EFFECT OF HUMAN ACTIVITIES ON COMPOSITION AND REGENERATION OF WOODY SPECIES IN MOROGORO FUELWOOD RESERVE, MOROGORO, TANZANIA

BY

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ABSTRACT

Morogoro Fuelwood Reserve (MFR) is a productive forest under the management of Mvomero district and Morogoro Municipal Authority. The reserve has been modified through human activities. The aim of this study was to investigate effect of human activities on composition and regeneration of woody species in MFR. Seventy four plots each with an area of 0.07 hectare were systematically established in 10 transects. Socio-economic data obtained through household (5%) interviews using structured questionnaire, informal discussion and direct observations in the village of Wami Sokoine and Maili kumi na nane & Mawasiliano streets. Microsoft excel software was used to analyse the quantitative data for forest parameters, while SPSS program, content and structural-functional analytical tools applied on socio-economic data. A total of 52 woody species belonging to 18 families were identified. The three most dominant tree species in terms of their IVI were *Combretum molle*, *Sclerocary birrea*, and *Pteleopsis myritifolia*. Tree stocking was 403 stems ha^{-1} while basal area and volume were $2.12m^2ha^{-1}$ and $9.58m^3ha^{-1}$ respectively. On average there were 7 233 stems ha^{-1} of regenerants. *Combretum molle* had higher regeneration potential in the reserve. The Shannon Wierner (2.7293) and Simpson (0.0705) Indices were reasonably average. Chi-square test showed that charcoal making, firewood collection, livestock grazing and wild fire were the major human activities that cause significant degradation of forest resources in the MFR. Logistic regression analysis revealed that the socio-economic factors that significantly influence demand for forest resources and subsequent degradation of the MFR are household size, cropping system, mode of farm preparation, average income, mode of livestock keeping and distance to sources of forest products. The study concludes that, although tree species richness and diversity are on average high, the MFR has been affected by activities of the adjacent human communities, which is shown by reduced wood stocks, basal area and volume. It is recommended that there should be regular assessment and monitoring to maintain ecological and environmental integrity of this reserve.

DECLARATION

I, IJUMAA KOMBO MCHARO SINGO, 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 a degree award at any other University.

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This work is dedicated to my beloved parents, the late Mohamedi Mcharo Singo and Halima Nanzia Mrindoko for devoting their little resources to educate me.

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forest overstorey, it is likely that at least part of these pioneer species will eventually grow into the forest overstorey, thus affecting the tree composition of the forest (Riswan et al., 1985; Newberry et al., 2000). 75

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LIST OF ABBREVIATIONS AND SYMBOLS

^{o}C	Degree Centigrade
CCT	Christian Church of Tanzania
CIFOR	Center for International Forestry Research
CEC	Cation Exchange Capacity
FAO	Food and Agriculture Organization
D	Density
G	Basal Area
GN	General Notice
GPS	Geographical Position System
Exp (ß)	The odds ratio
FBD	Forestry and Beekeeping Division
H’	Shannon Wiener Index
ID	Index of Dominance
IVI	Important Value Index
LN	Natural Logarithm
Mg	Miligramme
MNRT	Ministry of Natural Resources and Tourism
MFR	Morogoro Fuelwood Reserve
N	Number of Stems per hectare
NTFPs	Non Timber Forest Products
Pi	Proportion of individuals of the abundance of species i in the sample

RELMA	Regional Land Management Unit
RF	Relative Frequency
RN	Relative Density
RD	Relative Basal Area
RSCU	Regional Soil Conservation Unit
S	Shrub
SADC	South African Development Conference
Sida	Swedish International Development Agency
SPH	Stems Per Hectare
Spp	Species
SPSS	Statistical Package for Social Sciences
ST	Small Tree
SUA	Sokoine University of Agriculture
T	Tree
TTSA	Tanzania Tree Seed Agency
TEB	Exchangeable base
TFAP	Tanzania Forest Action Plan
URT	United Republic of Tanzania
UV-B	Ultra Violet- Beta
V	Volume
WBG	The World Bank Group
Xi	Independent Variables

CHAPTER ONE

1.0 INTRODUCTION

1.1Background

Tanzania's forests and woodlands cover about 38.8 million hectares. This area is about 41% of the total land area of 94.5 million hectares (MNRT, 2002). Of the total forests and woodlands area, about 13 million hectares have been gazetted as forest reserves (MNRT, 2002). There are 540 forest reserves in Tanzania varying in size from 3.0 ha to 580,000 ha (Nshubemuki, 1990). Forest reserves are managed for both protection and production purposes and they may be under the jurisdiction of central, or local government. These forests, which are found on diverse vegetation types including the miombo woodlands, montane, mangrove and lowland rain forests provide both services and products to adjacent communities (Malimbwi *et al.*, 1998). Catchments and biodiversity conservation forests and forests in national parks fall under the protection category, where human interferences are strictly kept at a minimum level while production forests managed mainly for round wood production involve development (silvicultural management) and harvesting (Maliondo, 1997).

After realizing the increasing demand for woodfuel, the government of Tanzania decided to establish model forests for production of fuelwood that include Ruvu South, Korogwe and Morogoro fuelwood reserves. These forest reserves were selected in view of their legal status (as state-owned property) that facilitated immediate intervention by the government in finding a solution to the supply of

Dar-es-salaam, Tanga and Morogoro municipality respectively with woodfuel on a sustainable basis by allowing natural regeneration and /or enrichment planting. The Morogoro Fuelwood Reserve (MFR), which is dominantly dry miombo woodlands, is one of the productive forest reserves under the Mvomero district and Morogoro Municipal Authority managed for providing fuelwood to Dar-es-Salaam City, Morogoro Municipality and adjacent areas.

Miombo woodlands cover an estimated 2.7 million km^2 in Southern, Central and Eastern Africa (White, 1983; Frost, 1996) and are important for the production of valuable hardwood timber and support the economic livelihood of millions of people (Frost, 1996). The miombo woodlands have a high floristic diversity (White, 1983) but a low proportion of commercially valuable timber species (Gauslaa, 1989). Therefore, miombo woodlands are most important as a non-timber resource, particularly for woodfuel, poles, beekeeping, handcrafts, fruits and medicines. In Tanzania, about 90% of the people rely on wood for heating and cooking. In fact, to the rural and peri-urban communities, fuelwood is a very basic need, like water. Quantitatively, fuelwood is the major product from miombo woodland (Temu, 1979). Shaba (1993) reported that wood, most of which is obtained from miombo, supplies 70% of the energy consumed in the southern African region. In Tanzania, about 97% of all wood consumed is used for woodfuel and this constitutes about 91% of the country’s total energy consumption (Ahlback, 1986; 1988). Charcoal constitutes a significant fraction of the total woodfuel consumed (Mnzava, 1986). The dynamics of miombo woodlands are largerly affected by human activities through clearance of land for cultivation (slash and burn), subsequent abandonment, selective harvesting of trees for different purposes and fires (Frost, 1996; Luoga, 2000).

In developing countries, land is perhaps the most basic resource available for social and economic development of the people. However, with high population growth rates, total demand is increasing, exerting increasing pressure upon the natural resource base and productive land resources are increasingly becoming scarce in most of these countries (FAO, 1985). As a result, some of forests are being degraded in both quality and quantity. To streamline social and economic activities both within and outside forests, governments have often promulgated laws to protect, manage and guide the use of forests (URT, 2002). However, despite forest protection laws in Tanzania being in place, the forest reserves in the country have continued to be degraded through encroachment for permanent settlements, timber/wood fuel harvesting, livestock grazing, wildfires and farming (MNRT, 1998).

1.2 Problem statement and justification

Throughout the miombo eco-region, the woodlands supply many products and services essential to the well being of rural communities. Some products act as inputs to livestock and agriculture (browse, leaf mulch), while others provide basic needs, such as food, shelter and health (Clarke, *et al*., 1996). Despite all the benefits derived from forests and woodlands, they are not well managed (Maliondo, 1997). They are subjected to uncontrolled exploitation, encroachment and wild fires during the dry seasons. Agricultural activities, especially shifting cultivation significantly cause deforestation of miombo woodlands (Chidumayo, 1990). Pitsawing, which is regarded as selective logging as well as species-specific and charcoal making, can also lead to forest degradation (Grainger, 1993).

The MFR was gazetted in 1953. Since then, the reserve has been subjected to different levels of utilization. The proximity of the MFR to the market in Morogoro Municipality and Dar-es-Salaam City provides opportunities to engage in the forest produce business especially woodfuel, thus accelerating the rate of exploitation of the forest reserve and its subsequent degradation. The changes due to transformation in this reserve are reflected in reduced tree density, species composition and regeneration. Such changes may have a wide range of long-term socio-economic and environmental consequences (Frost and Desanker, 1998).

Uncontrolled exploitation, livestock grazing and wild fires have affected the reserve. These socio-economic activities of the communities adjacent to the forest have progressively been increasing. The management of a forest calls for the application of appropriate research, silvicultural treatments, regular forest inventory, forest protection measures and regulation of exploitation (Matsebula, 1992). There is scanty information on regeneration, species composition and diversity in the reserve and the human activities that affect them. The degree of dependence of forest adjacent communities on the forest resources from the reserve has not been quantified and the relationship between forest resource degradation and socio-economic factors are not well known. Therefore, this study provides different stakeholders with information on status of the vegetation in the forest reserve under various types of human impacts and socio-economic factors that influence composition and regeneration of the forest reserve. This information will contribute towards preparing appropriate management strategies and hence sustainable management of the reserve.

1.3 Objectives

1.3.1 Overall objective

The overall objective of this study was to investigate the effect of human activities on composition and regeneration of woody species in MFR.

1.3.2 Specific objectives

The specific objectives were to:

(i) Assess regeneration, woody species composition and diversity.

(ii) Identify and assess human activities, which cause degradation of forest resources in the study forest.

(iii) Assess the degree to which the livelihoods of forest adjacent communities depend on the forest resources from the MFR.

(iv) Assess the influence of socio-economic factors on local people dependence on forest resources.

1.4 Research questions

This study was guided by the following questions:

(i) What is woody species composition, diversity and extent of regeneration after being disturbed?

(ii) What human activities affect forest resources in MFR?

(iii) To what extent does livelihood of forest adjacent communities depend on the forest resources from the reserve?

(iv) To what extent do socio-economic factors influence the status of forest resources?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Miombo woodlands

In Africa, around 3.6 million square kilometers are covered by woodlands and associated wetlands popularly known as "miombo" (Millington *et al.,* 1994). Miombo is the *Kinyamwezi* word for *Brachystegia boehmii* (Mansfield *et al.,* 1976) used to describe those central, southern and eastern African woodlands dominated by the genera *Brachystegia, Julbernardi*a and/or *Isoberlinia*, three closely related genera from the legume family *Fabaceae,* subfamily C*aesalpinoideae*. Miombo woodlands are amongst the largest continuous dry deciduous forest formations in the world (Desanker *et al.*, 1997).

In miombo woodlands human population densities are still low in comparison with other savanna areas of Africa under similar climatic conditions (Moyo *et al.,* 1993). The density of domestic livestock is also relatively low. The cause of low population is due to the nutrient poor soils that limit agricultural potentials, the widespread infestation of tse-tse fly (Glossina spp.) and vectors of trypanosomiasis, which affect human as well as domestic livestock. Historically, the threat of this disease prevented people from bringing cattle into most miombo areas (Matzke, 1983).

Despite the relatively small human populations, particularly in the wetter regions, much of the woodlands have been, and continue to be, modified by people, principally through the removal of woodland cover (Backéus *et al.*, 2006). The woodland structure, vegetation communities and species composition has partially been created through human intervention, especially through the use of fire, pastoralism and shifting cultivation. Human activities are therefore important in the dynamics of miombo ecosystems (Banda *et al*., 2006). The main traditional form of land use in miombo woodland involves cultivation of small fields of sorghum, millet, and maize either under some form of shifting agriculture, usually involving ash fertilization (*Chitemene*) and hand cultivation or in drier regions free from trypanosomiasis, in conjunction with rearing livestock which provide the necessary draught power for cultivation (Puzo, 1978).

A large proportion of the human population inhabiting miombo woodlands is poor, rural and semi subsistence agriculturists. The resources of miombo woodlands are therefore central to the livelihood systems of millions of these rural people and urban dwellers (Lawton, 1982; Campbell *et al.,* 1991a; Bradley and Dewees, 1993). Range of products from the woodlands, from medicines and food to building timber and fuel support rural living. The woodlands are not only the source of material goods, they are also central to the spiritual needs of the people, with specified trees even blocks of woodlands being conserved by communities for cultural reasons (Morris, 1995). Miombo woodlands also provide products for towns and cities of the region, the most important of which is wood fuel.

2.2 Ecological features of miombo woodland

2.2.1 Climate

Miombo woodlands are situated within the southern sub-humid tropical zone of Africa. About two-thirds of the region falls within the Köppen Cw climate class, indicating a warm climate with a dry winter, the rest falls into the A*w* (hot climate with dry winter – 26% of 62 sites) and B*sh* (hot dry steppes- 8%) climate classes (Frost, 1996). The 10-90 percentiles for mean annual precipitation and mean annual temperature are 710-1365mm and 18.0-23.1 ºC respectively. Coefficients of variation in annual rainfall are less than 30%. More than 95% of annual rainfall occurs during a single 5-7 months wet season. A few sites in northern Tanzania and north eastern Angola have two wet seasons. These and some sites in south-eastern Mozambique receive > 5% of their annual rainfall during the dry months (Frost, 1996). The ratio of annual precipitation to evapotranspiration varies from 0.5 to 1.1.

2.2.2 Geology and soils

The distribution of miombo woodlands is largely coincident with the flat-to-gently undulating landscapes of the African and post-African planetion surfaces that form the central African plateau (Cole, 1986). The underlying geology of the plateau is largely

Precambrian, comprising mainly Archean metavolcanics and metasediments of the Basement complex and intrusive granites and granitic gneisses of varying ages.

The soils are generally freely drained although drainage can be restricted locally by shallow depth, low relief, clay subsoils or indurated laterite. Nodular laterite is often present at variable depths, marking the past and sometimes present upper limits of a fluctuating water table. The through-country drainage is sluggish and diffuse as a consequence of the relatively flat landscape (Young, 1976).

Miombo woodlands soils are typically acid, have low cation exchange capacities (CEC) and are low in nitrogen, exchangeable cations (Exchangeable bases: TEB) and extractable phosphorus. Organic matter levels are generally low, except under densely wooded vegetation. Nevertheless, organic matter contributes substantially to cation exchange capacity in these soils.

2.2.3 Phenology

Most miombo trees and shrubs, including all of the dominant species are deciduous, shedding their leaves during the dry season. Leaf fall peaks in July-August in dry miombo woodlands and August- September in wet miombo woodland (Malaisse *et al.*, 1975). About 91% of leaf litter falls during the dry season (May-October) in dry miombo woodlands compared with only 64% in wet miombo woodlands(Freson *et al.*, 1974). The timing of leaf fall and the duration of the leafless period vary from year to year, depending on prevailing weather conditions and on the species. About 8% of the trees and

3% of the shrub species in miombo woodlands in Zimbabwe e.g. *Pseudolachynostylis maprouneifolia*, *Monotes* spp. are briefly deciduous, only shedding their leaves late in the dry season irrespective of the preceding wet season rainfall (Frost, 1996). Shallow- rooted species such as *Lannea discolar* and V*angueria infausta* shed their leaves at the onset of the dry season and remain leafless until the next rain season, after the leaves of most canopy species have already flushed.

The tendency of many species to retain their leaves long into the dry season is linked to their ability to access to sub soil moisture. Most of the dominant trees are relatively deep-rooted (Savory, 1963; Timberlake and Clavert 1993). Nevertheless, most species are intolerant of perched water tables and poorly aerated, seasonally waterlogged sub soils. Where they do occur on such sites, they are usually stunted and misshapen (Savory, 1963). Seasonally waterlogged soils are usually occupied instead either by hygrophilous grasses or shallow rooted, evergreen trees and shrubs.

The flush of new leaves 4-8 weeks before the first spring rains is one of the characteristics features of miombo woodlands and is quite different from patterns of leaf flush in other tropical deciduous forests and woodlands. The red colour of the leaves is striking, particularly those of *Brachystegia spiciformis.* This colouration is due to the synthesis of *anthocyanins* soon after bud burst and reaches a peak about 3 weeks later (Ernst, 1988; Johnson and Choinski, 1993). The precise function of the anthocynins is unclear. They may absorb UV-B radiation and thereby protect the young leaves from damage (Bate and Ludlow, 1978). Anthocynins may also function to protect the leaves against pathogens and herbivores (Coley and Aide, 1989).

Most trees and shrubs in miombo woodlands flower during the warm, dry pre-rains season (September-October). *Julbernadia* species are notable exceptions. *Julbernadia paniculata* flowers in the latter half of the wet season from February to April, while *J. globiflora* flowers from November to April (Campbell *et al.*, 1988). Some shrubs species also flower in the mid and late wet season. A few trees and shrubs (e.g. *Pterocarpus angolensis*) and herbs (Rhynchosia *insignis*) flower before leaf flush but for most trees and shrubs, flowering is synchronous with, or follows immediately after, leaf emergence.

2.2.4 Associated vegetation types of miombo woodlands

Miombo has variously been classified as savanna (Frost *et al.*, 1986), woodland (White, 1983) and forest (Malaisse 1978a), a reflection of the long-standing argument among ecologists in Africa over how best to categorize those wooded formations in areas receiving markedly seasonal rainfall.

Arid-eutrophic savannas, such as Acacia savanna, mopane (*Calophospermum mopane*) woodland and other dry savanna woodlands (White, 1983), are found in the large valleys of the Zambezi and Luangwa rivers, within the miombo region, and as one moves south and south west from the main miombo region into drier areas. In Tanzania, grassland and *Acacia* savanna replace miombo woodlands on the nutrient-rich volcanic soils, in drier areas and in areas with two rainfall peaks. Open woodlands dominated by *Combretum* spp. with a tall grass understorey occur on more fertile soils in lower catenary positions adjacent to miombo woodlands on the upper slopes. Fire induced tall grass savannas with scattered fire tolerant trees (*Pterocarpus angolensis*, *Burkea africana, Erythrophleum africanum* and mixed woodlands and thickets dominated by *Combretum* spp., *Acacia* spp., *Afzelia quanzensis*, *Pericopsis angolensis*) occur on the nutrient-rich soils (Trapnell and Clothier, 1937). In the west of miombo zone dry evergreen forest and deciduous closed woodlands occur on Kalahari sands, which cover a layer portion of Zambia, Zimbabwe and Angola. These areas are dominated by *Cryptosepalam pseudotaxus* where water tables are seasonally high and by *Baikiaea plurijuga* on deeper, better drained sands. In areas with high rainfall, miombo woodlands give way to evergreen forest as found along the northern limit of miombo woodlands in Angola and Democratic Republic of Congo. A similar transition occurs on the Mozambican coastal plain, which is dominated by forest and scrub forest (Campbell *et al.,* 1996).

Fire sensitive evergreen thickets and partly evergreen woodlands occur on deep soils and in lower, wetter catenary positions adjacent to grasslands (*chipya)*. This juxtaposition of infertile miombo and other more fertile, moister and productive vegetation types may be important in maintaining populations of large wild and domestic herbivores in miombo woodlands (Campbell *et al.,* 1996).

Dambos (*Mbuga*) are distinctive features of the miombo region. They occupy seasonally waterlogged shallow valley depressions. The dambos largely form the headwater reaches of drainage lines of the unrejuvanated surface of the central plateau. Dambos are hygrophilous, largely treeless grasslands and in some areas can cover up to one third of the landscape (Whitlow 1985a; 1985b). Evergreen groundwater forests (*Mushitu*) occur in the perennially moist central parts of dambos in areas with higher rainfall. The north-south ranges of mountains in the eastern parts of the miombo zones are characterized by afro-montane vegetation, grassland and forests (White, 1983), forming archipelago-like islands within a sea of miombo woodlands.

2.3 Structure, composition and species diversity of miombo woodlands

2.3.1 Miombo woodlands structure

In miombo woodlands the density of woody plants varies widely (between 1500-4100 stems ha^{-1}). Tree densities range from 380-1400 stems ha^{-1} (Trapnell 1959, Boaler and Sciwale 1966; Robertson 1984; Chidumayo, 1985; Campbell *et al.*, 1995c). Density of woody plants is apparently not related to rainfall or to any other single factor. In contrast, tree height appears to be related to moisture availability and soils depth (Savory 1963; Grundy 1995a). Canopy height is less than 15m and the vegetation is floristically impoverished. Canopy dominants such as *Brachystegia spiciformis, Brachystegia longifolia, Brachystegia utilis* and *Julbernardia paniculata* growing on deep (>3m), well-drained soils can reach up to 27m in heght in wet miombo woodlands.

The recorded basal area of trees in old-growth, mixed-age stands ranges from as little as 7 m^2ha^{-1} on lithosol in southern Malawi at about 650 mm mean annual precipitation (Lowore *et al.*, 1994a) to 22 m^2 ha^{-1} in wet miombo woodlands on deep soils in Democratic Republic of Congo at 1270 mm rainfall (Freson *et al.*, 1974). Higher values (30-50m^2 ha^{-1}) have been recorded locally on small plots (Chidumayo, 1985; Grundy, 1995a). Most stands have basal areas of 7-19 m^2ha^{-1} (Boaler and Sciwale, 1966; Allen, 1986, Chidumayo 1987c). Strang (1974) studying the miombo woodlands of Zimbabwe observed that wood basal area stabilizes at 10 –11 m^2ha^{-1} after 50 years since last clearing. Studying the miombo woodlands of Tanzania Bystrom *et al.*, (1987) reported mean basal area of 8.8 m^2ha^{-1} and 16.5 m^2ha^{-1} in Iringa and Tabora respectively. Stand basal area increases linearly with increasing mean annual rainfall, with the ratio of annual rainfall to annual potential evapotranspiration (Chidumayo, 1987d); and with the ratio of mean annual temperature to mean annual rainfall.

Stand basal area provides an index of both the harvestable volume and above ground woody biomass of miombo stands (Frost, 1996). Average harvestable volumes in dry miombo woodlands range from 14m^3ha^{-1} in Malawi (Lowore *et al.*, 1994a) to 59 m^3ha^{-1} in Zambia with a maximum value of 117m^3ha^{-1} (Chidumayo 1988d). Wood volume has been observed to range from 39m^3ha^{-1} to above 120m^3ha^{-1} for miombo woodlands of Tanzania (Kielland-Lund, 1990; Malimbwi *et al.*, 1994). Nduwamungu (1996) observed mean total volume and basal area of 71m^3ha^{-1} and 10 m^2ha^{-1} respectively at the Kitulang’alo SUA training forest reserve. In Rufiji district, Tanzania, Malimbwi and

Mugasha (2000) reported maximum volume and basal area of $110m^3ha^{-1}$ and $12.5m^2ha^{-1}$ respectively in miombo woodlands.

Reported values for above ground biomass in individual stands range from less than 1.5 $Mgha^{-1}$ for 3-6 year old coppice woodlands regenerating under an imposed late dry season fire regime (Chidumayo, 1990) to 144 $Mgha^{-1}$ in mature miombo woodlands in Democratic Republic of Congo (Malaisse and Strand, 1973). Above ground biomass in old growth, mixed-age stands averages about 55 $Mgha^{-1}$ in dry miombo woodlands in Zambia and Zimbabwe (Martin, 1974; Guy, 1981a; Chidumayo, 1991b) and about 90 $Mgha^{-1}$ in old-growth stand in wet miombo woodlands (Malaisse and Strand, 1973; Malaisse 1978a; Chidumayo, 1990). Much less is known about the amount of woody biomass below ground. Miombo species have horizontally and vertically extensive root systems. Maximum-recorded lateral distances are 27m for *J. globiflora* (Strang, 1965) and 15m for *B. longifolia, B. spiciformis and J.paniculata* (Savory, 1963). The taproots of these species can exceed 5m in deep soils. Root biomass measured in old-growth stands of dry miombo woodlands in central Zambia averaged 32.7 $Mgha^{-1}$ where the measured Cordwood biomass averaged 41.8 Mg ha^{-1} (Chidumayo, 1993).

2.3.2 Species composition in miombo woodlands

In miombo woodlands, woody plants comprise 95-98% of the above ground biomass of undisturbed stands; grass and herbs make up the remainder (Malaisse, 1978a; Chidumayo, 1993a). Differences in species composition and structure are more apparent at a local scale (Frost, 1996). The origin of these differences is unclear. Geomorphic evolution of the landscape (Cole, 1986), edaphic factors, principally soil moisture and soil nutrients (Astles, 1969; Campbell *et al.,* 1988), the effects of fire (Freson *et al*, 1974; Lawton, 1978; Kikula, 1986b), wildlife impacts (Anderson and Walker, 1974; Thomson 1975; Guy 1981a; 1989) and past and present land use and other anthropogenic disturbances (Robertson, 1984; Chidumayo, 1987c) have all been implicated.

The dominance of the genera *Brachystegia, Julbernardia* and *Isoberlinia* (*Fabaceae*, subfamily *Caesalpinioideae*) makes miombo woodlands floristically distinct from most other African woodlands. These genera are seldom found outside miombo. Although this dominance by C*aesalpinioideae* is characteristic, their contribution to numbers and biomass varies widely within and between communities (Frost, 1996). Factors suggested to favour this dominance are interesting but as yet largely an unanswered question, though the wide spread occurrence of ectomycorrhizae in their roots may enable them to exploit porous, infertile soils more efficiently than groups lacking ectomycorrhizae (Högbery and Nylund, 1981).

White (1983) divided miombo woodlands into dry and wet miombo woodlands. Dry miombo woodlands occur in southern Malawi, Mozambique, east-southern Tanzania and Zimbabwe in areas receiving less than 1000 mm rainfall annually. The dominant *Brachystegia* species of the wet miombo woodlands are either absent or local in occurrence. *Brachystegia speciformis, B. boehmii* and *J. globiflora* are the dominant deciduous species. The herbaceous layer varies greatly in composition and biomass and include grasses (mainly of the genera *Hyparrhenea*, *Andropogon*, *Loudetia*, *Digitaria* and *Eragrostis*, sedges, shrubs particularly legume such as *Indigofera*. Wet miombo woodlands occur over much of eastern Angola, Northern Zambia, Southwestern Tanzania and central Malawi in areas receiving more than 1000mm rainfall per year. Canopy height is usually greater than 15 m, reflecting the generally deeper and moist soils that create favourable conditions for growth. The vegetation is floristically rich and includes nearly all of the characteristic miombo species. *Brachystegia floribunda*, *B. glaberrima*, *B. longifolia*, *B. wangermeeana, Julbernadia paniculata, Isoberlinia angolensis* and *Marquesia macroura* are widely distributed (Frost, 1996). The understorey comprise a mixture of grasses, bracken (*Pteridium equilibrium*) and shrubs, including the monocot *Aframomum biauriculatum.* Despite the high density of overstorey, the dominant grasses are all heliophytic C_4 species of *Hyperrhinia, Andropogon* and *Loudetia*.

Miombo woodlands have been viewed by some people to be sub-climax to evergreen forests, maintained as such by frequent fires and exploitation by people and wildlife (Freson *et al.,* 1974; Lawton, 1978). Lawton (1978) concluded that topographic and edaphic factors are relatively unimportant in determining vegetation pattern in miombo woodlands in Zambia, however White (1983) noted that where evergreen forest occurs alongside miombo woodlands it coincides with a transition to deeper soils, suggesting that there is an edaphic influence.

2.3.3 Miombo species diversity

Diversity is defined as the structural and functional variety of plants and animals at genetic, population, community and ecosystem levels (Misra, 1989). It has two components: species richness or actual number of species contained within a community and evenness of the community (Kent and Coker, 1992). Factors which are associated with disturbances are the most important to determine species composition in miombo woodlands especially when the edaphic factors are similar (Luoga, 2000).

Communities that are subjected to harsh or unfavourable environmental conditions continuously or periodically, tend to be composed of a small number of species that are abundant. In mild or favourable environments the number of species is often large, but none of them is very abundant (Michael, 1984). Species diversity is a very useful parameter for comparison of two communities. High species diversity is considered by most ecologists as a desirable property of any community or ecosystem and this criterion has dominated most methods for ecological and conservation evaluation techniques (Kent and Coker, 1992). The knowledge of species diversity is particularly useful when one wishes to study the influence of biotic disturbances or the state of succession and stability in the environment (Misra, 1989). The author further notes that diversity indices provide important information about rarity and commonness of species in a community.

2.4 Contribution of miombo woodlands to rural livelihoods

2.4.1 Rural livelihoods

Heninger (1998) defines livelihood as adequate stocks and flows of food and cash to meet needs. “Livelihoods” is the concept that has emerged from a growing understanding of the complex and diverse ways in which marginalized people provide for themselves and their families (Clarke and Grundy, 2004). Households do not survive on crop production or wages alone, but on a complex mix of different activities, many of which depend on the resource available to them and are closely tied into the social network of which they are part.

In order for livelihoods to be sustainable, it must have the ability to cope with and recover from shocks and stresses (Chambers and Conway, 1992; Carney, 1998; Scoones, 1998). Livelihoods which are not able to cope with short term shocks and adopt to long-term pressures or changes in conditions are likely to be forced to undermine their asset base, and are unlikely to be sustainable. The sustainable livelihoods framework provides valuable bases for understanding the role that a forest and woodlands play in the lives of rural households. Sustained livelihood also refers to the maintenance or enhancement of resource productivity on a long-term basis. Assessment of short-and-longer-term risks and related coping mechanisms are crucial human-welfare issues on sustainable livelihoods (Chambers, 1987).

2.4.2 Goods and services derived from miombo woodlands

Miombo woodlands provide a wide range of products and services to rural households (Figure 1), and that these are likely to make an appreciable contribution to rural household income and welfare (Campbell and Byrone, 1996). Miombo woodlands products contribute to rural household welfare in a range of direct ways, providing food and non-food consumption goods, durable goods, inputs into agricultural and other production activities, and inputs into asset formation and maintenance (Construction, livestock, food). In addition, miombo woodlands provide a range of indirect values whether environmental (watershed protection, soil preservation), aesthetic or spiritual.

Bradley and Dewees (1993) suggest that households in heavily populated rural areas face a difficult decision when deciding the fate of woodlands growing on land allocated to the family: the usual choice being to clear it to increase the supply of agricultural land. If the woodlands are retained then the family forgoes short term-benefits of lost agricultural production. If woodlands are cleared, access to essential products is reduced or even lost, including essential inputs into the cropping systems via livestock (browse for livestock, which in turn provide draught power and manure as well as direct fertility inputs from leaf litter.

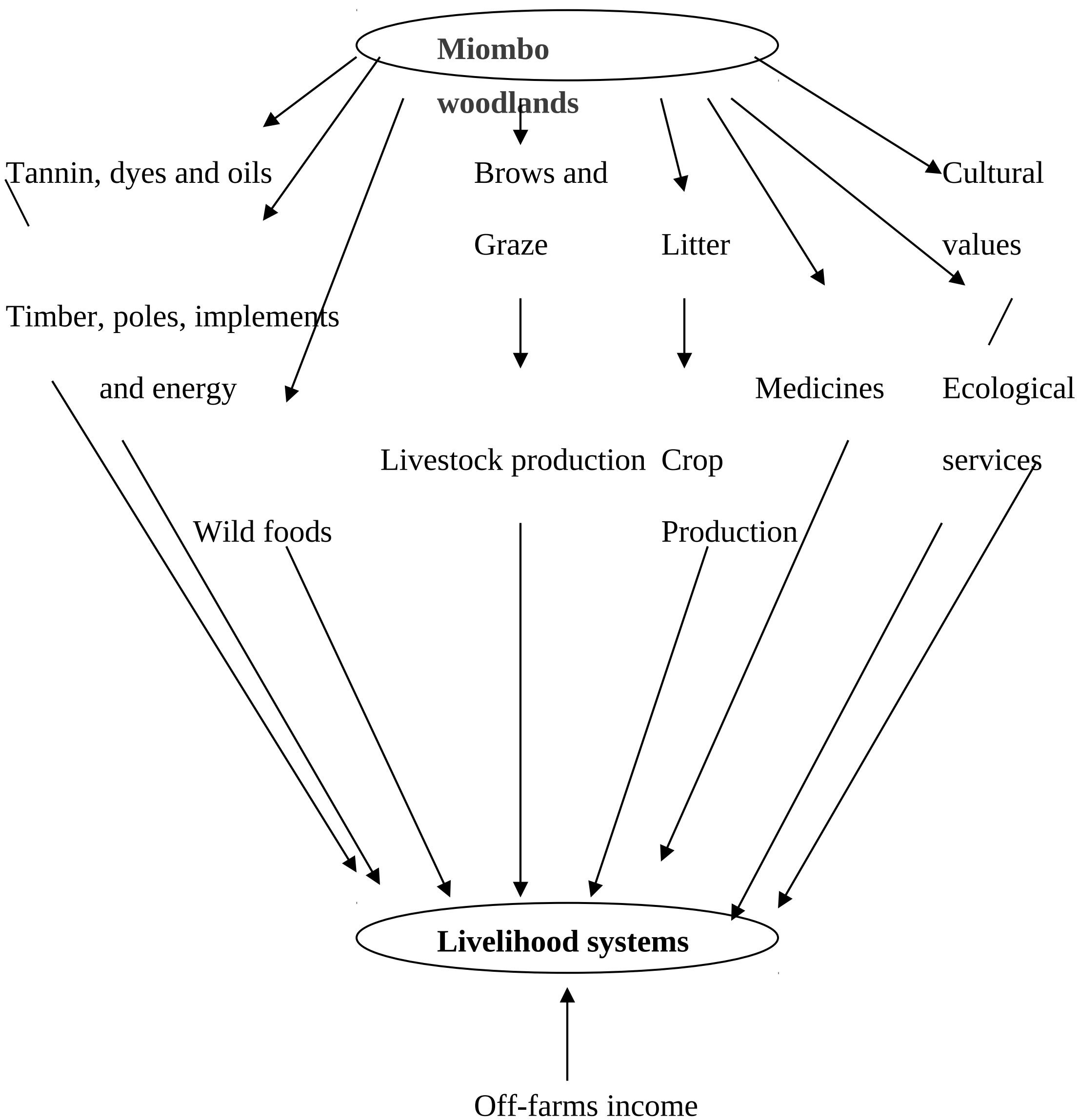

Figure 1. The goods and services of miombo woodlands (Clarke *et al*., 1996)

Just as communities and households are socially and economically differentiated, so is their access to and use of NTFPs (Kepe, 1997). There are clear indicators that poorer and more isolated communities, as well as, households that are less well off or headed by women, are often more dependent on the natural resources base (Shackleton *et al.,* 1999).

Cavendish (2000; 2002) found for commercial area of Zimbabwe (Shindi ward) that wild resources contributed on average 40% of the total household income for poor households, while the corresponding figure for more wealthy households was 29%. NTFPs also provided proportionately more cash income to poor households (20%) than better off households (5%). However, unlike the income share data, absolute demands for natural resources did not decline with increasing wealth (Shackleton and Shackleton, 2004). Indeed, more wealth households were found to consume greater absolute amount of natural resources goods than poorer households (Cavendish, 2000).

2.4.3 Factors influencing the use of miombo resources

Factors, which influence resource demands and lead to differential use patterns can be clustered into four broad groups (Campbell and Byron, 1996). These factors include nature and value of the resources, household characteristics and livelihood strategies, market for forest products and land and resource management institutions. All these variables are inter-related, forming a complex of biophysical, social and economic variables, which underpin patterns of use and value across forest and woodland types (Campbell and Byron, 1996).

***Nature of the resource*:** The types and quantities of goods and services available are directly related to the existing vegetation types and conditions. Miombo woodlands can be defined along rainfall continuum, ranging from dry to wet (White, 1983). The actual species found in each type and therefore the specific categories of products derived from them will differ from place to place. Furthermore, the availability of particular sources derived from natural environments constantly fluctuates, both seasonally and over larger period of time (Leach *et al.,* 1997).

Households' characteristics and livelihood strategies: Communities are not homogeneous, but are made up of diverse set of households and individuals each with their own entitlements and priorities which influence their access to and use of resources (Leach *et al.,* 1997).

Markets for forest products: Miombo woodlands are the primary source of energy in the form of woodfuel and crucial source of essential substance goods (Dewees, 1994, Morris, 1995). Important products include poles, timber, medicines, foods leaf litters and materials for tool handles. The commercial use of these resources has been on the increase in recent years (Murphree, 2000). The ease of entry and proximity to widely dispersed rural markets enable large numbers of people to generate some income from forest products.

Land and resource management institution: In rural communities access to resources is mediated through institutions. Access to and control over resources is socially differentiated depending on how the rules affect different members of the community or what 'environmental entitlements' they have. The concept of 'environmental entitlements' (Leach et al., 1997) is the key to understanding resource-use patterns at the local level.

2.5 Regeneration of miombo woodlands

2.5.1 Natural regeneration and plant communities

Natural regeneration is one of the most important processes in perpetuating plant communities. It is the process through which new plants replace their predecessors of the same species (Misra, 1989). Natural regeneration is important in understanding forest dynamics. It is therefore necessary to know the regeneration potential of any forest and the associated factors affecting it.

Natural regeneration of harvested or otherwise disturbed forest stands typically occurs in four sequential stages namely stand initiation and regeneration stage, thinning or stem exclusion stage, transition or understory regeneration stage and steady-state or old-growth stage (Oliver, 1981; Oliver and Larson, 1996). Each of these stages exhibits some unique characteristics. Disturbance during any of these stages may induce physiological disfunctions in trees and results in failure of adequate stand regeneration (Kozlowski, 2000).

Following tree harvesting or disturbances, forest stands regenerate through interactions among propagules, including seed in seed banks and those dispersed into a site as well as sprouting or layering of residual trees and soil and climatic conditions (Kozlowski, 1971).

In the case of pines for example, regeneration of forest stands may occur from seed stored in the soils or in serotinous cones in forest canopies. Some species such as Pines, store viable seed in cones that remain unopened while still attached to trees for many years. The germination of seeds involves resumption of embryo growth and seed coat rupture followed by seedling emergency.

2.5.1.1 Sexual regeneration in miombo woodlands

Seeds of the majority of miombo trees and shrubs germinate immediately after dispersal, as long as there is adequate water supply (Strang, 1966; Chidumayo, 1991a; 1992a). Seed germination rate among miombo trees determined by seedling emergency, ranges from 10-99% (Chidumayo and Frost, 1996). There is no extended dormancy and no extensive store of seed in the soils, at least among the canopy species. By mid summer, no viable seed of *Brachystegia spiciformis* remain in the soil (Ernst, 1988). However, under controlled storage conditions *Brachystegia spiciformis* and *Pterocarpus angolensis* seed can maintain viability for more than one year (Msanga, 1998). The seed germination period for the majority of miombo trees ranges from 2-6 weeks, although this may be extended to 10 weeks under drought conditions (Chidumayo, 1993a). Germination rates under field conditions may be lower than under laboratory conditions due to mortality during the germination period induced by the dry spells at the beginning of the rain season (Strang, 1966). *Pterocarpus angolensis* seed in Tanzania are known to germinate during the second rain season after surviving through the first rainy season following dispersal (Boaler, 1966a). For the majority of miombo trees, seeds die and decompose if they fail to germinate during the rain season. For this reason, seed are scarce in miombo woodland at the end of the rain season.

Most seedlings experience a prolonged period of successive annual die back during their development phase. Their success to reach the tree canopy depends on their ability to survive fires and to exhibit rapid growth in years without grass-burns (Kielland-Lund, 1982). Fire and water-stress during the dry season are responsible for the annual shoot die back (Strang, 1966; Ernst, 1988). This is probably why seedlings in miombo grow very slowly in height because they initially allocate more biomass to root growth (Chidumayo, 1993). For example, Groome *et al.*, (1957) reported that, it takes at least 7 years before seedlings of *Pterocarpus angolensis* are able to pass into sapling stage. During this period, reserves are stored in the root system until the plant is strong enough to withstand fire.

2.5.1.2 Asexual regeneration in miombo woodlands

Fanshawe (1971) noted that miombo woodlands regrow virtually unchanged in species composition following clearing. This is because regeneration consists mainly of stump coppices, stump/root sucker shoots and recruitments from old stunted seedlings already present in the grass layer at the time of tree cut, fall or death.

Miombo species regenerate largely through coppice regrowth and root suckers rather than through seeds (Trapnell, 1959; Boaler and Sciwale, 1966; Strang, 1974; Robertson, 1984). Stumps of almost all miombo woodlands trees have the ability to produce sucker shoots (Trapnell, 1959; Lees, 1962; Boaler and Sciwale, 1966; Strang, 1974; Banda, 1988; Chidumayo, 1989b). Sucker shoots arise from buds, which develop on roots and stem bases. Stump survival rate in regrowth is high. Chidumayo (1989b; 1993a) recorded rates of over 95% in woodland of under 25 years, while in old growth miombo woodlands the range was 65-75%.

Miombo species show a remarkable capacity to sustain regrowth, even when regrowth is regularly cut back. The response of trees to stem breakage, either from elephant damage or from chopping depends among other things, on the species concerned, climate, soil conditions and tree size and shape. The implication of this capacity to sustain regrowth is that miombo woodlands can sustain heavy cutting pressure.

2.6 Deforestation in miombo woodlands

2.6.1 Deforestation and degradation

Deforestation is usually defined as the loss of forest. FAO (1999) defines deforestation as converting forests to another land use (agriculture or grazing land) or the long-term (more than 10 years) reduction of tree-canopy cover below the 10% threshold. When a forest has been badly damaged through careless logging or any other activities but has not been converted to another land use and still retains 10% of the crown cover it is designated as degraded (Heinrich, 1992). Despite differences in definitions, the two terms are used synonymously and interchangeably. There are several factors, which are responsible for deforestation. These are namely:

2.6.1.1 Human factors causing deforestation in miombo woodlands

Human activities are central to the current dynamics of miombo ecosystems. Other than fire, the main disturbances to be considered are partial and complete clearance of woodland, conversion of woodland to cropland, and heavy grazing (Desanker *et al*. 1997). Large areas of forest have been and continue to be modified or transformed by people. The changes include reductions in tree density and declines in forest cover. Such changes will potentially have a wide range of long-term socio-economic and environmental consequences. By affecting atmospheric chemistry and land surface properties, the impacts of land-use and land-cover change are likely to influence global and regional climate processes, which, in turn, could feedback to affect the patterns of productivity, resource availability, and land use (Frost and Desanker 1998).

The following are human activities that are found to cause deforestation and thus affect miombo regeneration and composition.

2.6.1.2 Cultivation

The main traditional forms of land use are sedentary and shifting cultivation of small fields. Shifting cultivation is an agricultural system in which a person uses a piece of land (usually for five years) and abandons it or alters the initial use a short time later (Wikipedia, 2006). Shifting cultivation is synonymous to “ slash and burn” cultivation. In Europe it is described as *Swidden* agriculture and in Southern and Central Africa is called *Chitemene* while in Bhutan, South Asia, it is known by the term *Tsheri.*

Chitemene usually involves ash fertilization and hand cultivation. The word "Chitemene" means "to cut". Crops are grown in an ash garden (infield) made from burning a pile of plant material. The material burned comprises usually branches which have been lopped from trees in the surrounding area (outfield). The outfield is about ten times larger (half a hectare, for example) than the infield. Lopping branches (or at least leaving a tall stump), ensures rapid regeneration during the fallow period. About one third of the aboveground biomass of the outfield is harvested for the ash garden. The piled woody biomass is burnt just before the onset of the rain season. Finger millet (*Eleusine coracana*) and cassava (*Manihot esculenta*) are then in these gardens cultivated during a 3 – 4 year period. In ideal conditions, the fallow period lasts at least 30 – 40 years. If only branches are consumed, periods of 10 – 15 years are possible (Chidumayo 1996; Frost 1996a). Long fallow periods are needed to allow the soils and the vegetation to recover, but these periods are becoming shorter as the amount of suitable uncultivated land declines (Puzo 1978, Frost and Desanker 1998).

Shifting cultivation has long been considered a poor system of land utilization and cause of deforestation (FAO, 1996). In many areas, practicing shifting cultivation resulted into the following adverse environmental conditions:

- Declining of composition and regeneration of the natural vegetation after each cycle of cultivation.
- Damage to crops from growing populations of wild animals and birds, which could be the result of ecological imbalances created by shifting cultivation.

- Development of sheet, rill and gully erosion especially in lower altitudes lands where there is high intensity rainfall just after clearing, burning and sowing.

2.6.1.3 Livestock grazing

In Tanzania, animal grazing is normally done by pastoralists who believe that all land belongs to them and it is their God-given right to graze in woodlands (Abeli and Nsolomo, 1998). Presence of a luxuriant grass layer rich in sugar and a tree layer rich in protein enhances the potential for pastoralism in miombo woodlands. Furthermore the growing behaviour (phenology) of grasses and trees in miombo, which ensures availability of fodder almost throughout the year, also contributes to the potential of miombo for livestock husbandry (Nduwamungu, 1997). While the grass biomass is highest during rain season and declines with progressing dry season, woody plants in miombo flush one to two months before the onset of the rain season and their young foliage supplies the required feed.

Miombo woodlands are associated with tse-tse fly (*Glossina* ssp.), which causes sleeping sickness (trypanosomiasis) to human beings and cattle thus limiting the rearing of livestock in these areas. Various methods for controlling the fly have been employed and these have included bush clearing. In shinyanga, Tanzania, the clearing of the woodlands was done through forced mobilization of local labour, creating an enduring stigma on present day local perception of woodlands and afforestation campaign (Mung'ong'o, 1995). By 1952, the tse-tse flies had almost been eliminated in the cleared areas.

Regenerating vegetation was slashed to ensure that the areas did not revert to woodlands again. Thus the woodlands, which had previously formed suitable habitats for tse-tse flies were reduced to open vegetation types (Misana *et al.,* 1996).

Livestock grazing causes soil compaction. Severe compaction inhibits both seed germination and seedlings growth, and also induces early seedlings mortality (Kozlowski, 2000).

2.6.1.4 Forest fires

Fire has been used by man in Africa for at least 1.5 million years and has during this period influenced vegetation. Fire is a major factor structuring animal and plant communities in a miombo ecosystem (Madoffe *et al.,* 1998). In African savannas, intentional burning has been practiced for at least 50,000 years (Rose-Innes, 1972). Unlike in other places, in very few occasions in Tanzania are forest fires caused by lightning (Lulandala *et al.*, 1995). Thus, most fires are human caused. The reasons for burning include stimulation of grass regrowth for improved livestock fodder, to control pests, such as ticks (Acarina) and tsetse flies (*Glossina* spp., Diptera), clearing forest for agricultural crop production and ash fertilization (Chitemene), hunting and improving landscape visibility. Fire can therefore be used as a management tool within forestry (Gillon 1983; Chidumayo *et al.,* 1996).

Woody plants are favoured by early burning while long intervals between fires are harmful due to accumulation of fuels (Trapnell, 1959). Miombo woodlands are resistant to fire, if burning takes place during the early dry season. Early burning does not prevent regeneration of trees (Trapnell, 1959). However late fires are destructive

The extent and frequency of forest fires in Tanzania is alarming and shocking. Forest fires are so common in public forests (even in forest reserves now adays) to the extent that they only become of national concern when catchments forests like Kilimanjaro, Meru, Uluguru and Usambara mountains or plantation forests are on fire. A study done at Mamboya forest reserve (Kilosa district) showed that about 1% of the forest is destroyed every year by fire (Nsolomo & Chamshama, 1990).

2.6.1.5 Poles cutting

People inhabiting miombo woodlands use poles of variable sizes for building houses, huts and other structures with clear species preferences. The Bemba of northern Zambia prefers *Erythrophleum africanum*, *Monotes sp.* and *Pericopsis angolensis* for poles (Holden, 1998).

Species favoured for poles production from miombo woodlands in Tanzania include *Pteleopsis myritifolia*, *Julbernardia globiflora*, *Brachystegia spiciformis* and *Combretum* spp. Most of these poles harvested are straight young good trees yet to produce seed for regeneration. Thus, harvesting of these trees not only deprives the country of good quality sawn timber but also interferes with the natural regeneration in the forests (Abeli & Nsolomo, 1998). *Spirostachys africana*, which used for scaffolding in major construction works are also cut indiscriminately from the forests and woodlands in the neighbourhood of big towns and settlements.

2.6.1.6 Harvesting of Non-Timber forest Products

Main non-timber products harvested from miombo woodlands are honey, beeswax, fruits, wild meat and medicines. Production of honey and beeswax whose annual capacity is estimated to be 50,000 tonnes and 5000 tonnes respectively (Kowero & O'Kting'ati, 1990) demands considerable felling and debarking of trees. On the otherhand, traditional honey collectors use fire to chase away bees during honey collection. In most cases these fires are left unattended and become bush fire. Bush fire is destructive and may influence the structure and composition of some ecosystems including grasslands, savannahs, closed forests and woodlands (Madoffe *et al.*, 1998). Animal hunters just like honey collectors, use fire to clear the bush for improving visibility. Collection of wild fruits also interferes with normal reproductive system of the plant. Species that regenerate sexually may undergo extinction if seed collected together with fruits may not be propagated

Plants are used in traditional medicines and modern pharmaceuticals. Most miombo trees and herbs are used for a variety of medicinal purposes. More than 80% of the rural population relies on herbal remedies as a principal means of preventing and curing illness and several traditional medical systems are based on the use of plants (WBG, 2003).

There are several advantages to such systems: the plants involved are readily available, are easy to transport, and do not spoil fast. Remedies based on these plants often have minimal side effects, and the relatively high cost of synthetic medicines in developing countries often makes traditional herbal medicines an affordable choice for the poor.

Open access to medicinal plants in the wild is perhaps one of the main reasons for the current unsustainable levels of harvesting. Other factors contributing to unsustainability include lack of sufficient data on wild plant populations, marketing, and trading; inadequate regulations and legal protection (including intellectual property rights for local practitioners with local knowledge); and poor access to appropriate technology for sound harvesting and plantation development. The most common parts of the tree used for medicines are leaves, bark and roots. Storrs (1995) described 106 trees reported to have medicinal value in Zambia of which the frequency with which the various parts are used ranges from 4% for wood, 9% for fruit/seed, 50% for leaves, 66% for bark and 74% for roots. India recognizes more than 2,500 plant species as having medicinal value, Sri Lanka about 1,400, and Nepal around 700. Leaf harvesting for medicinal uses really harms the tree, however bark and root harvesting can damage plants and lower their survival rate and consequently their regeneration and composition (Storrs, 1982). Few species in miombo woodlands have been subjected to chemical screening. Among these few is the miombo understorey tree or shrub *Mytenus buchananii* that has recently proved active against cancer (Lawton, 1982).

2.6.1.7 Selective logging

Logging which is the process of felling, extracting and transporting logs from the forests often lead to degradation of forestland. Improper and uncontrolled logging leads to unnecessary clearing of forests, damages to the residual trees and ground cover, accelerates soil erosion and causes soil compaction which hampers natural regeneration (Abeli & Nsolomo, 1998).

2.6.1.8 Woodfuel production

Woodfuel is the most important domestic energy source in developing countries. The average annual per capita woodfuel consumption for East Africa has been estimated at about 2.1 m^3 (Earl, 1974). This ever-increasing demand for woodfuel has had severe environmental impact (TFAP, 1989). The miombo woodlands, which make up about 90% of the total forest reserves in Tanzania, produce most of the woodfuel for the urban and peri-urban population. With increasing population, miombo woodlands appear to be incapable of supporting the ever-increasing demand for wood. This interferes with regeneration ability and forest composition.

2.6.1.9 Settlements

As population grows, more land is required for settlements. In Morogoro region it is estimated that about 20,000 ha of forests are being cleared to give way for settlements every year while in Arusha region about 10,000 ha of forests are cleared each year for the same purpose (Abeli and Nsolomo, 1998). Population growth therefore leads to more of woodlands clearing and results in reduced regeneration and forest composition.

2.6.1.10 Uncontrolled Mining

Mining is the process of extracting minerals from the soil including precious metal such as Gold, Tanzanite, Rubby, Diamond and other materials like Bauxite and Coal. Mining operations involve clearing of vegetation and excavation of soils. On the otherhand, mining operations involve use of chemicals such as Mercury (Artesanal miners) and Cyanide in mineral processing/recovery which if not controlled may have lethal effects to the flora and fauna.

Mining operations degrade significant areas of land and replace existing ecosystems with undesirable waste materials in the form of mine spoils dumps (Singh *et al.*, 2004). Mine spoils refer to overburdened material not specifically salvaged in the pre-mining phase (Jha and Singh, 1992). Mine spoils are nutritionally impoverished habitats characterized by low nitrogen mineralization rates, low phosphate availability, low soil organic matter, poor soil structure, low water holding capacity and lack of microbial activity (Gonzalez-Sangregorio *et al*., 1991). Clearing of original vegetation during mining operations if not controlled can therefore affect species composition and regeneration.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of study area

3.1.1 Background history

MFR is a productive forest reserve owned by the Local Government and is presently under the management of Morogoro municipality and Mvomero district, which own and manage 80% and 20% of the reserve respectively. The MFR was ideally established and can be effectively used for production of wood fuels and other products required to meet the demands of Morogoro municipality, Dar-es-salaam city and forest adjacent communities. The forest reserve was gazetted in 1953 through Government notice number G.N. No. 204/17/7/1953 and is estimated to cover an area of 12,950 ha (URT, 2001).

The long-term objective of MFR was to increase forest cover and provide forest products in a sustainable manner such that the forest reserve would provide economic base for the villages surrounding the forest reserve while providing wood fuels and other services to the local community and Morogoro municipality (Ruffo, C.K. pers. comm., 2005). Present exploitation of the forest reserve with an insufficient plan of operation has resulted in uncontrolled harvesting of trees for timber, firewood, charcoal and building poles. The MFR is close to the market (it is about 20km to Morogoro municipality and 200km to Dar-es-Salaam city) and is close to /borders the Morogoro – Dodoma main road,. This proximity and accessibility provides opportunities to engage in the forest produce business especially charcoal and firewood thus accelerating the rate of exploitation of the forest reserve and its subsequent degradation.

3.1.2 Location and general ecology

The MFR is situated 20 km north of Morogoro Municipality (Fig. 2). The forest reserve is lying between 6º 38'S to 6º 44' S and 37º39'E to 37º49'E at an altitude between 475 and 500 masl and estimated slope ranging from 5% to 10%. In the Eastern side Tungi Sisal Estate and Wami- Mbiki game reserve border the MFR, in the north the forest is bordered by Wami-Sokoine village while the Morogoro – Dodoma main road forms the western boundary. Ngulu ya Ndege, Mawasiliano and Maili Kumi Nanane streets which are close to the forest, lie in the west. In the south there is Nguvu kazi, CCT and Kiegea A and B streets.

3.1.3 Climate

The area is influenced by oceanic rainfall with oceanic/continental temperature (Lovett and Pócs, 1993). It experiences long rains from March to May followed by short rains, between October and December. The mean annual rainfall is 800 mm. Dry season is June to December. The coldest months of the year are June and July when the minimum temperatures range between 16ºC and 18ºC.

3.1.4 Soils and Geology

The study area comprises formations of both migmatites (microcline quartz rocks with abundant muscovite and biotite) and acid gneisses (with garnet, mica and sometimes hornblende). The soils throughout the study area are generally sandy loam, with varying amounts of clay characterized by acidic reaction (Lovett and Pócs, 1993; Mugasha *et al.*, 2005).

3.1.5 Vegetation

The major vegetation type of the study area is dry miombo woodland with other vegetation communities interspaced within including *Acacia*/*combretum* woodlands and mbuga grassed woodlands. The reserve consists mostly of *Julbernardia globiflora*, *Brachystegia boehmii*, *Combretum molle, Pteleopsis myritifolia, Bauhinia petersian and Sclereocarya birrea.* The undergrowth layer comprises grass dominated by *Hyparrhenia filipendula, Hyparrhenia cymbaria* and *Themeda triandra*.

3.1.6 Demography

According to the National Census carried out in 2002, Morogoro urban and Mvomero districts where the forest reserve falls have a total population of 228,863 and 260,523 respectively with an annual growth rate of 2.6% and average household size of 4.6 (URT, 2003). Household size in the study area ranged from 1 to 6 people.

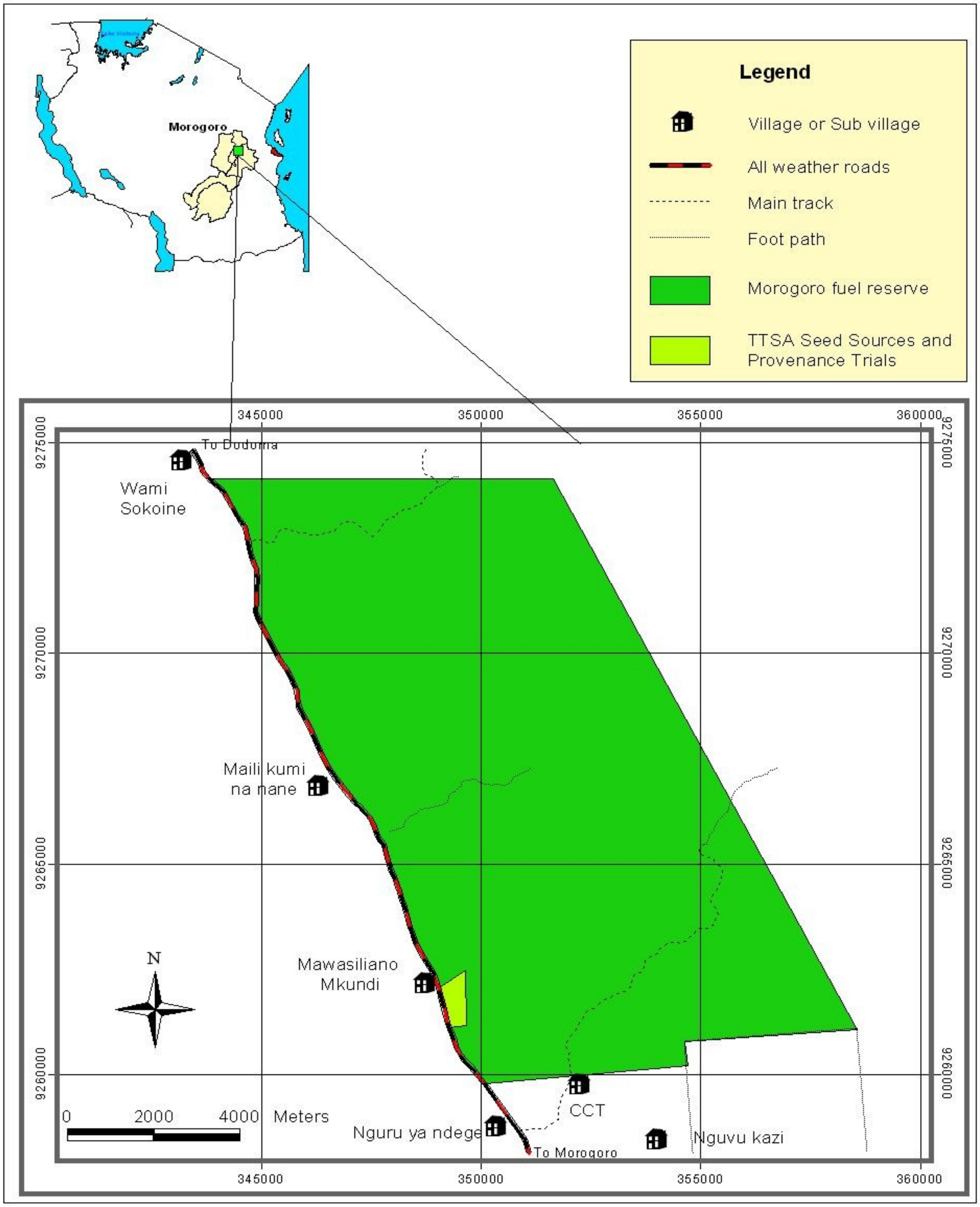

Figure 2. Location of MFR, Morogoro, Tanzania

3.1.7 Socio-economic activities

The local communities living around the forest reserve are agrarian whereby crop cultivation, livestock production and forest utilization are the main land uses. The communities grow mainly food crops and some cash crops. The most important food crops include maize, millet, beans and sorghum. Cassava, sweet potatoes and paddy are the main cash crops. Some people also engage in petty business like selling firewood, charcoal and retail commodity shops. The ethnic composition of the area include Gogo, Luguru, Sukuma, Nyamwezi, Ha, Maasai, Zigua, Barbaig, Hehe, Bena and Zaramo. The Maasai and Barbaig are mainly engaged in livestock production. Livestock are being grazed freely in the forest reserve and public land and livestock owners have no responsibility towards the maintenance or improvement of grazing lands, and if one area becomes exhausted they tend to move temporarily or permanently to other areas. The study forest is exploited for forest resources including timber, charcoal, firewood, building poles and medicine.

3.2 Methods

3.2.1 Data Collection

Data were collected from both primary and secondary sources. Two types of data were collected, namely forest inventory and socio-economic. This activity involved collection of the vegetation information (Biophysical), and socio-economic activities of Wami Sokoine village (Mvomero district), Maili Kumi Nanane and Mawasiliano streets (Morogoro municipal).

3.2.1.1 Forest inventory data

(i) Reconnaissance survey

The forest inventory was carried out to collect information on important stand parameters of the forest reserve. The actual forest inventory work was preceded by a reconnaissance survey to get the general impression of the forest to facilitate fieldwork.

(ii) Plot shape, size and sampling intensity

Concentric circular sample plots of the standard size of 0.07 hectare with sub plots of 2, 5 and 10meter radii were adopted for inventory data collection. Circular sample plots were adopted because they are easy to establish and counting errors during inventory of border trees are minimized (De Vries, 1986)

The sampling intensity recommended for use in natural forests inventory fall within a range of 0.5% to 0.7% (Synnott, 1979). For a forest reserve with 12,950 hectares using a sampling intensity of 0.5%, a total number of 925 sample plots with the size of 0.07 hectare would have been measured. However, due to limited financial and time resources, only 8% of the total number of plots was taken for measurement. Therefore, a total of 74 sample plots were established along transects.

In order to cover the whole area, a systematic sampling design was adopted. The forest was divided into 10 transects located at an interval of 1.5km apart with the first transect starting at a distance of 1km from the starting point to avoid edge effects. These transects were laid perpendicular to the Morogoro – Dodoma highway which is one of the boundary features of the forest reserve (Fig. 3). Equipment used in setting transects included Geographical Positioning System (GPS), Compass and Tape measure. Along transects, plots were placed at the interval of 1km with the first plot starting at a half distance.

Circular plots with four concentric rings of different radii (Fig. 4) were used to carry out the vegetation census. Calliper was used to measure dbh while Tape measure was used to established radius of the plot.

(i) Within the innermost 2m radius (0.0013ha.), all woody plants with diameter ≥ 1cm but ≤ 4cm (i.e. seedlings and saplings) were counted and identified to species level.

(ii) Within a 5m radius (0.0079ha.), all woody plants with dbh ≥ 4cm but ≤ 10cm were measured for dbh and identified to species level

(iii) Within a 10m radius (0.031ha.), all woody plants with dbh ≥ 10cm but ≤ 20cm were measured for dbh and identified to species level.

(iv) Within a 15m radius (0.07ha.), all woody plants with dbh ≥ 20cm were measured for dbh and identified to species level.

These classes were designed with reference to the structural composition of the woodlands (Luoga et al., 2002) and for particular use categories (Luoga et al 2000a, b).

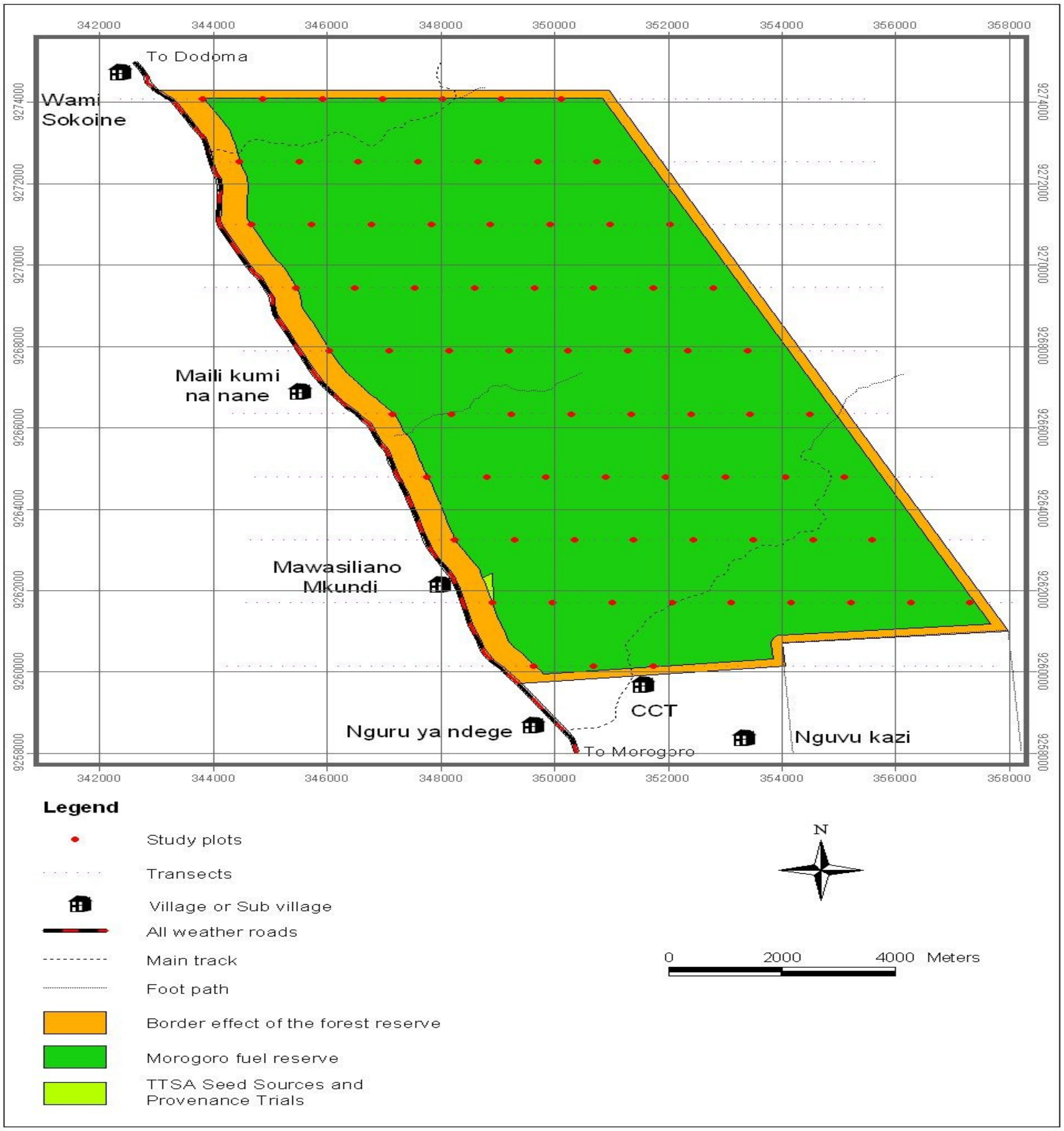

Figure 3. Lay out of transects and plots in M FR, Morogoro, Tanzania

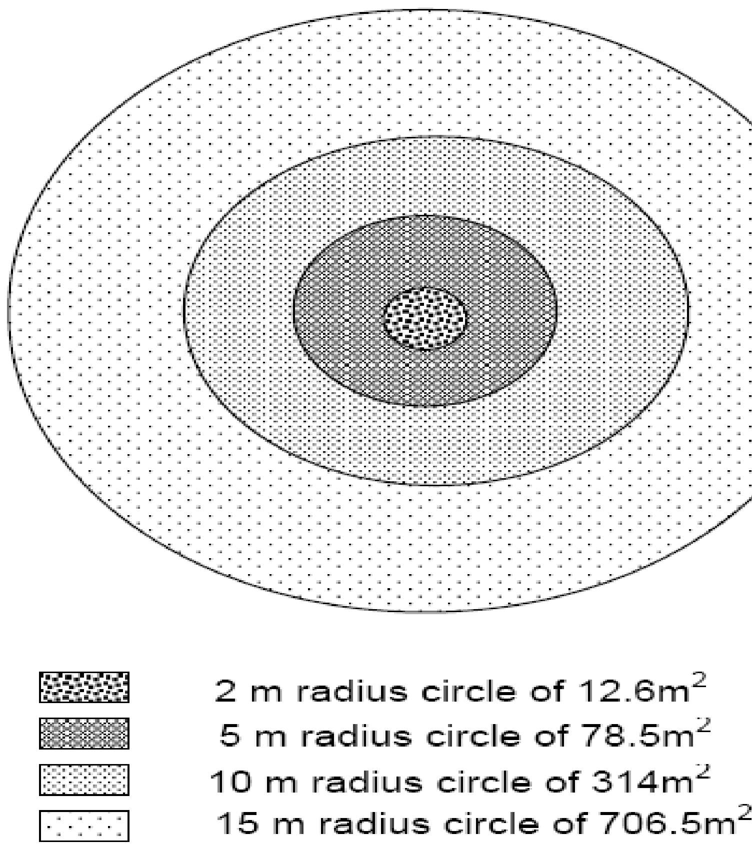

Figure 4. Concentric circular shapes of nest Key **ple plots used in MFR, Morogoro, Tanzania**

2m radius circle of $12.6m^2$
5m radius circle of $78.5m^2$
10m radius circle of $314m^2$
15m radius circle of $706.5m^2$

3.2.1.2 Socio-economic data

Data from primary sources were collected through hous... structured questionnaire (Appendix 6) with both open and closed-ended questions, informal discussion with village elders and direct observation. Here, a household is defined as "a group of people who eat from the same pot, stay and work together". Dependent children who stay outside but usually come back for weekends and holidays were included as they belong to the same consumption unit, as described by (Monela, 1995).

The research design involved random sampling of village/ streets and households. Two streets of Mawasiliano and Maili Kuminanane of Kihonda division, Morogoro Municipality and the Wami Sokoine village in Mvomero district were selected. The selection was based on two criteria:

(i) Degree of dependency on forest resources.

Some streets/villages are more close to the forest and utilize it more intensively than other villages/streets.

(ii) Accessibility

Streets/ villages, which were easily accessed, are the ones sampled for the research.

Sampling

At least 5% of the total number of households in each village/street was sampled. This sample was taken as a representative as described by Boyd *et al.*, (1981). Village register was used as a sampling frame and households were randomly picked from the register.

3.2.1.3 Secondary data collection

Secondary data sources were Morogoro Regional Secretariat Office and Tanzania Tree Seed Agency (TTSA) where reports for MFR were obtained. Maps were obtained from Morogoro Regional Catchments Forest Office. Other data were obtained from Library at Sokoine University of Agriculture (SUA) and the Internet.

3.2.2 Data Analysis

3.2.2.1 Forest inventory data

Forest inventory data were analyzed using Microsoft Excel Program. The analysis based on the four-sub divisions of each sample plot (Fig. 4). From the collected data the following stand parameters were computed:

(i) Number of stems (N) per hectare

Number of stems per hectare was calculated using total counts pooled from all 74 plots in the forest reserve. The formula used was:

$$N = \frac{\left(1/ai \right)}{n}$$

Where,

N = number of stems per ha.

a_i = area of i^{th} plot (ha)

n = number of sample plots

(ii) Basal area (G) per hectare

Basal area (m^2ha^{-1}) was calculated from measurements of stem diameters at breast height (1.3m) for all woody individuals and was pooled from the 74 plots in the forest reserve. The basal area in m^2 per hectare was determined using the following formula:

$$G = \sum \left(Gi/n \right)$$

Where,

G = average basal area per hectare of the stand (m^2/ha).

G_i = basal area of the i^{th} plot (m^2ha^{-1})

n = number of sample plots.

(iii) Volume (V) per hectare

Volume equation model developed by Malimbwi *et al.*, (2004) for miombo woodlands in the Eastern Tanzania was used to determine single tree volumes. This equation was as follows:

$$V = 0.000011972D^{3.191672}$$

Where,

V = total tree volume (m^3)

D = tree dbh (cm)

(iv) Species Important Value Index (IVI)

This is the sum of relative frequency, relative density and relative basal area (dominance) of a given species. The IVI was calculated as follows:

$$IVI = \sum\left(\frac{RF + RN + RD}{3}\right)$$

Where,

IVI = Important value index

$\sum$ = Summation symbol

The constituent's parameters were calculated as follows:

$$RF = \text{Relative frequency} = \frac{\text{Frequency of occurrence of a species}}{\text{Frequency of occurrence of all species}}$$

$$RN = \text{Relative density} = \frac{\text{Number of individuals of species}}{\text{Number of individuals of all species}}$$

$$RD = \text{Relative basal area} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}}$$

(v) Diversity indices

Shannon Wiener index of diversity (H')

This is the most widely used index of diversity, which combines species richness and evenness and is not affected by sample size. The index is calculated as follows (Kent & Cooker, 1992).

$$H' = -\sum_{i=1}^{S}(Pi LN Pi)$$

Where: H' = Shannon index of diversity.

∑ = Summation symbol.

S = Number of species

Pi = Proportion of individuals or the abundance of species i in the sample.

LN = Natural Logarithm

\- = Negative sign multiplied with the rest of variables in order to make the H' positive.

Krebs (1989) explained the Shannon – Wiener index of diversity as a measure of information content of a sample and since information content is a measure of uncertainty, the larger the value of H' the greater the uncertainty. The index increases with the number of species in the community, but in practice for biological communities H' does not exceed 5.0 (Krebs, 1989).

Index of dominance (Simpson Index)

The index of dominance is a measure of the distribution of individuals among the species in a community. This index is also called *Simpson Index of diversity* and is equal to the probability of picking two organisms at random that are of different species (Krebs, 1989). The greater the value of dominance index, the lower is the species diversity in the community and vice versa. This index is calculated as follows (Misra, 1989).

$$ID = \sum \left(\frac{ni}{N} \right)^2$$

Where;

ID	=	Index of dominance
ni	=	Number of individuals of species i in the sample
N	=	Total number of individuals of all species in the sample.
∑	=	Summation symbol.

3.2.2.2 Socio-economic data

(i) Quantitative data

The Statistical Package for Social Sciences (SPSS) was the main tool used for data analysis. Both descriptive and inferential statistical analyses were carried out to analyze the quantitative data. Descriptive statistical analysis using frequency counts and percentages was used to describe the socio-economic characteristics of the communities adjacent to the forest reserve. Inferential statistical analysis involved using logistic regression to establish the existence of functional relationship between dependent variable i.e. Consumption (degradation) of forest resources in the forest reserve and independent variables i.e. socio-economic factors.

In this study, the main socio-economic activities such as cropping system, farmland size, mode of farm preparation, mode of livestock keeping, average income, distance to forest product and household size were the independent variables influencing consumption (degradation) of forest resources in the reserve. The following model was used:

$$Y_i = \frac{1}{1+e^{-z}}$$

Where;

Yi = the ith probability of event to occur for the dependent variable (a binary/ dichotomous) variable with value of 1 if there is consumption (degradation) of forest resources in the reserve and 0 if otherwise.

$Z = bo+b_1X_1+b_2X_2+\ldots\ldots\ldots.b_nX_n+e$

bo and b1 to bn = coefficients of independent variables

e = natural logarithm base (2.718)

I = 1,2,3…n; where n is the total number of variables

X_1 to Xn = Independent variables

X_1 = Main socio-economic activities

X_2 = Household size

X_3 = Cropping system

X_4 = Mode of farm preparation

X_5 = Average income

X_6 = Mode of livestock keeping

X_7 = Distance of forest product

The probability of event not occurring was estimated as: probability (no event) = 1- probability (event). The odds ratios represented by Exp (ß) from logistic regression analysis were used in explaining the likelihood of consumption (degradation) of forest resources in the reserve.

Goodness of fit of the logistic regression model was assessed using model Chi-square which measures how well the independent variables affect the outcome or dependent variable, -2log likelihood (-2LL) which indicates that the model fits the data reasonably well, and the overall percentage of correct predictions where the bigger the percentage the better the model.

Proper interpretation of logistic regression results involved looking at Wald statistic (t-value) to see whether the effect of a particular independent variable is statistically significant. The increase in independent variable increased or decreased the probability of success (in this case degradation of forest resources in the reserve) and the Exp (ß) to see how much a 1 unit increase in Xi changes the odds of success (this is because the odds of success is not the same as the probability of success).

(ii) Qualitative data

The qualitative data were analyzed using content analysis. In this case components of the verbal discussion held with key informants were analyzed in an objective and systematic manner. The recorded dialogue with the respondents was broken down into smallest and meaningful units of information or themes and tendencies (Kajembe, 1994). This helped the researcher in ascertaining values and attitudes of the respondents.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Status of the forest resources base

Table 1 summerizes stand parameters, which give the status of the resource base in the MFR

Table 1. Stand Parameters in MFR, Morogoro, Tanzania

Stand Parameter	Value
Density (stems ha^{-1})	403
Basal area (m^2 ha^{-1})	2.12
Wood Volume (m^3 ha^{-1})	9.58
Regeneration (stems ha^{-1})	7233
Species Richness	52
Species Diversity:	
• Dominance Index (C)	0.0705
• Shannon Index (H')	2.7293

4.1.1 Stocking

The mean stocking was 403 stems ha^{-1} (SPH). Among these, 375 stems ha^{-1} were in diameter class 1 (at dbh 4-10cm), 22 stems ha^{-1} in diameter class 2 (at dbh 11-20cm) and 6 stems ha^{-1} in diameter class 3 (dbh > 20 cm) (Fig 5). This stocking is slightly lower than that of 454 stems $ha^{-1.}$ obtained by Malimbwi *et al.*, (1998) in old growth miombo at Kitulang'alo Forest Reserve, Morogoro, Tanzania. In another study carried out in the same reserve, Malimbwi and Mugasha (2001) reported a total of 352 and 561 stems ha^{-1} in miombo and Semi-evergreen forests respectively. The stems per hectare obtained from this study are relatively lower than miombo stocking reported by Nduwamungu (1996) of 691 stems ha^{-1} at Kitulang'alo SUA Training Forest for trees with >5cm dbh. Malaisse (1978) in Katanga (Democratic Republic of Congo) estimated that the stocking of miombo woodlands ranged from 520 to 645 stems ha^{-1}. From the observations above it can be deduced that stocking in MFR is lower than other findings reported in miombo woodlands due to uncontrolled exploitation.

The distribution of stem numbers per hectare follows the usual reversed J-shape (Fig. 5); common in natural forests that its frequencies decrease with increasing dbh. This is an indication of good forest recruitment and regeneration trend (Malimbwi and Mgeni, 1991; Nduwamungu, 1996).

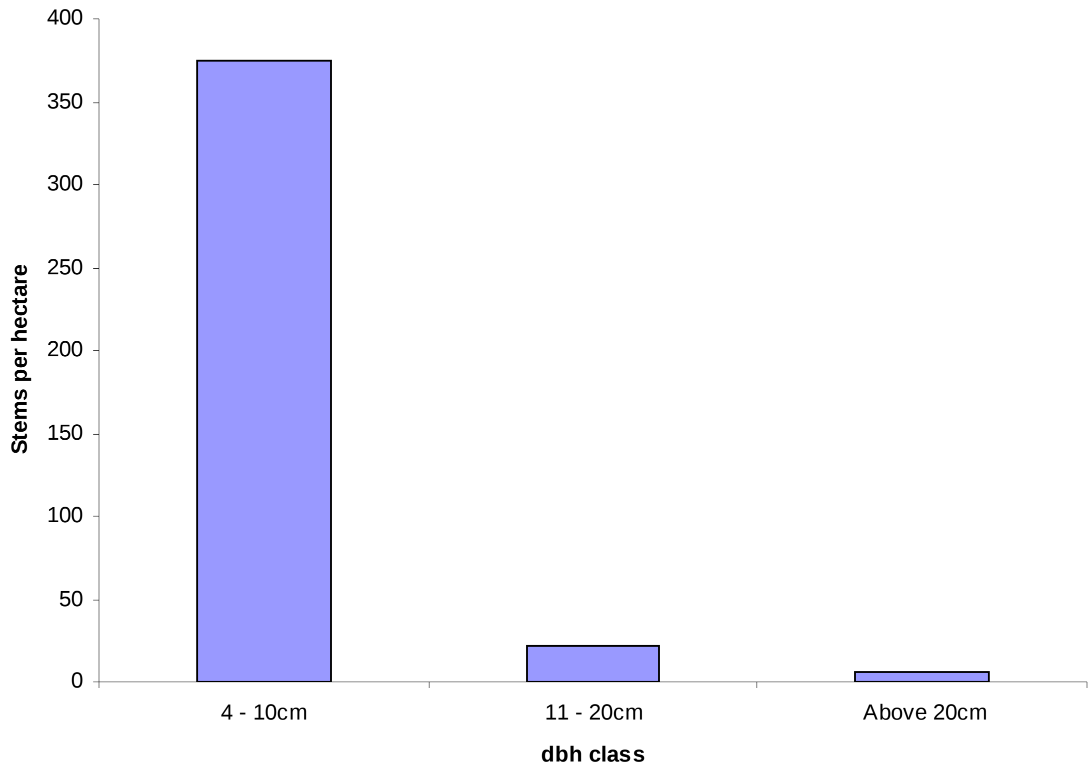

Figure 5. Diameter distribution of trees in the MFR, Morogoro, Tanzania

4.1.2 Stand Basal Area

The mean basal area in MFR was found to be 2.12m^2 ha^{-1} distributed in three diameter classes as 1.2m^2 ha^{-1} in class 1 (4 – 10cm), 0.33m^2 ha^{-1} in class 2 (11 –20cm) and 0.59m^2 ha^{-1} in class 3 (above 20cm) (Figure 6).

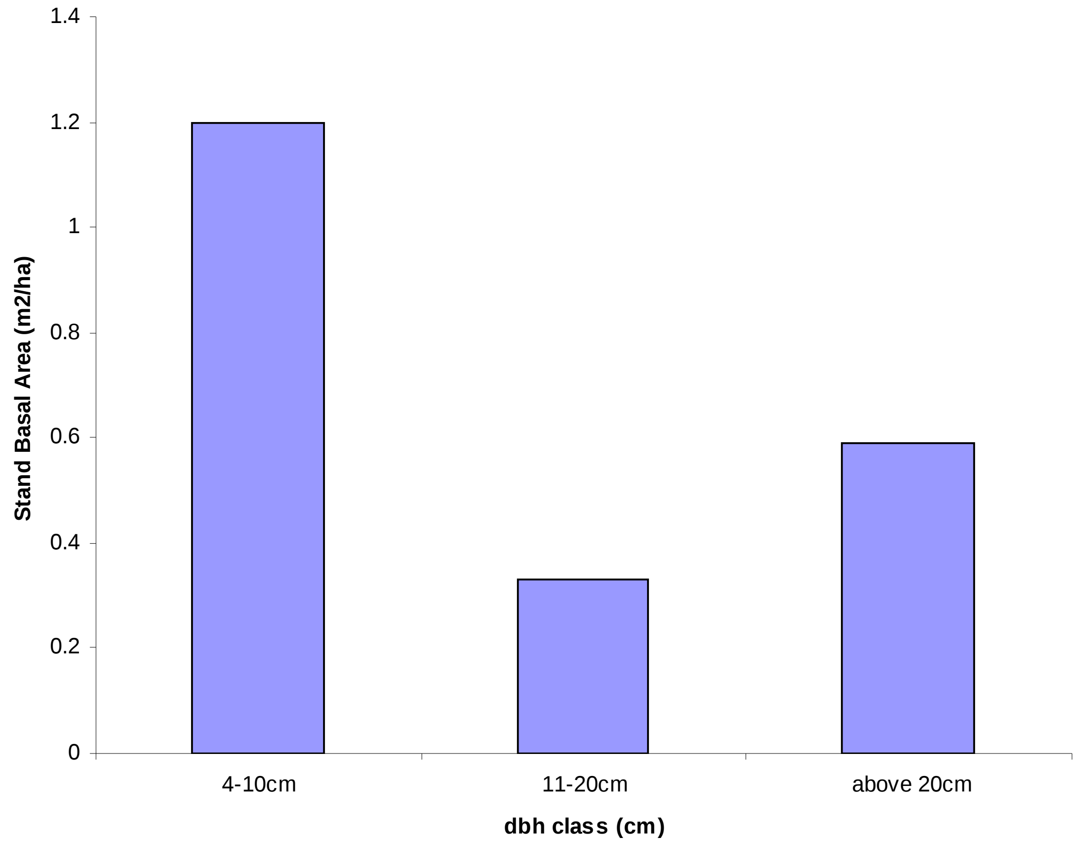

Figure 6. Basal Area distribution by diameter classes in the MFR, Morogoro, Tanzania

The recorded basal area of trees in old growth, mixed-age stands ranges from as little as $7m^2ha^{-1}$ in southern Malawi at about 650 mm mean annual precipitation (Lowore *et al.*, 1994a) to 22 m^2ha^{-1} in wet miombo woodland on deep soils in the Democratic Republic of Congo at 1270 mm rainfall (Freson *et al.*, 1974). Most stands have basal areas of 7-19 m^2 ha^{-1} (Boaler and Sciwale, 1996; Allen, 1986; Chidumayo, 1987c). Boaler (1966) reported a basal area of $14m^2ha^{-1}$ for the miombo woodlands in Tanzania. Zahabu (2001) reported basal area of $7m^2ha^{-1}$ in Kitulan'galo Forest Reserve while Nduwamungu (1996) in the same reserve observed a basal area of 10.34 m^2ha^{-1}. In another study conducted in Kilosa district, eastern-central Tanzania by Backéus *et al.*, (2006), the basal area varied between 3.9 and 16.7m^2ha^{-1}.

The basal area obtained in this study is relatively lower than the minimum basal area (7 m^2ha^{-1}) reported in other studies. This reveals that there is excessive exploitation of trees with big diameters for different economic uses, which resulted to degradation of forest resources and therefore lowering the basal area.

4.1.3 Wood volume

The wood volume was 9.58m^3 ha^{-1}. This volume is distributed in the three diameter classes as follows: 1.68 m^3ha^{-1} 1.25m^3 ha^{-1} and 6.64m^3ha^{-1} in class 1 (at dbh 4 - 10cm), 2 (at dbh 11- 20cm) and 3 (above 20cm) respectively (Fig. 7).

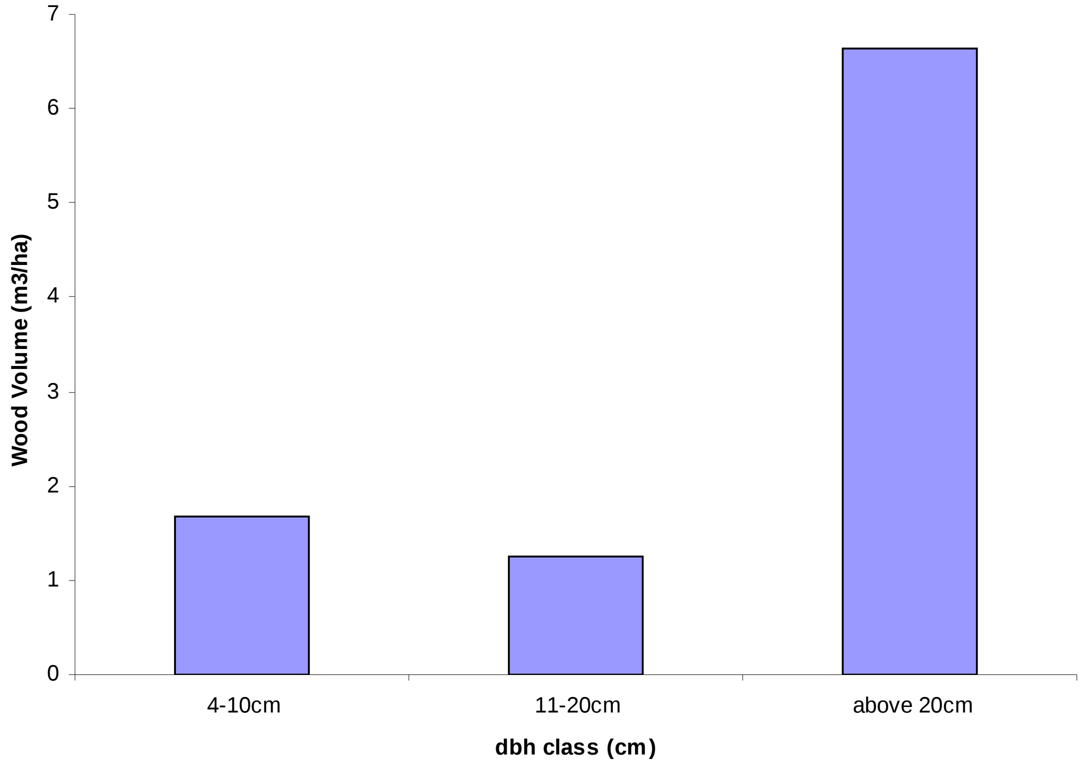

Figure 7. **Wood volume distribution in different diameter classes at MFR Morogoro, Tanzania**

Lowore *et al.,* (1994a) reported that, harvestable volume in dry miombo woodland ranges from 14 m^3ha^{-1} in Malawi to 59m^3 ha^{-1} in Zambia with a maximum value of 117m^3 ha^{-1} (Chidumayo, 1988d). In Tanzania, the volume of commercial timber from the open woodlands has been estimated to be 40 m^3 ha^{-1} (TFPA, 1989). Zahabu (2001) recorded a total of 78.8 m^3 ha^{-1} in Kitulang'alo forest reserve.

The low volume obtained in this study suggests that, there was high extraction of the larger diameter trees from the MFR, which may subsequently have resulted to forest degradation. The distribution of volume in MFR shows a J-shaped trend as expected in a natural forest with good regeneration and recruitment.

4.1.4 Tree species composition, richness and abundance

4.1.4.1 Species richness

A total of 52 woody species were identified in 74 plots belonging to 18 families in three life forms category namely Shrubs (S), Small trees (ST) and Large Trees (Appendix 1). Of the three life form categories, trees contributed 87% followed by small trees (12%) and shrubs with 1%. The most dominant families found in the reserve were Combretaceae (49%), Caesalpinioideae (13%) and Mimosoideae (11%) (Fig. 8)

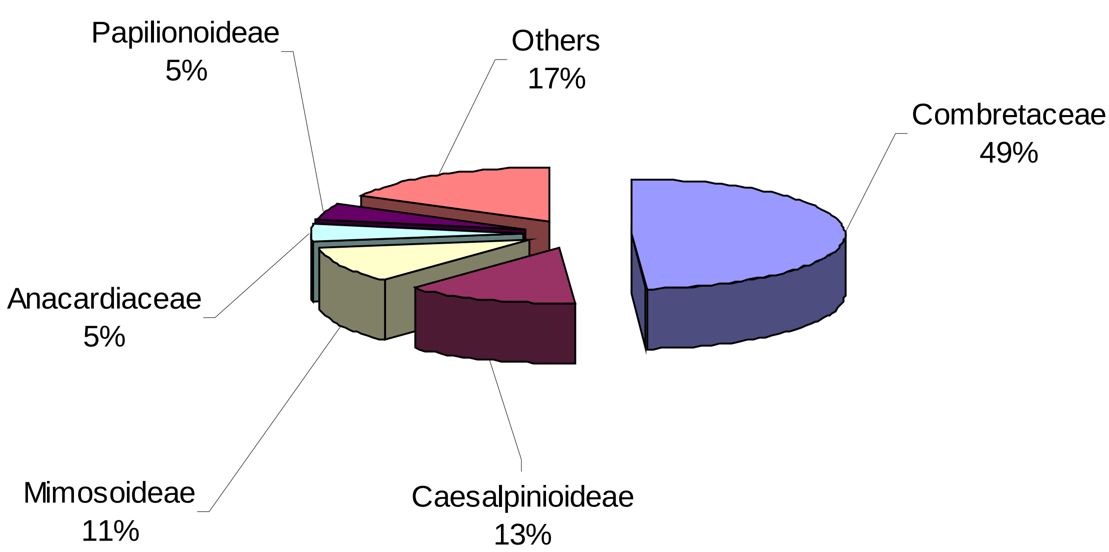

Figure 8. Tree family compositions in the MFR, Morogoro, Tanzania

Contrary to other miombo woodlands whose species abundance is dominated by *Julbernardia*, *Brachystegia* and *Isoberlinia*, the MFR species abundance is dominated by *Combretum molle* (17%) followed by *Pteleopsis myritifolia* (12%) and *Bauhinia petersiana* (8%) (Appendix 2) Malimbwi *et al.*, (2001) and Dirninger, (2004) reported *Julbernardia globiflora* and *Brachystegia boehmii* to have higher species abundances in Kitulang'alo and Kilombero miombo woodland stands respectively. This result again shows the extent of exploitation of these miombo commercial species in the MFR.

4.1.4.2 Species Composition and Dominance (IVI)

A complete list of the MFR woody species obtained from the plot is given in Apendix 1. Distribution of N, G, and V by Important Value Index (IVI) is given in Appendix 3. The top ten dominant tree species in terms of their important value index (IVI) is presented in Figure 9. *Combretum molle* was the most important tree species followed by *Sclerocarya birrea*, *Pteleopsis myritifolia Acacia nigrescence* and *Acacia robusta*. In miombo woodlands stand at Kitulang'alo Forest Reserve and public land *Julbernadia globiflora* was reported as the most important tree species for both vegetation types (Zahabu, 2001). The genus *Brachystegia*, which is the major component of miombo woodlands elsewhere (Luoga, 2000) was not well presented in MFR. Furthermore, the low composition of *Julbernardia spp*, *Pterocarpus angolensis* and *Afzelia quanzensis* may be

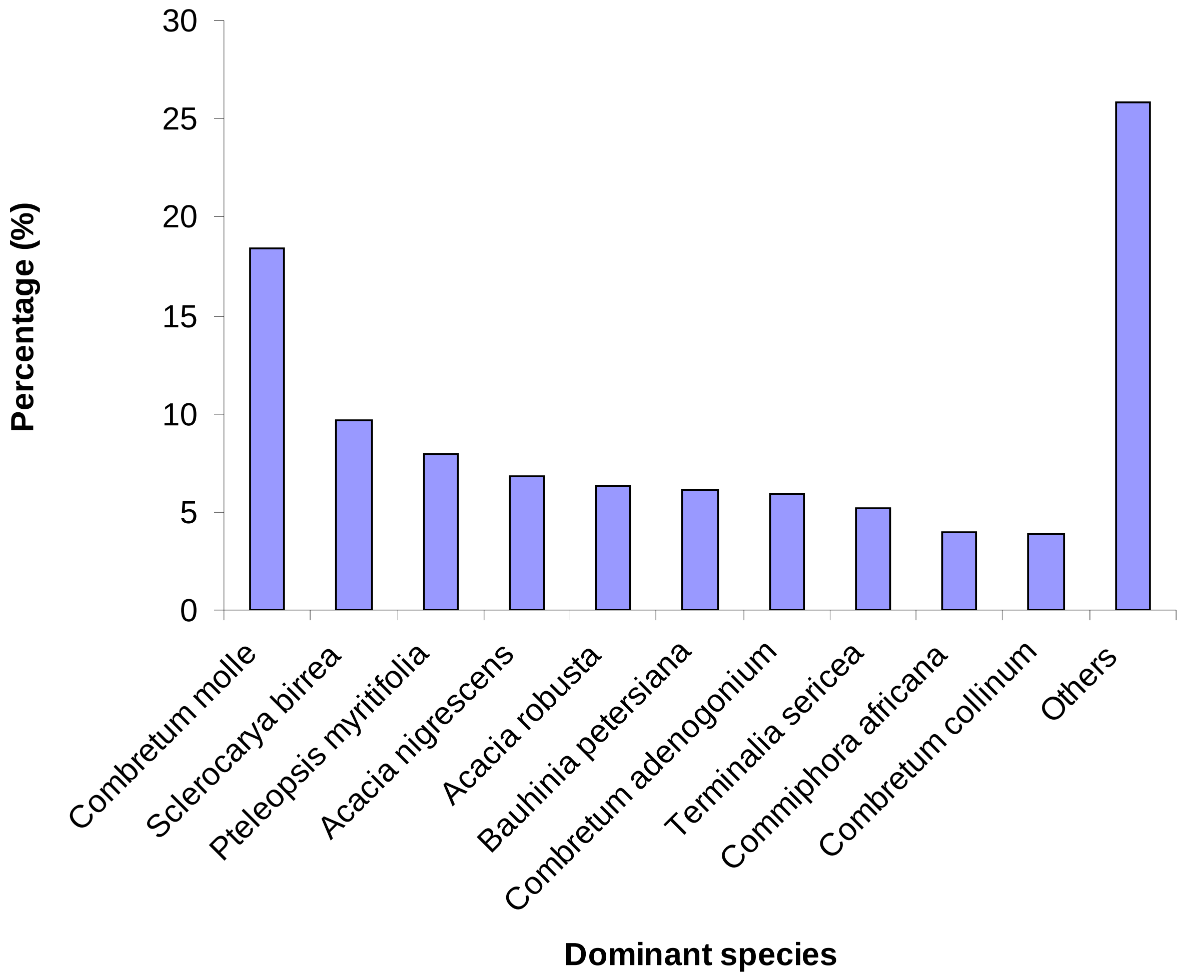

Figure 9. The top ten dominant tree species in terms of their Important Value Index (IVI) in MFR, Morogoro, Tanzania

due to high exploitation of these species in the study area. On the otherhand, (White, 1983; Rodgers, 1996) in Luoga (2000) observed that the proportional dominance of *Combretum* spp. demonstrates a transition between miombo and coastal woodlands to the east, which are dominated by species of *Combretum*, *Terminalia* and *Lannea.*

4.1.5 Species diversity

The Simpson's Diversity Index (C) was 0.071 in the MFR (Appendix 4). Malimbwi *et al.*, (1998) reported (C) value of 0.07 in re-growth miombo at Kitulan'galo public land. In another study in the same reserve Zahabu (2001) reported Simpson's Diversity Index of 0.065. Shannon Index of Diversity (H') calculated using natural logarithms was 2.72 (Appendix 4.). Zahabu (2001) reported H' values of 2.9 and 3.13 in public land and forest reserve respectively. The values of C and H' obtained in this study are comparable to other studies conducted elasewhere for the same vegetation types.

4.1.6 Regeneration

Table 2 shows the list of regenerating woody species with dbh< 4cm in the MFR. The regeneration density was 7 233 stems ha^{-1} from a total of 37 different woody species. *Combretum molle, Commiphora africana, Pteleopsis myritifolia, Combretum zeyheri, Dicrostachys cinerea* and *Dalbergia melanoxylon* appear to have higher regeneration potential in the reserve. This regeneration is slightly higher than that reported by Malimbwi and Mugasha (2001) of 4 637stems ha^{-1} at Kitulang'alo Forest Reserve which indicates greater disturbance in MFR. In another study in the miombo woodlands stands in Kilombero Valley, Dirninger (2004) reported an average regeneration of 13 430 stemsha^{-1}.

Although generally the seed production of *Afzelia quanzensis* and *Pterocarpus angolensis* is high and the germination rate is good (Mbuya *et al.*, 1994), no regenerants of the species were found. The lack of the potential seed trees is the most striking fact as far as the two-miombo commercial trees are concerned. The formerly practiced selective logging of these species because of their timber quality and preferred use for railway sleepers led to a rigorous over exploitation of these species in the MFR.

Miombo species regenerate largely through coppice regrowth and root suckers rather than seed (Robertson, 1984). Chidumayo (1988) observed that stumps of almost all miombo woodland trees have the ability to produce sucker shoots. Although also seed of majority of miombo trees and shrubs germinate immediately after dispersal when there is enough moisture, tree density in regrowth miombo woodlands decreases with time due to moisture and heat stress. The majority of seedlings of miombo trees experience a prolonged period of successive shoot dieback during their development phase in order to cater for these stresses. Shoot dieback is caused by water stress and/or fire during the dry season. Also, with the case of suckers and coppice fire can either slow or accelerate growth. If a destructive fire occurs before dominant shoots attain a safe height to escape mortality, the process of sucker shoot domination reverts to the initial stage and stumps respond by producing an equal or larger number of replacement shoots (Chidumayo, 1988).

Table 2. List of regenerating tree species with dbh < 4 cm in the MFR, Morogoro, Tanzania

S/N	Local Name	Botanical Name	N (stems/ha)
1	Mlama mweusi	*Combretum molle*	1483
2	Mtwintwi	*Commiphora africana*	849
3	Mngoji	*Pteleopsis myritifolia*	774
4	Mlama mweupe	*Combretum zeyheri*	613
5	Kikulagembe	*Dicrostachys cinerea*	419
6	Mpingo/Mhingo	*Dalbergia melanoxylon*	398
7	Mkumbi	*Brackenridgea zanguebarica*	311
8	Msofu	*Uvaria acuminata*	258
9	Mdudu	*Thylachium africanum*	215
10	Mlama	*Combretum collinum*	215
11	Mpululu	*Terminalia sericea*	204
12	Msegese	*Bauhinia petersiana*	172
13	Mkirika	*Eheretia amoeana*	161
14	Mtutuma	*Catunaregum spinosa*	150
15	Mdaa	*Diospyros loureiriana ssp. rufescens*	129
16	Mkambala	*Acacia nigrescence*	97
17	Hombo, Kilumbulumbu	*Ormocurpum kirkii*	86
18	Mkululu	*Diospyros consolatae*	64
19	Mtondoro	*Julbernardia globiflora*	54
20	Kilemandembo	*Gardenia resinflua*	54
21	Myombo	*Brachystegia boehmii*	54
22	Msese/Mzonapoli	*Acacia hockii*	54
23	Mng'ong'o	*Sclerocarya birrea*	43
24	Msighe, Mumbu	*Lannea schweinfurthii*	43
25	Kibaazi pori	*Indigofera rhinchocarpa*	43
26	Mkole	*Grewia biocolar*	43
27	Mkongowe	*Acacia robusta*	43
28	Mdaa	*Euclea divinorum*	32
29	Mhunungu	*Zanthoxylum chalybeum*	21
30	Mpingi	*Ximenia caffra*	21
31	Mnyenye	*Xeroderris stuhlmanii*	21
32	Mhambalasha	*Pterocarpus rotundifolius ssp. polyanthus*	21
33	Msolo	*Pseudolachynostylis maprouneifolia*	21
34	Mkoko	*Diospyros kirkii*	21
35	Mfirigisi	*Albizia harveyii*	21
36	Myuwe	*Stereospermum kunthianum*	11

37	Mhumbahumba	*Senna auriculata*	11
		Total	**7233**

4.2 Social Economic Aspects

4.2.1 Human activities causing degradation of forest resources

Human activities undertaken in the MFR are given in Table 3. Of these, livestock grazing, charcoal making, wildfires, timber extraction, firewood gathering and honey collection appear to have severe forest degradation. Charcoal making, livestock grazing and wild fires have significantly higher effect on the forest resources compared to other human activities identified in MFR. Cultivation and hunting have statistically insignificant effect on the forest resources.

Table 3. Human activities causing degradation of forest resources in MFR, Morogoro, Tanzania

Activities implemented	Implementing	Not implementing	Chi-square	P-value	Significance
Livestock grazing	77.2 (78)	22.8 (23)	29.95	0.001	**
Wild fires	74.3 (75)	25.7 (26)	23.77	0.001	**
Crop farming	41.9 (42)	58.1 (59)	2.86	0.091	NS
Charcoal burning	89.1 (90)	10.9 (11)	61.79	0.001	**
Timber harvesting	3.0 (3)	97.0 (98)	89.36	0.001	**
Firewood Collect.	82.2 (83)	17.8 (18)	41.83	0.001	**
Honey collection	26.7 (27)	73.3 (74)	21.87	0.001	**
Hunting	44.6 (45)	55.4 (56)	1.19	0.274	NS

Figures in parenthesis indicate number of households (Total N= 101). NS=not significant, **=highly significant

4.2.1.1 Livestock grazing

About 77 % of the people interviewed admitted that livestock grazing is undertaken in the forest reserve. It is estimated that 5000 livestock from different parts of Morogoro and neighbouring regions graze in the reserve during rain season (December to April) to avoid quarrelling with farming communities outside the reserve (Ruffo pers. comm. 2005). The MFR is in this case used by livestock keepers as pastureland and holding ground during rain season. Livestock grazing in the reserve is evidenced by presence of "*Maasai Boma*" (Kraal) constructed across the reserve (Plate 2) together with proportion of bare grounds and abundance of livestock manure.

Plate 1. Pile of livestock manure and stumps of cut trees in an abandoned " Maasai Boma"inside the MFR, Morogoro, Tanzania

Livestock grazing impedes growth of plant communities through tree seedling removal and trampling (Maraikar and Amaraisira, 1989; Myers *et al.*, 1994). Overgrazing leads to increases in run off and soil erosion due to compaction. Compaction, which is simply the increase of a soil's bulk density, is the result of trampling and root thinning. As a result of grazing, the composition of plants community will change as palatable species will be replaced by less palatable ones.

4.2.1.2 Wildfires

Wildfire is one of the anthropogenic activities causing damage to the forest resources in the reserve. About 74% of the respondents revealed that human caused fire is a threat to the forest resources in the forest reserve. In the MFR wild fires are caused by human during hunting, farm preparation, and sometimes burning is done purposely to encourage growth of tender grass for livestock feed. During inventory data collection, the field crew occasionally encountered wild fire incidences. Plate 2 shows burnt areas in the reserve during the inventory work. Most fires in this forest occur during the dry season due to lower fuel moisture content after the long dry season. Fire frequency is largely determined by potential ignition sources, the prevailing weather conditions of an area and the time taken to build up levels of available fuel after fire (Whelan, 1997). The frequency at which fires occur has the potential to alter the floristic composition of vegetation communities (Morrison *et al.,* 1995; Bradstock *et al.*, 1997). Miombo woodlands have been considered a disclimax dependent on fire, but most trees, including dominating miombo species of *Brachystegia* and *Julbernardia* are fire sensitive at young age (Kikula, 1986; Trapnell, 1995).

In African savannas, intentional burning has been practiced for at least 50,000 years (Clerk, 1959; Rose-Innes, 1972). In general, fire is more destructive to woody plants than to grasses (Barbour *et al.*, 1980). Physiologically active plants are generally less tolerant than dormant ones (Frost and Robertson, 1987).

Plate 2. Area of the MFR burnt by human caused fire, Morogoro, Tanzania

4.2.1.3 Crop farming

This study revealed that crop farming in the forest reserve has insignificant effect on the forest resources available. Of all the respondents 42% reported that crop farming is being undertaken in the forest reserve. Cultivation inside the reserve seemed not to be a significant problem due to the fact that there is plenty of land outside the reserve that can be used for crop production. It has however, been observed that people who established camps inside the reserve for charcoal production were planting *Cajanus cajan* (Pigeon peas) *and Zea mays* (Maize) in the abandoned livestock “boma”. The area cultivated was estimated not to exceed 2ha annually.

Agriculture continues to be the dominant sector of the economies of the rural communities in Tanzania (Misana *et al.*, 1996), and it was further observed that smallholder production of food and cash crops has increased overtime particularly since the mid 1980s, which has led to increased acreage of cultivated land at the expense of woodlands. About 130,000 ha per annum are being clered for agriculture and other human activities (MNRT, 1998).

4.2.1.4 Charcoal production

Charcoal making is the major economic activity, which causes degradation of the forest resources in the study area. Among the respondents, 90% revealed that charcoal making is undertaken in the forest reserve (Table 3). The involvement of people in charcoal making in this forest is evidenced by availability of large number of earth kiln observed during the inventory survey (Plate 3).

Plate 3. A heap of wood being prepared for charcoal production in an Earth kiln in the MFR, Morogoro, Tanzania

Miombo woodlands that constitute about 90% of the total area of forests in Tanzania (Malimbwi *et al*., 2004) are the chief source of firewood and charcoal. The most important use of wood in Tanzania is for fuel and about 95% of the country's energy supply is met by fuelwood (Iddi&Hakan, 1997). Woodlands trees produce a heavier and more concentrated fuel than most fast growing softwood species and trees from tropical rainforests (Gauslaa, 1988). Woodfuel extraction is among the factors, which affect the dynamics of miombo woodlands in Tanzania (Malimbwi *et al.*, 2004). According to the present economic status, the majority of urban population in Tanzania will continue to depend on woodfuel for long time to come (Moyo *et al.*, 1993; MNRT, 1998). Furthermore, due to the anticipated steady increase in population at an annual rate of increase of 2.5% (URT, 2002), it is expected that actual consumption of firewood and charcoal will continue to rise to a greater extent. This can put strains on natural forest from where the charcoal is obtained resulting in deforestation of the forest ecosystem.

4.2.1.5 Selective logging

The study revealed that selective logging is not dominant due to unavailability of large trees and has therefore minor effect to the forest resources in the forest reserve. Table 3 shows that only 3% of the respondents reported that selective logging is being done in the reserve. The inventory survey spotted few species, with suitable form and large enough diameter for timber extraction. These included *Erythrophleum africanum* (Mkarati) and *Terminalia sambesiaca* (Mpululu). During the inventory assessment, the crew encountered logs of the species in pits ready for timber production (Plate 4).

Plate 4. A log of *Terminalia sambesiaca* prepared in a pit ready for sawing at MFR, Morogoro, Tanzania

Logging under the selection system involves the harvesting of individual trees selected and marked with intention of maintaining good growth through reduced tree densities while improving forest health and quality. On the otherhand, sufficient residual tree numbers are left to allow for a continuos supply of wood products over short (10-25years) cutting period (Renè and Clara 2003). Tree mortality in the understorey of selective logged forest occurs near and on skid trails (Woods, 1998; Webb, 1998; Pinnard *et al*., 2000). The increased light levels in the forest understorey after selective logging usually results in the sudden occurance of many herbaceous and woody pioneer species (Woods, 1989; Nykvist, 1996; Pinard *et al*., 2000.). Since the understorey plays an an important role in the regeneration of the forest overstorey, it is likely that at least part of these pioneer species will eventually grow into the forest overstorey, thus affecting the tree composition of the forest (Riswan *et al*., 1985; Newberry *et al*., 2000).

4.2.1.6 Firewood collection

Table 3 shows that 83% of the people collect firewood from the reserve. However, most of them argue that firewood collected is dry and therefore has little effect on the composition and regeneration of wood resources available. On the otherhand, during inventory data collection, there was a big influx of people in the reserve cutting any standing tree of reasonable stem size regardless of their form. It was during this time that the remaining big trees of *Sclerocarya birrea* (Mng'ong'o) and *Erythrophleum africanum* (Mkarati) were cut (Plate 5). According to Ruffo (Pers. comm., 2005) *Sclerocarya birrea* was left untouched during early extraction because of its unsuitability to produce quality charcoal and timber while *Erythrophleum africanum* was not harvested, as its wood is difficult to work with. People were encouraged to cut these trees during this time, due to their high demand by one textile factory in Morogoro municipality where wood was required to operate boilers as an alternative to electricity.

Rural people mostly use firewood for cooking, heating and to some extent sell to support their livelihood (Clarke *et al.,* 1996). Miombo woodlands in Southern Africa account for 60-70% of annual consumption of firewood and for 3.5 million m^3 of wood for charcoal production (Brigham *et al.,* 1996). In Tanzania around 91% of all energy consumed in the country is wood fuel (Brigham *et al.,* 1996) and about 90% of this comes from miombo woodlands (Mugasha *et al*., 2004)

Plate 5. One of remaining big trees of *Erythrophleum africanum* in the reserve cut for operating boilers in one of the textile factories in Morogoro municipality, Morogoro, Tanzania

4.2.1.7 Honey collection

Honey collection was one of the significant economic activities undertaken in the reserve. About 27% of the respondents reported that they carry out honey collection activities in the reserve (Table 3). However, honey collection was not an important income generating activity in the study area, as local people are not practicing beekeeping. Beekeeping and honey hunting are wide spread practices in many areas of the miombo region and both have a long history of traditional practice (Fischer, 1993). Production of honey demands considerable felling and debarking of trees thus reduces composition and regeneration of plant species (Kowero and Okting'ti, 1990).

4.2.1.8 Hunting

Hunting is not significantly affecting forest resources in the reserve. Out of 101 respondents 45% reported that hunting is being carried out in the forest reserve (Table 3). However, this activity does not have significant effect on forest resources in the reserve. Game hunting under license occurs in the miombo region, in some cases for marketing to urban areas, in others as part of tourist trade (Chihongo, 1993). Deforestation and hunting have reduced many game populations (Wilson, 1990). Animal hunters utilize fire to clear bush for improving visibility. When fire is used during the dry season it becomes destructive and interferes with sustainable development of plant communities.

4.2.2 Dependency of forest adjacent communities on the forest reserve

4.2.2.1 Forest products extracted from MFR

The study revealed that charcoal, firewood, building poles, timber, fruits, medicine and honey were amongst the forest products extracted from the forest reserve. Of the forest products extracted, the first three are harvested in significantly large quantities (Table 4).

In the study area, about 69% of the people interviewed revealed that charcoal and firewood are being extracted from the forest reserve. Most of the charcoal and firewood extracted are being sold in Morogoro municipality and generate income for households in the area. While woodfuel markets are relatively uncommon in rural areas, urban households are generally dependent on the market to meet their energy needs (Dewees, 1993). Miombo woodlands are the chief source of wood fuel utilized by the urban population (Temu and Kaale, 1985, Monela *et al.*, 1993).

Building poles extraction was reported by 39% of all respondents that were interviewed. Most of the poles were used for building purposes (i.e. Scaffolding) in Morogoro municipality and Dar-es-Salaam city. Extraction of poles reduced species composition by exploiting the better quality individuals and also may influence the forest structure and regeneration. Tree species favoured for extraction of poles include *Pteleopsis myritifolia, Combretum molle, Terminalia sericea, Julbernardia globiflora* and *Brachystegia boehmii.* Extraction of this resource in the forest reserve has gone to the extent that large diameter posts of durable timber traditionally used have become scarce or unavailable.

Research in Malawi found the highest demand for poles appeared to be from trees above five centimeters diameter at breast height (Lowore *et al.*, 1995b).

Table 4. Types of Forest Products extracted from the MFR, Morogoro, Tanzania

Product extracted	Extracting	Not extracting	Chi-square	P-value	Significance
Charcoal	69.3 (70)	30.7 (31)	15.059	0.001	**
Firewood	68.3 (69)	31.7 (32)	13.554	0.001	**
Building pole	38.6 (39)	61.4 (62)	5.238	0.022	*
Timber	2.0 (2)	98.0 (99)	93.158	0.001	**
Wild fruits	14.9 (15)	85.1 (86)	49.911	0.001	**
Medicines	21.8 (22)	78.2 (79)	32.168	0.001	**
Honey	3.0 (3)	97.0 (98)	89.356	0.001	**

Figures in parenthesis indicate number of households (Total N=101). *= Significant, **=Highly significant

Medicines and wild fruits were extracted from the forest reserve in large quantities. About 22% of all respondents reported that medicinal plants are extracted while 15% indicated to collect wild fruits from the reserve. Globally two billion people relay on traditional medicines, many of which comes from the forest (CIFOR, 2003). The roots, leaves and bark of many different species are used in health care, both as medicine and for magic (Clarke *et al.*, 1996). During the inventory, few remaining trees of *Zanthoxylum chalybeum* were found heavily debarked. Local people claimed that the powder from the stem bark of the species treat malaria. Plant material combinations are used in self –treatment of common ailments such as coughs, headaches, diarrhoea and sores and people are generally very knowledgeable about which plants can be used and how to prepare them. It has been argued that in rural areas plants are used to protect homes and crops, in hunting or warfare (Clarke *et al.,* 1996).

Miombo woodlands are rich in variety and quantity of fruit trees (Campbell, 1997). In Tanzania a total of 83 species of indigenous fruit trees have been recorded, most of which occur in miombo woodlands (Temu and Msanga, 1994). Wild fruit is not normally a major constituent in the diet, but is an important supplementary source of food, as well as vitamins and nutrients. Few Tanzanian wild fruits have been analyzed for their nutritional content and available data indicate that many have higher nutritive value than exotic fruits commonly sold in markets (Ruffo *et al.*, 2002). Some wildfruits such as *Adansonia digitata*, *Annona senegalensis*, and *Parinari curatelifolia* are high in protein and fat. Furthermore, the fruits of *Adansonia digitata* and *Ximenia caffra* have higher vitamin C content than Mango (*Mangifera indica*) and Orange (*Citrus sinensis*). Wild fruit is consumed mainly during the dry season and early rain season before cultivated crops are ripe. Wild fruits are more important in remote areas and especially during times of famine as they can be used as food substitute (Campbell, 1987).

Timber extraction was observed to be an insignificant economic activity in the studied community with only 2% of the respondents reporting existence of extraction for timber. This is perharps due to low basal area in the reserve as witnessed during inventory survey. Most of the suitable timber species have been exploited to the level that species regrowth may take longtime before reaching merchantable size. One of the main miombo timber species are *Pterocarpus angolensis,* whose timber is very durable, works well and shrinks very little after drying and is one of the most valuable timbers in Africa (Gauslaa, 1989). *Afzelia quanzensis* is another important species of miombo whose timber is straight-grained, hard which is used for internal and external joinery as well as being favoured for dug out canoes (Williamson, 1975). According to Ruffo (Personal communication 2005) the MFR was rich in valuable tree species of *Pterocarpus angolensis, Afzelia quanzensis* and *Dalbergia melanoxylon*. However, these commercial timber species were extracted during the 1980s when timber business for furniture making and other construction was at a boom.

Bee honey was another of the forest products extracted from the reserve as expressed by 2% of the respondents. Miombo woodlands are prime for bee keeping due to the presence of a large number of excellent bee forage species including *Brachystegia spiciformis*, *Julbernadia globiflora*, *Julbernardia paniculata* and to a lesser extent but still important, *Vitex doniana, Uaparka kirkiana* and *Parinari excelsa* (Njovu, 1993).

4.2.2.2 Sources of forest products for communities adjacent to MFR

It was observed that communities around the reserve obtain forest products to meet their daily needs from four sources including the forest reserve, public land, private farms and the local market. Among the four sources, MFR ranks the main source of the forest products. Table 5 shows that 85% of the respondents accept that the contribution of forest reserve to supply forest products is significantly higher compared to other sources.

Table 5. Sources of Forest Products for communities around MFR, Morogoro, Tanzania

Source of Supply	Supply	Not supply	Chi-square	Rank of sources	P-value	Significance
Forest Reserve	85.1 (86)	14.9 (15)	49.911	1	0.001	**
Public land	62.4 (63)	37.6 (38)	6.188	2	0.013	*
Private farms	19.8 (20)	80.2 (81)	36.842	3	0.001	**
Market	6.9 (7)	93.1 (94)	74.941	4	0.001	**

Figures in parenthesis indicate number of households (Total N = 101). *=Significant, **=Highly Significant

The MFR is a reliable source of the forest products and services consumed by the adjacent communities. This has an implication that more than three-quarters of the forest products consumed in the area are being extracted from the reserve. The existence of the forest reserve is therefore important to the livelihood of the forest adjacent communities. Forest reserves are enormously important to mankind. They not only supply essential harvestable products but also ornament landscapes (Kaufman *et al.*, 1999). Conversely, about 7% of the adjacent communities do obtain their forest products from the local market. However, forest products obtained from the local market are either collected from the MFR of private farms.

4.2.3 Socio-economic factors influencing local people's dependence on forest resources

Logistic regression model was used to establish the socio-economic factors influencing demand for forest resources and the subsequent degradation of forest reserve. The significant socio-economic factors observed to influence demand for forest resources include household size, cropping system, mode of farm preparation, average income, mode of livestock keeping and distance to forest resources. The goodness of fit of the logistic regression model was found to fit very well to the data as shown by the significant value of 0.010 (Table 6). The model chi-square value of 46.073 was highly significant (p=0.001) implying that the independent variables were well correlated with the dependent variable and had significant influence on the independent variable. The –2log likelihood (-2LL) value of 124.9 and the overall percentage of correct predictions of 65.3% also indicated that the model fitted the data reasonably well.

4.2.3.1 Influence of household size on forest dependence

Household size had a positive regression coefficient (ß) of 1.001 and the odds ratio Exp (ß) 2.722 (Table 6). This means that since the coefficient of this factor is positive a unit change in this variable will increase the likelihood of the event, i.e. demand for forest resources and its subsequent degradation in the forest reserve to occur by a factor of 1.133.

Table 6. Socio-economic factors influencing demand for forest resources and its degradation in MFR, Morogoro, Tanzania.

Variable	ß	S.E	Wald	df	Sig.	Odds Ratio Exp (ß)
Household size	1.001	0.254	15.588	1	0.001(**)	2.722
Farmland size	0.086	0.276	0.098	1	0.754 (NS)	1.090
Cropping system	2.141	0.450	22.659	1	0.001(**)	8.510
Mode of farm preparation	-0.060	0.832	0.005	1	0.942 (NS)	0.942
Mode of Livestock keeping	1.001	0.355	7.954	1	0.005 (*)	2.720
Average income	0.449	0.263	2.906	1	0.088 (NS)	1.566
Distance to forest product	0.024	0.227	0.012	1	0.914 (NS)	1.025
Constant	-1.080	0.421	6.592	1	0.010	0.340

Note: (1) Model Chi-square = 46.073 ($p<0.001$); -2LL=124.099; Overall percentage=65.3
(2) ß = Regression coefficient; SE= Standard error of estimate; Sign = Significance level; Wald = ß/(SE$)^2$; df = Degree of freedom; Exp (ß) = Odds ratio; NS= Not significant; *= Significant; **= Highly Significant.

Usually the increase in number of households of the communities adjacent to the forest reserve increases demand for forest resources in the forest reserve. The community is therefore forced to encroach the reserve to meet their demand. This pressure in turn leads to unsustainable utilization hence degradation of forest resources.

4.2.3.2 Influence of farm size on forest dependence

The results in Table 6 show that farm size has a positive regression coefficient of 0.086 and the odds ratio of 1.090. This means that degradation of forest resources in the forest reserve increases by a factor of 1.090 for a unit increase of the variable. Farm size, however was not statistically significant ($p<0.754$) and thus its influence on forest degradation is not significant. When households have large farms it means that they have cleared all the woody resources from their farms for planting agricultural crops. Forest products like firewood and charcoal can only now be obtained in the forest reserve. The dependency of the community to obtain forest resources from the reserve will exert pressure and lead to forest degradation. On the other hand, increasing the household farm size would demand more land and therefore increasing the likelihood of annexing forestlands.

4.2.3.3 Influence of cropping system on forest dependence

Cropping system has a positive regression coefficient value of 2.141 and the odds ratio of 8.510 (Table 6). This indicates that the likelihood of demand for forest resources and its degradation in the reserve increases by a factor of 8.510 for every unit change in the cropping system. The study indicates that cropping system of the forest adjacent communities is statistically highly significant (p=0.001) and increases demand for forest resources and its degradation.

Most of the households are undertaking monoculture-cropping system of maize, millet, cassava, groundnuts and sorghum. Monoculture cropping has also contribution to deforestation through shifting cultivation. This system deteriorates the soil and consequently reduces crop production. This may force the community to depend more on forest resources to supplement agricultural crop production.

4.2.3.4 Influence of mode of farm preparation on forest dependence

The results in Table 6 show that, the mode of farm preparation has a negative regression coefficient value of –0.060 and the odds ratio 0.942. This indicates that for every unit change in this variable the demand for forest resources and its degradation in the forest reserve decreases by a factor of 0.942. However, the study revealed that the mode of farm preparation did not have statisticall significance on forest degradation ($p>0.942$). This may be explained by the fact that, the communities adjacent to the forest reserve clear all the vegetation during farm preparation. The cleared vegetation is collected and used as fuel. This tendency reduces pressure to the forest reserve temporarily and relieves forest resources from degradation.

4.2.3.5 Influence of mode of livestock keeping on forest dependence

The mode of livestock keeping shows positive regression coefficient value of 1.001 and the odds ratio 2.720. This indicates that increase in livestock keeping by one unit increases the chances of consumption of forest resources available in the nearby forest by a factor of 2.720. The study shows that the influence of the mode of livestock keeping on forest degradation is statistically significant ($p<0.005$).

Mode of livestock keeping in the area of study is free grazing. This has an impact on the forest resources as most of the livestock keepers are holding big herds of cattle beyond carrying capacity. Holding of cattle beyond forest reserve capacity results in the degradation of the forest resources in the reserve. Overgrazing depletes favoured species and trampling hardens the soil, which reduces the number of plants that can grow in the area. Reduction of forest resources by livestock keeping, outside the reserve, results in increase in demand for the forest resources from the reserve and its subsequent degradation.

4.2.3.6 Influence of average households' income on forest dependence

Table 6 shows that average income of the households has a positive regression coefficient of 0.449 and the odds ratio 1.566. This would mean that demand for forest resources and its degradation increases by a factor of 1.566 for a unit change in household income. This has an implication that an increase in the income of the households in the forest adjacent community increases the demand for forest resources, which leads to the forest reserve degradation.

Households with relatively high income serve more than two meals a day thus demand more energy (fuelwood), which likely would come from the forest hence more likelihood of degradation of forest resources. Cavendish (2000; 2002) observed that in a commercial area of Zimbabwe (Shindi ward) that wild resources contributed on average 40% of the total household income for poor households, while the corresponding figure for more wealthy households was 29%. Non Timber Forest Products also provided proportionally more cash income to poor households (20%) than better off households (5%). However, unlike the income share data, absolute demands for natural resources did not decline with increasing wealth (Shackleton and Shackleton, 2004). Indeed, more wealthy households were found to consume greater absolute amount of natural resources than poorer households (Cavendish, 2000).

4.2.3.7 Influence of distance to forest reserve on forest dependence

Distance of forest products has a positive regression coefficient of 0.024 and the odds ratio of 1.025 (Table 6). This means that demand for forest resources and its degradation in the forest reserve increases by a factor of 1.025 for a unit change in distance to the forest products. This implies that forest resources far from the main road in the forest reserve are extracted more than that close to the road. This is because people have tendency to feel safe to be away from the area where they cannot be seen extracting wood resources. When there is no control, the interior forest will be extracted most, leading to forest degradation. It was further observed that the reserve had a road network that facilitated extraction of forest resources. By using lorries and bicycles big quantities of forest resources (charcoal, firewood and poles) are being extracted from the reserve at a lesser time than if one was carrying on the head (Plate 6 & 7)

Plate 6. **Good road network inside MFR facilitates entrance of lorries for carrying forest resources, Morogoro, Tanzania**

Plate 7. **Bicycles used to transport forest resources from interior of the MFR, Morogoro, Tanzania**

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

5.1.1 Forest resource base

Morogoro Fuelwood Reserve had regeneration of 7 233 stems ha^{-1} and a composition of 52 woody species. The Shannon Wierner index value obtained was 2.7293 while Simpson diversity index was 0.0705. The reserve recorded a wood stocking of 403 stems ha^{-1} with basal area and wood volume of $2.12m^2ha^{-1}$ and $9.58m^3ha^{-1}$ respectively.

Basing on the forest resource base results it can be concluded that, the MFR is under severe human disturbance. This is evidenced by low tree stocking, less basal area and volume as compared to other reported study conducted in the reserves of the Eastern miombo woodlands. The study has further revealed that the commercial timber species such as *Brachystegia, Afzelia quanzensis and Pterocarpus angolensis* that are commonly dominant in this vegetation types had poor regeneration. This is to say that if the trend of exploitation is not controlled, these species are in danger of extinction in the reserve.

5.1.2 Social Economic activities

From this study it is concluded that livelihood of forest adjacent communities, to a great extent, depend on the reserve. However, uncontrolled human activities, which are undertaken in the area including charcoal making, livestock grazing, firewood cutting and wild fires caused severe disturbance to the extent that it has interfered with the sustainable management of the reserve.

5.2 Recommendations

The following recommendations are made in order to achieve sustainable management of the reserve.

- The ecological integrity of the forest reserve must be maintained on the long-term basis by regular assesment and monitoring of its status to evaluate the extent and nature of changes that is taking place.

- There is a need to undertake forestry extension and public education to enhance awareness of the multiple roles and values of the reserve and other miombo woodlands to the communities living adjacent to it/them.

- Human activities should be controlled in the reserve to avoid turningnegative impacts. This can be achieved through preparing effective management plans to ensure proper implementation of forestry activities.

- Adjacent community should be encouraged to establish woodlots by planting and leaving natural regenerants in their farmlands to provide fuelwood, building poles and charcoal and reduce pressure to the reserve.

- Boundary planting and marking is needed to dermacate the forest and patrolling should be done to stop illegal logging and unnecessary burning.

- Encourage the community to utilize energy saving stoves to reduce consumption of fuelwood.

- Punitive measures should be taken against individuals who carrying out activities that lead to degradation of the reserve.

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APPENDICES

Appendix 1. List of woody species found in the plots in MFR, Morogoro Tanzania

Botanical name	Sp. Code	Family	Local name
Acacia hockii De Wild	*1*	Mimosoideae	Msese
Acacia nigrescens Oliv.	*2*	Mimosoideae	Mkambala
Acacia robusta Burch	*3*	Mimosoideae	Mkongowe
Albizia harveyii Fourn	*4*	Mimosoideae	Mfirigisi
Bauhinia petersiana Bolle	*5*	Caesalpiniodeae	Msegese
Brachystegia boehmii Taub	*6*	Caesalpiniodeae	Myombo
Brackenridgiea zanguebarica Oliv.	*7*	Ochnaceae	Mkumbi
Bridelia carthartica Bertol.f	*8*	Euphorbiaceae	Msinzila
Cassia abbreviata Oliv.	*9*	Caesalpiniodeae	Mkundekunde
Catunaregum spinosa (Thurnb.) Tirveng	*10*	Rubiaceae	Mtutuma
Combretum adenogonium Steud. Ex A.Rich	*11*	Combretaceae	Mlama ng'ombe
Combretum collinum Fresen	*12*	Combretaceae	Mlama
Combretum hereroense Schinz.	*13*	Combretaceae	Mgonanyehe
Combretum molle R.Br.ex G.Don	*14*	Combretaceae	Mlama mweusi
Combretum zeyheri Sounder	*15*	Combretaceae	Mlama mweupe
*Commiphora africana (*A.Rich.) Engl.	*16*	Combretaceae	Mtwintwi
*Crossopterix febrifuga (*Afzel.ex G.Don)	*17*	Rubiaceae	Msikosiko
Dalbergia boehmii Taub	*18*	Papilionoidae	Mhuge/Mjaja
*Dalbergia melanoxylon*Guillemin & Perrottet	*19*	Papilionoidae	Mpingo/Mhingo
Dicrostachys cinerea (L.) Wight & Arn	*20*	Mimosoideae	Kikulagembe
Diospyros consolate Chiov.	*21*	Ebenaceae	Mkululu
Diospyros kirkii Hiern	*22*	Ebenaceae	Mkoko
Diospyros loureiriana ssp. rufescens Hiern.	*23*	Ebenaceae	Mdaa
*Diplorynchus condylocarpon (*Muell. Arg.) Pichon	*24*	Apocynaceae	Mtogo
Ehretia amoeana Klotzsch.	*25*	Boraginaceae	Mkirika
Erythrophleum africanum Harms	*26*	Caesalpiniodeae	Mkarati
Euclea divinorum Hiern	*27*	Ebenaceae	Mdaa
Gardenia resiniflua Hiern	*28*	Rubiaceae	Kilemandembo
Grewia bicolor Juss.	*29*	Tiliaceae	Mkola
Haplocoelum foliolosum (Hiern.)	*30*	Sapindaceae	Mhaka
Indigofera rhinchocarpa Bak	*31*	Papilionoidae	Kibaazi pori
*Julbernardia globiflora (*Benth.) Troupin	*32*	Caesalpiniodeae	Mtondoro
Lannea schimperi(A. Rich) Engl.	*33*	Anacardiaceae	Mumbu-Luzigwe
Lannea schweinfurthii (Engl.) Engl.	*34*	Anacardiaceae	Msighe, Mumbu
Ormocarpum kirkii S. Moore	*35*	Papilionoidae	Hombo
Pseudolachynostylis maprouneifolia Pax	*36*	Euphorbiaceae	Msolo

Botanical name	Sp. Code	Family	Local name
*Psydrax livida (*Hiern) Bridson	*37*	Rubiaceae	Mlavilavi
*Pteleopsis myritifolia (*Welw.ex.C.Lawson) Engl. & Diels	*38*	Combretaceae	Mngoji
Pterocarpus angolensis DC.	*52*	Papilionoideae	Mninga/Mhagata
Pterocarpus rotundifolius ssp. polyanthus (Sond.)	*39*	Papilionoidae	Mhambalasha
Sclerocarya birrea (A.Rich.) Hochst	*40*	Anacardiaceae	Mng'ong'o
Senna auriculata (L.)	*41*	Caesalpiniodeae	Mhumbahumba
Stereospermum kunthianum Cham	*42*	Bignoniaceae	Myuwe
Terminalia sericea DC.	*43*	Combretaceae	Mpululu
Thylachium africanum Lour	*44*	Capparaceae	Mdudu
Uvaria acuminata Oliv.	*45*	Annonaceae	Msofu
*Vitex payos (*Lour.) Merr.	*46*	Verbenaceae	Mfuru
Ximenia caffra Sond.	*47*	Olacaceae	Mpingi
Xeroderris stuhlmanii (Taub.)	*48*	Papilionoidae	Mnyenye
Xylotheca tettensis (Klotz.)	*49*	Flacourtiaceae	Msekaseka
Zanthoxylum chalybeum Engl.	*50*	Rutaceae	Mhunungu
Zizyphus mucronata Willd.	*51*	Rhamnaceae	Mkunazi mwitu

Appendix 2. Species abundance in MFR, Morogoro, Tanzania

S/N.	Species name	Frequence	%
1	*Combretum molle*	68	17
2	*Pteleopsis myritifolia*	50	12
3	*Bauhinia petersiana*	33	8
4	*Combretum collinum*	22	5
5	*Combretum adenogonium*	20	5
6	*Terminalia sericea*	20	5
7	*Sclerocarya birrea ssp. caffra*	19	5
8	*Acacia nigrescence*	18	4
9	*Acacia robusta*	16	4
10	*Diospyros consolatae*	16	4
11	*Commiphora africana*	11	3
12	*Erythrophleum africanum*	10	2
13	*Combretum hereroense*	8	2
14	*Pterocarpus rotundifolius ssp. polyanthus*	8	2
15	*Albizia harveyii*	7	2
16	*Combretum zeyheri*	7	2
17	*Diospyros kirkii*	7	2
18	*Diplorynchus condylocarpon*	7	2
19	*Brackenridgia zanguebaricum*	6	1
20	*Dalbergia melanoxylon*	6	1
21	*Diospyros loureiriana ssp. rufescens*	6	1
22	*Catunaregum spinosa*	5	1
23	*Julbernardia globiflora*	4	1
24	*Xeroderris stuhlmanii*	4	1
25	*Brachystegia boehmii*	3	1
26	*Psydrax livida*	3	1
27	*Dicrostachys cinerea*	2	0
28	*Grewia biocolar*	2	0
29	*Senna auriculata*	2	0
30	*Bridelia carthartica*	1	0
31	*Cassia abbreviata*	1	0
32	*Dalbergia boehmii*	1	0
33	*Eheretia amoeana*	1	0
34	*Haplocoelum foliolosum*	1	0
35	*Lannea schimperi*	1	0
36	*Lannea schweinfurthii*	1	0
37	*Pseudolachynostylis maprouneifolia*	1	0
38	*Pterocarpus angolensis*	1	0
39	*Stereospermum kunthianum*	1	0

S/N.	Species name	Frequence	%
40	*Vitex payos*	1	0
41	*Xylotheca tettensis*	1	0
42	*Ziziphus mucronata*	1	0
	Grand Total	**403**	**100**

Appendix 3. Distribution of number of stems (N), Basal area (G) and Volume (V) by order of important value index at MFR, *Morogoro, Tanzania*

Spp. Code	Botanical name	DBH CLASSES												IVI
		4 - 9.9 cm			10 - 19.9 cm			>20 cm			TOTAL			
		N	G	V	N	G	V	N	G	V	N	G	V	
14	*Combretum molle*	72	0.18	0.23	3	0.03	0.10				75	0.21	0.33	**10.03**
40	*Sclerocarya birrea*	3	0.01	0.01	2	0.04	0.17	2	0.18	2.28	7	0.23	2.45	**5.44**
38	*Pteleopsis myritifolia*	77	0.20	0.25	2	0.03	0.12				79	0.22	0.38	**4.41**
2	*Acacia nigrescens*	10	0.02	0.02	1	0.01	0.03	3	0.31	3.37	15	0.34	3.42	**3.73**
3	*Acacia robusta*	10	0.04	0.08	4	0.08	0.34	0	0.04	0.61	14	0.16	1.02	**3.55**
5	*Bauhinia petersiana*	55	0.17	0.26	0	0.01	0.02				55	0.18	0.28	**3.42**
11	*Combretum adenogonium*	28	0.09	0.13	2	0.02	0.07				29	0.11	0.21	**3.29**
43	*Terminalia sericea*	22	0.05	0.07	0	0.00	0.01				23	0.06	0.08	**2.89**
16	*Commiphora africana*	15	0.04	0.06							15	0.04	0.06	**2.24**
12	*Combretum collinum*	24	0.07	0.10	2	0.02	0.04				26	0.08	0.14	**2.17**
13	*Combretum hereroense*	14	0.02	0.02							14	0.02	0.02	**1.14**
24	*Diplorynchus condylocarpon*	7	0.02	0.02	1	0.01	0.02				8	0.02	0.04	**1.05**
51	*Zyziphus mucronata*				0	0.01	0.02				0	0.01	0.02	**1**
25	*Ehiretia amoeana*	2	0.01	0.01							2	0.01	0.01	**1**
21	*Diospyros consolatae*	28	0.10	0.17							28	0.10	0.17	**0.88**
7	*Brackenridgiea zanguebarica*	10	0.03	0.04							10	0.03	0.04	**0.84**
39	*Pterocarpus rotundifolius*	9	0.02	0.03							9	0.02	0.03	**0.82**
32	*Julbernardia globiflora*	7	0.02	0.03							7	0.02	0.03	**0.78**
19	*Dalbergia melanoxylon*				2	0.04	0.17				2	0.04	0.17	**0.72**
4	*Albizia harveyii*	9	0.02	0.02	0	0.00	0.01				9	0.02	0.04	**0.71**
29	*Grewia biocolor*	3	0.01	0.01							3	0.01	0.01	**0.6**
15	*Combretum zeyheri*	7	0.01	0.01							7	0.01	0.01	**0.54**
22	*Diospyros kirkii*	2	0.00	0.01	0	0.00	0.01	0	0.01	0.09	3	0.02	0.10	**0.52**
42	*Stereospermum kunthianum*										0	0.00	0.00	**0.5**
6	*Brachystegia boehmii*	3	0.01	0.02							3	0.01	0.02	**0.45**
23	*Diospyros loureriana*	5	0.01	0.01	0	0.00	0.01	0	0.01	0.04	6	0.02	0.07	**0.38**
20	*Dicrostachys cinerea*	3	0.01	0.02							3	0.01	0.02	**0.33**
41	*Senna auriculata*	3	0.01	0.00							3	0.01	0.00	**0.31**
		DBH CLASSES												**IVI**

Spp. Code	Botanical name	4 - 9.9 cm			10 - 19.9 cm			>20 cm			TOTAL			
		N	**G**	**V**	**N**	**G**	**V**	**N**	**G**	**V**	**N**	**G**	**V**	
26	*Erythrophleum africanum*										0	0.02	0.20	**0.26**
33	*Lannea schimperi*	2	0.00	0.00				0	0.02	0.20	2	0.00	0.00	**0.25**
48	*Xeroderris stuhlmanii*	3	0.01	0.01							3	0.01	0.01	**0.25**
10	*Catunaregum spinosa*				1	0.01	0.02				1	0.01	0.02	**0.21**
37	*Psydrax livida*	3	0.02	0.03	0	0.00	0.01				4	0.02	0.03	**0.17**
52	*Pterocarpus angolensis*	2	0.00	0.00							2	0.00	0.00	**0.14**
36	*Pseudolachynostylis maprouneifolia*							0	0.01	0.06	0	0.01	0.06	**0.13**
34	*Lannea schweinfurthii*	2	0.00	0.00							2	0.00	0.00	**0.13**
18	*Dalbergia boehmii*	2	0.00	0.01							2	0.00	0.01	**0.09**
46	*Vitex payos*										0	0.00	0.00	**0.09**
9	*Cassia abbreviata*				0	0.01	0.07				0	0.01	0.07	**0.07**
49	*Xylotheca tettensis*	2	0.00	0.00							2	0.00	0.00	**0.05**
30	*Haplocoelum foliolosum*	2	0.00	0.00							2	0.00	0.00	**0.05**
8	*Bridelia carthartica*										0	0.00	0.00	**0**
		375	**1.20**	**1.68**	**22**	**0.33**	**1.25**	**6**	**0.59**	**6.64**	**403**	**2.12**	**9.58**	

Appendix 4. Shannon and Simpson diversity indices in MFR, Morogoro, Tanzania.

Botanical name	N	Pi	Simpson (C)	LNPi	Shannon (H’)
Acacia nigrescens	18	0.0447	0.0020	-3.10856	-0.13884
Acacia robusta	16	0.0397	0.0016	-3.22635	-0.12809
Albizia harveyii	7	0.0174	0.0003	-4.05303	-0.0704
Bauhinia petersiana	33	0.0819	0.0067	-2.50243	-0.20491
Brachystegia boehmii	3	0.0074	0.0001	-4.90032	-0.03648
Brackenridgiea zanguebarica	6	0.0149	0.0002	-4.20718	-0.06264
Bridelia carthartica	1	0.0025	0.0000	-5.99894	-0.01489
Cassia abbreviata	1	0.0025	0.0000	-5.99894	-0.01489
Catunaregum spinosa	5	0.0124	0.0002	-4.3895	-0.05446
Combretum adenogonium	20	0.0496	0.0025	-3.0032	-0.14904
Combretum collinum	22	0.0546	0.0030	-2.90789	-0.15874
Combretum hereroense	8	0.0199	0.0004	-3.9195	-0.07781
Combretum molle	68	0.1687	0.0285	-1.77943	-0.30025
Combretum zeyheri	7	0.0174	0.0003	-4.05303	-0.0704
Commiphora africana	11	0.0273	0.0007	-3.60104	-0.09829
Dalbergia boehmii	1	0.0025	0.0000	-5.99894	-0.01489
Dalbergia melanoxylon	6	0.0149	0.0002	-4.20718	-0.06264
Dicrostachys cinerea	2	0.0050	0.0000	-5.30579	-0.02633
Diospyros consolatae	16	0.0397	0.0016	-3.22635	-0.12809
Diospyros kirkii	7	0.0174	0.0003	-4.05303	-0.0704
Diospyros loureiriana ssp. rufescens	6	0.0149	0.0002	-4.20718	-0.06264
Diplorynchus condylocarpon	7	0.0174	0.0003	-4.05303	-0.0704
Eheretia amoeana	1	0.0025	0.0000	-5.99894	-0.01489
Erythrophleum africanum	10	0.0248	0.0006	-3.69635	-0.09172
Grewia biocolar	2	0.0050	0.0000	-5.30579	-0.02633
Haplocoelum foliolosum	1	0.0025	0.0000	-5.99894	-0.01489
Julbernardia globiflora	4	0.0099	0.0001	-4.61264	-0.04578
Lannea schimperi	1	0.0025	0.0000	-5.99894	-0.01489
Lannea schweinfurthii	1	0.0025	0.0000	-5.99894	-0.01489
Pseudolachynostylis maprouneifolia	1	0.0025	0.0000	-5.99894	-0.01489
Psydrax livida	3	0.0074	0.0001	-4.90032	-0.03648
Pteleopsis myritifolia	50	0.1241	0.0154	-2.08691	-0.25892
Pterocarpus angolensis	1	0.0025	0.0000	-5.99894	-0.01489
Pterocarpus rotundifolius ssp. polyanthus	8	0.0199	0.0004	-3.9195	-0.07781
Sclerocarya birrea	19	0.0471	0.0022	-3.0545	-0.14401
Senna auriculata	2	0.0050	0.0000	-5.30579	-0.02633
Stereospermum kunthianum	1	0.0025	0.0000	-5.99894	-0.01489
Terminalia sericea	20	0.0496	0.0025	-3.0032	-0.14904
Vitex payos	1	0.0025	0.0000	-5.99894	-0.01489
Xeroderris stuhlmanii	4	0.0099	0.0001	-4.61264	-0.04578
Xylotheca tettensis	1	0.0025	0.0000	-5.99894	-0.01489
Ziziphus mucronata	1	0.0025	0.0000	-5.99894	-0.01489
Grand Total	**403**		**0.0705**		**2.72925**

Appendix 5. General List of woody species found in the MFR their life form and uses

S/N	Botanical name	Family	Local name	Life form	Economic importance
1	*Acacia hockii*	*Mimosoideae*	Msese	T	3,4,6,11,12,14,17,21
2	*Acacia nigrescens*	*Mimosoideae*	Mkambala	T	1,2,3,4,6,8,9,14,17,21
3	*Acacia nilotica*	*Mimosoideae*	Mfunganyumbu	T	2,3,4,6,11,12,17
4	*Acacia polyacantha*	*Mimosoideae*	Muwindi	T	2,3,4,6,11,12,14,15,17
5	*Acacia robusta*	*Mimosoideae*	Mkongowe	T	3,4,11,14,17,21
6	*Albizia anthelmintica*	*Mimosoideae*	Mfuleta	T	2,3,4,7,11,17,28
7	*Albizia harveyi*	*Mimosoideae*	Mfirigisi/Msisimizi	T	2,3,4,6,11,13,14,17,21
8	*Albizia versicolar*	*Mimosoideae*	Mkungu	T	1,2,3,4,7,8,10,11,13,14,15,17,21,28
9	*Annona senegalensis*	*Annonaceae*	Mtopetope	S, ST	3,4,5,7,11,14,15,17,21,28
10	*Antidesma venosum*	Euphorbiaceae	Mgwejameno	S	3,4,5,11,15,17
11	*Bauhinia petersiana*	*Caesalpinioideae*	Msegese	S, ST	3,4,6,12,13,17,18
12	*Boscia salicifolia*	*Capparaceae*	Mguluka	T	2,3,4,7,11,12,13,17,19,28
13	*Brachystegia boehmii*	*Caesalpinioideae*	Myombo	T	3,4,6,7,11,13,17,18,21,25
14	*Brackenridgiea zanguebarica*	*Ochnaceae*	Mkumbi	T	3,4,12,17,27,28
15	*Bridelia carthartica*	*Euphorbiaceae*	Msinzila/Chikundilakwima	S, ST	2,3,4,11,12, 17
16	*Cadaba farinosa*	Capparaceae	Mdudu	S. ST	3,4,6,11,13,17
17	*Cassia abbreviata*	*Caesalpinioideae*	Mkundekunde	T	2,3,4,7,9,11,12,13,17
18	*Catunaregum spinosa*	*Rubiaceae*	Mtutuma	ST	2,3,4,8,11,17.23.28
19	*Combretum adenogonium*	*Combretaceae*	Mlama ng'ombe	T	3,4,11,13,17
20	*Combretum collinum*	*Combretaceae*	Mlama	T	2,3,4,11,13,17
21	*Combretum hereroense*	*Combretaceae*	Mgonanyehe	T	2,3,4,9,13,17
22	*Combretum molle*	*Combretaceae*	Mlama mweusi	T	2,3,4,7,9,11,13,17
23	*Combretum zeyheri*	*Combretaceae*	Mlama mweupe	T	2,3,4,11,17
24	*Commiphora africana*	*Burseraceae*	Mtwintwi	T	11,16,17,20,26
25	*Commiphora pteleifolia*	*Burseraceae*	Mtwintwi	T	3,8,20,28
26	*Cordia monoica*	Boraginaceae	Msasa	S, ST	2,3,4,5,7,17,21
27	*Crossopterix febrifuga*	*Rubiaceae*	Msikosiko	T	3,4,11,17,28
28	*Dalbergia boehmii*	*Papilionoideae*	Mhuge/Mjaja	T	2,3,4,9,11,13,17
29	*Dalbergia melanoxylon*	*Papilionoideae*	Mpingo/Mhingo	T	1,2,3,4,7,8,9,17,28
30	*Dalbergia nitidula*	*Papilionoideae*	Mzezegelo	ST	2,3,4,7,9,17

31	*Deinbollia borbonica*	Sapindaceae	Mmoyomoyo	S, ST	3,4,11,13,17
S/N	**Botanical name**	**Family**	**Local name**	**Life form**	**Economic importance**
32	*Dicrostachys cinerea*	*Mimosoideae*	Kikulagembe	S, ST	2,3,4,6,11,12,17
33	*Diospyros consolatae*	*Ebenaceae*	Mkululu/Msungura	T	2,3,4,7,9,17,28
34	*Diospyros kirkii*	*Ebenaceae*	Mkoko/Mkulwi	T	3,4,5,6,17,28
35	*Diospyros loureiriana ssp. Rufescens*	*Ebenaceae*	Mdaa	S,T	3,4,11,17,27,28
36	*Diplorynchus condylocarpon*	*Apocynaceae*	Mtogo	T	3,4,11,17
37	*Ehretia amoeana*	*Boraginaceae*	Mkirika	S, ST	3,4,11,17,27,28
38	*Erythrophleum africanum*	*Caesalpinioideae*	Mkarati	T	1,2,3,4,9,11,15,17
29	*Euclea divinorum*	*Ebenaceae*	Mdaa	T	2,3,4,11,13,17,27,28
40	*Ficus sycomorus*	*Moraceae*	Mkuyu	T	3,5,6,13,15,22
41	*Gardenia resiniflua*	*Rubiaceae*	Kilemandembo	S	3,4,12,17
42	*Gardenia ternifolia*	*Rubiaceae*	Kilemandembo	S, ST	3,4,11,12,15,17
43	*Grewia bicolor*	*Tiliaceae*	Mkole	S, ST	2,3,4,5,6,7,11,17,22
44	*Haplocoelum foliolosum*	*Sapindaceae*	Mhaka	T	2,3,4,5,6,7,13,17
45	*Harrisonia abyssinica*	*Simaroubaceae*	Mkunju	S, ST	3,4,11,20
46	*Holarrhena pubescens*	Apocynaceae	Imelemele	S, ST	3,4,11,12,13,17
47	*Indigofera rhinchocarpa*	*Papilionoideae*	Kibaazi pori	S	3,4,6,11,17
48	*Julbernardia globiflora*	*Caesalpinioideae*	Mtondoro	T	2,3,4,6,7,11,13,17,18,25
49	*Kigelia africana*	*Bignoniaceae*	Mwegea	T	3,5,10,11,12,14,15,17,22
50	*Lannea schimperi*	*Anacardiaceae*	Mumbu-Luzigwe	T	3,11,13,17,18,20
51	*Lannea schweinfurthii*	*Anacardiaceae*	Msighe, Mumbu	T	3,4,5,8,10,11,13,15,17,20,28
52	*Lonchocarpus cappassa*	*Papilionoideae*	Mfumbili	T	2,3,4,9,10,13,14,15,17
53	*Manilkara mochisia*	Sapotaceae	Mgama	T	1,2,3,4,5,6,7,8,9,13,17,28
54	*Mansonia diatomanthera*	*Stercurliaceae*	Mtikipori	T	1,2,3,4,7
55	*Mondulea sericea*	Papilionoideae	Mluwangenje	S, ST	2,3,4,7,11,12,13,17,23
56	*Ormocarpum kirkii*	*Papilionoideae*	Hombo/ Kilumbulumbu	S, ST	3,4,6,11,17,24
57	*Piliostigma thorningii*	*Papilionoideae*	Msegese	T	2,3,4,5,6,7,12,15,17
58	*Pseudolachynostylis maprouneifolia*	*Euphorbiaceae*	Msolo	T	2,3,4,6,13,17,19,23
59	*Psydrax livida*	*Rubiaceae*	Mlavilavi	T	2,3,4,7,13,15,17,28
60	*Pteleopsis myritifolia*	*Combretaceae*	Mngoji/Mgoji	T	1,2,3,4,7,13,17
61	*Pterocarpus angolensis*	*Papilionoideae*	Mninga/Mhagata	T	1,3,4,7,8,10,11,17,20,25
62	*Pterocarpus rotundifolius ssp. polyanthus*	*Papilionoideae*	Mhambalasha	T	1,2,3,4,7,17
63	*Sclerocarya birrea*	*Anacardiaceae*	Mng'ong'o	T	1,5,6,8,10,17,25

S/N	Botanical name	Family	Local name	Life form	Economic importance
64	*Senna auriculata*	*Caesalpinioidea*	Mhumbahumba	S	3,4,12,17
65	*Senna singueana*	*Caesalpinioideae*	Mhumba	S. ST	2,3,4,5,6,11,12,14,17,21
66	*Spirostachys africana*	*Euphorbiaceae*	Msaraka/Mcharaka	T	2,3,4,11,13,15,17
67	*Stercurlia africana*	Sterculiaceae	Moza/Moze	T	5,11,17,18
68	*Stercurlia appendiculata*	*Ste Stercurliaceae*	Mgude	T	1,3,5,6,10,13,15,17
69	*Stercurlia quinqueloba*	*Stercurliaceae*	Mhembeti	T	1,3,10,17,25
70	*Stereospermum kunthianum*	*Bignoniaceae*	Myuwe	T	3,4,7,11,12,13,17,28
71	*Strychnos potatorum*	Loganiaceae	Mpande	T	2,3,4,11,23
72	*Strychnos spinosa*	*Loganiaceae*	Mtonga	T	2,3,4,5,7,11,17,28
73	*Tamarindus indica*	Caesalpinioideae	Mkwaju	T	1,2,3,4,5,6,7,9,10,11,13,17,19,28
74	*Terminalia sambesiaca*	*Combretaceae*	Mkurunge/Mpululu	T	1,2,3,4,10,13,17
75	*Terminalia sericea*	*Combretaceae*	Mng'ong'o	T	2,3,4,11,17
76	*Terminalia spinosa*	*Combretaceae*	Mtakala	T	2,3,4,11,13,17,19,28
77	*Thylachium africanum*	*Capparaceae*	Mdudu	S, ST	3,4,11,13,17,26
78	*Uvaria acuminata*	*Annonaceae*	Msofu	S	3,4,5,11,17
79	*Vitex payos*	*Verbenaceae*	Mfuru	T	3,4,5,6,11,17
80	*Xamenia caffra*	*Olacaceae*	Mpingi	ST	2,3,4,5,7,11,17,28
81	*Xeroderris stuhlmanii*	*Papilionoideae*	Mnyenye	T	1,3,4,6,8,9,10,11,13,17,25,28
82	*Xylotheca tettensis*	*Flacourtiaceae*	Msekaseka	S	3,12,17
83	*Zanthoxylum chalybeum*	*Rutaceae*	Mhunungu	T	2,3,4,8,11,17,24,25,28
84	*ziziphus mucronata*	*Rhamnaceae*	Mkunazi mwitu/Mgagawe	T	2,3,4,5,6,11,17,20

Key to plant economic uses

1 Timber
2 Building poles
3 Firewood
4 Charcoal
5 Edible fruits
6 Fodder
7 Tool handles

1**5** Water conservation
16 Boundary marking
17 Bee forage
18 Ropes
19 Wind break
20 Live fence
21 Mulch

Key to life form

S = Shrub
ST = Small Tree
T = Tree

8 Carvings
9 Pestles
10 Grain mortars
11 Medicinal
12 Ornamental
13 Shade
14 Soil enrichment
22 Ceremonial
23 Fish poison
24 Vegetable
25 Beehives
26 Famine food roots
27 Dyes
28 Spoons

Appendix 6. Household Questionnaire Form

I IDENTIFICATION VARIABLES
Questionnaire number……………………………………………..…..

1.1 Date of interview…………………………………………….….…..
Name of interviewer ……………………………………………….…..
Village…………………………………………………………..…
Sub-village…………………………………………………………..
Ward………………………………………………………….……
Division……………………………………………………………
1.7 District…………………………………………………………….

II HOUSEHOLD CHARACTERISTICS

2.1 Name of respondent…………………………………………...……..
2.2 Sex (1) Male ☐
(2) Female ☐
2.3 Age……………………………years…………………….………..
2.4 Tribe…………………………………………………………...……
2.5 Marital status (1) Married ☐
(2) Unmarried ☐
(3) Separated ☐
2.6 Occupation…………………………………………………………
2.7 Education
(1) No formal education ☐
(2) Adult education ☐……………………….years
(3) Primary education ☐……………………….years
(4) Secondary education ☐……………………….years
(5) Tertiary education ☐……………………….years.
2.8 Size of the household…………………………………………………….

2.9 Household age composition

Age (years)	Male	Female
< 18		
18 - 55		
> 55		

III LAND USE AND TENURE

3.1 Does your household own land for agricultural use? (1) Yes ☐ (2) No ☐

If yes, (1) How many land parcels do you have?…………………………….…
(2) What is their total farm size (acres)?………………………………..
(3) How far are they from the homestead? (Km/time)…………….……
(4) How much area is annually cultivated? (Acres)…………………..…….

3.2 Do you consider the land you own to be enough? (1) Yes ☐ (2) No ☐

3.3 Is it possible to get more land? (1) Yes ☐ (2) No ☐
(Where and how…………….

IV CROPS AND LIVESTOCK

4.1 What are the crops raised in your farm? What are the main uses of each crop?

Crop	**Area (Acres)**	**Main use**		
		Food	**Cash**	**Both**

4.2 Which cropping system do you practice?

(1) Shifting cultivation ☐

(2) Agroforestry ☐ Specify tree species & crops………………
……………………………………………

(3) Monoculture ☐ Specify crops……………………………….
……………………………………………..

(4) Mixed cropping ☐ Specify crops……………………………….
………………………………………………

4.3 How do you prepare your farms?

(1) By clearing all the vegetation ☐

(2) By clearing all the vegetation and burning the brushes ☐

(3) By burning the brushes ☐

(4) By leaving some trees in the farm ☐ Specify tree specie and uses………
……………………………………...

4.4 Do you have Livestock? (1) Yes ☐ (2) No ☐

If yes, please explain the following details

Type of livestock	Number	Uses

4.5 What is the mode of livestock keeping?

(1) Cut and carry ☐
(2) Zero grazing ☐
(3) Free range grazing ☐

4.6 If free range grazing where does you graze your livestock?

(1) In the forest reserve ☐
(2) In the public lands ☐
(3) In the agricultural farms ☐

(V) INCOME AND ENERGY CONSUMPTION

5.1 What are the major sources of income for your household?

Source of income	Availability: 1. Seasonal; 2. Constant Throughout the year; 3 Unreliable	Average income per month (T shs)	Rank (1,2,3….)
1. Agricultural crops			
2. Livestock			
3. Charcoal			
4. Firewood			
5. Timber			
6. Wild fruits			
7. Honey			
8. Crafts			
9. Petty business			
10. Casual employment			
11. Credit/loans			
12. Remittance			
13. Others (specify)			

5.2 In the following activities, which energy source does your household use?

Activities	Sources of Energy						
	1. Firewood	2. Charcoal	3. Crop residues	4. Animal dung	5. Paraffin/ Kerosene	6. Electricity	7. Others
1. Cooking							
2. Preparing local beer							
3. Warming							
4. Lighting							
5. Others (specify)							
Amount per month (e.g Firewood Loads, Tins/bags of charcoal etc)							
Overall cost per month (Tshs)							

(VI) FOREST RESOURCES AND USES

6.1 Which forest product does your household collect? Can you guess how far, the level of availability and the species most preferred?

Forest product	**Source:** 1. Forest reserve; 2. Public land; 3. Private farms; 4. Market; 5. Others	**How far?** (km/hr)		**Availability**: 1.Plenty; 2. Fair; 3. Very little.		Species most prefered
		Last 20 years	Now	Last 20 years	Now	
1. Charcoal						
2. Firewood						
3. Building poles						
4. Timber						
5. Fruits						
6. Medicinal plants						
7. Honey						
8.Wild						
9. Others (specify)						

6.2 Do you have a market for forest products you are collecting? Yes ☐
No ☐

If yes where is the market center for your forest products?

At home ☐
Along the Highway ☐ what is the distance from homestead……………………
In Morogoro town ☐ what is the distance from homestead……………………

6.3 Did forest materials build your household house(s)? Where did you obtain the materials?
From forest reserve ☐
From public land ☐

Which building materials did you use for the;
(1) Wall…………………………………………………………………………
(2) Roof…………………………………………………………………………

6.4 List government laws that you know regarding forest reserves and public forested land?
(1) ………………………………………………………………………………
(2) ………………………………………………………………………………
(3) ……………………………………………………………………………….
(4) ……………………………………………………………………………….
(5) ………………………………………………………………………………..

6.5 What is the trend of MFR for the past 20 years?
(1) Constant ☐ Why………………………………………………..
(2) Increased ☐ Why………………………………………………..
(3) Decreased ☐ Why……………………………………………..….

6.6 Which of the following activities are major threats to MFR

Threat	**Rank of the threat seriousness (1,2,3… 13)**	**Possible causes**
1. Settlements		
2. Livestock grazing		
3. Wild fires		
4. Cultivation		
5. Hunting		
6. Charcoal making		
7. Honey collection		
8. Logging		
9. Firewood gathering		
10. Encroachment		
11. Poles cutting		

6.7 Do you know any measures taken to contain MFR threats? (1) Yes ☐
(2) No ☐

If yes explain…………………………………………………………………

6.8 In general, what do you think should be done to slow down the rate of MFR clearing and consolidate their protection? ……………………………………
……………………………………………………………………………………..

Appendix 7. **Sample plot field form**

1. Site……………………………….…..
2. Transect no ……………………..……
3. Sample plot no ……………………
4. Coordinates
   UTM: …………………………..…
   …………………………….

5. Inventory date…………………
6. Altitude masl………………….
7. Slope & Aspect (slope)………
8. Name of the recorder………..…

(A) DBH Measurement

S/N	Code	Botanical Name	Local name	DBH (cm)	Remarks
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

(B) Regenerants

S/N.	Code	Botanical Name	Local name	NS
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
Total				