | 0.0000 | 1.58 |
| 64 | 63 | *Securidaca longipedunculata* | 0.0180 | 0.0000 | 0.57 |
| 65 | 70 | *Solanum incanum* | 0.0028 | 0.0000 | 0.25 |
| 66 | 66 | *Strychnos cocculoidos* | 0.0649 | 0.0002 | 2.52 |
| 67 | 28 | *Strychnos innocua* | 0.0101 | 0.0000 | 0.56 |
| 68 | 20 | *Strychnos potatorum* | 0.0196 | 0.0000 | 0.83 |
| 69 | 78 | *Strychnos spinosa* | 0.0056 | 0.0000 | 0.28 |
| 70 | 57 | *Tamarindus indica* | 0.0110 | 0.0000 | 1.36 |
| 71 | 5 | *Tapiphyllum floribunda* | 0.0251 | 0.0000 | 1.15 |
| 72 | 24 | *Terminalia mollis* | 0.0096 | 0.0000 | 0.90 |
| 73 | 81 | *Terminalia sericea* | 0.1355 | 0.0019 | 11.32 |
| 74 | 39 | *Vangueriopsis lanciflora* | 0.0077 | 0.0000 | 0.62 |
| 75 | 14 | *Vitex doniana* | 0.0056 | 0.0000 | 0.27 |
| 76 | 60 | *Vitex mombassae* | 0.0437 | 0.0001 | 1.48 |
| 77 | 41 | *Xeroderris stunmannii* | 0.0240 | 0.0000 | 2.41 |
| 78 | 54 | *Xylopia antunesii* | 0.0056 | 0.0000 | 0.24 |
| 79 | 23 | *Zanha africana* | 0.0091 | 0.0000 | 1.47 |
| 80 | 3 | *Ziphus mucronata* | 0.0437 | 0.0001 | 1.39 |
| **Grand Total** | | | **3.3992** | **0.0555** | **300.00** |

## Appendix 9: Distribution of N, G and V by species and diameter classes of cut wood in UFR

| SPP code | Botanical name | DBH classes (cm) | | | | | | | | | | | | | | | | | | Total | | | Annual wood outtake |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | | | II | | | III | | | IV | | | V | | | VI | | | | | | |
| | | 1 -10 | | | 11 - 20 | | | 21 - 30 | | | 31 - 40 | | | 41 - 50 | | | > 50 | | | | | | |
| | | N | G | V | N | G | V | N | G | V | N | G | V | N | G | V | N | G | V | N | G | V | (m^3/ha/year) |
| 83 | *Afzelia quanzensis* | | | | 0 | 0.004 | 0.023 | | | | | | | | | | 0 | 0.058 | 0.646 | 0 | 0.062 | 0.669 | 0.2229 |
| 69 | *Azanza garckeana* | 0 | 0.001 | 0.003 | | | | | | | | | | | | | | | | 0 | 0.001 | 0.003 | 0.0010 |
| 30 | *Berchemia discolor* | 0 | 0.000 | 0.002 | | | | | | | | | | | | | | | | 0 | 0.000 | 0.002 | 0.0006 |
| 77 | *Brachystegia boehmii* | | | | 0 | 0.002 | 0.014 | 0 | 0.004 | 0.029 | 0 | 0.011 | 0.099 | | | | | | | 0 | 0.018 | 0.142 | 0.0473 |
| 71 | *Brachystegia spiciformis* | | | | 0 | 0.007 | 0.040 | 1 | 0.035 | 0.251 | 1 | 0.063 | 0.534 | 1 | 0.174 | 1.682 | 0 | 0.072 | 0.753 | 3 | 0.351 | 3.261 | 1.0868 |
| 16 | *Brychystegia microphylla* | | | | 0 | 0.006 | 0.031 | | | | 0 | 0.011 | 0.090 | | | | | | | 0 | 0.016 | 0.121 | 0.0402 |
| 47 | *Clerodendrum myricoides* | 0 | 0.000 | 0.001 | | | | | | | | | | | | | | | | 0 | 0.000 | 0.001 | 0.0002 |
| 33 | *Combretum collinum* | 0 | 0.001 | 0.006 | 0 | 0.005 | 0.028 | | | | | | | | | | | | | 1 | 0.007 | 0.034 | 0.0114 |
| 51 | *Combretum zeyheri* | 1 | 0.002 | 0.009 | 1 | 0.013 | 0.071 | 0 | 0.005 | 0.039 | | | | | | | | | | 1 | 0.021 | 0.118 | 0.0393 |
| 45 | *Commiphora africana* | 0 | 0.000 | 0.001 | | | | | | | | | | | | | | | | 0 | 0.000 | 0.001 | 0.0003 |
| 17 | *Dalbegia melanoxylon* | 0 | 0.000 | 0.001 | | | | | | | | | | | | | | | | 0 | 0.000 | 0.001 | 0.0003 |
| 58 | *Diplorhynchus condylocarpon* | 0 | 0.001 | 0.005 | 0 | 0.001 | 0.007 | 0 | 0.009 | 0.060 | | | | | | | | | | 1 | 0.011 | 0.072 | 0.0239 |
| 15 | *Erythrophleum africanum* | 0 | 0.001 | 0.002 | 0 | 0.001 | 0.005 | 0 | 0.006 | 0.044 | 0 | 0.008 | 0.066 | | | | | | | 0 | 0.016 | 0.117 | 0.0391 |
| 74 | *Jubernadia globiflora* | 1 | 0.004 | 0.015 | 1 | 0.011 | 0.064 | 1 | 0.037 | 0.253 | 1 | 0.068 | 0.592 | | | | | | | 3 | 0.120 | 0.925 | 0.3083 |
| 19 | *Lannea schiniperi* | | | | | | | 0 | 0.006 | 0.047 | | | | | | | | | | 0 | 0.006 | 0.047 | 0.0156 |
| 7 | *Pericopsis angolensis* | | | | 0 | 0.007 | 0.039 | 0 | 0.008 | 0.061 | | | | | | | | | | 0 | 0.014 | 0.100 | 0.0332 |
| 40 | *Pterocarpus angolensis* | 0 | 0.001 | 0.003 | 0 | 0.003 | 0.018 | 0 | 0.013 | 0.095 | | | | | | | | | | 0 | 0.016 | 0.115 | 0.0384 |
| 27 | *Pterocarpus tinctorius* | | | | 0 | 0.004 | 0.020 | | | | | | | | | | | | | 0 | 0.004 | 0.020 | 0.0068 |
| 49 | *Schrebera trichoclada* | 0 | 0.000 | 0.001 | | | | | | | | | | | | | | | | 0 | 0.000 | 0.001 | 0.0005 |
| 24 | *Terminalia mollis* | 0 | 0.001 | 0.003 | | | | | | | | | | | | | | | | 0 | 0.001 | 0.003 | 0.0011 |
| 81 | *Terminalia sericea* | | | | | | | 0 | 0.008 | 0.061 | | | | 0 | 0.019 | 0.190 | | | | 0 | 0.027 | 0.251 | 0.0835 |
| 23 | *Zanha africana* | 0 | 0.001 | 0.004 | | | | | | | | | | | | | | | | 0 | 0.001 | 0.004 | 0.0012 |
| | **Grand Total** | | **0.014** | **0.055** | **4** | **0.064** | **0.360** | **3** | **0.131** | **0.940** | **2** | **0.161** | **1.381** | **1** | **0.193** | **1.871** | **1** | **0.130** | **1.399** | **13** | **0.694** | **6.006** | **2.0020** |