PLANT SPECIES COMPOSITION, DIVERSITY AND UTILIZATION IMPACTS ON THE MIOMBO WOODLAND ECOSYSTEMS OF HANANG DISTRICT, TANZANIA

BY

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ABSTRACT

Miombo woodlands constitute one of the most extensive forest vegetation types in Africa. This complex ecosystem provides vital products and services to the livelihood systems of millions of rural and urban dwellers. The study was carried out in four forest reserves to assess plants species composition, diversity, dominance, human utilization and its impacts on the miombo woodland of Hanang District, Tanzania. Ecological data were collected through forest inventory while socioeconomic data were collected through household questionnaire survey. Data from forest inventories were analyzed in MS EXCEL program to compute species richness, dominance and diversity. Descriptive statistics in cross tabulation were carried out to analyze socioeconomic data using Statistical Package for Social Sciences (SPSS) software. A total of 69 tree species belonging to 22 families were identified. The average Shannon-Wiener index of diversity (*H'*) for all the forests reserves were 3.3 and 0.1 respectively, having high species diversity in all forests. Based on the species Importance Value Index (IVI), *Julbernardia globiflora* was the most dominant in three of the four forest reserves while *Brachystegia spiciformis* was most dominant in the fourth reserve in the district. A total of 12 species were common in all forest reserves and therefore widespread. A total of 49 tree species are utilized by the surrounding local communities for different purposes. Major products utilised from the woodlands include firewood (95%), charcoal (58%), poles (56%) and timber (5%). Harvesting of various tree species for different purposes were the most common human impacts observed in the area. It is concluded that, given the variation in species diversity and dominance between individual forest reserves, management strategies should be site specific so as to balance both ecological diversity of the individual forest and local uses in a sustainable manner. It is recommended that, there is a need to promote and encourage alternative activities such as improved cooking stoves, biogas use, beekeeping and tree planting that will aim at reducing future utilization pressure of miombo woodland in the district. Enrichment planting with indigenous plant species in those forested areas where substantial tree removal was evident as well as increase law enforcement to protect the forest reserves is also recommended.

DECLARATION

I, ELIASAPH FEDDY, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is a result of my original work and has never been submitted for a degree award at any other University.

07/10/2008

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The above declaration is confirmed

08/10/2008

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Date

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This work is dedicated to my dearly loved late parents Mr. Eliasaph Munyaga and Fodia Bwire who laid the foundation of my education. Today they are not present to share together with me the fruits of their labour. May the almighty God rest their souls in eternal peace, Amen.

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CEC	Cation Exchange Capacity
DBH	Diameter at Breast Height
DRC	Democratic Republic of Congo
ECM	Ectomycorrhizae
FR	Forest Reserve
G	Basal area per hectare
ha	Hectare
HANDC	Hanang District Council
H'	Shannon-Wiener index of diversity
IVI	Importance Value Index
m.a.s.l	Metre above sea level
PFM	Participatory Forest Management
PRA	Participatory Rural Appraisal
spp	Species
SPSS	Statistical Package for Social Science
SUA	Sokoine University of Agriculture
TC	Total cut
TONC	Total Number of New Cuts

CHAPTER ONE

1.0 INTRODUCTION

1.1Background information

Miombo woodlands constitute one of the most extensive forest vegetation types in Africa (Frost, 1996). They make up about 70% of the Zambezian phytochorion and are found in seven eastern, central and southern Africa countries namely Angola, Malawi, Mozambique, Tanzania, Democratic Republic of Congo (DRC), Zambia and Zimbabwe over an area of about 2.7 million km^2 (Chidumayo, 1997). The distribution of miombo forests is basically determined by climatic and edaphic factors (Campbell *et al.*, 1996; Desanker *et al.*, 1997). In Tanzania, the miombo woodland ecosystem covers about 40% of the country (White, 1983).

The miombo woodlands are normally woodlands dominated by species of *Brachystegia*, either alone or in association with *Julbernardia* or *Isoberlinia* species. These genera are seldom found outside the miombo range (White, 1983; Frost, 1996). Although the diversity of canopy trees species is low, the overall species richness of the flora is very high. Rodgers *et al.* (1996) reported that miombo woodlands have an estimated 8500 species of higher plants of which 334 are trees. More interestingly, over 54 % of the miombo plant species are endemic in the region.

Products and services from the miombo woodlands, including food (e.g. fruits, honey, insects, game meat, mushrooms and vegetables), energy (e.g. firewood and charcoal), shelter (e.g. timber and poles), medicines, and a number of invaluable environmental benefits (e.g. soil conservation, water catchments and carbon sequestration) and spiritual services (e.g. ritual ceremonies), are vital to the livelihood systems of millions of rural and urban people (Clarke *et al.* 1996).

Campbell *et al.* (1996) estimated that in 1990, about 40 million people inhabited areas covered by, or formerly covered by miombo woodlands while about 15 million of urban people relied on miombo for firewood or charcoal as source of fuel. However, the sustainability of the multitude of products obtained from miombo woodlands is currently threatened by combined forces of exploitation and forest degradation due to forest fires, grazing, commercial fuelwood and timber harvesting, and forest reclamation (Munyanziza and Wiersum, 1999). Thus, there is a need for concerted efforts (scientific, socio-economic and political interventions) to ensure sustained supply of the valuable products from the miombo woodlands.

1.2 Problem statement and study justification

Human disturbances in miombo woodlands differ from one place to another depending on their type, intensity and frequency (Luoga, 2000). While on one hand, in some places miombo woodland degradation is a result of agricultural practices by local shifting cultivators, on the other hand, commercial fuelwood and timber production, and bush fires may be the major causes of degradation in other places (Stromgaard, 1986; Monela *et al.*, 1993; Nduwamungu, 2001).

Most natural resource problems are human-created problems that have been shaped under a variety of political, social and economic systems. It is acknowledged by many scholars that no ecosystem remains so far untouched by human activities and there are worrying signs that the world's ecosystems are reaching the limits of their ability to adapt to human impacts. Hence, the need for management interventions to mitigate and moderate human impacts on various threatened ecosystems.

Given their importance to the livelihoods of millions of people now and in the future, ensuring sustainability of miombo woodlands and sustained supply of goods and services from the ecosystem are laudable and important objectives in Tanzania. Thus, managers and policy-makers need accurate information to carry out effective management planning, monitoring and implementation of management actions that guarantee sustainable use.

In the past, Hanang district had a dense forest and woodland cover. However, the rate of forest and woodland depletion and degradation has been alarmingly high due to forest fires, shifting agricultural practices, increased population leading to increased demand for farmland and fuelwood, illegal tree harvesting, overgrazing and lack of community participation in forest management (HANDC, 2004). There remains however, a substantial natural forest cover on Mount Hanang Forest Reserve and around it and towards the south of the district there are miombo woodlands which are of vital importance to the livelihoods of local communities.

Most of management failures in the miombo woodlands have been reported and lack of site specific ecological and human induced information on this resource impair efforts by the District to manage this ecosystem adequately. Furthermore, as Tanzania engages in Participatory Forest Management (PFM) under the current policy changes, baseline information on the forest resource base which is lacking is important as an input into the process. Absence of reliable information for site specific on composition and diversity status of miombo woodlands has been a real obstacle to management effectiveness. Therefore, in an attempt to bridge up this knowledge gap, this study aims at providing baseline information on the status of the miombo woodlands in Hanang district, Manyara Region, Tanzania.

1.3 Objectives and hypotheses

1.3.1 Overall objective

The overall objective of the study was to assess plant species composition, diversity and human impacts on the miombo woodland ecosystem of Hanang district so as to provide baseline information on the status of this ecosystem in the district.

1.3.2 Specific objectives

The specific objectives were to:

(i) Assess the species composition and diversity of the woodland ecosystem;

(ii) Assess species dominance in the woodland ecosystem;

(iii) Assess local use and its impacts on the miombo woodland stock.

1.3.3 Hypotheses

(i) Species richness and diversity of the miombo woodlands in Hanang district is low.

(ii) There are no significant utilisation impact on the miombo woodlands of Hanang district.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Miombo woodland ecology

The miombo region lies within the sub-humid tropical zone, generally within the unimodal rainfall zone. The climate is characterised by a long dry season that alternates with a short rainy season. The mean annual rainfall ranges from 600 to 1500 mm distributed from November to March or April (Chidumayo, 1997). Basing on annual rainfall, White (1983) divided the miombo vegetation into two subtypes: Wet miombo and dry miombo. The wet miombo occurs in areas with annual rainfall usually exceeding 1000 mm and the canopy height is often greater than 15m. The vegetation is floristically rich including nearly all of the characteristic miombo species. The dry miombo occurs in areas with annual rainfall less than 1000 mm and the canopy height is usually less than 15m and the vegetation is floristically poor and the dominant *Brachystegia* species of wet miombo are either absent or local in occurrence.

Miombo trees are frost sensitive and may not survive absolute minimum temperatures of less than -4^0C. Werger and Coetzee (1978) argued that this is probably the significant factor that determines the southern limit of miombo distribution in the Zambezian phytoregion. However, during the cool dry season, frosts do occur in low-lying areas (vernacular terms dambo or mbuga or bonde) within the miombo region. The mean annual temperatures usually range from 18 to 23^0C (Frost, 1996), but depending on altitude, daily temperature may rise as high as 40^0C during the hot season (Temu, 1980).

Miombo woodlands occur on a geologically ancient plateau (end-tertiary pediplain) with heavily leached and infertile soils. Most miombo soils are of eluvial origin on basement quartzites, schists and granitic rocks (Cole, 1986). The soil texture is predominantly sandy loam, sand clay loam and sandy clay. Because of the eluviation process, the clay content often increases with depth (Chidumayo, 1997) sometimes resulting in a marked contrast between the texture of the topsoil and that of the subsoil.

Miombo woodlands soils are typically acidic, i.e., with pH ranging between 4 and 6. They have generally low cation exchange capacity (CEC) and low organic matter and macronutrient content (Chidumayo, 1993) with the exception of soils under densely wooded vegetation (Frost, 1996). Low organic matter is believed to originate from several factors of which the most salient include the predominance of low activity clays, high soil temperatures, frequent fires and the abundance of termites (Chidumayo, 1993).

According to Storrs (1982), some miombo trees are indicator species in Zambia. For instance, *Brachystegia boehmii* and *Parinari curatellifolia* indicate shallow soils with partial waterlogging or high water table in poorly drained areas. *Diplorhynchus condylocarpon* and *Pseudolachnostylis maprouneifolia* are often indicators of the presence of copper or nickel, while *Brachystegia microphylla* in wet miombo and *Brachystegia glaucescens* in dry miombo prefer rocky habitats. Edaphic gradients determine the distribution of miombo species. Hills and escarpments have greater small-scale edaphic heterogeneity and more complex sequences of species dominance than plateau landscapes (Chidumayo, 1997).

2.2 Miombo vegetation composition, diversity and structure

Local variations in structure and composition are common within the broad divisions between wet and dry miombo. Salient factors responsible for these local variations are thought to include: the landscape geomorphology (Cole, 1986); soil moisture, nutrients, depth, texture and drainage (Chidumayo, 1997); fire regime (Kikula, 1986); wildlife impacts (Guy, 1989); past and present land use and other anthropogenic disturbances (Chidumayo, 1987).

However, despite variations, miombo woodlands are always dominated by species of the genera *Brachystegia* and/or *Julbernardia* or *Isoberlinia* of the legume sub-family of *Caesalpinioideae* (White, 1983; Frost, 1996). The extent and variety of other species in miombo differ from place to place with frequent local concentration of certain species. The most frequently encountered and most characteristic genera include: *Afzelia, Albizia, Burkea, Dalbergia, Erythrophleum, Ostryoderris, Pterocarpus, Swartzia, Combretum, Monotes, Strychnos, Sterculia, Pericopsis* and *Uapaca* (Lind and Morrison, 1974). The dominant tree genera of the miombo woodland such as *Brachystegia*, *Julbernardia*, *Isoberlinia* and *Uapaca* have ectomycorrhizae (ECM) rather than vesicular-arbuscular mycorrhizae (VAM) associations (Munyanziza, 1994). Most of the fungal species involved in miombo mycorrhizae produce mushrooms, many of which are edible.

Despite the apparent uniformity of miombo woodland in structure and composition over large areas (Frost, 1996), the miombo vegetation is extremely rich in plant species, many of which are endemic. Rodgers *et al.* (1996) estimated the number of higher plant species to be 8,500 species of which 334 are trees and over 54 % are endemic to the region. In Tanzania, Temu (1985) quoting Schultz, *et al.* (1971) reported that at least 175 tree species most of which belong to the legume sub-families of *Caesalpinioideae* and *Papilionoideae* are indigenous to the miombo woodland. Nduwamungu and Malimbwi (1997) inventoried a total of 99 tree and shrub species in 46 plots (0.07 ha each) sampled in a miombo woodland of 500 ha under the management of Sokoine University of Agriculture. In this woodland, the *Caesalpinioideae*, *Mimosoideae* and *Papilionoideae*

were dominant representing respectively 21 %, 20 % and 13 % of total recorded individuals. Maliondo *et al.* (2005) found 46 tree species belonging to sixteen families with 34% and 25% of the stems in *Caesalpinioideae* and *Papilionoideae* respectively on an area of 40 ha of communal miombo woodland in Handeni, district, Tanzania.

The structure of miombo woodlands consists of three layers. The upper canopy comprises mainly umbrella-shaped trees 14 to 18 m tall (sometimes up to 21 m) with a density of about 65 stems/ha. The second layer, often absent or scattered, of sub-canopy trees 8 to 12 m tall (sometimes up to 18 m) with about 80 stems/ha. The third layer consists of a discontinuous understorey of saplings and shrubs less than 8 m tall with a range of 375 to 500 stems/ha (Malaisse, 1978).

The density of woody plants in miombo woodlands varies widely, though it mostly ranges between 380 and 1400 stems per ha (Malaisse, 1978; Ek, 1994; Nduwamungu and Malimbwi, 1997). In most miombo stands, the basal areas range from 7 to 25 m^2 per ha (Lowore *et al.*, 1994; Nduwamungu and Malimbwi, 1997; Zahabu, 2001). Both stand basal area and mean biomass increase with increasing rainfall of a site (Frost, 1996). Stand basal area is linearly related to both harvestable volume and aboveground woody biomass. The mean harvestable volumes in miombo range between 14 m^3 per ha in dry miombo of Malawi (Lowore *et al.*, 1994) and 117 m^3 per ha in Zambian wet miombo (Chidumayo, 1988). Average aboveground biomass in old growth miombo varies mostly from around 30 tons per ha to about 140 tons per ha (Malaisse, 1978; Malimbwi *et al.*, 1994; Ek, 1994). The mean annual increment in a mature miombo woodland is 2.35 m^3/ha/year (Zahabu, 2001) while that of biomass in coppice woodland range from 1.2 to 3.4 tons/ha/year, which is about 4-7% of above ground biomass (Chidumayo, 1993; Ek, 1994).

2.2.1 Miombo woodland regeneration and development

Miombo regrows virtually unchanged in species composition following clearing. This is because, regeneration consists mainly of stump coppices, stump/root sucker shoots and recruitment from old stunted seedlings already present in the grass layer at the time of tree cut, fall or death (Chidumayo, 1993; 1997). After one year, the sapling population in regrowth may consist of one third coppiced stumps and two thirds seedlings recruited from the stunted seedling pool (Chidumayo, 1997)

The dispersal of fruits and seeds is concentrated in the late dry season (August-November), but in few species (e.g *Isoberlinia angolensis*) goes on in the early rainy season (Chidumayo, 1993). In miombo, fruit types and dispersal mechanisms are highly diversified. In canopy species, the pod is the most common fruit type and seed is either dispersed by an explosive pod (i.e. **autochorous** species such as *Brachystegia*, *Isoberlinia* and *Julbernardia* species) or by wind (i.e. **anemochorous** such as *Albizia* and *Pterocarpus* species). The fleshy fruit that is common among understorey and shrub species are dispersed by animals (i.e. **Zoochorous** species) mainly birds and mammals (Chidumayo, 1993).

Most seedlings and other tree regeneration (e.g. suckers, coppices) 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-backs (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). Stumps produce many sucker shoots, but during the establishment period the number of shoots decreases due to inter-shoot competition and only dominant shoots contribute to the next generation of regrowth miombo. Sucker shoots grow relatively faster than shoots of stunted old seedlings. This is because stumps retain their well-developed root systems after tree cutting. However, stem height growth in regrowth miombo declines after 5-6 years and remains extremely slow thereafter (Chidumayo, 1993).

Early interpretations of the dynamics of miombo forests were based largely on a single-state equilibrium model of regional climax vegetation. Miombo forests were considered sub-climax to evergreen or semi-evergreen forest, maintained as such by frequent fires and other disturbance (Lawton, 1978). More recently, multi-state models have been presented, which suggest that there are multiple quasi-stable states in miombo vegetation structure and composition. Each state has its own characteristics, dynamics and a threshold beyond which a shift occurs to a different state. The shifts are driven by a variety of disturbances (Stromgaard, 1986). With repeated disturbances, closed-canopy miombo forests may degrade to open woodland and secondary grasslands, but the process is reversible if fire is excluded and other disturbances are minimized (Lawton, 1978).

The dominant trend in regenerating miombo woodland in the absence of frequent late fires or other intense disturbance is towards the recovery of miombo forest. Unless the plants have been thoroughly uprooted (e. g. ploughing may affect stump survival), most of the subsequent development of woodland derives from regrowth of coppice from the surviving stems and rootstocks (Chidumayo, 1997). Four phases can be identified in regenerating woodland: (i) initial regrowth, (ii) dense coppice. (iii) tall sapling phase, and (iv) mature woodland. Most woody plants in the initial regrowth phase are less than 1 m tall.

2.2.2 Disturbances and impacts of human activities in miombo woodlands

For thousands of years, human beings have been occupying and utilizing the miombo ecosystem. However, currently the kinds and intensity of land use are changing (Desanker *et al.*, 1997), which raises worries as to whether or not the ecosystem will survive prevailing threats from human pressure. There is very little unmodified vegetation remaining (Misana *et al.*, 1996). Shaba (1993) estimated that approximately 5000 km² of miombo forest are cleared annually.

2.2.2.1 Excessive tree cutting and clearing for agriculture

The main traditional forms of land use in miombo woodland areas are sedentary and shifting cultivation of small fields. Shifting agriculture usually involves ash fertilisation and hand cultivation. Since shifting cultivation requires much land, as long fallow periods are needed to allow the soils and the vegetation to recover, it is gradually being replaced by more permanent agriculture as human population pressures increase and the fallow periods are becoming short due to declining amount of suitable uncultivated land (Desanker *et al.*, 1997).

2.2.2.2 Recurrent wild fires

Miombo bush fires probably constitute the largest single area burned in the world. Scholes *et al.* (1996) estimated that around one million km² of miombo are burnt annually. Besides clearing land for agriculture, people burn woodlands for various purposes including providing a green flush for livestock, controlling pests, such as ticks and tsetse flies, driving animals or attracting them later to the regrowing grass on burnt areas. However, many of the miombo fires originate accidentally from people preparing land for cultivation, collecting honey or making charcoal (Chidumayo, 1997). It is generally agreed that one of the best ways of protecting and managing miombo woodlands is to carry out early burning. Nevertheless, cultural issues are also involved in land use practices. For example, Morris (1995) reported that in Malawi the late burning has symbolic significance associated to Malawian cosmology.

The dynamics of miombo woodlands are largely the dynamics of the woody component, which in turn is affected by three interacting disturbance factors: people, fire (mainly initiated by people) and elephants (Frost, 1996). Human activities are central to the current dynamics of miombo ecosystems. Large areas of forest have been and continue to be modified or transformed by people. The changes include depletion and degradation of forest cover through complete conversion into farms, fuelwood and timber harvesting and overgrazing. 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 affect the patterns of productivity, resource availability, land use, and livelihoods (Desanker *et al.*, 1997). Some of the impacts of woodland depletion include erosion and loss of soil productivity; acute shortages of timber, fuelwood and other forest products and services; drying of water sources and shortage of water for various purposes; floods, sedimentation of rivers, reservoirs and irrigation systems; global warming, and species extinction due to habitat fragmentation and over-exploitation (Whitmore and Sayer, 1992; Grainger, 1993).

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 Study area description

3.1.1 Location

Hanang district is one of the five districts making up the Manyara Region, Nothern Tanzania. It lies between longitudes 34^{0}45' and 35^{0}48' East and latitudes 4^{0}25'and 5^0 00' South. The great part of the district lies at an altitude between 1000 and 2000 meters above sea level. It borders with Mbulu and Babati districts in the north, Kondoa and Singida districts to south and Iramba district to the west. The district land covers an area of 3 639 km^2 or 36 900 ha out of which 80 078 ha (about 23% of total land area) are used for agriculture. The area of the district suitable for grazing is about 224 000 ha (about 65 %) while only 400 ha are used for irrigation and the rest under forestry and mountains (HANDC, 2004).

3.1.2 Climate and soils

The district can be subdivided into three agro-climatic zones by altitudes (HANDC, 2004) namely: (i) **High altitude areas** comprising mount Hanang which rises up to 3,676 m above sea level. Most of the villages at the foot of mount Hanang fall under this zone. The area receives 700-900 mm of precipitation annually. There is loam soil and the main crops include banana, Irish potatoes, wheat, barley, maize, beans and coffee. (ii) **Medium altitude areas**, which is the largest and receives rainfall ranging from 500 to 600 mm annually. Soil types include black loamy, clay and loamy-sandy soils. Main crops include maize, beans, onions, pigeon peas, sugarcane, fruits, vegetables, sweet and round potatoes, wheat, banana, cotton and finger millet and (iii) **Low altitude areas**, which is found in the southern part of the district. The soil type is mainly sandy and in few places loamy-sandy. Major crops include beans, sorghum, sunflower, groundnut, finger millet, pigeon peas, sweet potatoes, cowpeas, cotton and cassava. The zone receives about 450 mm or less of rainfall per annum.

Generally the daily average temperature in Hanang District is 23.5^{0}C. There are two rainy seasons with short scanty rains during the months of September and October and main or long rains from December to April. The upland areas get an average rainfall of 900 mm per annum while lowest parts of the district get between 500-700 mm per annum (HANDC, 2004).

3.1.3 Vegetation composition

In the highlands, the common vegetation is dominated by tree species like *Juniperus procera, Podocarpus spp., Hagenia Abyssinica, Cussonia holstii, Rauvolfia caffra, Cordia spp. Croton macrostachys, and albizia spp.* In the medium zone, major tree species include *Kigelia africana, Erythrina abyssinica, Albizia spp., Acacia spp., Balanites aegyptiaca* and *Euphorbia spp.* The vegetation on the lowlands is predominant miombo woodland, bushes and thickets. Dominant and important tree species include *Brachystegia spiciformis, Julbernardia globiflora, Afzelia quanzensis and Pterocarpus angolensis* (HANDC, 2004).

3.1.4 Socioeconomic status

The dominant ethnic groups in the district are Iraqw and Barabaig, though there are also a few Nyaturu and Rangi ethnic groups. The district has 62 villages and had a population of 205 133 people in 2002 with a population density of 26 people per km^2 and a population growth rate of 3.2%. The major economic activities of the district are agriculture (70%) and livestock keeping (20%). There are also some fishing and beekeeping activities and trading, which constitute about 10% of economic activities. Agriculture comprises both large-scale state farming and small-scale peasantry farming. Agriculture is wholly dependent on rainfall, which is quite unreliable in some parts of the district. Fortunately, soils are fertile enough that inorganic fertilizers are not necessary though farmyard manure is widely applied. Livestock keeping is done on traditional system (Nomadic pastoralism). There are about 31 156 cattle, 136 481 goats, 58 597 sheep, 14 439 donkey, 6 467 pigs and 90 380 poultry (HANDC, 2004).

The district has a total forest area of 198 442 ha of natural forest including miombo woodlands cover 96 571 ha where 90 000 ha comprise of bush land thickets and shrubs. Mount Hanang Forest Reserve which covers about 5817 ha is the major water catchment in the district.

3.2 Data collection

Both forest inventory and questionnaire surveys were employed to collect ecological and socioeconomic data respectively. Prior to survey, a reconnaissance mission to the site was undertaken to have clear understanding of the physical and socioeconomic characteristics of the area.

3.2.1 Forest inventory

Forest inventory was used to collected ecological data. A systematic cluster sampling design with random start was adopted for the selection of study sites within the miombo woodlands. Since the miombo woodland zone falls in four administrative divisions of Hanang district, the study area was stratified into four blocks based on administrative divisions and each block corresponded to the portion of the division covered by miombo woodlands. In each block, four clusters were systematically laid out starting at a random distance from the edge of the forest. A cluster consists of four plots established 300 m apart to form a rectangle on which the plots were set at the four corners. A total number of sixty four plots were laid out.

Circular sample plots were adopted because they are easy to layout and counting errors during inventory of border trees are minimised (Krebs, 1989). The sample plot was divided into three areas of measurement to form nests as follows:

- *Within 2m radius*: identify and record all trees/shrubs including seedlings and saplings;
- *Within 5m radius*: identify, record and measure all trees/shrubs with DBH $\geq 5 \leq$ 10cm.
- *Within 15m radius*: identify record and measure all trees/shrubs with DBH $\geq$ 10 cm.

Variables recorded in each plot included: local and/or botanical names and species code, number of stems, diameter at breast height (DBH), and diameter and height of stumps of felled/cut trees (if any). These variables were recorded in the field inventory form provided in Appendix 2. Botanical identification was done in the field using a botanist and competent local tree identifier.

Human impacts were assessed through disturbance assessment. Disturbance was assessed by counting the number of cut trees/ poles or saplings in each inventory plot by species. The cut trees were categorised into newly cut (stump not darkened) and old cut to enable computation of utilisation pressure. Any sign of human disturbance such as charcoal kilns, pit sawing, and mining was keenly noted during the inventory.

3.2.2 Socio-economic survey

A Socio-economic study was done using PRA and questionnaire surveys. In PRA, a sample of fifteen to twenty members was selected in each study village to participate in PRA exercise. In addition to focus group discussions, PRA also involved transect walk through the miombo woodland stand close to the meeting place. The discussion was focused on miombo woodland products and services and impacts on livelihoods of local communities.

The socio-economic involved household interviews using structured questionnaires (Appendix 1). Questionnaire survey provides quantitative data on uses and preferences of miombo woodland products and services and on other relevant socio-economic information. Questionnaire survey was conducted in four villages (one in each study block or administrative division) located within the miombo woodlands and involved administering structured questionnaires to heads of households. The villages surveyed were Dirima, Diloda, Gidahabaieg and Waama. In each village 5% of the population were randomly selected which makes the total sample of 81 households in the study area.

3.2.3 Secondary data

Secondary data was collected to complement and explain primary data. Relevant documents including textbooks, pamphlets, journals and reports, both published and unpublished were consulted to get an overview and identify information gaps in meeting the identified study objectives.

3.3 Data analysis

3.3.1 Ecological data

3.3.1.1 Species composition and dominance

Species dominance was assessed based on the species Important Value Index (IVI). The stand density (N) (stems ha^{-1}) and basal area (m^2 ha^{-1}) (G) for individual species were computed using standard formulae (Equations 1 and 2).

The species Importance Value Index was computed as the average of relative basal area and relative density.

$$N = \frac{n}{Plot\ area\,(ha)} \quad \text{.......... (Equation 1)}$$

$$G = \frac{\pi d^2}{4} \quad \text{.......... (Equation 2)}$$

Where;

π = 3.14

G = Basal area (m^2ha^{-1})

N = Stand density (umber of stems/ha)

d = Diameter at breast height (1.3m) for the individual tree (m) and

n = Number of individual tree species occurred.

3.3.1.2 Species richness and diversity

Species richness was estimated as the total number of species in the area, while species diversity was computed using Simpson and Shannon Wiener indices of diversity and species evenness based on the Species Importance Value Index (Kent and Coker 1992). The following formulas were applied.

(i) Importance Value Index (**IVI**) =R elative basal Area + Relative Density

(ii) Shannon's Index of diversity (H') = $-\sum_{i=1} [P_i * ln(P_i)]$

Where: - P_i = Species Importance Value Index or proportion of individuals

- ln = natural logarithm; - s = number of species

(iii) Simpson index (C) $=\sum_{i=1}^{s}(P_i)^2$

Where: C = The index number (Diversity index)

S = Total number of species in the sample

P_i= The proportional of all individuals (using IVI) in the sample belonging to species i

(iv) Equitability (evenness) (J) = H'/lnS

Where: - H' = Shannon's Index of diversity

S = Total number of species

3.3.2 Human disturbances

The number of cut stems was converted to per hectare basis by dividing the number of cut stems by the plot size. This was expressed as a percentage stem density. The utilization pressure was computed as the proportion of the cut stems (stem/ha) and the total stocking.

3.3.3 Socio economic data

The information obtained from PRA was analyzed on the spot by recording consensus conclusions from participants and communicating back to PRA audience. Household questionnaire data was coded, tabulated, entered into computer and analysed using Statistical Package for Social Science (SPSS). The information from both assessments is presented in tables and graphs. The data were summarized into user categories.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Species composition, richness and diversity

4.1.1 Species composition and richness

A total of 69 tree species belonging to 22 families were encountered in all four forests. In Gidahabaiegh Forest Reserve (FR) a total of 34 tree species from 16 different families were identified and recorded while in Waama FR 52 tree species were identified. Dirima and Diloda FRs had similar number of tree species (32) originating from 17 and 13, different families respectively (Table 1).

Table 1: Tree Species composition and richness in Hanang District, Tanzania

Name of Forest Reserves	Number of tree species	Number of families
Gidahabaiegh	34	16
Dirima	32	17
Dlioda	29	13
Waama	52	21
All forests	69	22

Further analysis revealed that out of the 69 tree species identified in all forest reserves only 12 were common to all forest reserves. These included *Acacia robusta.Albizia, Harveyii, Afzelia quanzensis, Brachystegia spiciformis, Combretum zenheri, Commiphora africana, Commiphora mossambicensis, Dalbergia melanoxylon, Julbernardia globiflora, Lannea schimperi, Sclerocarya birrea, Stychnos innocua* and *Zanha africana* (Table 2).

Table 2: Comparative species composition in Diloda, Gidahabaiegh, Dirima and Waama Forest Reserves in Hanang District Tanzania

No	Species name	Forest reserves			
		Dlioda	Gidahabaiegh	Dirima	Waama
1	*Acacia drepanolobium*	-	-	√	√
2	*Acacia nigrescens*	-	-	-	√
3	*Acacia nilotica*	-	-	-	√
4	*Acacia polyacantha*	-	-	-	√
5	*Acacia robusta*	√	√	√	√
6	*Acacia senegal*	√	-	-	√
7	*Acacia tortilis*	√	-	-	-
8	*Afzelia quanzensis*	-	-	-	√
9	*Albizia harveyi*	√	√	√	√
10	*Albizia petersiana*	-	-	-	√
11	*Albizia versicolor*	-	-	-	√
12	*Azanza garckeana*	√	-	√	-
13	*Boscia sp*	-	√	√	-
14	*Brachystegia boehmii*	-	√	-	-
15	*Brachystegia microphylla*	-	√	√	-
16	*Brachystegia spiciformis*	√	√	√	√
17	*Bridelia cathartica*	-	√	√	√
18	*Burkea africana*	-	-	-	√
19	*Cassia abbreviata*	-	√	-	√
20	*Combretum collinum*	-	√	√	√
21	*Combretum molle*	√	√	-	√
22	*Combretum zeyheri*	√	√	√	√
23	*Commiphora africana*	√	√	√	√
24	*Commiphora mossambicensis*	√	√	√	√
25	*Dalbergia boehmii*	√	√	√	√
26	*Dalbergia nitidula*	-	-	-	√
27	*Denibolia bobonica*	√	-	-	√
28	*Dichrostachys cinerea*	-	-	√	-
29	*Diospyros sp*	√	√	-	-
30	*Diplorynchus condylocarporn*	-	-	-	√
31	*Dodonea sp*	-	-	√	-
32	*Dombeya rotundifolia*	√	-	-	√
33	*Erythrina abyssinica*	√	√	-	-
34	*Erythrina burtii*	-	-	√	-
35	*Eurphobia candelabrum*	-	√	-	-
36	*Eurphobia matabalensis*	-	√	-	-
37	*Ficus thonningi*	-	√	√	-

Note: √ = Species present in a forest, - = Species absence in a forest

Table 2: Continue....

No	Species name	Forest reserves			
		Dlioda	Gidahabaiegh	Dirima	Waama
38	*Grewia bicolor*	-	√	√	√
39	*Grewia similes*	-	-	-	√
40	*Hoslundia opposita*	-	-	-	√
41	*Julbernardia globiflora*	√	√	√	√
42	*Kigelia africana*	-	-	√	√
43	*Lannea humilis*	-	√	-	√
44	*Lannea schimperi*	√	√	√	√
45	*Lannea schweinfurthii*	√	-	√	√
46	*Lonchocarpus capassa*	√	-	√	-
47	*Lonchocarpus eriocalyx*	√	-	-	√
48	*Markhamia obtusifolia*	-	√	√	√
49	*Ochna sp*	-	√	-	√
50	*Ozoroa insignis*	√	√	-	-
51	*Pterocarpus angolensis*	√	-	-	√
52	*Pterocarpus tinctorius*	-	-	-	√
53	*Rhus natalensis*	-	-	-	√
54	*Sclerocarya birrea*	√	√	√	√
55	*Senna singuena*	-	√	-	√
56	*Sterculia africana*	-	-	√	-
57	*Stereospermum cuanthianum*	√	-	-	√
58	*Strychnos innocua*	√	√	√	√
59	*Terminalia ivorensis*	√	√	-	-
60	*Terminalia mollis*	√	√	-	-
61	*Unknown1*	√	-	-	-
62	*Vangueria infausta*	-	√	√	√
63	*Vernonia sp*	-	√	√	√
64	*Vitex kinensis*	√	-	-	-
65	*Xeroderis stuhlmannii*	√	-	√	√
66	*Ximenia caffra*	-	√	√	-
67	*Zanha africana*	√	√	√	√
68	*Zanthoxylum sp*	√	-	√	-
69	*Ziziphus sp*	√	-	-	√

Note: √ = Species present in a forest, - = Species absence in a forest

These results are almost similar to those reported by Nduwamungu (1997) in miombo woodland vegetation in Kitulangalo Forest Reserve in Morogoro who found that among others the most frequently encountered species in miombo woodlands belonged to the genera; *Albizia*, *Dalbergia*, *Combretum* and *Strychnos*.

Surprisingly other species such as *Acacia nigrescens, Acacia nilotica, Acacia polyacantha, Acacia tortilis, Afzelia quanzensis, Burkea africana, Dalbergia nitidula, Dichrostachys cinerea, Diplorynchus condylocaporn, Erythrina burtii, Eurphobia candelabrum, Eurphobia matabalensis, Grewia similis, Hoslundia opposita, Pterocarpus tinctorius, Rhus natalensis, Sterculia africana* and *Vitex kiniensis* only appeared once in each forest (Table 2); despite of being in the same ecological zone where rainfall pattern and edaphic factors are almost the same. This variation is presumably linked to existence of different levels of disturbance in these forests. Luoga (2000) argued that among the factors associated with variation in species composition and richness in miombo woodlands is disturbances, especially when edaphic factors are similar. Furthermore, Munishi (2002) argued that sparse distribution of some species may be an indication of natural phenomena (species having restricted range), outlines species population outside their normal range or may represent species at state of decline or as a result of human impact and utilization pressure.

4.1.2 Tree species diversity

Assessment of individual tree species diversity showed that the four forests differ from one another. Results indicated that the values Shannon-Wiener index of diversity (H') was higher in Gidahabaiegh Forests than others followed by Waama, Diloda and Dirima,(Table 3).The average Shannon-Wiener index of diversity for all the forests was 3.3. Also the exponential values of H' indices (n_i) in each forest were 113 for Gidahabaiegh FR.

Table 3: Species diversity and dominance in four forest reserves of Hanang District, Tanzania

Diversity measure	Forest reserves			
	Gidahabaiegh	Dirima	Waama	Diloda
Shannon's diversity (*H'*)	4.7	2.51	3.0	2.8
Exponential value of *H'* denoted as (n_1)	113	12	20	16
Simpson's index	0.21	0.15	0.11	0.10
Simpson's diversity index (D=1-C)	0.792	0.851	0.888	0.899
Total # of species	33	33	47	34

For any biological data the highest value of Shannon index is 5.0 (Krebs, 1989), the value obtained in Gidahabaiegh indicate highest diversity index (*H'*=4.7), a situation suggesting relatively high species diversity and evenness as compared to the rest forests in the study area. The species diversity in Waama FR was moderate (*H'*=3.0). The other forests; Dirima, Diloda and Waama were less diverse (Table 3). The number of equaly common species which would produce the same index of diversity (*H'*) as indicated by the exponential values of Shannon diversity indices (n_i) were higher for Gidahabaiegh FR compared to the other forest reserves. This value of n_i confirm high species diversity at least in Gidahabaiegh forest reserve.

High species diversity in Gidahabaiegh forest could be as a result of diverse micro habitat found within miombo woodland ecosystem (Campbell *et al,* 1996). The topography of miombo ecoregions as described by Lind and Morrison (1974) indicated that moderately undulating peneplains where flat, gently sloping ridges alternate with shallow, flat bottom and seasonal valleys. The well drained ridges bear typical miombo species on the upper and middle slopes, the valley bottom wooded grasslands and the narrow marginal region in between bushlands with *Combretum* and other species. Among other forest reserves this description is presented for Gidahabaiegh forest reserve which is elevated up to 3 676 m above sea level. On the other hand low diversity observed in Dirima (H'=2.5) and Diloda (H'=2.8) forest reserves are well comparable to those observed by Mafupa (2006) who reported Shannon Winner index value of H'=2.4 in disturbed strata of Igombe Forest Reserve in Tabora Tanzania. These indices suggest different levels of disturbance between the forests.

4.1.3 Species dominance

Species dominance based on Simpson's index was 0.21 for Gidahabaiegh forest reserve. The remaining forests: Dirima, Waama and Diloda FRs had dominance indices of 0.15, 0.11 and 0.10 respectively (Table 3). The dominance index observed in Gidahabaiegh forest reserve implies that the probability of picking randomly two individuals belonging to the same species is very low in Gidahabaiegh FR followed by Dirima, Waama and finally Diloda FR. In other words this means probability that two individuals picked at random in Gidahabaiegh forest reserve belongs to different family. This again suggests that plant communities studied are diverse in tress species.

4.1.4 Dominance based on Important Value Index (IVI)

Based on the IVI the dominant species which dominates in all forest reserves was *Brachystegia speciformis*. This species had an IVI of 6.55 in Gidahabaiegh Forest Reserve, 2.98 in Waama FR, 2.54 in Diloda and 1.93 in Dirima Forest Reserve (Table 3). Such observation suggests that species regenerates relatively well in Gidahabaiegh FR and if no accidental disturbance occurred in future, it will remain the most dominant species.While Gidahabaiegh FR was highly dominated by *Brachystegia speciformis* (IVI = 6.55), Dirima, Waama and Diloda FRs were highly dominated by *Julbernardia globiflora* with IVI of 4.90, 4.27 and 3.55 respectively. In addition the IVI for *Brachystegia microphylla* observed in Gidahabaiegh was

2.05 and Dirima FRs (IVI =2.9) are well comparable to that of *Brachystegia spiciformis* in Dilidoda and Waama FRs (Figure1).

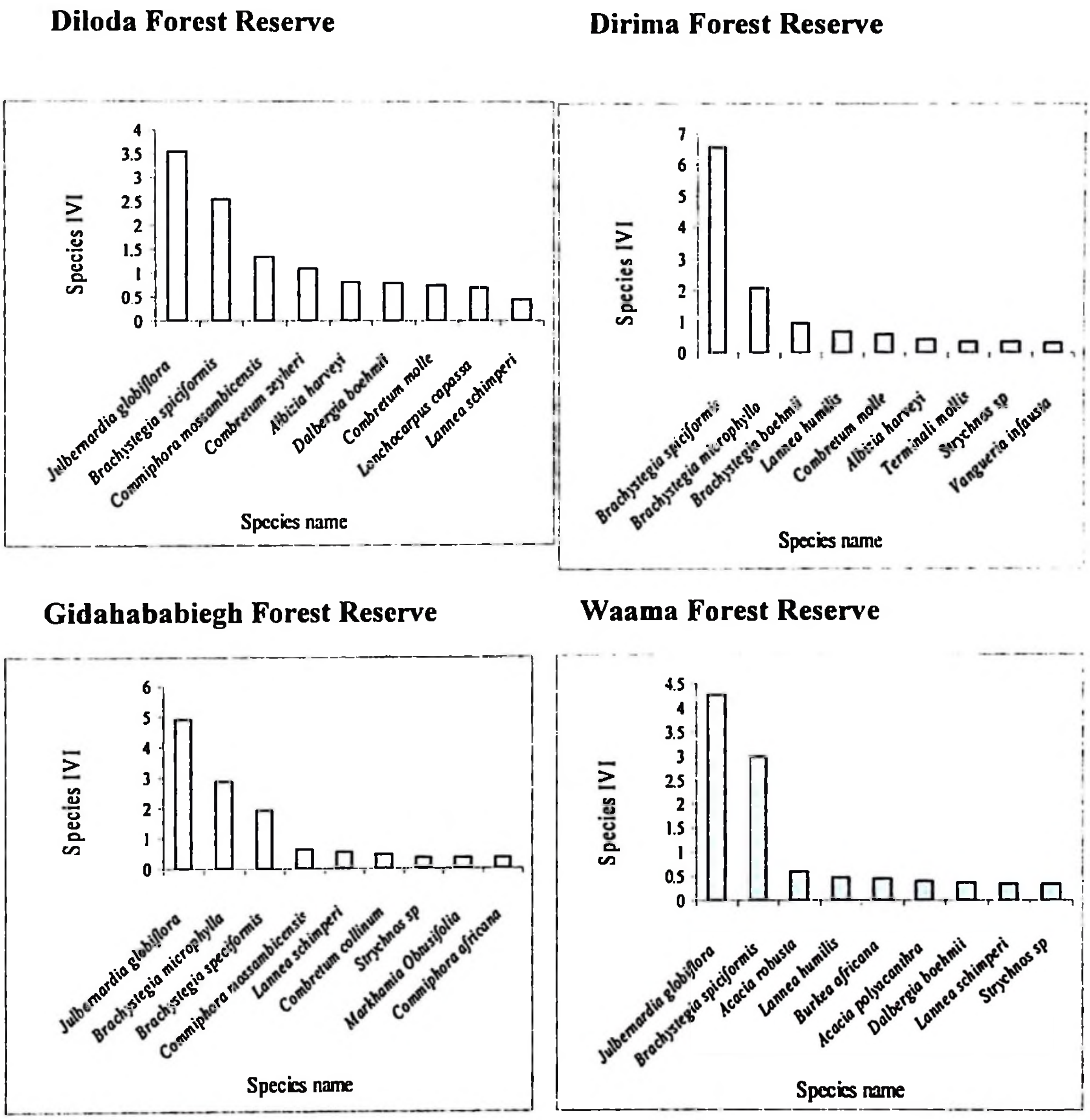


Figure 1: Tree species dominance in miombo woodlands based on Important Value Index

It therefore implies that without accidental disturbances in these forests *Brachystegia microphylla* also will remain codominant with *Julbernardia globiflora* and *Brachystegia spiciformis* in tree population. These results are similar to Mgeni and Malimbwi (1990) observations that the common and dominant woody species include *Julbernardia sp.* and *Brachystegia sp.*, which constitutes up to 80 % of trees in miombo woodlands in Tanzania.

4.1.5 Family dominance

Like other miombo woodlands the family *Combretaceae* and *Caesalpinioideae* dominated the miombo woodland in Hanang District with about 15% and 12% of all individual species. The other dominant families included *Papilionoideae* *Anacardiaceae* and *Mimosoideae* which give contribution of above 10 %. Other families have contributed below 7% (Table 4).

Guy (1988) estimated that the family *Caesalpinioideae* made up 41% of the total families of miombo woodland in Sengwa-Zimbabwe. Also study in miombo woodlands by Nduwamungu (2001) in Kilosa District- Tanzania observed that the family *Combretaceae* and *Papilionoideae* made up to 24% and 11% of the total tree population. Thus the 15% contribution of *Combretaceae* miombo woodland of Hanang District falls in the intermediate position in terms of percentage share of *Combretaceae* family.

Compared to other forest reserves, *Caesalpinioideae* dominates the miombo woodlands in these forests while *Mimosoideae* (17.3%) dominated much in Waama Forest Reserve.

Table 4: Family dominance in four Forest Reserves of Hanang District, Tanzania

No	Family name	No of species and % share by family								Overall	
		Dilooda		Gidahabaiegh		Dirima		Waama			
		No	%	No	%	No	%	No	%	No	%
1	*Combretaceae*	6	20.7	7	20.6	4	12.5	5	9.6	22.0	15.0
2	*Caesalpinioideae*	3	10.3	6	17.6	3	9.4	6	11.5	18.0	12.2
3	*Papilionoideae*	6	20.7	2	5.9	4	12.5	6	11.5	18.0	12.2
4	*Anacardiaceae*	4	13.8	4	11.8	3	9.4	5	9.6	16.0	10.9
5	*Mimosoideae*	0	0.0	2	5.9	4	12.5	9	17.3	15.0	10.2
6	Bignoniaceae	1	3.4	1	2.9	3	9.4	4	7.7	9.0	6.1
7	*Sapindaceae*	2	6.9	1	2.9	1	3.1	2	3.8	6.0	4.1
8	*Euphorbiaceae*	0	0.0	3	8.8	1	3.1	1	1.9	5.0	3.4
9	*Logoniaceae*	1	3.4	1	2.9	1	3.1	1	1.9	4.0	2.7
10	*Tiliaceae*	0	0.0	1	2.9	1	3.1	2	3.8	4.0	2.7
11	Compositae	0	0.0	1	2.9	1	3.1	1	1.9	3.0	2.0
12	*Ebenaceae*	1	3.4	1	2.9	0	0.0	1	1.9	3.0	2.0
13	*Malvaceae*	1	3.4	0	0.0	1	3.1	1	1.9	3.0	2.0
14	*Moraceae*	0	0.0	1	2.9	1	3.1	1	1.9	3.0	2.0
15	*Olacaceae*	0	0.0	1	2.9	1	3.1	1	1.9	3.0	2.0
16	*Rubiaceae*	0	0.0	1	2.9	1	3.1	1	1.9	3.0	2.0
17	*Rutaceae*	1	3.4	0	0.0	1	3.1	1	1.9	3.0	2.0
18	*Sterculiaceae*	1	3.4	0	0.0	1	3.1	1	1.9	3.0	2.0
19	*Ochnaceae*	0	0.0	1	2.9	0	0.0	1	1.9	2.0	1.4
20	*Rhamnaceae*	1	3.4	0	0.0	0	0.0	1	1.9	2.0	1.4
21	*Lamiaceae*	0	0.0	0	0.0	0	0.0	1	1.9	1.0	0.7
22	*Verbenaceae*	1	3.4	0	0.0	0	0.0	0	0.0	1.0	0.7
	Total	29	100.0	34	100.0	32	100.0	52	100.0	147.0	100.0

4.2 Forest utilization and its impacts on the woodland stock

Various woodland products including both timber and non timber were mentioned to be utilised by the local population from all forest reserves in Hanang District. The products mentioned included timber, poles, charcoal, firewood, wild fruits, and medicinal plants. Other products were wild vegetables, wild mushrooms, honey, thatching grass and weaving materials.

Results indicated that highest proportion of population surrounding the four forest reserves namely Gidahabaiegh, Waam, Dilidoda and Dirima obtain timber (5%) poles (56%), charcoal (58%) and firewood (95%) from these forest reserves in Hanang District (Table 5). This shows that firewood is mostly used product from the reserve followed by charcoal and poles. Also among other products wild vegetables, wild mushrooms, honey, thatching grass, and weaving materials were collected by more than 20% of the population in the district (Table 5).

Table 5: Responses on utilization of woodland products in Hanag District,

Products	Percentage responses by villages				Overall (N=81)
	Gidahabaiegh n= 20	Waam n= 20	Dilidoda n= 21	Dirima n= 20	
Timber	0	2	8	10	5
Poles	62	50	49	70	58
Fire wood	88	96	96	98	95
Charcoal	31	71	52	68	56
Wild fruits	30	20	28	34	28
Medicinal plants	40	38	31	52	40
Wild vegetables	31	50	42	48	43
Wild mushrooms	18	33	19	25	24
Honey	22	11	21	28	21
Thatching grass	54	30	42	56	46

Note: There was multiple responses for utilization of itemized woodland products, therefore percentages can not summed up to 100

It can be noted form these results that utilization of trees and collection of the woodland products from the forest reserves is a vital activity of the local population in Hanang District to meet daily household needs and income. Previous studies by Arnold and Perez (1996), Kajembe *et al.* (2000), Mbwambo (2000), Mapolu (2002), Nyigili (2003) and Lema (2003) in Tanzania reported similar experience that people depended on forests and trees for food and income.

4.2.1 Local uses of woodland trees species

A total of 49 tree species were utilized as a source of different forest products for household use. Among others, 12 different tree use categories were quantified with respect to the particular species (Figure 2).

The study found that among other tree species identified *Brachystegia spiciformis* and *Acacia Senegal* were ranked highest as a mostly species used for firewood by 17% and 15% respectively. Rating species for charcoal were relatively high for *Dalbergia boehmii* (25%), *Julbernardia globiflora* (20%) and 18% for *Acacia spp* (Figure 2). Grundy *et al.* (1993) observed that three most abundant and frequently used firewood and charcoal species in Zimbabwe included *Julbernardia globiflora* and *Brachystegia boehmii*, which were also among the firewood species, mentioned Hanang District. The reasons linked to their preference could be ability to produce wood of high calorific value with less smoke and smell.

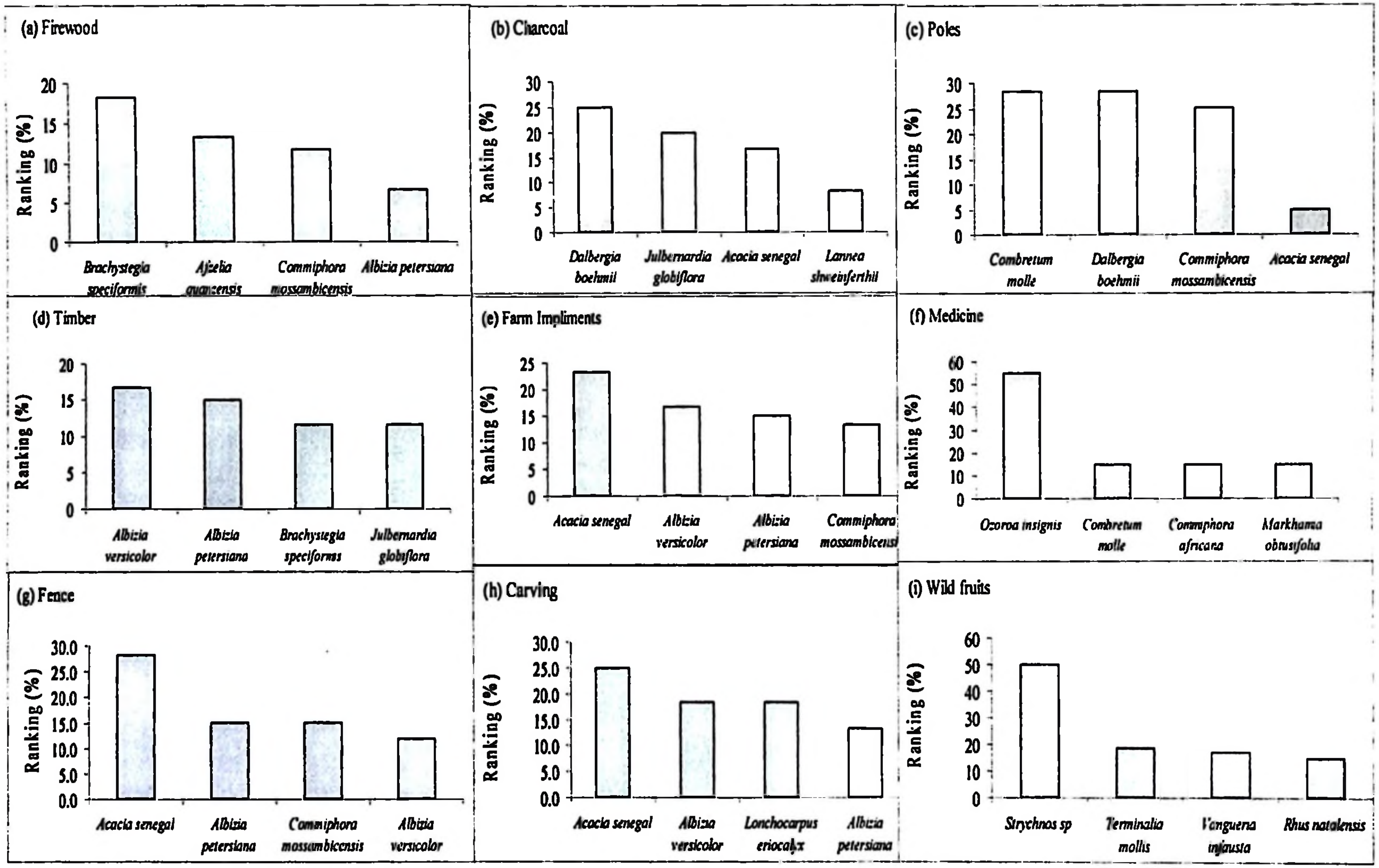


Figure 2: Different tree species from miombo woodlands for various use categories in Hanang District, Tanzania

Tree species mostly used for building poles were *Combretum molle* (28%). *Dalbergia boehmii* (28%) and *Commiphora mossambicensis* (26%) (Figure2). Building poles were found to be the most used construction materials for both permanent and temporary houses in the surveyed villages. Temporary houses were located in farms and were occupied for at least five months a year by all members of the family while protecting crops from vermin before harvesting. Other species mostly uses for fences, construction of storage facilities, making huts, traditional beds and tool handles included *Acacia senegal* (29%) and 15% for *Commiphora mossambicensis* (Figure 2).

Furthermore the main miombo timber species mentioned were *Pterocarpus angolensis* (20%), *Pterocarpus tinctorius, Julbernardia globiflora* (12%) and *Dalbergia nitidula.* Studies in Malawi reported that most of the accessible stock of *Pterocarpus angolensis* has been felled for timber and the furniture industry relies on supplies from across the border in Mozambique (Lowore *et al.* 1994b).

Trees species of medicinal value in the study were *Ozoroa insignis* (55%). *Combretum molle* (15%) and 15% *Commiphora africana* (Figure 2). The medicinal species are normally used to treat diseases like stomachache, aphrodisiac, venereal diseases, anaemia and blood pressures. The utilization knowledge of various medicinal tree species were acquired from their ancestors. The parts of the plants used for medicine vary from roots, leaves, barks, and fruits to tubers. The parts of tree species commonly used for medication are roots and leaves.

Similar findings have been reported in various studies. Abdalah (2001) reported that the most commonly harvested local medicines in miombo woodland of Tabora

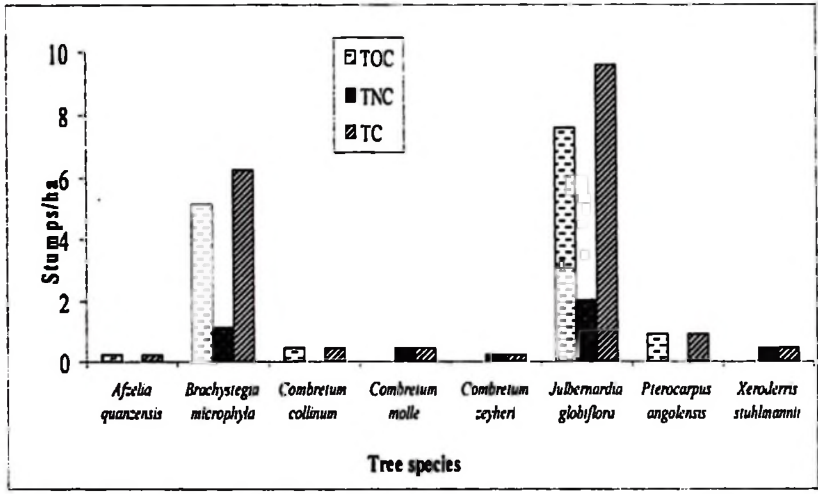
Tanzania were tree roots, barks and leaves. It was interesting that most tree species identified had multiple uses; for example *Brachystegia speciformis* can be utilized for timber, building pole, charcoal making as well as fire wood. In addition, *Commiphora spp* was mentioned to be used for medicinal, farm implements and building poles. This trend of species use confirms the importance of miombo and associated tree species to the livelihood of the local communities.

4.2.2 Human impact on miombo woodland stock

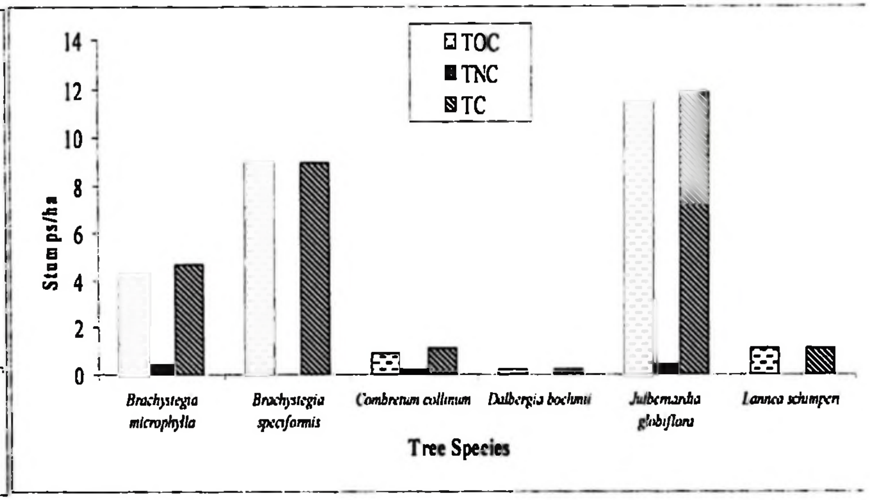
Human impact on miombo woodland stock through harvesting of different trees species and shrubs were evident in Hanang District. It was observed that different species were removed from all forest reserves though at different levels.

In Gidahabaiegh FR the number total cuts for *Brachystegia speciformis* was 10 stems per hectare while in Dirima and Didolda FRs the total cuts (TC) for this species were bellow 10 stems hectare except for Waama FR where no stem cut for *Brachystegia speciformis* were recorded (Figure 3).

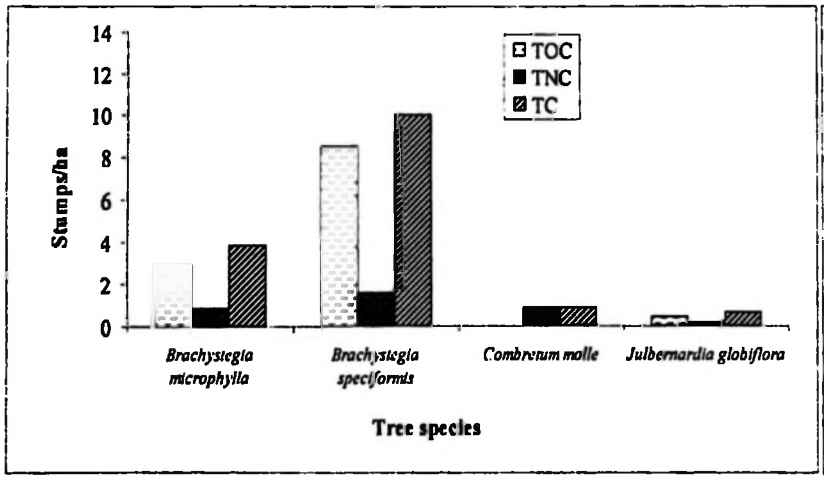
Diloda Forest Reserve



Dirima Forest Reserve



Gidahababiegh Forest Reserve



Waama Forest Reserve

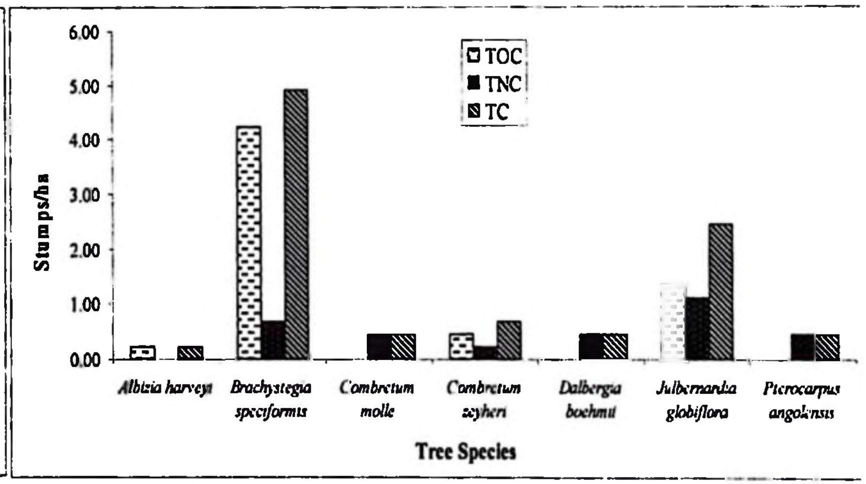


Figure 3: Average number of old and new stumps (cuts) in four forest reserves of Hanang, Tanzania.

Note: TOC= Total old cuts, TNC= Total new cuts and TC= Total cuts (old + new cuts)

Similarly, *Julbernadia globoflora* contributed to the highest (12 stems) total number of stems cuts per hectare (TC) in Dirima FR followed by Waaama FR (10 stems) while relatively few stem cut (1 stem per hectare) were observed in Gidahabaiegh FR (Figure 3). Other tree species had total cuts below 4 stems per hectare in all four forest reserves. These include *Albizia harveyi, Afzelia quanzensis, Combretum collinum,Combretum molle, Combretum zeyheri, Dalbergia melanoxlyon, Pterocarpus anglolensis and Xeroderris stuhlimannii.*

It is therefore evident from the results that *Brachystegia spiciformis* and *Julbernadia globoflora* contributed to the most of the harvested stock in all forest reserves. High utilization level these species in almost all forest reserves could be linked to the multipurpose nature of the species. This was also mentioned by the local people during socioeconomic survey that *Brachystegia spiciformis* can be utilized for building pole, timber and charcoal making as well as fire wood (see Figure 2). The findings are closely related to what was reported by Nduwamungu (2001) in Kilosa District, Tanzania that most of tree species harvested in miombo woodlands are those preferred for charcoal production such as *Brachystegia sp*, *Julbernadia sp*. and *Combretum sp* for timber.

Comparatively, there were only four different types of tree species noted to be removed in Gidahabaiegh FR while in Dirima FR were 6 species, Didolda FR 7 species, and 8 species Waama FR. Relatively few species removed in Gidahabaiegh FR are presumably attributed by high level of diversity index (H'= 4.7) depicted in this forest. This situation confirm very minimal disturbance in Gidahabaiegh FR.

More interesting, the total number of new cuts (TONC) for the species identified in all forest reserves was below 2 stems per hectare (Figure 3). This indicated that trees harvesting pressure has decreased recently. This implies low utilization pressure compared to the past utilization. The observed situation could be attributed to increased level of control in the use of forest resources in recent times than it was earlier. This might probably be due to the effect of introduction of Participatory Forest Management (PFM) in Hanang District.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Miombo woodlands in Hanang district are generally rich in species diversity. Difference in levels of human use and disturbances are linked to this variation in species composition between individual forest reserve. The forests are typically of miombo woodlands dominated by *genera Brachystegia* and *Julbernadia* with *Brachystegia spiciformis* and *Julbernadia globiflora* being the most dominant species. Different micro-habitat found in Gidahabaiegh FR where moderately undulating gently slopes alternating with shallow valleys and well drained a ridge bearing different types of miombo species on the upper and middle slopes has contributed to high tree species diversity. Like other miombo woodlands families *Combretaceae* and *Caesalpinioideae* dominated the miombo woodland in Hanang District. Different levels of human disturbance and microhabitat variation seem to be linked to differences in species composition, diversity and richness.

Furthermore, miombo woodlands in Hanang District are potential in supporting the livelihoods of the local communities surrounding all forest reserves through harvesting of various tree species for various uses including firewood, charcoal, pole, and medicinal plants among others. *Brachystegia spiciformis* and *Combretum* species were noted to be among the most harvested tree species. Multipurpose nature of these species is linked to observed differences in utilization level of all forest reserves.

However, the level of utilization seems to have decreased probably due to increased monitoring in recent years than in the past and introduction of Participatory Forest Management (PFM) approach in Hanang District.

Considering the variation in species diversity and dominance between individual forest reserves, management strategies should be site specific so as to balance both ecological diversity of the individual forest reserve and local uses in a sustainable manner.

5.2 Recommendations

In order to achieve sustainable management of miombo woodlands in Hanang District for its multiple economic and ecological values the following recommendations are pertinent:

- Selective harvesting of trees species for paricular product and harvestig of other woodland products is the comminest system in Hanang district. Considereing the future status of the woodland stock under growing demand of woodland resources, there is a need establisment and encourage alternative activities such as improved cooking stoves, biogas, beekeeping, nursery establishment and home based tree planting program/woodlots for firewood and other household uses.
- Enrichment planting with indigenous plant species in those forested areas where severely where substantial removal was evident in an important
- The PFM Initiatives underway in the district need to be fortified so as to enhance effective stewardship to the woodland resources by the local communities.

- Given the growing ecological and economic value of miombo woodlands of Hanang district, a further study on plants spceies association patterns and potential alternative income generating activities including non consuption utilisation activities that will reduce pressure in the miombo woodlands are recomended.

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APPENDICES

Appendix 1: Sample plot field form

1. REGION ....2. DISTRICT ....
3. SITE ....4. CLUSTER NO.........................
5. SAMPLE PLOT NO:................ .6. FIELD FORM NO:...................
7. INVENTORY DATE.................

No.	Code	Local/Botanical names	No. stem cut		DBH (cm)	HT (m)	Rem
			Poles	Timber			

DBH - Diameter at Breast Height (cm)
HT - Total tree/shrub Height (m)
Rem - Remarks or other observations.

Appendix 2: Household questionnaire

HOUSEHOLD QUESTIONNAIRE FORM

Name of Enumerator:...

Date:.....................

Village......................................

Ward................................Division:........................

Household Identification Number.................

1.0 Respondent Personal Information

1. Name...

1.2. Sex: 1. Male

2. Female

1.3. Age:................. years (or born in.............)

1.4. Marital Status: 1. Single

2. Married

3. Divorced or Separated

4. Widowed

1.5. Education: 1. No formal education

2. Primary education

3. Secondary education

4. Post secondary education

5. Others (specify)..

1.6. Size of household: ....

1.7. Major economic activity of the household...

1.9 For how long have you lived in this area..

2.0. Forest resources utilization

2.1. How do you get access to nearest protected forests?

1. Free

2. Request for a permit (license)

3. Pay access fee

2.2. Which tree species are you not allowed to harvest from the forests unless license is given..

2.3. Which three tree species (in order of priority) are most preferable for the following uses and where do you get them from?

No	Types of uses	Species name			Sources*		
		1	2	3	1	2	3
1	Firewood						
	Charcoal						
2	Building poles						
3	Timber						
4	Farm implements						
5	Medicine						
6	Fence						
7	Carving wood						
8	Wild fruits						
9	Others (specify)						

* Sources: (1) Forest Reserve (2) Forests on general lands
(3) Private woodlots (4) Homestead garden
(5) Farms (6) Market

3.0 Forest management

3.1 What do you think are the major reasons for forest depletion?

1. Creation of new farms
2. Creation of new settlements
3. Fires
4. Tree cutting for poles, timber, fuelwood;
5. Pests and insects
6. Others

(specify)...

3.2 What changes have you noted as a result of decreasing forest cover in the area?

1. Soil erosion
2. Shortage of fuelwood
3. Shortage of building materials
4. Scarcity of fodder
5. Shortage of rains
6. Presence of strong winds
7. Others (specify)........................

3.3. How are people involved in the protection of forests?...

....

Appendix 3: Uses of trees species and the rank for preference in Hanang District.

Use of trees	First preferred species		Second preferred species		Third preferred species	
	Name of preferred species	% rated	Name of preferred species	% rated	Name of preferred species	% rated
Fire wood	*Acacia robusta*	1.7	*Acacia drebanalobium*	5.0	*Acacia senegal*	30.0
	Afzelia quanzensis	13.3	*Acacia negrescens*	1.7	*Albizia harveyi*	13.3
	Albizia petersiana	6.7	*Acacia nilotica*	1.7	*Albizia petersiana*	1.7
	Brachystegia spiciformis	18.3	*Acacia polyacanthra*	13.3	*Albizia versicolor*	3.3
	Cassia abreviata	5.0	*Acacia senegal*	15.0	*Brachystegia spiciformis*	6.7
	Combretum molle	6.7	*Albizia harveyi*	1.7	*Combretum molle*	3.3
	Commiphora mosambicensis	11.7	*Albizia petersiana*	3.3	*Denbolia bobonica*	5.0
	Dalbergia nitidula	5.0	*Albizia versicolor*	5.0	*Diplorychus condilocaporn*	18.3
	Denbolia bobonica	6.7	*Brachystegia spiciformis*	10.0	*Julbernadia globiflora*	1.7
	Diplorychus condilocaporn	5.0	*Bridelia cathartica*	1.7	*Lannea schweinfurthii*	15.0
	Dombeya rotundifolia	5.0	*Cassia abbreviata*	3.3	*Lonchocarpus eriocalyx*	1.7
	Lanea humilis	5.0	*Dalbergia boehmii*	15.0		
	Lannea schimperi	5.0	*Denbolia bobonica*	1.7		
	Lanea schweinfurthii	3.3	*Diplorychus condilocaporn*	8.3		
	Markhamia obtusifolia	1.7	*Grewia bicolor*	5.0		
			Hoslundia opposita	1.7		
			Lannea schimperi	5.0		
			Lannea schweinfurthii	1.7		

Appendix 3: Continue...

Use of trees	First preferred species		Second preferred species		Third preferred species	
	Name of preferred species	% rated	Name of preferred species	% rated	Name of preferred species	% rated
Charcoal	*Acacia senegal*	16.7	*Acacia robusta*	6.7	*Acacia senegal*	26.7
	Albizia harveyi	5.0	*Acacia senegal*	20.0	*Albizia petersiana*	10.0
	Albizia petersiana	5.0	*Albizia petersiana*	6.7	*Brachystegia speciformis*	16.7
	Brachystegia spiciformis	5.0	*Bridelia micrantha*	20.0	*Commiphora mosambicensis*	3.3
	Bridelia cathartica	6.7	*Dalbergia boehmii*	46.7	*Julbernadia globiflora*	31.7
	Cassia abbreviata	5.0			*Lonchocarpus eriocalyx*	11.7
	Dalbergia boehmii	25.0				
	Hoslundia opposita	3.3				
	Julbernadia globiflora	20.0				
	Lannea schweinfurthii	8.3				
Building poles	*Acacia polyacantha*	1.7	*Acacia senegal*	25.0	*Acacia senegal*	26.7
	Acacia senegal	5.0	*Albizia petersiana*	10.0	*Albizia petersiana*	13.3
	Albizia petersiana	1.7	*Albizia versicolor*	11.7	*Albizia versicolor*	16.7
	Albizia versicolor	3.3	*Brachystegia speciformis*	23.3	*Commiphora mosambicensis*	13.3
	Cassia abbreviata	3.3	*Dalbergia boehmii*	5.0	*Dalbergia boehmii*	3.3
	Combretum molle	28.3	*Dalbergia nitidula*	10.0	*Dalbergia nitidula*	6.7
	Commiphora mosambicensis	25.0	*Julbernadia globiflora*	3.3	*Julbernadia globiflora*	3.3
	Dalbergia bohemii	28.3	*Lonchocarpus eriocalyx*	11.7	*Lonchocarpus eriocalyx*	15.0
	Julbernadia globiflora	1.7			*Pterocarpus angolensis*	1.7
	Lonchocarpus eriocalyx	1.7				

Appendix 3: Continue…

Use of trees	First preferred species		Second preferred species		Third preferred species	
	Name of preferred species	% rated	Name of preferred species	% rated	Name of preferred species	% rated
Timber	*Acacia senegal*	5.0	*Acacia senegal*	6.7	*Acacia senegal*	8.3
	Afzelia quanzensis	6.7	*Afzelia quanzensis*	5.0	*Afzelia quanzensis*	8.3
	Albizia harveyi	10.0	*Albizia harveyi*	3.3	*Albizia harveyi*	1.7
	Albizia petersiana	15.0	*Albizia petersiana*	26.7	*Albizia petersiana*	18.3
	Albizia versicolor	16.7	*Albizia versicolor*	11.7	*Albizia versicolor*	16.7
	Brachystegia spiciformis	11.7	*Brachystegia spiciformis*	6.7	*Brachystegia speciformis*	3.3
	Commiphora mosambicensis	1.7	*Dalbergia boehmii*	1.7	*Dalbergia nitidula*	10.0
	Dalbergia boehmii	3.3	*Dalbergia nitidula*	13.3	*Julbernadia globiflora*	13.3
	Dalbergia nitidula	6.7	*Hoslundia opposita*	1.7	*Pterocarpus tinctorius*	20.0
	Julbernadia globiflora	11.7	*Julbernadia globiflora*	16.7		
	Lonchocarpus eriocalyx	1.7	*Lonchocarpus eriocalyx*	1.7		
	Pterocarpus angolensis	1.7	*Pterocarpus tinctorius*	5.0		
	Pterocarpus tinctorius	8.3				
Farm implement	*Acacia senegal*	23.3	*Acacia senegal*	23.3	*Acacia senegal*	28.3
	Albizia petersiana	15.0	*Albizia petersiana*	10.0	*Albizia petersiana*	11.7
	Albizia versicolor	16.7	*Albizia versicolor*	15.0	*Albizia versicolor*	15.0
	Burkea africana	1.7	*Commiphora mosambicensis*	18.3	*Commiphora mosambicensis*	15.0
	Commiphora mosambicensis	13.3	*Dalbergia boehmii*	6.7	*Dalbergia boehmii*	5.0
	Dalbergia boehmii	3.3	*Dalbergia nitidula*	11.7	*Dalbergia nitidula*	10.0
	Dalbergia nitidula	11.7	*Julbernadia globiflora*	1.7	*Julbernadia globiflora*	3.3
	Julbernadia globiflora	1.7	*Lonchocarpus eriocalyx*	13.3	*Lonchocarpus eriocalyx*	11.7
	Lonchocarpus eriocalyx	13.3	*Combretum molle*	15.0	*Combretum molle*	15.0

Appendix 3: Continue…

Use of trees	First preferred species		Second preferred species		Third preferred species	
	Name of preferred species	% rated	Name of preferred species	% rated	Name of preferred species	% rated
Medicine	*Combretum molle*	15.0	*Commiphora africana*	20.0	*Commiphora africana*	20.0
	Commiphora africana	15.0	*Kigelia africana*	30.0	*Kigelia africana*	35.0
	Markhamia obtusifolia	15.0	*Markhamia obtusifolia*	20.0	*Zanthoxylum sp*	30.0
	Ozoroa insignis	55.0	*Zanthoxylum sp*	15.0		
Fence	*Acacia senegal*	28.3	*Acacia senegal*	25.0	*Acacia senegal*	25.0
	Albizia petersiana	15.0	*Albizia petersiana*	10.0	*Albizia petersiana*	10.0
	Albizia versicolor	11.7	*Albizia versicolor*	16.7	*Albizia versicolor*	16.7
	Commiphora africana	1.7	*Commiphora mosambicensis*	13.3	*Commiphora mosambicensis*	18.3
	Commiphora mosambicensis	15.0	*Dalbergia boehmii*	8.3	*Dalbergia boehmii*	3.3
	Dalbergia nitidula	11.7	*Dalbergia nitidula*	8.3	*Dalbergia nitidula*	10.0
	Julbernadia globiflora	5.0	*Julbernadia globiflora*	3.3	*Julbernadia globiflora*	1.7
	Lonchocarpus eriocalyx	11.7	*Lonchocarpus eriocalyx*	15.0	*Lonchocarpus eriocalyx*	15.0
Carving wood	*Acacia senegal*	25.0	*Acacia senegal*	18.3	*Acacia senegal*	25.0
	Albizia petersiana	13.3	*Albizia petersiana*	6.7	*Albizia petersiana*	8.3
	Albizia versicolor	18.3	*Albizia versicolor*	21.7	*Albizia versicolor*	15.0
	Commiphora mosambicensis	10.0	*Commiphora mosambicensis*	10.0	*Commiphora mosambicensis*	13.3
	Dalbergia boehmii	6.7	*Dalbergia boehmii*	11.7	*Dalbergia boehmii*	10.0
	Dalbergia nitidula	6.7	*Dalbergia nitidula*	6.7	*Dalbergia nitidula*	10.0
	Julbernadia globiflora	1.7	*Julbernadia globiflora*	3.3	*Julbernadia globiflora*	5.0
	Lonchocarpus eriocalyx	18.3	*Lonchocarpus eriocalyx*	21.7	*Lonchocarpus eriocalyx*	13.3
Wild fruits	*Rhus natalensis*	15.0	*Lannea schweinfurthii*	33.3	*Lannea schweinfurthii*	15.0
	Stychnos sp	50.0	*Vangueria infausta*	15.0	*Stychnos sp*	16.7
	Vangueria infausta	16.7	*Ximenia caffra*	18.3	*Vangueria infausta*	18.3
	Terminalia mollis	18.3	*Terminalia mollis*	33.3	*Ziziphus sp*	18.3

.15