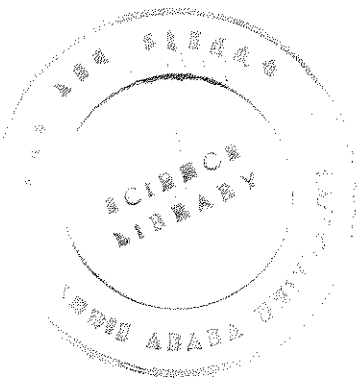
ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

WILD PLANT USE BY LOCAL COMMUNITIES WITHIN THE "KWAKUCHINJA" WILDLIFE CORRIDOR IN TARANGIRE-MANYARA ECOSYSTEM, TANZANIA

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, ADDIS ABABA UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN DRYLAND BIODIVERSITY

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DEDICATION

"EBENEZER"



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ABSTRACT

The study was undertaken to investigate the utilization of wild plants by local communities along the Kwakuchinja wildlife corridor in Tarangire-Manyara ecosystem, Tanzania. To accomplish this, an ethno-botanical survey was carried out in the two villages found within the corridor, Minjingu and Vilima Vitatu. The surveys involved an assessment of plant use, preferred species and their availability. This was combined with vegetation study. Ecological stand parameters inside and outside the National Park were compared and related to the level of exploitation. This was done with special observation on the mentioned useful plants encountered in the field. Data analysis was aided by Computer Programs and Statistical packages including INSTAT, Microsoft excel and SPSS V11. The vegetation study revealed that the wood component in the study area was dominated by the genera Acacia, with highest abundance of *Acacia tortilis* and *Acacia kirkii*, while the field layer was predominantly *Dactyloctenium aegyptium* and *Themeda triandra*. These were interspersed with a tree/shrub layer of *Maerua triphylla* among others. During ethnobotanical survey, 64 useful plant species were mentioned out of which only 24 were encountered in vegetation survey. The uses were altogether classified into eight categories and major uses were medicinal, construction, firewood and food. As expected, there was a clear pattern of species diversity following the level of disturbance, whereby plots closest to settlements, hence highest disturbance, had lowest diversity index and those relatively at a distance, with intermediate disturbance had comparatively the highest diversity. This pattern aligns with the Intermediate Disturbance Hypothesis, which states that diversity will be highest at sites that have had an intermediate frequency of disturbance and will be lower at sites that have experienced very high or very low disturbance frequencies.

1.0 INTRODUCTION

1.1 Background

Tanzania has one of the richest flora in tropical Africa. Lowlands, highlands, inland lakes and a variable climate produce a multitude of biotopes: (semi-) deciduous or humid forests, Savannah and steppe, Miombo forests, all contribute to that exceptional biodiversity. Recently, the Eastern African Afromontane area is included as a global biodiversity hotspot. Because of the large number of species it contains, Tanzania has been termed a megadiversity country (WCMC, 1992). Based on plant distribution, Tanzania has the highest biogeographical regions (phytochoria) in Africa. These include Zambezian-Congolian region, the Somali-Maasai region, the Afromontane archipelago-like region, the Lake Victoria region and Zanzibar-Inlambane region (VPO, 1998). Tarangire National Park and Kwakuchinja wildlife corridor form part of the Somali-Maasai biogeographic region. Ranking the second out of the 48 countries of Afrotropical realms, Tanzania has a total of not less than 10,000 distinct indigenous vascular plant species, out of which 10% are endemic (Mwalyosi, 1993; Mahunnah and Mshigeni, 1996; Walter and Gillet, 1997). The first country is South Africa which had a record of 20,000 species (Stuart *et al.*, 1990).

Dwindling of wildlife resources in Tanzania has been linked to human actions. Over 90% of the Tanzanian population depends on plant biodiversity for different uses (Mwalyosi, 1993; Mahunnah and Mshigeni, 1996). Tanzania has an estimated forest and woodland cover of 335 000 km^2, of which almost two-thirds is on public lands (Kihiyo, 1998 in IIED and TRAFFIC, 2002). Approximately 130 000 km^2 are gazetted forest reserves, including some 16 000 km^2 of catchment areas and over 800 km^2 under plantation forestry (FAO 1993; Kihiyo 1998 in IIED and TRAFFIC, 2002). It is estimated that deforestation continues at around 3500 to 5000 km^2 per annum (Ahlback 1988). Causes of deforestation are mainly heavy pressure from agricultural expansion, livestock grazing, wildfire, over-exploitation of wood resources for various purposes and other human activities.

The term "wild" when applied to plants or plant species refers to those that grow spontaneously in self-maintaining populations in natural or semi-natural ecosystems and can exist independently of direct human action (FAO, 1999). Useful wild plants are the trees, flowers, and grasses, vines and bushes and even the weeds from the lawn to as far as the wilderness. They're what ancestral ties ate and solely used to treat the sick and make their tools. They're still used currently and will be used in the future as renewable sources of oil, fuel, food, pharmaceuticals, and more. Wild plants are vital link to life and they are among the most important resource for the future. The term is contrasted with "cultivated" or "domesticated" plants or plant species that have arisen through human action, such as selection or breeding, and that depend on management for their continued existence. Domestication developed out of food gathering, which almost imperceptibly led to cultivation. It is a long and complex process, and many plants are found in various stages of domestication as a result of human selection, however slight. Many species, especially trees, are widely planted, although genetically and culturally in a nearly wild state. For example, in Borneo, mangoes (*Mangifera indica*) have a long history of semi-cultivation along rivers (FAO, 1999). Trees whose fruits are preferred are planted in the vicinity of houses. At a later stage, trade or exchange of fruit or seedlings occurs among villages. Depending on the degree of human intervention or management involved, there is a complete spectrum between completely wild and completely domesticated species and therefore the clear cut distinction is not an easy one to make.

Throughout the world, and more especially in developing countries, wild plants make an important contribution to the life of local communities. They play a significant part in a wide range of agricultural systems as a source of wild foods and fuelwood, and they have an important socio-economic role through their use in medicines, shelter, fibres and religious and cultural ceremonies. In most societies the use of wild plants forms part of traditional or indigenous systems of knowledge and practice that have developed and accumulated over generations. These systems form the basis of local-level decision-making in agriculture, food production, human and animal health and natural resource management (Slikkerveer, 1994). However, wild resources are often ignored and receive little recognition from the development community (Scoones *et al.*, 1992). Moreover, little systematic knowledge has been gathered on the uses of wild plants and they tend to be ignored in considerations of farming systems by

extension workers, policy-makers and economists. As suggested by FAO report on the Use and Potentials of Wild Plants (FAO, 1999) the reasons for this neglect centres around:

- lack of information about the extent of their use and importance in rural economies;
- lack of information, especially statistics, concerning the economic value of wild plants;
- lack of information and reliable methods for measuring their contribution to farm households and the rural economy;
- lack of world markets, except for a small number of products;
- irregularity of supply of wild plant products;
- lack of quality standards;
- lack of storage and processing technology for many of the products;
- bias in favour of large-scale agriculture.

Angelo (2001), classified wild plant use of the Pare community in the Northern Tanzania into medicinal use category, firewood use category, charcoal use category and edible use category of which medicinal group ranked the first while edible use category ranked the second in terms of number of plant species being used. The threatened plant species in Tanzania is estimated to be 4.4% (Walter and Gillet, 1997), some being at the verge of extinct even before their uses are identified (UNEP, 1991, Tolba *et al.*, 1992).

The physical and socio-economic conditions in wildlife areas generally imply that sources of employment, income and subsistence are scarce and livelihoods are insecure for the majority of populations. Most wildlife areas are rural economies where the dominant mode of production is subsistence mixed agriculture, supplemented by wild resource utilization especially in times of scarcity. In search of secure livelihood, people engage in a range of economic activities which have impact on wildlife. The nature of activities by which people generate income and subsistence provide the economic context within which communities conserve or destroy wildlife. Local communities around national parks depend on biodiversity

for food, medicines, building material, income, ecosystem services and cultural and spiritual needs. Faced with a diminishing resource base and increasing human population, conflicts between local people and conservation authorities have continued to escalate. With poverty, opportunities for short-term gain are selected over environmentally sound local practices.

The Tarangire ecosystem is a vibrant and important ecological stronghold for the wildlife and people of northern Tanzania. Encompassing approximately 20,500 km², Tarangire supports two major national parks (Lake Manyara and Tarangire), several game controlled areas (professional sport hunting areas), and many local communities (village lands). Large herds of zebra, wildebeest, buffalo, eland, and elephants as well as other species such as hartebeest and oryx move throughout the ecosystem traversing a variety of land use zones including prime conservation, hunting, agricultural, and livestock grazing areas. Tarangire National Park (2600 km²) was officially declared in 1970 due to its importance as a dry season grazing refuge for large herbivores. Tarangire is one of a few protected areas providing significant income to the Tanzanian National Parks authority. Plant loss and consequently a decline in wildlife could see a corresponding decline in tourism and revenue, and hence research work to support conservation efforts to the Tanzanian protected areas is essential.

The Convention on Biological Diversity specifically mentions wild species such as crop relatives and those of medicinal and agricultural value in the indicative list of categories of the components of biological diversity to be identified and monitored (Convention on Biological Diversity, 1994).

1.2 Problem Statement

The Kwakuchinja wildlife corridor was kept open due to pastoral activities of three main ethnic groups - the Masaai, Mbugwe and Barbaig. The corridor connects Tarangire and Lake Manyara National Parks in Tanzania. The overall trend shows more and more land is being settled, cultivated and fenced. Land under cultivation in the Kwakuchinja corridor has increased from 1,980 ha in 1987 to 6,308 ha in 1998 when the proportion of area utilised for cultivation was 16.4% (IUCN, 2004). Recent land reform in Tanzania has meant that many of the settlers have legal title to the land they have occupied. The net result is that much of the Kwakuchinja corridor can no longer be utilised by wildlife. If the current trend continues,

Tarangire National Park will be cut off from its northern dispersal areas including Manyara National Park. Of the nine main migratory routes identified during the 1960s emanating from Tarangire National Park to the dispersal areas, four have been blocked or partially blocked by settlements and cultivated areas, implying an increase of human impact (Byarugaba, 1988). Wildlife corridor acts as a source of connectivity between two isolated habitat patches, making a natural landscape more confluent. Like other wildlife corridors, the Kwakuchinja corridor has a number of advantages, including increased foraging area for a wide range of wildlife species, increased immigration rate between population which could maintain diversity, increase population size and decrease probability of extinction, and prevent inbreeding (Bennett 1990), allow an escape of refuge from predators, fire and other disturbances.

The importance of open wildlife routes from Tarangire National Park to the dispersal areas has been well documented. However, there is limited or no indication of presence of any viable data and interpretation to quantify the impacts of indigenous plant use within the Kwakuchinja wildlife corridor. Moreover, it is acknowledged that arid lands in general lack serious ethno-botanical works (Wickens *et al.,* 1985; Allan and Warren, 1993; Bie and Imevbore, 1995).

The study and conservation of biological diversity as a whole and plant diversity in particular is of subtle importance due to the fact that the resources make numerous valuable contributions to the development and well being of humans in various ways. For example, when species are lost, their economic and evolutionary potential is as well lost and so is their role in supporting ecosystems in which they occurred. Projections based on habitat loss suggest that if the current deforestation trend continues, some 5% - 10% of the world's species will be lost per decade over the next 30 years (Bibby *et al.*, 1988 in Mwalyosi 1993). Changes in species composition of an area can reduce its ability to provide foreseen ecological services (Mwalyosi, 1993).

Ethnobotany remains the leading tool in finding out how people have traditionally used plants (Martin, 1995; Balick and Cox, 1996). Despite the indispensability of the plant biodiversity to the Tanzanian population, no thorough ethnobotanical studies have been conducted in the country. In the context of conservation and sustainable and equitable use of wild plant

resources, quantitative ethnobotany can contribute to the scientific base for management decisions. For this reason, this study was undertaken.

2.0 OBJECTIVES OF THE STUDY

2.1 Main Objective

To study the wild plant use by local communities in selected villages within Kwakuchinja wildlife corridor in Tarangire-Manyara ecosystem and their impact on plant diversity.

2.2 Specific Objectives

- To inventorise useful plant species in the study area
- To assess plant species composition, diversity and abundance in and outside the park
- To assess the impacts of human use on plants
- To investigate the local practices which have impacts on biodiversity conservation

2.3 Hypotheses

- There is significant difference in pattern of plant diversity in the study area in relation to human influence.
- The local practices have significant impacts on biodiversity conservation
- The level of threats to plants differs with the type of use

3.0 LITERATURE REVIEW

Studies have indicated that numerous factors affect the structure and composition of dry woodlands and the Tarangire ecosystem in particular. These include both abiotic and biotic factors. Abiotic factors include edaphic components such as nitrogen or phosphorus concentrations (Stromgaard, 1992; Chidumayo, 1994) and disturbances such as fire (Kikula, 1986; Chidumayo, 1988). Among the biotic factors, there are those caused by natural processes of the ecosystem, for instance damage by herbivores such as elephants (Campbell *et al.*, 1996) and anthropogenic factors, of which wild plant use is considered. The main wild plant use include, among others, charcoal production (Monela *et al.*, 1993), collection of fuelwood (Abbot and Homewood, 1999) and cutting of building poles (Luoga *et al.*, 2000). Anthropogenic factors give cause for the greatest concern with respect to maintenance of wild plants / forest diversity. Wild animals such as elephants might have a dramatic adverse effect on the regeneration of some species as well (Guy, 1989; Western and Gichohi, 1993). However compared to human populations, elephant populations are relatively stable or declining in most areas whereas human populations are growing rapidly.

3.1 Wild Plant Use World-wide

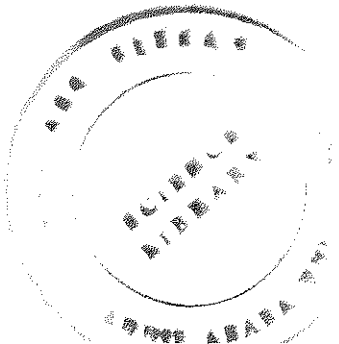
Throughout the world, many thousands of plant species are used in human activities. About 5,000 have been cultivated at one time or another, but of the 250,000 to 300,000 known higher plant species, only a few hundred species have been fully domesticated and enter world trade (Heywood, 1999).

Thousands of species grown locally are scarcely or only partially domesticated and many thousands more are gathered from the wild. Most of the partially domesticated or wild-collected species are found in the tropics. For example, the project on the Plant Resources of South-East Asia (PROSEA) records nearly 6,000 species in its basic list of species (some of them exotic) used by humankind in that region, and assuming similar levels in other tropical regions, a figure of 18,000 to 25,000 species can be extrapolated for the tropics as a whole (Heywood, 1999). In addition, several thousands plant species are used in human activities in

the Mediterranean and temperate regions of the world. Also it has been estimated that there are 25,000 different species that have been used or are still in use as herbal medicines in various parts of the world, especially China, tropical Asia, the Indian subcontinent, Africa and Central and South America, and the many thousands of species grown as ornamentals in parks and in public and private gardens and in the horticultural trade (Heywood, 1999). Estimates of higher plants species used in traditional medicines ranges from 35,000 – 70,000 (Bronner, 1990).

The contribution of wild plants to household economies depends largely on individual circumstances. Wild plants may help to meet minimal subsistence needs or may be used as luxuries; if an excess is gathered it may be used for barter, for sale in local markets or for trading as small business. In Turkey, for example, widely diverse wild plant foods (including many wild mushrooms) are collected for personal and home consumption. On the Greek island of Crete, for example, about 200 wild species are eaten and "mountain greens" are a frequent item on menus both at home and in restaurants (FAO, 1999). They are collected in the wild by local peasants who not only consume them themselves but bring them to market for sale to supplement their income. On the Italian island of Sicily, 24 wild Brassicaceae from 16 genera are occasionally exploited as vegetables (FAO, 1999). Wild foods are of great importance to the rural poor living in the vast area of southern and East Africa covered by nutrient poor, drought susceptible sands of the coastalplain along the east coast (which stretches from Somalia to South Africa, the Namib coast to the west and the Kalahari sands region in the centre).

About 90% of the people of Africa rely upon fuelwood, which is the second major cause of deforestation throughout the developing world (UN, 1994). Fuelwood, comprising of firewood and charcoal, supply the energy needs of numerous industries and small business in the third world. Medicinal plants constitute one of the most important groups of wild plants in terms of their contribution to the economy and well-being of farm households. It has been estimated by the World Health Organization (WHO) that 80 percent of the developing world's population meets its primary health care needs through traditional medicines. In China, for example, about 1 000 million people, both urban and rural, depend largely on plant-based medicines.



About 800 million inhabitants of South Asia rely on herbal medicines. In India traditional health care systems, such as Ayurvedic, Unani, Siddha and Tibetan medicine, run in parallel with the modern health-care sector, while the Sri Lankan Government has a Ministry of Indigenous Medicine which has set up medicinal plant nurseries. Despite the acknowledged importance of medicinal plants to both the global economy and local household economies, their use is generally poorly organized and poorly regulated, and most are still exploited with little or no regard to the future (Srivastava *et al.*, 1996).

The use of wild-harvested plants varies considerably. It may be used in small quantities by pharmaceutical companies looking for specific active compounds that may eventually lead to the development of new drugs, the fact that many modern day drugs owe their origin to plants (Bell, 1993); or large quantities may be needed.

When the harvested material comprises rare endemic species that only occur in small populations and are not cultivated, a serious problem arises, as in a recent case in the United States where the extraction of the anti-cancer drug taxol from the Pacific yew, *Taxus brevifolia*, threatened to destroy the forests where it grew (WWF, 1993).

3.2 Wild Plant Use in Tanzania

Major findings from the different surveys undertaken indicate that the level of dependence on forests, woodlands, and bush areas and the uses for indigenous trees varies considerably from region to region, district to district, sometimes even from village to village. There is a diverse range of ways that people exploit wild plant species such as for fuelwood, fodder, medicine, fruit, building materials, honey, household items, land improvement, and rituals. In other areas, the reliance on the forest, the retention of important trees, and the planting of indigenous species is less significant. However, in general, people in Tanzania still rely heavily on wild plants and surrounding forests for both subsistence needs and as a source of income. In many areas people would have difficulty surviving if they had to depend only on cultivated land for food, fuel, and cash income.

3.2.1 Fuelwood

In Tanzania firewood is the main source of energy for rural households, and is an important source of cooking fuel in towns. In rural areas many people rely solely on firewood for cooking and other household tasks. In urban areas people rely less on firewood and tend to use more charcoal. However, most urban households use more than one type of fuel. For example in Iringa, approximately 55% of the population use charcoal for cooking, 33% uses wood, with the remainder using kerosene and electricity (Hines 1991). Small scale charcoal production is a significant source of income for many small farmers, predominantly men, as well as a significant cause of deforestation, notably the Miombo woodlands (ESMAP, 1988).

3.2.2 Construction

In most rural areas of Tanzania forests are still the main sources of supply materials for constructing houses, fences, and cattles/livestock enclosures. Even though house construction styles are slightly different in various regions of the country, and they are changing in some areas, the majority of rural people still rely on local forests for their house construction needs. The preferred species tend to vary according to availability and the specific use within the construction scheme. Some of the highly preferred species for building materials include: *Acacia mellifera, Dichrostachys cinerea, Bridelia micrantha, Dalbergia arbutifolia, Prunus africana,* and *Olea capensis* (Campbell, 1996).

Timber is generally sawn into boards and used in house construction (rafters, doors, and frames), for furniture, and for other constructed items. Often timber is sold directly to the consumer at the pitsawing site.

In most areas, including the study area, men are responsible for constructing and maintaining structures. Rural households do not normally buy building materials for their own use; they just collect building materials from the forest. However, there is some selling of building materials but this is generally not within the village but to traders who take the materials to town.

3.2.3 Fencing

Live fences are grown around houses and home gardens. The cost of live fencing is low, and apart from some attention during initial growth stages, the fence continues to grow on its own. With properly selected species the fence can be a source of fuelwood, medicine, fruit, food or other useful household products. Highly valued species for live fences are *Euphorbia tirucalli, Albizia harveyi,* and *Commiphora africana.* Others include *Acacia tortilis, Acacia mellifera, Acacia xanthophloea, Markhamia obtusifolia* and *Ficus sycomorus* (FAO, 1999). Species used for fence poles include *Dichrostachys cinerea.*

3.2.4 Fodder

Livestock keeping is an integral part of most household production systems in Tanzania. Herds are generally considered to be a source of security for future and unexpected needs. Trees from forests, woodlands, farms, and fallow land are primary sources of fodder and are instrumental in supporting the livestock population of Tanzania. Some highly preferred species for fodder production include *Acacia albida, Vitex payos* and *Ficus sycomorous.* Animals are generally free grazing, though increasingly villages are introducing zero grazing laws requiring tethering and cut-and-carry systems. In many areas free grazing still inhibits tree planting, even in agroforestry systems. In some areas, for example Babati district of Arusha, the adoption of zero grazing on a large scale is unlikely for the foreseeable future due to the uncertainty of fodder crop production, the length of the dry season, and the availability and cost of labour (Johansson 1992).

3.2.5 Domestic Items

Raw materials from the forest are used to make a wide range of products that can broadly be classified as household utensils, tools, and equipment. Many different species are used to make tools and utensils that meet day-to-day household needs. However, the use of species for household utensils and tools is often not recognized, and it is portrayed from the fact that it is not mentioned by the community itself in the list of wild plant use. But a considerable amount of wood is used in these items. These are things like stirring sticks, pestle, mortar, rolling pin,

spoon, axe handle, hoe handle, spade handle, walking stick, bow, arrow and spear. Highly preferred species for domestic uses include *Rauvolfia caffra, Albizia harveyi, Teclea nobilis, Grewia bicolor,* and *Cordia sinensis* (FAO, 1999).

3.2.6 Beekeeping

There are two main groups of people who collect the products of honeybees in Tanzania. These groups are: the beekeepers, who make hives out of barks, logs or straw; the honey hunters, who collect the bee products from the natural nesting places of the honeybees, which may be some hollow trees or cavities in rocks (MNRT, 2003).

Traditional beekeepers make their living from the forests where hives are put on carefully selected trees. Honey is a uniquely exploited product in that it does not compete with other land uses, or cause land degradation, although forest fires caused by fires escaping from honey harvesting has been mentioned as an adverse effect of traditional beekeeping practices. Hives are made of hard durable species such as *Commiphora eminii, Rauvolfia caffra, Acacia albida* and *Ocotea usambarensis*. They are usually hung in trees that are easy to climb, and are not too large or soft. Species highly preferred by bees for gathering nectar include: *Afzelia quanzensis, Rauvolfia caffra, Commiphora ugogoensis, Albizia gummifera, Grewia spp., Parinari excelsa, Syzygium guineense,* and *Ficus sycomorus* (Hines, 1993).

3.2.7 Medicinal Plants

Traditionally, rural African communities have relied upon the spiritual and practical skills of the traditional medicinal practitioners (TMPs) whose botanical knowledge of plant species and their ecology and scarcity are invaluable. Throughout Africa, the gathering of medicinal plants was traditionally restricted to TMPs or to their trainees. Hedberg (1982) observed that the number of traditional practitioners in Tanzania was estimated to be 30,000 – 40,000 in comparison with 600 medical doctors by then. Most remedies in traditional medicine are prepared from various natural substances, animals and vegetables/plants. The plant remedies account for about 90% of all remedies used for treatment (Chhabra 1984). Weenen (1990) estimated more than 60,000 traditional healers in Tanzania.

3.2.8 Wild Food Plants

Wild food plants are plants with edible parts growing naturally on farms, fallow or uncultivated land. Wild plant food ranges from leaves, seeds, nuts, fruits, roots and tubers. Some may be eaten raw, while others require complicated processing. All these provide essential elements in the human diet. A study by Fleuret (1979) revealed that 81% of vegetable side dishes in Tanzania comprised of wild species and 17.7% of introduced or cultivated vegetables. Moreover, wild plants appeared in 32% of all meals. The contribution of forest foods to household diets seems to vary tremendously from area to area. In most cases, no household depends entirely on wild sources throughout the year, although in periods of famine wild gathered plants may tide the community over (FAO, 1999).

3.3 Threats to useful Wild Plants in Tanzania

Among the major threats to useful wild plants include expansion of agricultural land, uncontrolled exploitation of available wild species and increased incidences of bush fires (Barrow, 1996). The limited supply of resources and increasing demand to meet the needs of a growing population and growing aspirations of the people is also one of the main threats to biodiversity in Tanzania. The country's economy and national policies that lead to the destruction of ecosystems and natural resources is yet another threat to the biodiversity of the country which in turn poses a threat to the useful wild plants. In many areas of Tanzania, people who were once involved in charcoal making have been forced to look for alternative sources of income, because of over-exploitation of the woodlands and a lack of raw material but also in some areas charcoal burning is banned completely, including this study area, Kwakuchinja. The high demand for building materials puts considerable pressure on natural forests, especially those near villages and towns. Poles can be removed from forest reserves for personal use without a license and free of charge. Studies in Tanzania indicate the disappearance of well-known timber species. For example in some places it is revealed that farmers have not used *Prunus africana, Ocotea usambarensis* or *Olea europaea* ssp *cuspidata* for more than 5 years (FAO, 1999). Also, in medical field, collection of large quantities of some species of interest for research in search of cure for incurable diseases such as HIV/AIDS cause threat to those species (Tesha, 1991). The harvesting mode may also be a threat to sustainability of plant species. When harvesting involves total de-barking/ ring

barking (debarking all around the tree trunk) of the individual plants or by obtaining the roots there is an effect of killing the trees and could be disastrous where only few individuals of the species are present. Removal or damage of reproductive individuals may have the greatest impact on population growth in slow growing tree species. Studies have indicated that damaging harvesting methods affect resource populations equally or more than the actual removal of plant parts (Sinha, 2000). Disappearance of useful species in a local area/ environment is more of a threat to destructively harvested species (bark, roots, bulbs, stems/ woods); slow growing species, most popular in terms of use (species in highest demand).

3.4 Biodiversity in Drylands: Opportunities and Challenges

Dryland ecosystems cover extensive land areas stretching across more than one third of the earth's land surface. They are found on all continents in both the northern and southern hemispheres. They are the habitat and source of livelihood for about one quarter of the earth's population. It is estimated that half of dryland ecosystems are economically productive as range or agricultural land (CCD Secretariat, 1997). Dryland species and ecosystems have developed unique strategies to cope with low and unreliable rainfall. They are highly resilient and recover quickly from prevailing disturbances such as fires, herbivore pressure and drought. These attributes have great significance for the global system, especially in the context of climate change. The origins of many of the earth's most important food crops are found in drylands. For example, maize, beans, tomato and potatoes originate from the drylands of Mexico, Peru, Bolivia and Chile. Millet and sorghum, and various species of wheat and rice come from the African drylands. Also dryland people have engineered pastoral and farming systems, which are adapted to these conditions (SBSTTA, 1999).

The main threats of drylands and major cause of environmental degradation in Africa are centered on poverty-induced overexploitation of the land area (Barrow, 1996). These include:

(i) overcutting of trees and shrubs for fuel and building material;

(ii) encroachment of agriculture on grazing lands (marginal to cropping but high quality for wild or domestic animal grazing),

(iii) urbanisation, mining and industrialization with increase in demand for charcoal, other wood products, construction gravel and soil, and other natural resources

Degradation of habitats due to changes in land use is the immediate most serious threat to dryland biodiversity. Despite differences between various dryland ecosystem-types caused by differences in levels of aridity, topographic elevation, geological and biological conditions, these ecosystems have in common a unifying characteristic: precipitation is low and extremely variable (Barrow, 1996).

3.5 Biodiversity in Tanzania

Biodiversity in Tanzania provides a wide range of benefits, which are important at global, national, and local levels. These benefits constitute of consumptive and production use values. Consumptive use values are products, which are directly used while productive use values encompass commercial use of wildlife, wood and non-wood forest products. Indirect benefits from forest based biodiversity entail non-consumptive use values, option values and existence value.

3.5.1 Direct Benefits

Some of the direct benefits from forest based biodiversity products include wood fuel, building poles, lumber and other non-wood forest products like wild foods, honey, fodder and recreation. As an example, MNRT (1994) estimated that the value of forests at national level is at US$ 750 per ha. This calculation is based on the royalties collected, exports and tourism earnings. However, other direct use values and benefits accruing to local communities are not included in this; therefore it is most likely below the actual figure, but still gives an idea about the partial economic value of a unit area of the forest.

MNRT (1989) also estimated 24.4 million cubic meters per year as the projected sustainable yield from 23.8 million hectares of forest reserves gazetted for production purposes. Furthermore, it is estimated that the miombo woodlands contribute about US$ 1,050 per ha at local level (MNRT 1994). This is based on the value of sustainable wood harvesting, beekeeping, fruits, mushrooms, game meat, medicinal products, tobacco curing and water conservation. At local level, forest resources provide benefits in the form of livelihoods, which are often limited and uncertain. Forests have high value for local population and are often sources of income, subsistence and services, which are unavailable or unaffordable elsewhere.

3.5.2 Indirect Benefits

Tanzanian forests have high potential for recycling and fixing of carbon dioxide (sequestration) and conservation of globally important biodiversity. These vital ecological services, which protect natural and human resources, act as sink for wastes and residues and maintain essential life support functions both for the local and global communities. The direct economic value (US$ 750) of the forest per unit area is estimated to increase up to US$ 1,500 per ha at global level when these indirect values are added onto national values (VPO 1998). However, the value of the services offered by forests grows day after day as more and more forests are put under threat because more countries and communities realize their implications for economic growth and for development.

Moreover, forests provide watershed services through fulfilling water catchments functions vital for human and animal populations, agriculture, industry, energy production and maintaining other plant species. For instance rivers for the major hydropower supply in Tanzania (Kidatu and Mtera dams - Ruaha/Rufiji rivers and Pangani falls and Hale - Pangani river) have their catchments in the Eastern Arc forests. The Eastern Arc forests are also important for large-scale agriculture (the main estate crops being coffee and tea) as well as for other cash crops such as cardamom and *Cinchona* spp. The agricultural areas surrounding these forests have productive soils, and their climatic properties are responsible for their importance for large-scale agriculture (MNRT, 1994). In this way forests contribute to agricultural stability by regulating water balances, protecting the soil and pollinating crops.

Forest based activities also provide about 730,000 person-years of direct and indirect employment (MNRT 1989). There are enormous benefits that accrue to local livelihood. Regarding existence value, it is pleasure to know forests, animals, etc exist even if we do not use or see them because they have the right to live on the earth. Apart from this, potential values of biodiversity are still not fully known at present, hence there may be other option values which are yet unknown.

3.5.3 Major Problems of Biodiversity Conservation in Tanzania

Maganga (1994 in MNRT 2004) indicated that some of the major problems of biodiversity conservation in Tanzania are caused by ecological isolation of protected areas, fragmentation of protected areas, introduction of new species into protected areas, and overexploitation of plants and animals. Other problems are lack of coordination and linkages between institutions, unclear policies and laws, low capacity in forest management, lack of access and ownership to forest resources, and lack of strategy to involve participation of local communities and private sector.

- *Ecological isolation of protected areas*

Due to rapid population increase, large areas, which were once wild lands, are now either farm lands or grazing lands. Hence, protected areas are surrounded by human settlement to the extent that some have been ecologically isolated while others are becoming ecological islands. Examples are the Tarangire and Manyara national parks. Likewise, most montane forests are ecological islands because the forests on the lower slopes have been cleared for settlement, agriculture and forest plantations. The major effects of ecological isolation of wildlife or forest areas are the decline of species (Newmark *et al.*, 1991). There may also be local extinctions of especially rare species and small populations as habitats become more isolated. Because of discontinuous habitat, dispersal of both animals and plants becomes difficult, and this has more effect on amphibians and reptiles than mammals and birds. Habitat isolation also reduces plant diversity and quality and hence animal diversity also gets affected.

- *Fragmentation of protected areas*

Activities such as agricultural development, logging, mining, and construction of roads and railways are some of the factors leading to fragmentation of protected areas. Fragmentation reduces the effective area of habitats and divides plant and animal populations into smaller isolated populations that become viable to local extinctions due to natural decimating factors and catastrophes. Fragmentation of an ecosystem also creates gaps that become barriers preventing the dispersal or migration of animals and plants. Good example is the fragmentation of Selous Game Reserve and the Magombero Forest Reserve in Tanzania due to construction of the Tanzania-Zambia railway (MNRT, 2003).

- *Introduction of new species in protected areas*

Also known as enrichment planting, the introduction of new species into an area is usually done to increase diversity of species, to control other species or to act as nursing species especially for plants. Both the forest and wildlife policies of Tanzania state on the need to rehabilitate certain habitats by introduction and re-introduction of particular floral or fauna species, respectively. However, these introductions are implemented with limited information on performance and behaviour of the species in the new environment. Examples are the introduction of *Maesopsis eminii* in East Usambara forests, which has become a pest species of the environment. Other species in East Usambara invading the forest to the detriment of biodiversity are *Millettia dura*, *Rubus rosifolius* and *Lantana camara* (Sheil, 1994).

- *Over-exploitation of plants and animals*

The exploitation of plants, both legal and illegal, threatens the future existence of species. Felling of trees for poles, timber firewood and charcoal making depletes plant diversity, particularly of the most demanded species. Wild animals are thus affected by habitat modification due to clearing of vegetation and also directly by harvesting of the animals by legal and illegal killing. Examples are the declining number of elephants (*Loxodonta africana*) and the local extinction in some protected areas of the rhinocerous - *Diceros bicornis* (MNRT, 2004). In forestry, law against exploitation protects some tree species which have been over-exploited and which are endangered and liable to extinction (MNRT, 1994).

- *Lack of coordination and linkages between institutions*

There is a weak linkage between the Forestry and Beekeeping Division and the Local Governments. Regional forest officers usually involve themselves in similar responsibilities (e.g issuing of license) and this may result into over exploitation of the resource. An example is the Chome catchments forest in Same district which is simultaneously supported by JICA (Japan), NORAD (Norway) and the East Africa UNDP/GEF Cross-border project. The three donors have no direct links with each other and lack coordination in implementing their programs (Kamukala and Shauri 2000 in MNRT 2004). Cross-sectoral issues, such as between ministries, are covered in various policies but no details are given on the mechanism of coordination.

- *Unclear and conflicting policies and laws*

Some policies of different sectors conflict with each other regarding ecosystem conservation and management (FAO, 1996). Also some policy statements are unclear and have not been harmonized. The link between policies and the existing laws in some cases makes implementation of the policies difficult. Delays in updating legislation to march with new policies also affect implementation of the policies.

- *Low capacity in forest management*

Due to inadequate human resources and funding, there is inadequate administrative and technical guidance from central and local government authority which leads to increased destruction and degradation of forest ecosystems. The compulsory retirement of government employees including those in forestry has had significant effects on the management of forests. Inadequate and less motivated staff and lack of equipment and funds are obstacles to activities pertaining to surveys, inventory and preparation and implementation of management plans (FOSA, 2000).

- *Lack of access and ownership to forest resources*

Due to government measures to ban harvesting in forest reserves, access to and user rights have been prohibited. This has reduced the sense of ownership/responsibility, hence entertained illegal harvesting because local communities, which should conserve the forests, may no longer value the resource as their own (Newmark *et al.*, 1993).

- *Inadequate strategies to involve local communities*

Despite that policies on biodiversity have recognized an active involvement and participation of local communities and the private sector, strategies for such participation in the development and management of forest resources are yet to be developed. Indigenous knowledge which is important in controlling and regulating behaviour in relation to resource use, is not yet acknowledged and utilized to enhance biodiversity conservation (Scoones *et al.*, 1992).

3.6 Indigenous Practices and Beliefs which have Impact to Conservation in Tanzania

Through time, forests have been and still are an integral aspect of the social structure, religion, art, history, medicine, and politics of a community. Forests feature, both tangibly and intangibly, in all aspects of daily life. They are viewed as both sources of and protectors against evil and as providers of fortune and power. There are beliefs that certain trees can serve to link the living with their ancestors. Sometimes gifts are given as a means of showing ancestors that they have not been forgotten. Gifts such as flowers or alcohol are placed at the foot of the tree as an offering which is symbolic of giving food to ancestors through the tree.

Use of forests for ritual and spiritual functions differ across Tanzania. The variety of cultural functions are as numerous and diverse as the communities and tribes of the country. In Arusha, *Ficus sycomorus* is believed to bring good luck while in Dodoma it is revered by some as a provider of water. *Euphorbia candelabrum* is used to drive witches from a village. Both *Lannea schweinfurthii* and *Lonchocarpus capassa* are used to rid the body of witchcraft. If someone has been bewitched or has had a disaster, the person boils the roots of *Lannea schweinfurthii* and then washes in the water, which is then poured out at the nearest road junction. The root of *L. capassa* is tied around the leg of the bewitched person. After a certain time the bark of the root is boiled in water and the bewitched person takes a bath in the water. In several areas sacred groves of trees are protected by local people, and are a place to settle disputes. Each community has its own traditions associated with sacred trees, and as a result the species tend to vary greatly. Often-mentioned trees having special cultural significance in localized areas and never cut include *Ficus sycomorus, Syzygium cordatum,* and *Kigelia africana* (FAO, 1999).

3.7 Field Research Methods

Ethnobotanical studies are highly dependent on the effective use of anthropological, botanical, ecological and linguistic methods (Bayafers Temene, 2000). Both qualitative and quantitative methods are vital to collect accurate and relevant data. There are various techniques of inquiry tools for ethnobotanical data, depending on the aims and objectives of the study. These

include interviews, observation and guided field walks (Maundu, 1995). Ethnobotanical information could also be obtained from local names, beliefs, rituals, songs, dances and poems (Zemede Asfaw, 1989; Martin, 1995). There are four basic techniques of collecting data by interrogating with people: open-ended interview, semi-structured interview, structured interview and questionnaires. Several analytical tools are also used for data verification and quantification; these include preference ranking, free listing, direct matrix ranking, utilization survey, relative use value, paired and triadic comparisons (Martin, 1995).

A number of factors determine the research methods to be employed in the field. Major factors in all fields of study include:

- The purpose of the study/survey – data collection varies according to overall aims and objectives
- The scale of the study – very different methods will be required for a survey covering large scope compared to a detailed study of a small area.
- Resources available – methods to be used are determined by the availability of finance, equipment, manpower and time.

Therefore the primary determinant of the sampling design as pointed out by Kent and Coker (1992) should be the overall objectives of the project, time and resources available for study.

4.0 STUDY AREA AND METHODS

4.1 Study Area

4.1.1 Geographical Location

Tanzania is found on the East African Coast approximately between latitudes 1°S to 12°S and longitudes 29° to 40°E. Tanzania has borders with Kenya and Uganda to the north; Rwanda, Burundi and Zaire to the west; Zambia and Malawi to the south-west and Mozambique to the South; while to the east is the Indian Ocean. Out of about 94.5 million hectares total area 88.5 million hectares are on actual land surface, the rest is under water. More than 40% of the country's total land area is covered by indigenous vegetation which is in turn represented as coastal forest, open woodlands, closed mountain forests, wet lands, scrub and bush lands.

Kwakuchinja wildlife corridor is located between Tarangire and Lake Manyara National Parks in Tanzania (Figure 1) and to its full extent is approximately 40,000 hectares in size. The study area is on the part of the corridor bordering Tarangire National Park. Tarangire National Park, with an area of 2600 km², is located in northern Tanzania between latitudes 3° 40'S to 5° 35'S and longitudes 35°45'E and 37° 0'E. It is located 118 km Southwest of Arusha town, and 163 km from Kilimanjaro International Airport.

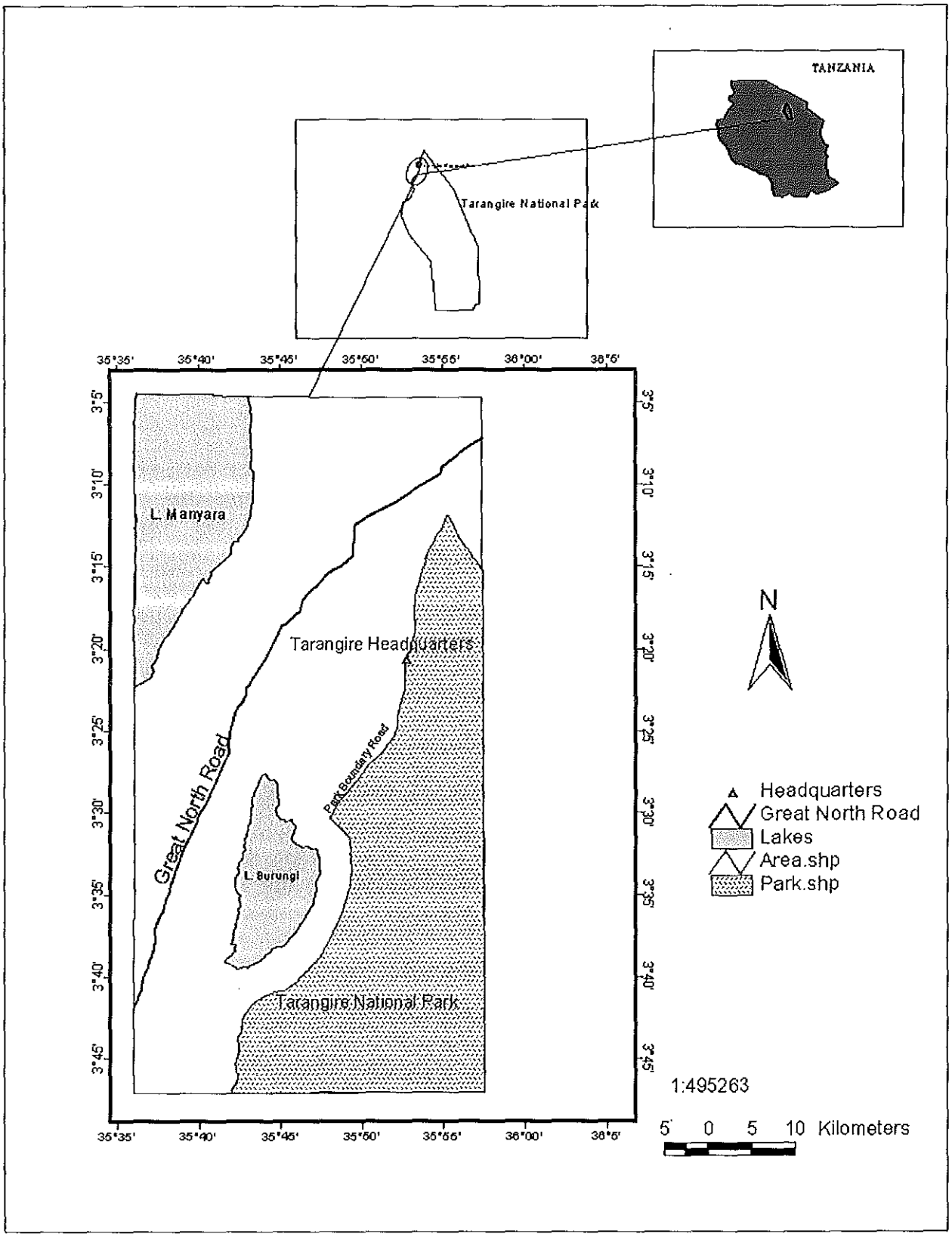


Figure 1: Map of the Study Area (Source: GIS Center, Tarangire National Park).

4.1.2 Climate

Due to Tanzania's varying geographical aspects, the climatic conditions differ. Overall, Tanzania is subject to tropical conditions. The plateau is relatively hot during the day and cool at night, due to its dry and arid nature. The north-west temperature is much cooler and temperate. During the months of June and September, it is much cooler. Minimum temperatures are around 15°C in July. The hottest months are between October and February when temperature can be as high as over 30°C. The dry season runs from June to October, the short rains come in November and the long rains begin in March ending in late May. Climatic diagram was not possible because the rainfall data in the area was not available.

4.1.3 Vegetation

The Tarangire National Park is located in wooded steppe with an arid *Acacia* savanna belt that is dominated by *Acacia* and *Commiphora* species (TANAPA 2004). This makes the area to fall under Somali-Maasai phytogeographical region which is dominated by thickets, woodlands and grassland. The various types of woodland include: *Acacia - Commiphora* woodland, *Acacia drepanolobium* woodland, *Combretum - Dalbergia* woodland and *Acacia tortilis* woodland. Other vegetation types include wetlands and seasonal flood plains, riverine grassland, deep gully vegetation and grasslands with scattered baobab trees (*Adansonia digitata*).

4.1.4 Geology and Soils

Soils are mainly alluvial and in the most part are rich, sandy, clay loams. The valley bottoms are narrow but where flood water and rainfall is impeded, black cotton soils occur.

4.1.5 People and Livelihoods

Three main ethnic groups are predominant in the Kwakuchinja wildlife corridor. These include the Maasai, Mbugwe and Barbaig. However, in recent years agriculturists, land speculators, and people affiliated with the phosphate mine at Minjingu have settled in the area adding to over 30 different ethnic groups with a population growth rate of 3.8% (IUCN, 2004).

In the past, majority of the population was depending on pastoralism. However, over the last 25 years, they have rapidly converted the semi-arid grazing areas to agricultural croplands. Part of their motivation has been to protect their land from encroachment by other ethnic groups, as farmers have more secure land tenure than livestock keepers. Major crops grown include maize, beans, rice and millet. The relative income is less than 1US$ per day (IUCN, 2004).

4.2 Methods

4.2.1 Site Selection

A survey was carried out on the whole strip of the park boundary road that form part of the Kwa kuchinja wildlife corridor. The length of the park boundary road forming the corridor was 21 km, out of which 5 points were randomly picked and belt transects were laid. Transects passed through the park boundary road on either side, from within to outside the park area. This was in order to establish the existing pattern/ trend of vegetation from the park to the open area.

Kwa kuchinja wildlife corridor falls on only 2 villages on Tarangire's side; therefore survey for ethnobotanical data collection was carried out in both Minjingu and Vilima vitatu villages. On choosing the sub-villages for survey within the villages, the level of plant use, representation of the three ethnic groups (namely Maasai, Mbugwe and Barbaig) were considered.

4.2.2 Team Composition

The study involved a number of key resource people. Team members included key informants, representative cross section of the community, selected from each village in collaboration with the local administrators, elders and other community members.

4.2.3 Reconnaissance Survey

The reconnaissance survey to study the area and familiarize with the plant species present in the area of study was conducted prior to the actual field work. A checklist of the useful wild

plants observed was recorded. This time was also used for questionnaire pre-testing and confirming the suitable sampling method for vegetation data collection based on the actual situation.

4.2.4 Data Collection

a) Ethnobotanical Data Collection

A participatory Rural Appraisal technique (PRA), as explained by Grenier (1998), was employed. The PRA techniques employed included semi-structured interviewing, free listing, preference ranking, resource collection, key probes and direct observation. As pointed out by Duangsa (1996), in order to enhance interaction and active participation, the number of participants for the PRA exercise was 20.

Semi-structured interviewing - some pre-determined questions and topics were prepared (Appendix 1 and 3) but also leaving a room for new similar topics of interest to be pursued as the interview develops. The questions were both open ended and closed. According to Newell (1993), open-ended questions allow the individual to respond in any way they wish. The questions were translated to Swahili. The interviews were kept informal and conversational but carefully controlled.

The survey was done in Minjingu (1056 households) and Vilima vitatu (481 households) villages within the "Kwakuchinja" corridor. The sample size in each village was 5% of the total number of households. Therefore a total number of 78 households were randomly surveyed out of which 53 households were surveyed from Minjingu village and 25 households from Vilima Vitatu. Techniques like participant observation and use of checklist were also employed.

Semi-structured interviews in the two villages along the corridor were conducted in order to obtain information on the important/ useful plant species found in the area and their current status, to indicate whether they were declining or increasing over time. Information was also sought about species that have become extinct in the study area and the possible cause of the extinction.

Free listing – 15 informants, mixture of Maasais and Mbugwes, volunteered free listing of the useful plant species. The list involved local names, uses and parts used, and were accompanied with a display of those species which could be located. Different use categories were identified.

Preference ranking – plant species were ranked based on uses starting with the most valuable for the specific use. This showed which plants are highly or least preferred or which have few or more alternatives. Also use categories were ranked from the least destructive to the most destructive.

Pairwise ranking – this was done to determine the plant use category of higher value to the local people; as well as most destructive harvesting method

Voucher collections - Plant samples were used to help in identifying with accuracy, the species mentioned as useful (e.g. edible) and learn about local biodiversity, taxonomies, and management systems. A botanist (field technician) from the University of Dar es Salaam and a knowledgeable local community member helped with voucher collection.

Guided field walk and Direct observation - According to Cunningham (2001), observation is an appropriate method to gather data on more sensitive issues. Through guided field walks, data on plant use was collected based on the observation of human-plant interactions. As suggested by Maundu (1995), prepared questions (Appendix 2) were sometimes used to get further clarifications where necessary. The habitats and growth habits of different useful wild plants (whether they are trees, shrubs or herbs) were also detected.

b) Vegetation Data Collection

Vegetation was sampled from within the National Park to the open area outside the park with an expectation to establish a gradient of high human influence, intermediate human influence and least human influence (National Park). Five transects of varying lengths were positioned across the 5 randomly picked points within the 21km strip of the park boundary road forming

part of the Kwa kuchinja corridor. Random sampling technique ensures that bias is not introduced in the survey. Transects varied in length due to the difference in distances from the protected area (National Park) to human settlements. Plots were laid systematically along transects at 100m interval from within the park to the open areas crossing the boundary road. Transects ran east west at a constant navigation bearing of 326°. A compass was used to maintain the course of navigation along the E-W bearing as much as possible. A total of 86 plots were sampled along the 5 transects of varying distances.

Square plots were used whereby trees were sampled in 20 x 20m plots and shrubs/ small trees (less than 5m height) in 5 x 5m plots. In the sampling procedure, individual plants were identified to species level. Trees and shrubs were counted and recorded, and contribution of each species to percentage cover was estimated and recorded. Information recorded from each plot for vegetation data included the number of individuals of species, and for the case of trees, diameter at breast height and tree heights. Unidentified species were identified with assistance from the established herbarium of the Tarangire National Park; further identification was done at the herbarium of the University of Dar es Salaam, Botany Department, where the voucher specimens are deposited. A list of voucher number with taxonomic information is appended to the thesis (Appendix 4).

4.2.5 Data Analysis

The analysis was based on descriptive approach and content analysis or general observation. A data matrix was prepared in Microsoft Excel for multivariate numerical analyses. Data analysis was aided by Computer Programs/ Statistical packages including INSTAT, Microsoft excel and SPSS V11. For each plot, species richness, evenness and diversity were calculated using the Shannon Weaver Statistic (Magurran, 1988) to make inference on variation and structure. Computer program to compute Shannon index, prepared and kindly availed by Prof. Zerihun Woldu was used. The Shannon Weaver index takes into account species richness and proportional abundance to calculate a single diversity measure. This is in effect a measure of evenness of species abundances in a sample, with more even samples gaining a higher value.

The Shannon Weaver index (H) is calculated with the formula:

$$H=-\Sigma\, p\,(i)*\ln p\,(i)$$

Where the term p (i) denotes the proportion of a particular species in a sample.

Basic assessment-based calculations of species numbers/richness; densities, frequencies, basal areas and mean dbh were undertaken. Species richness denotes a number of plant species in a plot, area or community, while density is a count of number of individuals of species in an area and frequency is the probability or chance of finding a species in a given sample area. Basal area was calculated from the values of species Diameter at Breast Height (DBH) obtained from the field. The data was subjected to INSTAT statistical package which helped in making comparisons between plots inside the National Park and those of outside. Parametric statistical tests such as t-tests were applied only if data are interval or ratio, normally distributed and there is homogeneity of variance. When the assumptions for a parametric test were not met then the corresponding nonparametric test was used, the counterpart of t-test being Mann-Whitney test.

Species "importance value index" (IVI) was calculated to get the most important species both inside and outside the National Park. Species with the highest IVI are referred to as the most "important" at that site. The IVI was calculated as follows:

Importance value index (IVI) = CVI + Relative frequency

Cover value index (CVI) = Relative density + Relative dominance

Relative density:

= (Number of individuals of a species/ Total number of individuals of all species) *100

Relative dominance = (Total basal area of the species/ Total basal areas of all species)*100

Relative frequency = (Frequency of species/Sum of all frequencies)*100

With ethnobotanical data, variables were coded in order to address the specific objectives in analysis and were subjected to SPSS. The descriptive approach included cross tabulations and

percentage computations. The results are summarized in the form of figures and tables. Simple preference ranking was used as elaborated by Martin (1995), where personal preference and perceived degree of importance of a given plant species in the community were observed.

4.3 Limitation of the results

Problems arose in identifying some of the useful species mentioned during interviews and PRA exercises, since the names were given in local languages and throughout the guided field walk and vegetation inventory they could not be located. As a result some species mentioned as useful during interviews in local languages were not recorded in the study.

Both time and funding could not carter for some details which would have enriched this study, such as harvesting experiments (stem cutting, defoliation, debarking), to measure the impact of harvesting on individual wild plants as well as an in-depth socio-economic aspect of it.

5. RESULTS

5.1 Results on the Vegetation Survey

5.1.1 Plant Species Composition in the Study Area

A total of 154 species were encountered during the whole inventory (from sized plots as well as associated species in the whole sampling area, Appendix 4). A total of 131 species were found outside the park while 93 plant species were encountered inside the park. The wood component is dominated by the genera *Acacia,* with highest abundance of *Acacia tortilis* and *Acacia kirkii,* while the field layer was predominantly *Dactyloctenium aegyptium* and *Themeda triandra.* These are interspersed with a tree/shrub layer of *Maerua triphylla* among others. All species encountered represent 33 families. The largest was grass family (Poaceae) with 28% of all species followed by Family Fabaceae 15% and Acanthaceae 8% (Table 1).

In plots sampling, 32 species were sampled in the shrubs layer (5x5 plots) and 16 in the trees layer (20x20 plots). Out of 64 useful plant species mentioned during interviews 24 species were encountered in the field (Appendix 7b). Of these, 17 were medicinal species, 14 for firewood, 9 for construction, 7 for food and 6 species for charcoal. All except 6 species were mentioned in more than one category of use.

Table 1: Plant Families and Number of Species Recorded

No.	Family	Total	Percentage (%)
1	Acanthaceae	12	8
2	Agavaceae	1	1
3	Aizoaceae	1	1
4	Amaranthaceae	5	3
5	Anacardiaceae	1	1
6	Asparagaceae	1	1
7	Balaniteceae	1	1
8	Bignoniaceae	1	1
9	Bombaceae	1	1
10	Boraginaceae	6	4
11	Burseraceae	2	1
12	Capparaceae	9	6
13	Celastraceae	1	1
14	Combretaceae	1	1
15	Commelinaceae	1	1
16	Asteraceae	10	6
17	Convolvulaceae	1	1
18	Euphorbiaceae	3	2
19	Fabaceae	23	15
20	Labiatae	5	3
21	Loganiaceae	1	1
22	Malvaceae	6	4
23	Oleaceae	1	1
24	Poaceae	42	28
25	Potulaceae	1	1
26	Rubiaceae	2	1
27	Salvadoraceae	1	1
28	Simaroubaceae	1	1
29	Solanaceae	4	3
30	Sterculiaceae	1	1
31	Tiliaceae	6	4
32	Verbenaceae	1	1
33	Vitaceae	1	1
	Grand Total	154	100

5.1.2 Stem Density

Student t test showed that shrub density was very significantly higher outside than inside the Park (2-tailed p value of 0.0021, t = 3.176 with 84 d.f, 95% C.I) with means of 839 stems/ha and 354 stems/ha respectively (Figure 2). Average tree densities inside and outside the Park had no remarkable difference, that of inside the Park was slightly higher than outside (p=0.7934, t=0.2624 with 84 d.f and 95% C.I; depicting no significant difference) having average densities of 45 stems/ha inside the Park and 41.7 stems/ha outside (Figure 2). Highest tree density was recorded at the 5th transect outside the National Park, and this could be explained by the fact that it was relatively remote from villages/settlements and the terrain not very encouraging for resource collectors.

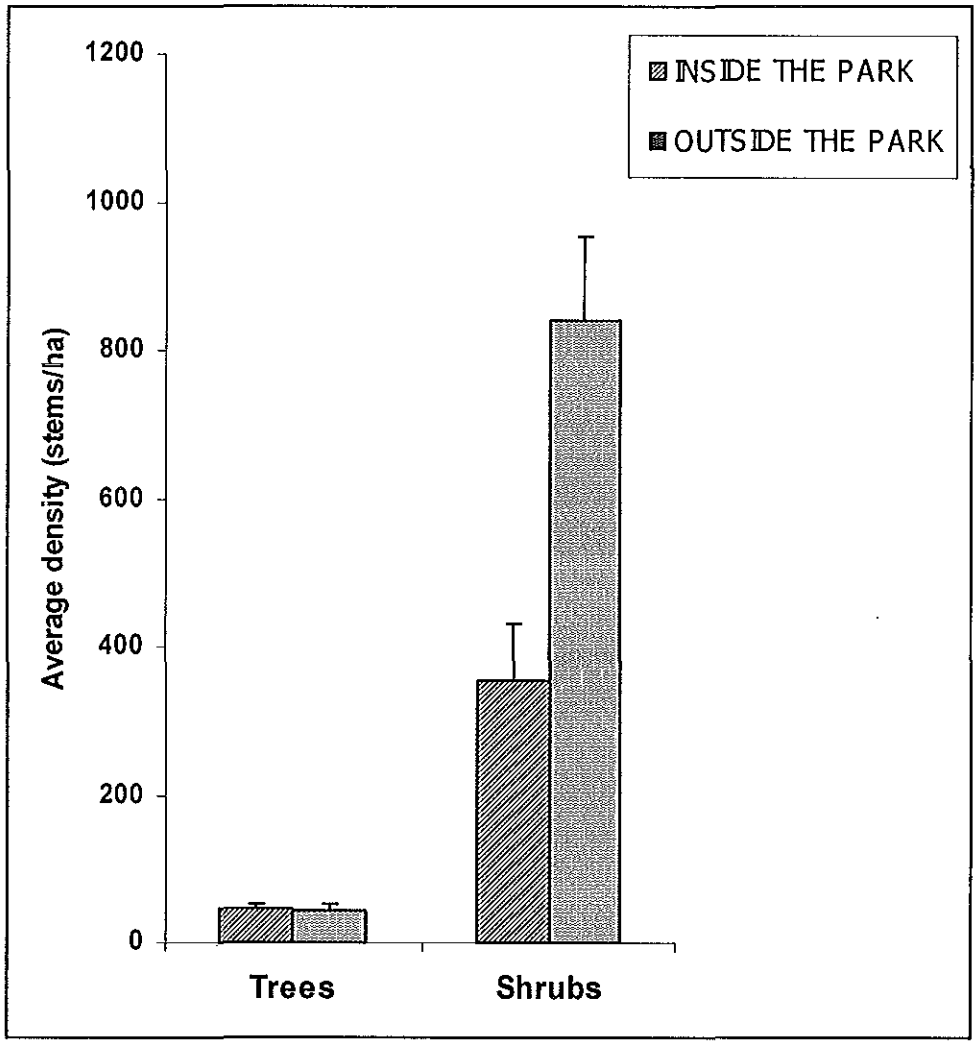


Figure 2: Comparison of shrubs and trees density inside and outside the Park

5.1.3 Species Importance Value Indices

The importance value indices (IVI) for tree species were obtained from their relative values of frequency, density and dominance (Appendix 8). Species with the highest IVI in the study area was *Acacia tortilis*, with an IVI of 229.3 (Appendix 8). This was followed by *Acacia kirkii* with IVI of 114.5, *Adansonia digitata* (76.9) and *Strychnos potatorum* (53.7). Species with least IVI were *Boscia angustifolia* (3.8) and *Boscia mossambicensis* (3.6).

5.1.4 Tree Size Classes

The distribution of trees in different size classes revealed that there were very few large trees depicting a reverse J curve of community structure (Figure 3).

5.1.4.1 Tree Height Distribution

Based on the range of tree heights in the inventory, four height classes were formed as follows:

Class 1 - trees with heights less than 5m

Class 2 – trees with heights ranging between 5m – 9.9m

Class 3 – trees with heights ranging between 10m – 14.9m

Class 4 - trees with heights from 15m and above

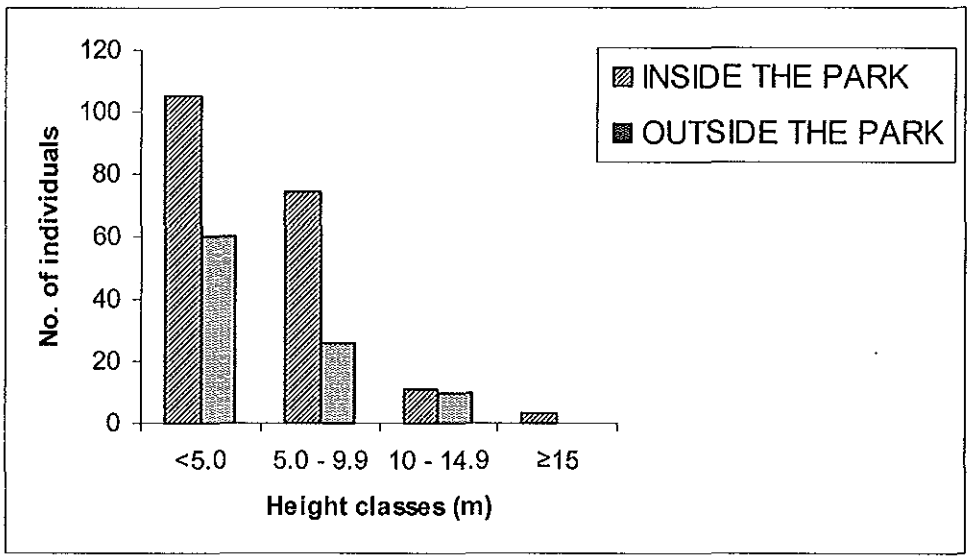


Figure 3: Height classes of trees inside and outside the Park

Both Mann-Whitney and student t test revealed that there is extremely significant difference in the mean heights of trees inside and outside the Park with two tailed p value < 0.0001, the mean inside the Park being higher (for t-test, t= 4.295, 226 degrees of freedom). A similar trend was observed with the useful species in particular, where two tailed p value is 0.0005, t= 3.544, with 137 d.f. (Figure 4).

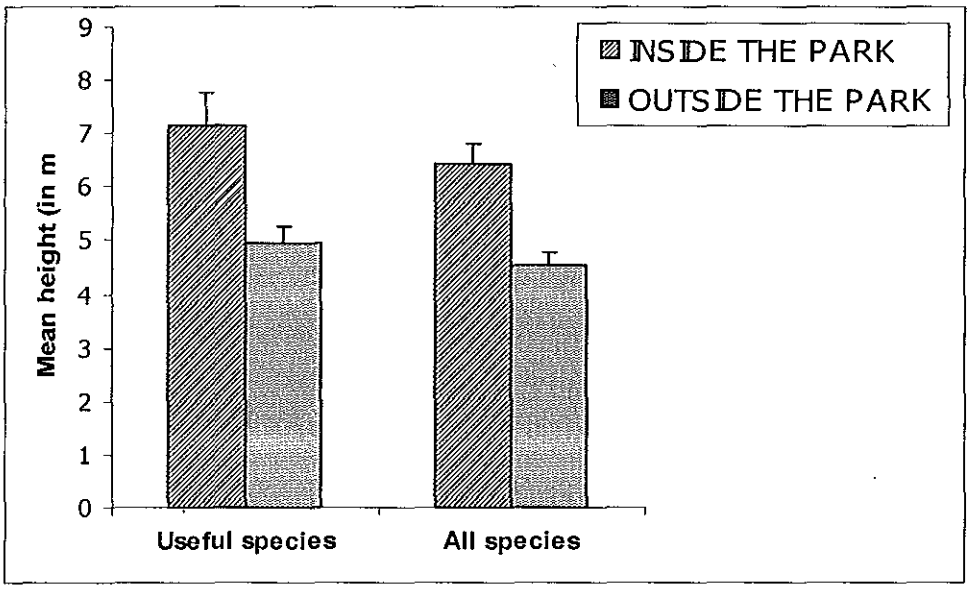


Figure 4: Average heights of trees inside and outside the Park

5.1.4.2 DBH Size Classes

Size classes for DBH included class of saplings and seedlings (2.5cm - 24cm); small trees (25cm – 37cm); medium sized trees (38cm – 49cm) and large trees (≥ 15cm). DBH class distributions also indicated similar population trends for species inside and outside the Park, with "inverse J-shaped" curves (Figure 5). Sharply declining densities of individuals in successively larger size classes produces the inverse J-shaped girth-class distribution for a species. This implies that there is high proportion of seedlings and saplings in relation to adult trees.

Mann-Whitney test indicated no significant difference between species inside and outside the Park on both DBH and basal areas, with two tailed p value of 0.2366 (95% C.I) for DBH and

0.9999 for basal areas. However, there were some appreciable differences in DBH, whereby species exhibited greater DBH in plots inside the Park compared to those outside the Park (Figure 6). When only useful species are considered, the test shows significantly higher DBH inside the Park compared to outside the Park with two tailed p value of 0.0315 at 95 C.I. while the difference in basal areas remain not significant with p value of 0.9999 and 95% C.I.

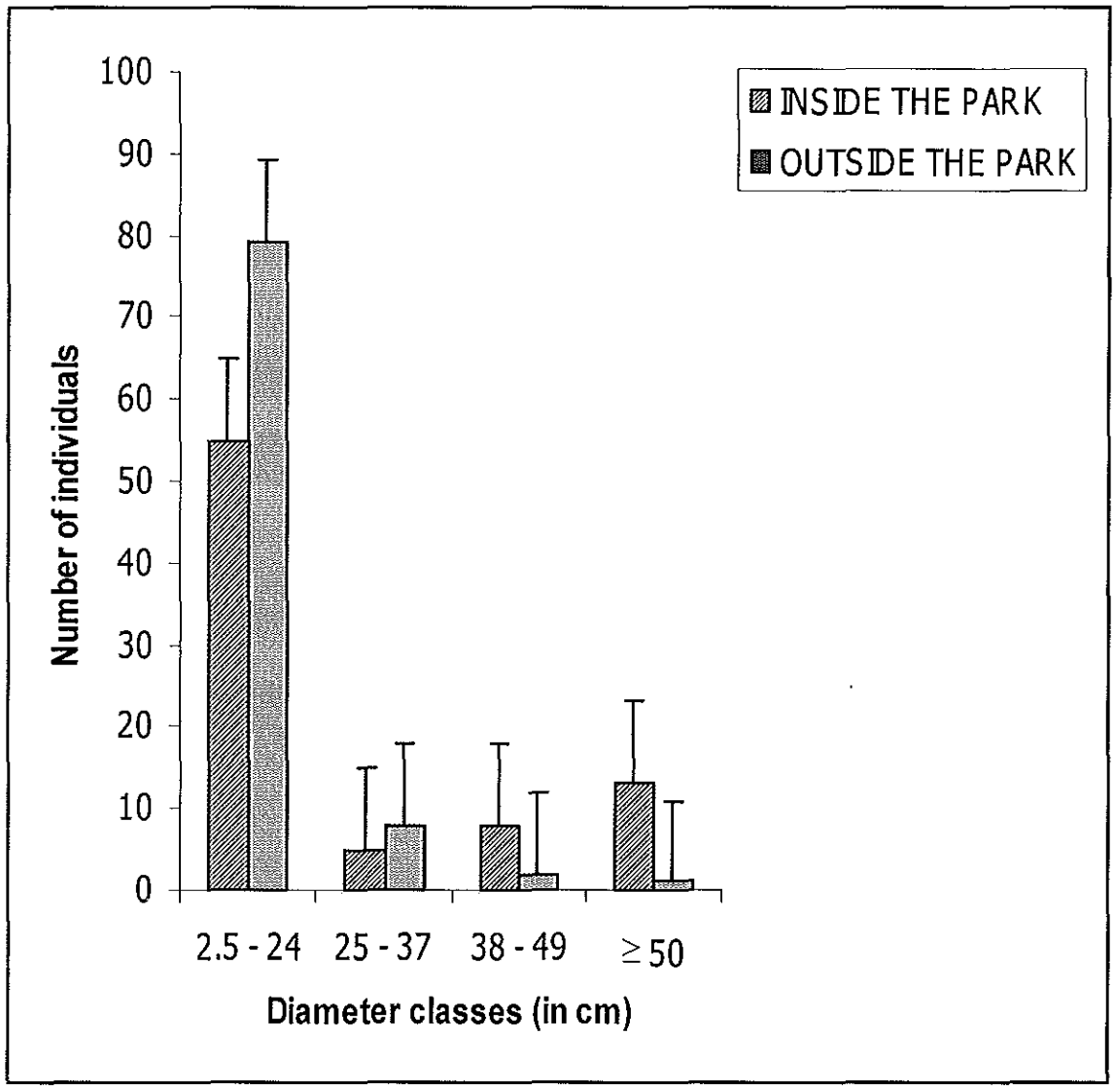


Figure 5: DBH size classes of all tree species encountered inside and outside the Park

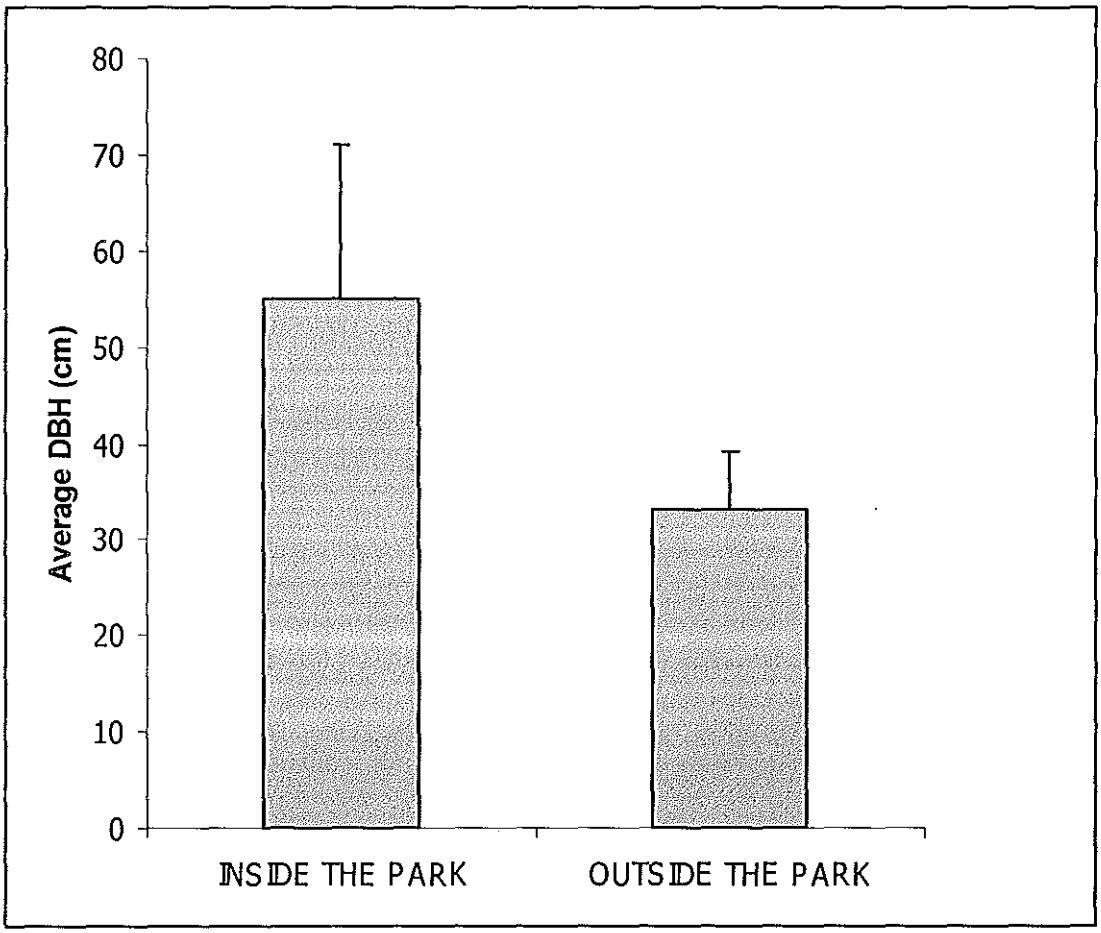


Figure 6: Average DBH of trees inside and outside the Park

5.1.5 Diversity Patterns

Generally the diversity of the individual plots in the study area was very low, with most plots having diversity (H) of less than 1. However, a clear pattern can be observed from the shrubs diversity graph (Figure 7). Plots 1 to 10 are those sampled inside the Park while from plot 11 onwards are plots sampled outside the Park. Overall diversity (H) outside the Park was 3.05 while that of inside was 2.30. The H values by plots exhibited a clear pattern.

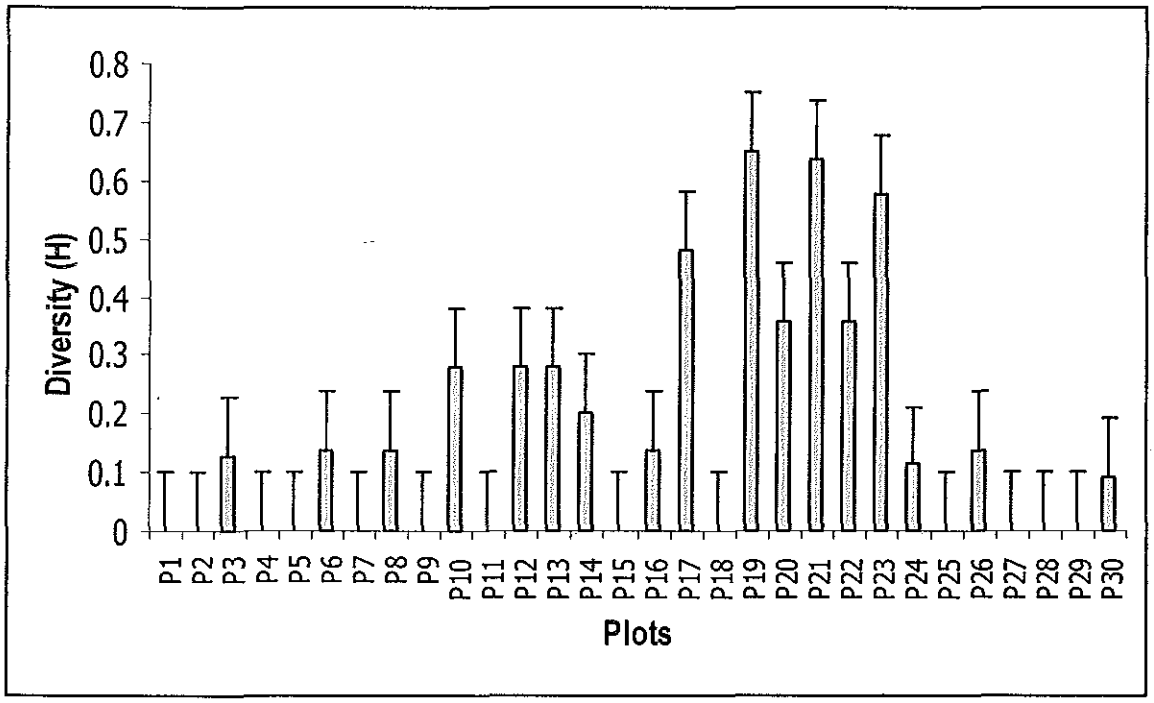


Figure 7: Shrubs diversity pattern

5.2 Results on the Ethnobotanical Study

5.2.1 Useful Plants Categories of the Study Area

Eight major categories of the uses of wild plants were consistently pointed out in both villages. These were firewood, charcoal, medicinal, building (construction), edible (food), domestic equipments (handles, furniture, walking stick), fodder and handcrafts. The order of merit based on the number of respondents to each category differed in the two villages (Table 3); however, the most popular use categories, which implied the major uses of wild plants in the area, were medicinal, food, construction and firewood which ranked the highest on both villages. These use categories are distributed in 64 species belonging to 31 families (Appendix 7a). The family with the highest number of useful species in the study area was Fabaceae (18) as Table 2 reveals.

Table 2: Number of species of most exploited families in Wild Plants

No.	Family Name	Number of Useful Species
1.	Agavaceae	1
2.	Amaranthaceae	1
3.	Anacardiaceae	1
4.	Asteraceae	1
5.	Balaniteceae	1
6.	Bignoniaceae	2
7.	Bombaceae	1
8.	Boraginaceae	3
9.	Burseraceae	1
10.	Combretaceae	2
11.	Cucurbitaceae	1
12.	Fabaceae	18
13.	Labiatae	1
14.	Liliaceae	1
15.	Malvaceae	1
16.	Moraceae	3
17.	Myrsinaceae	2
18.	Olaceae	2
19.	Palmae	2
20.	Poaceae	1
21.	Podocarpaceae	1
22.	Rhamnaceae	1
23.	Rosaceae	1
24.	Rutaceae	1
25.	Salvadoraceae	2
26.	Sapindaceae	1
27.	Sapotaceae	1
28.	Simaroubaceae	1
29.	Solanaceae	1
30.	Tiliaceae	3
31.	Verbenaceae	2

While the highest ranking category in Minjingu was medicinal, that of Vilima vitatu was food (Table 3). Taking an overall look for the ranking sequence, the most recognized category, mentioned more times than any other, was medicine, followed by construction category (building poles, pegs and doors, ceiling/roofing), firewood and food (Figure 8). The least mentioned was Fodder with only 5% of respondents. Contribution of wild plants as a source of rain and shade was also recognized. This was pointed out by 18% respondents for shade and 7% pointed the usefulness of wild plants as a source of rain. In the course of study, ceremonial plants (dispute resolution, circumcision ceremonies, and worship) were also noticeable among plants used and could yet be another important category.

Table 3: Use Categories in Order of Recognition at the Surveyed Villages

RANKS	MINJINGU VILLAGE	%	VILIMA VITATU VILLAGE	%
1	Medicinal	22.3	Food	21.4
2	Construction	17.2	Medicinal	20.5
3	Firewood	15.8	Firewood	19.6
4	Food	13.0	Construction	18.8
5	Charcoal	12.6	Charcoal	13.4
6	Handcraft	4.2	Domestic Uses	1.8
7	Domestic equipments	3.7	Fodder	0.9
8	Fodder	1.4	Handcraft	0.9
9	Timber	0.5		

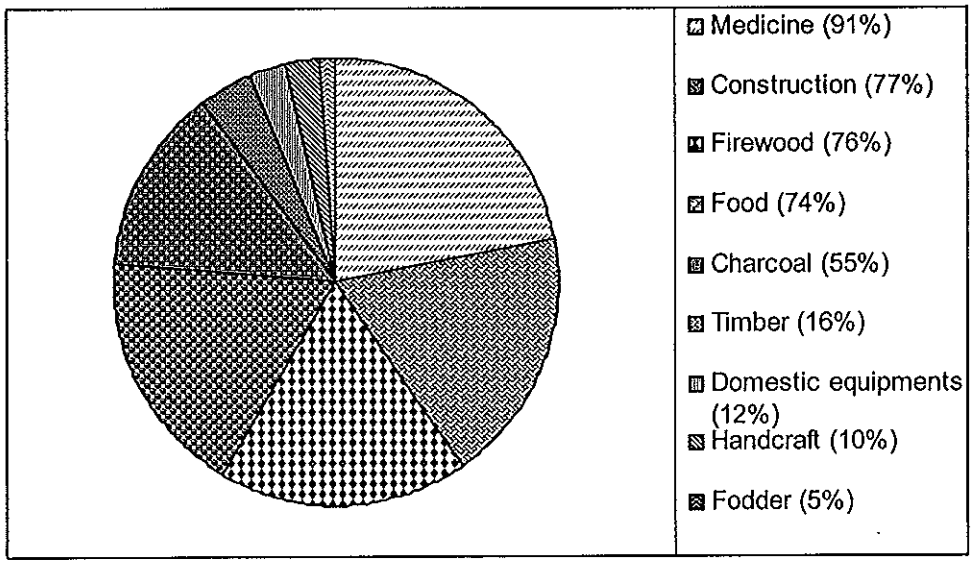


Figure 8: Pie chart showing the most popular uses of wild plants in the study area

5.2.1.1 Medicinal Plants

More than 50% of all the useful wild species pointed out in the study were medicinal (Appendix 7a). Most species could cure more than one disease (Table 4). Majority of the species are indicated to cure Sexually Transmitted Diseases (STDs) and in particular gonorrhoea (Table 4). Other medicinal plants mentioned include *Harissonia abyssinica, Tamarindus indica, Terminalia brownii, Solanum incanum* and *Rapanea melanophloeos.* There was a wide variation pertaining to the preffered medicinal plants amongst the two villages as preference ranking reveals. While *Zanthoxylum chalybeum* ranked the first in Minjingu village, it ranked the fifth in Vilima vitatu; on the other hand, *Harisonia abyssinica* which ranked the first in Vilima vitatu, it ranked the forth at Minjingu (Table 3). The vast number of medicinal species in comparison to other use categories is an indication of the important role played by plants in the health of the people.

Table 4: Species Reported As Cure for More Than One Health Problem

Species name	Disease it cures	Parts used
Salvadora persica	Body pains (stomach ache, chest pains and back-ache), wounds, sore throat, STDs	Leaves, roots, barks
Ximenia caffra	Chest pains, STDs, stomach-ache, coughs, malaria,	Leaves, roots
Zanthoxylum chalybeum	Toothaches, chest diseases, body pains,	Bark and roots
Acacia nilotica	STDs, pneumonia, chest pains, stomach disorders,	Leaves, barks and roots
Lannea schweinfurthii var. stuhlmanii	Anaemia (adds blood), diarrhoea, stomach-ache	Bark, roots
Achyranthus aspera	STDs, rashes, colds	Seeds, leaves and roots
Ficus sycomorous	Diarrhoea, chest, sore throat	Bark

5.2.1.2 Construction

A wide variety of species were mentioned as valuable for building houses, fencing and other structures (Appendix 6). In construction, plant species are used for roofing, pegs and poles (Figure 9). The most preferred species for pegs is *Cordia monoica*, while *Dalbergia melanoxylon* is the most preferred species for poles and *Hyphaene petersiana* for roofing; all these had the highest ranks in their respective groups in the preference ranking (Table 5). However, corrugated iron sheets are increasingly replacing thatched roofed houses. Both *Cordia monoica* and *Dalbergia melanoxylon* are reported to have disappeared from the neighbourhood. This was confirmed by the vegetation inventory whereby *Dalbergia melanoxylon* was only sampled inside the National Park, while *Cordia monoica* was sampled in the furthest transects from the communities (The first and the last transects).

Fencing is done around homesteads, animal enclosures, and to protect cropland. The type of fencing observed involved piling up branches of thorny acacias to keep away thieves and predators (Figure 9). They also use *Commiphora africana* for live fence, which roots easily from cuttings. Out of the 64 useful wild species pointed out, approximately 30% were mentioned as useful for construction (Appendix 7a).

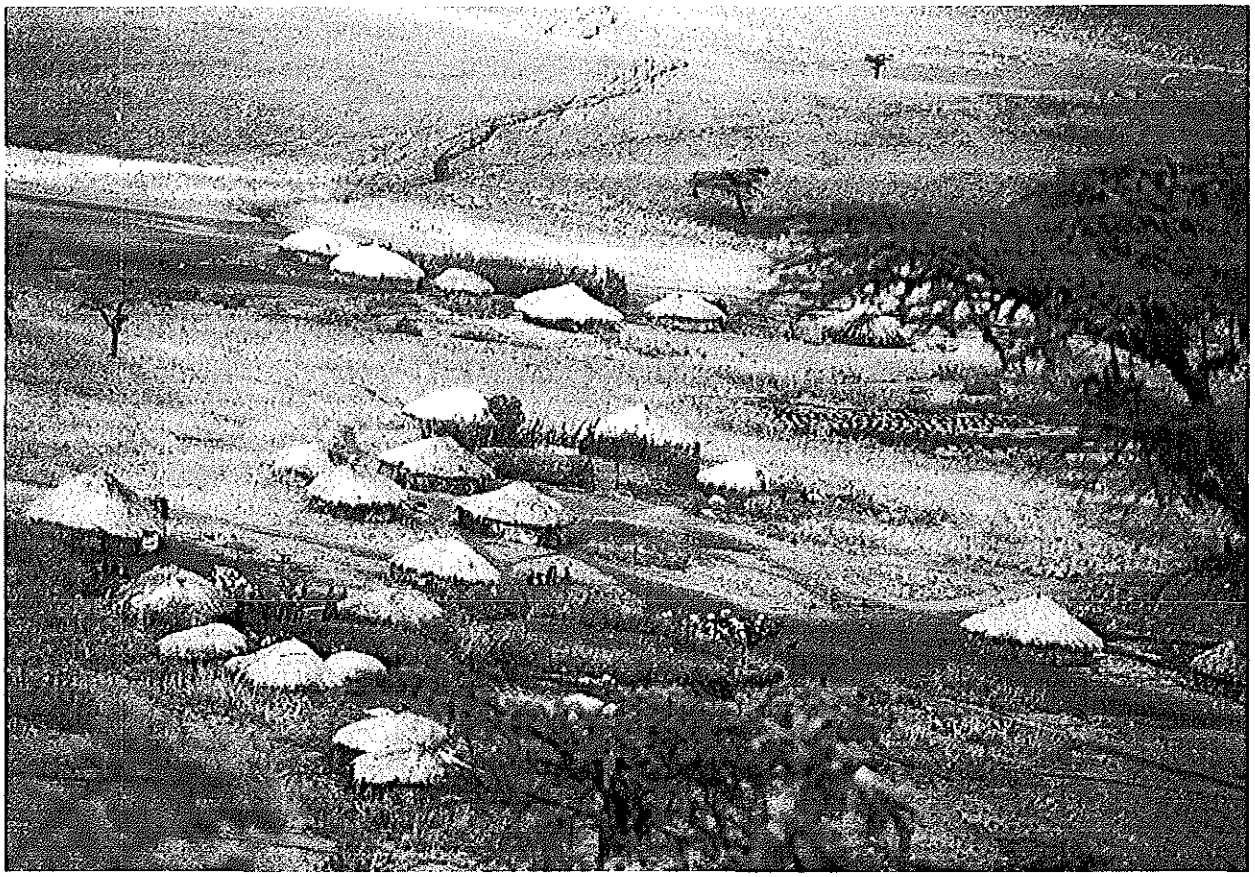


Figure 9: Picture showing thatched roofs and thorny acacia hedges in the study area

5.2.1.3 Fuelwood

Attributes that made species to be preferred for firewood or charcoal included that of the strength of wood/ longevity of burning or producing fuel and minimum smoke (especially for firewood). The tree species most preferred for firewood were *Acacia tortilis*, *Acacia mellifera* and *Grewia bicolor*. While for charcoal *Acacia tortilis* and *Balanites aegyptiaca* were of

leading preference (Table 5). Preference ranking from both Minjingu and Vilima Vitatu villages had *Acacia tortilis* as the highest ranking species for charcoal while it also ranked the first amongst firewood species in Minjingu (Table 5). Interviews and observations from the study area revealed that charcoal production was concealed, since it is among the banned activities in the area, therefore no charcoal kilns were observed throughout the study. Firewood collection was observed to be women's work in the study area (Figure 10).



Figure 10: Women looking for firewood outside the National Park (Open Area).

5.2.1.4 Wild Food Plants

In the edible plants category, majority were known for their fruits. Some of the popular fruit trees in the study area were *Adansonia digitata, Tamarindus indica, Hyphaene petersiana.* Adansonia digitata was ranked the first in preference ranking exercise both in Minjingu and Vilima vitatu villages (Table 5). Other edible fruits in the area were *Ximenia caffra* and *Ficus*

sycomorus. Also there were species used for tea infusions such *as Zanthoxylum chalybeum.* These infusions are nice smelling and can serve the dual purpose as a drink and medicine. *Zanthoxylum chalybeum* is also used as a remedy for coughs, body pain and toothaches. Barks mentioned as edible were those of Acacia species *(Acacia abyssinica),* the inner bark has a sweet taste and is used as chewing gum just for exercising the jaws and to pass time. A number of edible roots/ tubers species were also mentioned in the edible species category. One of these is *Commiphora africana.* The edible roots/tubers were explained to have a sweet taste and are juicy like sugar-canes. Edible vegetables are not common in the area, as there was no place it was mentioned and on provoking about wild vegetables (leaves), informants indicated that they only eat them when they have really been starved.

5.2.1.5 Plants Used in Ceremonies and Rituals

Number of different species are used during weddings, traditional dances and circumcision ceremonies. These include *Commelina benghalensis, Lagenaria siceraria, Pennisetum mexianum.* Stacks of *Ziziphus mucronata* are attached to the entrance of a house having circumcision ceremony as a symbol for special event; *Rudbeckia hirta* is used as a symbol of invitation during ceremonies. *Cordia monoica* is used to treat the wound on circumcision. Species used for preparation of local brews include *Aloe secundiflora* and *Kigelia Africana.* During bride price giving ceremony, leaves of *Lippia kituiensis (ukambensis)* are used to cover roasted meat. There are trees recognized as sacred trees and used during worshipping ceremonies. These include *Ficus thonningii* which is also used in rituals for rain making. *Cordia monoica* and *Zanthoxylum chalybeum* are used in conflict resolution/ to settle disputes.

Table 5: Preference Ranking Results On Five Most Popular Use Categories

Use Categories: A = Charcoal B = Firewood C = Construction

CA = Poles CB = Pegs CC = Roofing D = Medicine E = Food

Values X (Y) represent ranks for Minjingu (Vilima Vitatu) villages respectively.

Species	A	B	C			D	E
			CA	CB	CC		
Acacia drepanolobium	6 (7)	6 (9)					
Acacia mellifera	3 (3)	2 (1)	5 (4)			9 (8)	
Acacia nilotica						2 (4)	4 (7)
Acacia tortilis	1 (1)	1 (3)	9 (9)				
Acacia xanthophloea	9 (9)						
Adansonia digitata							1 (1)
Albizia anthelmintica						8 (9)	
Balanites aegyptiaca	2 (2)	5 (4)					
Combretum zeyheri	5 (4)						
Commiphora africana							5 (4)
Cordia monoica			3 (2)	1 (1)			
Dalbergia melanoxylon			1 (1)				
Ficus sycomorous						7 (7)	6 (8)
Grewia bicolor		3 (2)	7 (8)	6 (6)			
Grewia villosa				5 (4)			8 (5)
Harissonia abyssinica		4 (5)		3 (2)		4 (1)	
Hyphaene petersiana					1 (1)		2 (3)
Lannea schweinfurthii var *stuhlmanii*						3 (6)	
Manilkara mochisia			6 (6)	7 (7)			
Rudbeckia hirta	4 (5)		4 (5)	2 (3)			
Salvadora persica						6 (2)	
Tamarindus indica				4 (5)	2 (2)		3 (2)
Terminalia brownii	8 (6)	8 (6)	8 (7)				
Ximenia caffra		7 (7)				5 (3)	7 (6)
Zanthoxylum chalybeum	7 (8)	9 (8)	2 (3)			1 (5)	
Number of Species Ranked	**9**	**9**	**9**	**7**	**2**	**9**	**8**

5.3 Local Practices Which Have Impacts on Wild Plants

A number of strategies to minimize loss of useful plants were mentioned during discussions with the local community. This include covering back parts of roots remaining on the extracted plants (they return the soil after digging the roots) and tree planting. Besides, there are practices driven by taboos and beliefs which facilitate conservation. For example, there are sacred trees which are not to be cut, especially those associated with ritual activities and beliefs such as *Olea europeae ssp cuspidata* which is believed to bring good luck. However, the use of other wild plant species such as during traditional ceremonies as highlighted in the section 5.2.5 above, is not in favor to conservation of wild plants.

5.4 Availability of Useful Wild Plants

A total of 64 species with known uses were mentioned, out of which only 24 (less than 50%) were encountered in the vegetation/ survey inventory. A number of useful species were mentioned as having disappeared in the area, including *Zanthoxylum chalybeum*, *Dalbergia melanoxylon*, *Acacia nilotica* and *Rapanea melanophloeos*. This was verified from the vegetation inventory whereby none of these species was encountered with exception of only a 4% cover of *Dalbergia melanoxylon* found in a plot within the National Park.

5.5 Wild Plants of Commercial Value

Majority of the respondents (79.7%) indicated that wild plants have a market value. Wild plants for commercial purposes included handcrafts, timber and medicinal categories in an order of priority. The customers for these commodities are mainly local communities and tourists. The actual commodities of wild plants that could be observed were the handcrafts products such as mats, baskets, hats with more number of vendors selling these on a daily basis. Respondents indicated that with the rural set up, things like traditional medicine were supplied on a friendship basis and not commonly sold. Therefore customers were mainly people from distant areas. Charcoal was being sold but in hiding, since it is banned in the area. Commercial timber extraction is minimal and couldn't be observed in the course of this study.

5.6 Threats to Useful Species in the Study Area

Observed threats to useful wild plants in the study area include the vastness of agricultural land, incidences of bush fires and unsustainable harvesting of the useful species.

5.6.1 Destructive Harvesting Methods

Pairwise ranking results indicated that among the most popular harvesting methods (plant parts harvested) in the study area, stem harvesting was considered to be most destructive (Appendix 5). This was followed by root and bark harvesting. Leaves and fruits harvesting were the last in the order, with fruit harvesting considered to be harmless to plant life. Majority of plants subjected to stem harvesting are those which fell under firewood, charcoal and construction categories of use while root harvesting was mainly found with medicinal plant (Appendix 6). The useful species that were most threatened with these destructive harvesting methods include *Ximenia caffra, Acacia mellifera, Zanthoxylum chalybeum, Tamarindus indica, Terminalia brownii, Acacia tortilis, Acacia nilotica* and *Salvadora persica* and which were subjected either to stem, root or bark harvesting (Appendix 6). Species such as *Salvadora persica, Ximenia caffra* and *Acacia nilotica* were subjected to both, root and bark harvesting (Appendix 6).

5.6.2 Over-Exploited Species

Qualitative studies, PRA and household surveys suggested that some species are facing particularly severe harvesting pressure. For instance species such as *Acacia nilotica* and *Zanthoxylum chalybeum* were found in almost every aspect of Maasai cultural life (Table 5), from medicine and food to ceremonies. They are also preferred for firewood. In addition, these species provide the commonly used poles for the construction of traditional houses. Other species which were comparatively overexploited in the study area include *Terminalia brownii, Ximenia caffra, Harrisonia abbysinica* and *Acacia mellifera.* Vegetation inventory also established the risk of overexploitation facing these species from the fact that both *Acacia nilotica* and *Zanthoxylum chalybeum* were not encountered in the sampled plots. *Terminalia brownii* and *Harrisonia abyssinica* were found only twice in the whole inventory.

6. DISCUSSION

6.1 Plant Species Composition in the Study Area

Different elements influence the vegetation make up and species composition of an area. However, being the focus of this study, high human disturbance related to use of plants has shown a profound effect on vegetation structure of an area. This is exhibited by the results showing rarity of some of the most preferred species such as Dalbergia melanoxylon. Results of this study are consistent with an argument that high human interference plays a large part in plant abundance and diversity patterns. However, besides the anthropogenic factors which were the main focus, evidences for other disturbances to wild plant species were observed in the course of study, such as wild fire and damage by herbivores such as elephants (Figures 11 and 12).



Figure 11: A tree with clear evidence of damage by an elephant observed in the study area

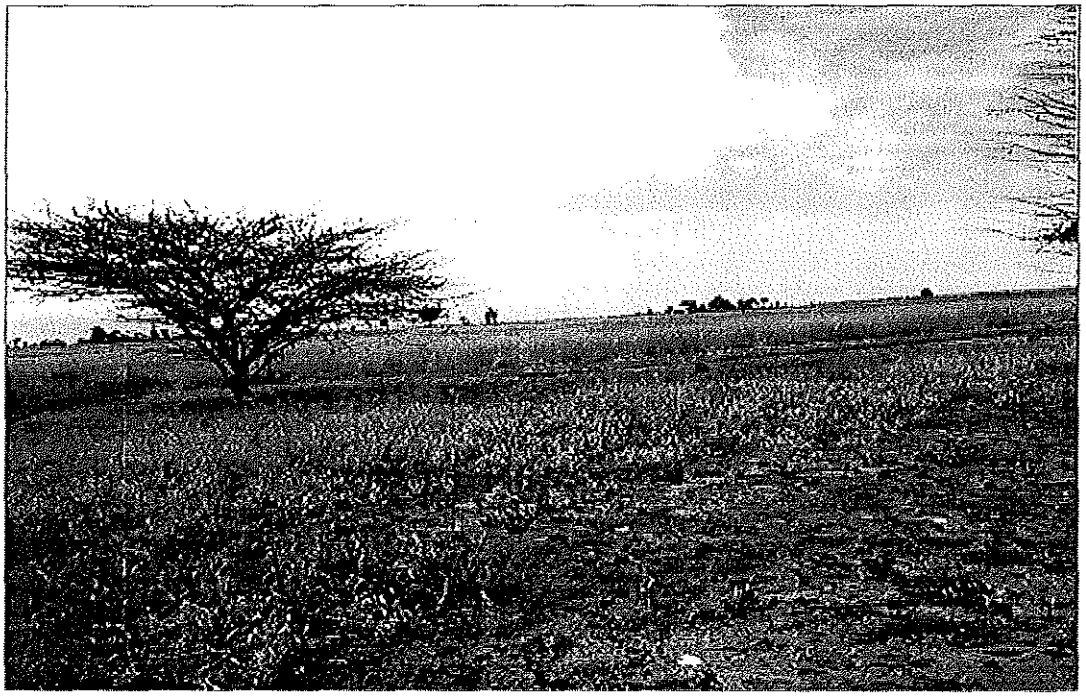


Figure 12: Part of the area with clear evidence of burning observed in the field

6.1.1 Stems Density

The higher average stems density outside the Park compared to inside the Park (means of 880 stems/ha and 399 stems/ha respectively, with Mann-Whitney p value of 0.003 at 95% C.I) was clearly contributed by remarkably higher shrubs density outside the Park. Higher average density of shrubs outside the Park could be due to higher rate of regeneration as a result of high use of mature trees. On the other hand, this is also consistent with the hypothesis that as individuals grow in size and stem diameters increase, their total number is predicted to decrease (Niklas *et al.*, 2003). This hypothesis is explained simply by the fact that the ability to fill space as gauged by stem size distributions appears equally well achieved by either many small or few large individuals (Enquist and Niklas, 2001). Grazing-induced bush encroachment could be another reason behind the high shrubs density outside the Park. The possibility of restricted movement of large wild mammals as a result of increase of human-wildlife competition for land and resources outside the Park could also be another explanation for the higher density of shrubs outside the Park. As observed by Dublin and colleagues (1990), mammals such as wildebeest and elephants have dramatic effects on woody vegetation, through herbivory and trampling respectively. As their population increase and their movement restricted their effect is even more experienced.

6.1.2 Tree Sizes

Useful tree species inside the National Park had significantly higher stem diameters compared to those outside the Park. However, the non-significant difference on basal areas between the two compared sites confirms on lower species density inside the Park compared to that of outside the Park. This points back to an inverse relationship between average stem diameter and plant density as discussed above. On the other hand, Mann-Whitney test revealed that there is extremely significant difference in the mean heights of trees inside and outside the Park, the mean inside the Park being higher. This implies that there were few, but larger tree species inside the National Park compared to outside the Park which points out the effect of exploitation of these species on one hand, outside the Park, and effective protection on the other hand, inside the Park hence they come to full maturity and size. An inverse J-shaped curve of size classes, showing very high proportion of smaller size classes in relation to adult trees implies that the vegetation has continuous recruitment (Sugita *et al.*, 1994).

6.1.3 Diversity Patterns

Arid and semi-arid lands are notable for their within-species genetic diversity, rather than between-species variation or species richness (UNDP and GEF 1998). This is also revealed in this study where generally the plots diversity is low ($H < 1$). However, variation in diversity is exhibited among the different plots. The diversity pattern confirmed the obvious, whereby areas where land-use is most intense recorded the least values. Plots with the least diversity were those closest to human settlement (Plots 24-30, Figure 7). Comparatively highest diversity is recorded at plots 19 and 21, which were relatively far from the settlements hence reduced disturbance (intermediate human influence). This pattern aligns with the Intermediate Disturbance Hypothesis, which states that diversity will be highest at sites that have had an intermediate frequency of disturbance and will be lower at sites that have experienced very high or very low disturbance frequencies (Chaneton *et al.*, 1991).

6.2 Useful Plants Categories in the Study Area

Most popular use categories were firewood, medicinal, construction and food. This is typical of a rural community where the actual use of species is mainly for their subsistence, at the same time well versed with medicinal plants due to the fact that in most parts, modern health care has been inaccessible and unavailable. Moreover, higher ranking of medicinal category at Minjingu village could be explained with the observation of a comparatively higher Maasai population in the village than in Vilima Vitatu village where food category ranked the highest. It is the duty of Maasai children to learn the medicinal value of plants as they grow up. Similar observation was done by Sindiga (1992), that ethnomedicine is deeply rooted in Maasai life. The villagers also acknowledge the forest's influence over climate in view of the fact that among the categories of wild plant use rain-formation appeared on both villages as much as it's not among the literal uses of wild plant species. Fodder category was mentioned the least as much as it is the oldest and most extensive use of wild plants by farming households. This could be due to the fact that it is an indirect use of plants by the community, through grazing or browsing of plant biomass by domesticated animals. A study on the multipurpose use of trees in Tanzania (Hines *et al.*, 1993) indicated similar results from drier areas of the country, particularly Dodoma region and the Southern Highlands, where fodder was not generally identified as one of the most important uses of trees, either by men or women.

6.3 Threats to Different Useful Wild Plants

Pairwise ranking results revealed stem harvesting as the most destructive harvesting method, followed by root and bark harvesting. Similar observation, that harvesting of leaves, fruits or flowers has far less impact on individual plant than does the damage to roots, bark, stems or removal of the whole plant was documented by Cunningham (2001). It was noted that *Salvadora persica, Ximenia caffra, Tamarindus indica, Acacia senegal* and *Acacia nilotica* were species most subjected to unsustainable (destructive) mode of harvesting. All these fell into medicinal use category, which complies with the observation that medicinal plants in particular, are threatened due to such harmful collection techniques (Cunningham, 1990).

6.4 Species of High Conservation Value

Species of high conservation value are regarded in this work as any of the species, which fall in any one of the following categories: overexploited species for different use categories (Table 5), plants whose harvesting mode was not sustainable (Appendix 6) and those with narrow range of distribution. Other species that need to be considered for conservation include species difficult to propagate and keystone species. Keystone species are those whose presence contributes to a diversity of life and whose extinction would consequently lead to the extinction of other forms of life, species that help to support ecosystem which they are part of. An example from this study is *Ficus sycomorus*, which have fruits all year round.

Due to their multiple uses, *Terminalia brownii, Acacia nilotica, Acacia tortilis, Acacia mellifera, Grewia bicolor, Tamarindus indica, Zanthoxylum chalybeum, Ximenia caffra,* and *Harissonia abyssinica* were species subjected to overexploitation in the range where they occur. *Tamarindus indica* and *Zanthoxylum chalybeum* are also neutracetical plants the fact that their food component is therapeutic. As much as exploited species face a threat to disappear in the area, some of the most exploited wild species were the ones found in greater abundance, such as *Acacia tortilis*, which was almost in all facets of livelihood in the area. Contrary to expectations, results indicated that this species had the highest Importance Value Index (IVI). This might be due to the physiological and environmental factors such as the nature of its seeds having very hard seed coat covered in edible pods. These pods are eaten by animals which in turn facilitate dispersal and propagation processes. However, the awareness of the high use of this species might have led to efforts in planting it. Some of these species

seem to be overexploited not only in Kwa kuchinja but country-wise as well as region-wise. For example, *Zanthoxylum chalybeum* and *Dalbergia melanoxylon* were also pointed out among the threatened species in a study by Oketch (1992) in Kenya. Therefore based on the research findings, among the species considered to be of high conservation value in the study area include *Terminalia brownii* and *Harrisonia abyssinica* which besides being over-exploited, they had a very narrow range of distribution (found only twice in the whole inventory); *Acacia nilotica* and *Zanthoxylum chalybeum* were not encountered at all in the sampled plots. And *Dalbergia melanoxylon,* which is already in the IUCN red-list, was found on one plot with a cover of 4% only.

***Terminalia brownii* Fresen. Combretaceae**

Mortimore (1992) and Mugo (1999) also marked the scarcity of this species in dry areas due to utilisation without adequate protection of seedlings. It is considered to be a good tree for charcoal production; its termite resistant timber is also used for construction of houses, ox-yokes and other farm and household tools. It is an indigenous tree that regenerates well even after burning. Leaves are used as medicine for stomach ache and diarrhoea (Mbuya *et al.*, 1994).

***Acacia nilotica* (L.) Willd. Ex Del. Fabaceae**

Acacia nilotica prefers savannah sites including wooded grasslands, Miombo woodlands, deciduous woodlands and coastal bushland. The species is tolerant to a range of conditions, can withstand drought, but it is susceptible to fire and browsing by livestock. It grows on sandy loam fine-textured soils, coastal sandy, rocky soils, heavy clays, or black cotton soils (RSCU 1992). It tolerates seasonal flooding and thrives with a certain amount of seasonal waterlogging (Teel 1984). It is resistant to termites but liable to attack by various wood borers and *Bruchid* beetles attack seeds (Webb 1984). In Tanzania, *Acacia nilotica* is found in Dodoma, Tanga, Morogoro, Mbeya, Coast Region and Dar es Salaam (Rulangaranga 1989). This species has shown to be useful not only to the local communities along Kwa kuchinja wildlife corridor but even across the borders of Tanzania. Because of its resins, it resists insects and water, and trees are harvested for the timber for boat-making, posts, buildings, water-pipes, well-planking, plows, cabinet-work, wheels, mallets and other implements. Inner

bark contains 18–23% tannin, used for tanning and dyeing leather black. The gum arabic tapped from its tree is used in making candles, inks, matches, and paints (NAS, 1980). In the Sudan and Ethiopia, tender pods and shoots are used as forage and said to improve milk from these animals (FAO, 1999). The wood is used for firewood and charcoal (Duke, 1981). The species is highly regarded for its medicinal value throughout Africa. In South Africa, the Zulu take bark for cough, Chipi use root for tuberculosis. In East Africa, both Maasai of Tanzania and Kenya use the bark for dysentery, leprosy, cancers and/or tumors. Leaves and young pods are used as antiscorbutic (preventive of scurvy) in Senegal (Duke, 1981). Egyptians believe that diabetics may eat unlimited carbohydrates as long as they also consume powdered pods (Duke, 1983).

***Zanthoxylum chalybeum* Engl. Rutaceae**

This is a deciduous shrub or tree 3-4 (-10)m high. *Zanthoxylum chalybeum* is one of the common traditional vegetables in the Southern African Development Community (SADC) countries and among the species of interest in the program of Conservation of Traditional Vegetable Germplasm in the SADC (Okigbo, 1990). Oketch (1992) recorded it to be among the threatened species in Kenya. SADC, through a network of National Plant Genetic Resources Centres (NPGRCs) maintain an active collection of germplasm for various national program activities. It is recorded in top ten medicinal trees of Tanzania. Others include *Securidaca longipedunculata, Zahna africana, Cassia abbreviata, Entada abyssinica, Turraea fischeri, Albizia anthelmintica, Entandrophragma bussei, Combretum zeyheri* and *Terminalia sericea* (Oduol *et al.*, 2004).

***Dalbergia melanoxylon* Guill. and Perr. Fabaceae**

This is an indigenous slow growing tree or shrub. It has a heavily branched; many stemmed growth habit and often intertwines with other trees. It is highly valued for woodcarving in Tanzania. It is found in deciduous woodland and savanna, often associated with dry, rocky areas and poor soils (Milne-Redhead *et al.*, 1971). In Tanzania it is found in low altitude savanna or woodlands around Morogoro and Itigi, down to the coast. Often it grows in areas where productive agriculture is impossible due to shallow, rocky soils. *Dalbergia melanoxylon* is a vital component of the African savanna ecosystem; the nodules on the roots fix nitrogen

producing a more fertile soil, the leaves provide vital browse for herbivores, and the extensive root system stabilizes the soil (BBC, 1992). It was classified as Lower Risk/ near threatened on the IUCN Red List of 2002 (IUCN, 2003). The species has been highly valued for many centuries for the properties of its heartwood; the oily, fine wood was used by the Egyptians for tomb artifacts (ABCP, 2003). The dark, resistant wood has been used by the Makonde tribe of Tanzania to make intricate carvings, which are among important source of tourist revenue in the country (ABCP, 2003). Whilst the mature trees are being harvested for this trade, younger specimens are under increasing pressure from man-made bushfires, which have increased in frequency as the land is cleared for agriculture. This species is already threatened in Kenya and noticeably scarcer within Tanzania.

6.5 Local Practices Which Have Impacts on Wild Plants

Results revealed that the sustainable use of useful plants is facilitated by several inadvertent or indirect controls and some intentional management practices. Study by Odera (1997) revealed similar observation as of this study that taboos and social restrictions on gathering wild plants, and the nature of plant gathering serve to limit useful plant harvesting. However, practices within Maasai communities in the study area have shown both the prospect of conserving the environment as well as destroying it despite the observation done by Minja (1998) that Maasai way of life exhibit a primary interest in the preservation of fauna and flora in their surroundings.

7. CONCLUSION

Wild plant resources are highly valued by the local communities within Kwakuchinja Wildlife Corridor. This is reflected by their proximity to reserved and unreserved wild life and relatively high reliance on both wild plant products and services. As part of the natural capital, resource from the wild plants is amongst the important assets and should be equally considered with other assets in an overall livelihood strategy. Still having access to, and being able to effectively use, local plant resources will certainly remain a central element contributing to the quality of life in Kwa kuchinja. However, preferred species such as *Terminalia brownii, Acacia nilotica, Acacia mellifera, Grewia bicolor, Tamarindus indica, Zanthoxylum chalybeum, Ximenia caffra* and *Harissonia abyssinica* are threatened due to overexploitation which can result into local extinction if they are not protected or cultivated.

Moreover, intensive wild plant use by the local population together with increasing number of different land users such as small and large scale agriculturists, charcoal producers, resident hunters, professional sport hunting companies, tour operators, and miners in the Tarangire ecosystem, is posing a threat to one of the few remaining wildlife migratory routes. The scarcity of *Dalbergia melanoxylon* in the study area emphasizes the fact that the more the harvesters, the scarcer a slow-growing species becomes. In theory, sustainable harvesting of plants from wild populations is possible, but depends as much on an understanding of the biological component as on the social and economic aspects of wild plant use. Higher preference to some of the wild plant species calls for conservation if they are to be preserved from depletion or extinction. The documentation of wild useful plants as in this thesis could also intensify exploitation if conservation measures are not put in place.

With ever-increasing habitat loss and fragmentation, wild plant resources could currently be of critical importance to the survival of threatened populations of animals, particularly those sourced from keystone species. The removal of a given plant product from the wild may adversely affect dependent animal populations, the effects of which could be replicated depending on the role played by the affected species in the ecosystem.

Medicinal plants are amongst the most threatened species in the study area, the fact that most are subjected to destructive harvesting methods such as root and bark harvesting. This use category is also the most recognized and with highest number of species in use in the area. This implies that without finding ways for protection and conservation of these species, the wild populations of medicinal plants will continue to suffer declines and are at risk of extinction.

From this study of useful wild plants one can deduce that natural resources management in Kwa kuchinja requires adequate information not only about species populations and ecosystems, but also the people who most frequently use the resources. The knowledge and perceptions of resource users such as traditional healers, craft workers and commercial medicinal plant harvesters provide valuable insights into the scarcity of useful plant species as it has been observed in this study. It is these resource users who get aware of scarcity of resources long before any conservation biologists. Their knowledge therefore enables biologists to monitor key species. It therefore calls for measures to respect, preserve and maintain knowledge, innovations and practices of local communities for sustainable use of wild plants within the Kwakuchinja wildlife corridor.

8. RECOMMENDATIONS

In the light of results highlighting overexploitation of species from this study, there should be intensive studies for all those species that are overexploited or likely to disappear in the study area such as *Dalbergia melanoxylon, Zanthoxylum chalybeum, Acacia nilotica, Terminalia brownii, Acacia mellifera, Grewia bicolor, Tamarindus indica, Ximenia caffra* and *Harissonia abyssinica*. Such studies should include their ecological and silvicultural aspects, and also to find out the distribution pattern of their populations wherever they occur in Tanzania. These key species could be subjected to appropriate techniques that will ensure cultivation, integration into farming systems, and hence availability of these important resources within the proximity of the local people. Therefore, information on the appropriate cultivation methods for these species should be disseminated to the local communities in the study area. Awareness campaigns on the importance of cultivating useful wild plants should also be considered. On the other hand, it is important to keep track of these wild useful species for conservation, especially those that make a direct contribution to the livelihood of the local community, such as medicinal plants and fuelwood species. Also, a local botanical garden can be established for those plants which appear to be endangered such as *Dalbergia melanoxylon, Zanthoxylum chalybeum, Acacia nilotica* and *Terminalia brownii*.

There should be strategies to reduce pressure on critical species such as resource substitution and plantation efforts as well as control of destructive harvesting activities through enacting bye-laws regulating harvesting. Assessment of the usefulness of traditional management systems such as types of punishment to discourage illegal resource exploitation could help to build on and adapt traditional authority to develop a functional community-owned management system.

Achieving conservation efforts also requires an understanding of the social, economic, ethical, religious and political factors that either encourage resource conservation or lead to resource depletion. Therefore research activities which focus on local needs, constraints and opportunities should be promoted.

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10. APPENDICES

Appendix 1: Items for Semi-Structured Interviews

Date: Questionnaire no: Name of interviewer:

Particulars of area

Name of village:_____

Sociodemographic data

Name of respondent (optional):

Sex (mark by a tick): Male_____ Female_____

Age (ask or estimate): 15- 24 25-34 35-44 Above 44

Questions on cultural knowledge and ethnobotany

1. Do you know any plant use?
2. If yes, what plant uses are common to you?
3. Which plants do you use, how do you call them?
4. What is their growth habit and habitat?
5. Do you have a system of categorizing useful wild plants?
6. If yes, what criteria do you use?
7. Which categories of plant uses are specific to children, men and women?
8. Who owns the different plots of land where useful wild plants are found?
9. How far do you have to go to collect the species of use? How much time do you use?
10. How much time did you need 5 years ago? 10 years ago?

11. What do you think will happen 5 years to come?
12. Are there some species that have disappeared? If yes, name them
13. What are the best and worst things about these species that have disappeared?
14. Are there species you knew were being used and are no longer used? Describe them and indicate why they are no longer used
15. Are there some cultural ceremonies connected with different wild plants use? If yes, indicate the ceremonies
16. Which species have a market value?
17. Are you engaged in any business that requires plant resource? If yes, which ones?
18. Which species is more preferable for your business, what commercial products does it make?
19. What items of the commercial products of species are more preferred than others?
20. Which of the species fetch more cash income than others?
21. To whom do you sell the produce?
22. What parts do you use?
23. What is the price for the different species sold from the area?
24. On average, how much cash do you obtain from each of the plant products sold?
25. How many times in the year do you sell your products?
26. What measures do you take to ensure the constant supply of the useful wild plants in the area?

Appendix 2: Items for Guided Field Walks

Name of village: _____ Name of respondent (optional): _____

Sex (mark by a tick): Male_____ Female_____

Age (ask or estimate): 15- 24 25-34 35-44 Above 44

1. How do you call this plant?
2. Why do you call it so?
3. What are its uses?
4. When do these plants set flowers/ fruits?

5. What are the possible threats to these plants and their habitats?
6. Do these plant regenerate easily after severe harvesting?
7. What role do you personally play to ensure these plants and their habitats are used sustainably?

Appendix 3: Items for Intriguing Practices and Beliefs

1. There is a belief that plants and human beings are inextricably intertwined. Is this true or false?
2. If true, can you please explain?
3. Some plants elsewhere are bound to deep secrecy whereas all members of the community can access most plants. Is it true to your community? True/ False
4. Can you please explain?
5. In your community, do plants have spiritual, cultural, ceremonial, superstitious values?
6. If yes, what are these plants and what are the practices related to those values mentioned above?
7. What do you think is the conservation values/ impacts of these practices?

Appendix 4: List of All Encountered Species in the Inventory

SPECIES BOTANICAL NAME	FAMILY	CODE
Abutilon hirtum (Lam.) Sweet	Malvaceae	CM 125-04
Abutilon mauritianum (Jacq.) Sweet	Malvaceae	CM 040-04
Acacia abyssinica Hochst. Ex Benth	Fabaceae	CM 146-04
Acacia cinerea Schinz.	Fabaceae	CM 075-04
Acacia drepanolobium Harms and Sjostedt	Fabaceae	CM 105-04
Acacia kirkii Oliv.	Fabaceae	CM 064-04
Acacia mellifera (Vahl)Benth	Fabaceae	CM 039-04
Acacia polyacantha Willd.	Fabaceae	CM 143-04
Acacia senegal (L.) Willd.	Fabaceae	CM 095-04
Acacia tortilis (Forssk.) Hayne	Fabaceae	CM 016-04
Achyranthes aspera L.	Amaranthaceae	CM 002-04
Adansonia digitata L.	Bombaceae	CM 072-04
Aerva lanata Juss. ex Schultes	Amaranthaceae	CM 112-04
Agave sisalena Perr. Ex Eng. *cultivated	Agavaceae	CM 128-04
Albizia amara (Roxb.) Boiv.	Fabaceae	CM 097-04
Albizia anthelmentica (A.Rich)Brogn	Fabaceae	CM 089-04
Argemone mexicana L.	Fabaceae	CM 123-04
Aristida adoensis Hochst.	Poaceae	CM 047-04
Aristida barbicollis Trin. and Rupr.	Poaceae	CM 147-04
Aristida hordeaceae Kunth	Poaceae	CM 098-04
Asparagus africanus Lam.	Asparagaceae	CM 103-04
Asystacia schimperi	Acanthaceae	CM 142-04
Balanites aegyptiaca (L.) Del.	Balaniteceae	CM 019-04
Barleria acanthoides (Vahl.)	Acanthaceae	CM 152-04
Bidens schimperi Sch.Bip	Asteraceae	CM 074-04
Blepharis affinis CB Clarke	Acanthaceae	CM 076-04
Blepharis longifolia Lindau	Acanthaceae	CM 029-04

Boscia salicifolia Oliv. Karbaseeji	Capparaceae	CM 084-04
Boscia angustifolia A. Rich.	Capparaceae	CM 116-04
Boscia mossambicensis Klotzch	Capparaceae	CM 101-04
Brachiaria brizantha (A. Rich.) Stapf	Poaceae	CM 053-04
Cadaba farinosa Forssk.	Capparaceae	CM 054-04
Capparis tomentosa Lam.	Capparaceae	CM 035-04
Cassia mimosoides L.	Fabaceae	CM 065-04
Cenchrus ciliaris L.	Poaceae	CM 046-04
Chloris gayana Kunth	Poaceae	CM 024-04
Chloris roxburgiana Schult.	Poaceae	CM 094-04
Chloris virgata Sw.	Poaceae	CM 042-04
Cleome hirta (Klotzsch) Oliver	Capparaceae	CM 014-04
Clerodendrum myricoides (Hochst.) Vatke	Verbenaceae	CM 022-04
Commiphora africana (A. Rich) Engl.	Burseraceae	CM 058-04
Commiphora schimperi (O.Berg.) Engl.	Burseraceae	CM 033-04
Corchorus olitorius L.	Tiliaceae	CM 038-04
Corchorus trilocularis L.	Tiliaceae	CM 086-04
Cordia monoica Roxb.	Boraginacae	CM 032-04
Cordia ovalis S. R. BR.	Boraginacae	CM 082-04
Crebbea velutina S. Moore	Acanthaceae	CM 036-04
Cyanotis foecuda (Hochst) Stapf	Commelinaceae	CM 115-04
Cyathula orthacantha (Asch.)Schinz	Amaranthaceae	CM 034-04
Cyathula polystachion L.	Amaranthaceae	CM 137-04
Cynodon nlemfluensis Vanderyst	Poaceae	CM 106-04
Cynodon plectostachyus (K. Schum.) Pilg.	Poaceae	CM 043-04
Dactyloctenium aegyptium (L.) Willd.	Poaceae	CM 005-04
Dalbergia melanoxylon Guill. and Perr.	Fabaceae	CM 129-04
Dalbergia nitudila Baker	Fabaceae	CM 127-04
Datura stramonium L.	Solanaceae	CM 124-04
Dicanthium annulatum (Forssk) Stapf.	Poaceae	CM 041-04

Dichrostachys cinerea (L.) Wight and Arn.	Fabaceae	CM 079-04
Digitaria abyssinica (Hochst. Ex A. Rich.) Stapf	Poaceae	CM 077-04
Digitaria macroblephara (Hack.) Hack.	Poaceae	CM 107-04
Duosperma crenatum (Lindau) PG Mey.	Acanthaceae	CM 067-04
Ehretia amoema Thon	Boraginacae	CM 015-04
Eragrostis aspera (Jacq.) Nees	Poaceae	CM 057-04
Eragrostis cylindriflora (Hochst.)	Poaceae	CM 012-04
Eragrostis superba Peyr.	Poaceae	CM 093-04
Erochloa trichopa Retz.	Poaceae	CM 120-04
Fluggia virosa (Roxb. Ex willd.)	Euphorbiaceae	CM 139-04
Gardenia ternifolia Schum and Thonn.	Rubiaceae	CM 056-04
Gomphrena celosioides (Mart.)	Amaranthaceae	CM 132-04
Grewia bicolor Juss.	Tiliaceae	CM 073-04
Grewia platyclada K. Schum	Tiliaceae	CM 045-04
Grewia tembensis Fresen.	Tiliaceae	CM 021-04
Guttenbergia polycephala (Oliv. and Hiern.)	Asteraceae	CM 081-04
Harissonia abyssinica Oliv.	Simaroubaceae	CM 096-04
Harpachyne schimperi (A. Rich)	Poaceae	CM 149-04
Heliotropium steudneri Vatke	Boraginacae	CM 006-04
Heteropogon contortus (L.)Roem and Schult.	Poaceae	CM 070-04
Hibiscus canabinus L.	Malvaceae	CM 055-04
Hibiscus micranthus L.f.	Malvaceae	CM 044-04
Hoslundia opposite Vahl	Labiatae	CM 140-04
Hypoestis forskaolii (Vahl) R. Br.	Acanthaceae	CM 104-04
Indigofera colutea Burm.f.Merr	Fabaceae	CM 013-04
Ipomoea sinensis (Desr.) Choisy	Convolvulaceae	CM 048-04
Jasminium fluminence Vell.	Oleaceae	CM 004-04
Justicia anseliana (Nees)T. Anders	Acanthaceae	CM 148-04
Justicia bretonica L.	Acanthaceae	CM 069-04

Leonotis nepetifolia Gurke	Labiatae	CM 080-04
Lepidagathis scabra CB Cl.	Acanthaceae	CM 068-04
Lonchocarpus bussei Harms	Fabaceae	CM 110-04
Lonchocarpus eriocalyx Harms	Fabaceae	CM 088-04
Maerua angolensis DC.	Capparaceae	CM 151-04
Maerua edulis (Gilg. Ben. and Benedict) De Wolf	Capparaceae	CM 066-04
Maerua triphylla A. Rich.	Capparaceae	CM 003-04
Markhamia platycalyx (Baher) Sprague	Bignoniaceae	CM 153-04
Maytenus senegalensis (Lam.) Exell	Celastraceae	CM 144-04
Melhania velutina Forssk	Sterculiaceae	CM 028-04
Melinis repens (Willd.) Zizka	Poaceae	CM 114-04
Merremia tridentata (Linn.) Hallier f.	Vitaceae	CM 049-04
Monechma debile (Forssk.) Nees	Acanthaceae	CM 009-04
Neurotenia nitis Baker	Fabaceae	CM 091-04
Ocimum bassilicum L. *cultivated	Labiatae	CM 026-04
Ocimum suave (Willd.)	Labiatae	CM 062-04
Ormorcarpum kirkii S. Moore	Fabaceae	CM 099-04
Orthosphon suffrutescens (Thonning). J.K. Morton (O. australis vatke)	Labiatae	CM 111-04
Panicum coloratum L.	Poaceae	CM 001-04
Panicum incanum L.	Poaceae	CM 113-04
Panicum maximam Jacq.	Poaceae	CM 052-04
Pennisetum mexianum Leek	Poaceae	CM 008-04
Pennisetum polystachion (L.) Schult.	Poaceae	CM 085-04
Pennisetum purpureum Schumach.	Poaceae	CM 154-04
Peristophe bicalyculata (Forssk.) Brum	Acanthaceae	CM 063-04
Perotis hildebrandtii Mez.	Poaceae	CM 050-04
Perotis patens Gand.	Poaceae	CM 020-04
Phyllanthus engleri (Pax.)	Euphorbiaceae	CM 138-04

Phyllanthus maderaspatensis (L.)	Euphorbiaceae	CM 051-04
Pluchea ovalis (Pers.) Dc.	Poaceae	CM 118-04
Portulaca oleracea L.	Portulaceae	CM 136-04
Salvadora persica L.	Salvadoraceae	CM 037-04
Sclerocarya birrea (A.Rich.) Hochst.	Anacardiaceae	CM 130-04
Sesamum angustifolium (Oliv.) Engl.	Poaceae	CM 018-04
Sesbania sesban (L.)Merr.	Fabaceae	CM 121-04
Setaria incrassate (Hochst.) Hack.	Poaceae	CM 108-04
Setaria sphacelata (Schumach.) Moss	Poaceae	CM 061-04
Setaria vexillata (L.) P. Beauv	Poaceae	CM 031-04
Sida acuta Burm. F	Malvaceae	CM 060-04
Sida alba L.	Malvaceae	CM 027-04
Solanum dubium Fresen.	Solanaceae	CM 126-04
Solanum incanum L.	Solanaceae	CM 025-04
Sorghum versicolor Anders	Poaceae	CM 141-04
Spermacose senensis (Klotzsch) Hiern	Rubiaceae	CM 083-04
Sphaeranthus gomphrenoides O.Hoffm.	Asteraceae	CM 122-04
Sphaeranthus ukambensis O.Hoffm.	Asteraceae	CM 102-04
Sporobolus consimillis Fresen.	Poaceae	CM 023-04
Sporobolus fimbreatus (Trin.) Nees	Poaceae	CM 017-04
Sporobolus panicoides A. Rich.	Poaceae	CM 059-04
Sporobolus stapfianus Gand.	Poaceae	CM 150-04
Strychnos potatorum L.f.	Loganiaceae	CM 007-04
Tegetes minuta Linn. J. Essen	Asteraceae	CM 131-04
Tephrosia pumila (Lam.) Persoon	Fabaceae	CM 087-04
Tephrosia virgata HM. Forbes	Fabaceae	CM 010-04
Terminalia brownii Fresen.	Combretaceae	CM 145-04
Themeda triandra Forssk.	Poaceae	CM 030-04
Tragus betreronianus Schult.	Poaceae	CM 135-04
Triumfetta rhomboidae Jacq.	Tiliaceae	CM 078-04

Trichodesma zeylanicum (Burm.f.) R.Br	Boraginacae	CM 090-04
Urochloa trichopus (Hoschst) Stapf	Poaceae	CM 109-04
Vernonia aydagdalina (Del.)	Asteraceae	CM 092-04
Vernonia galamensis (Cass.) Less	Asteraceae	CM 100-04
Vernonia hildebrandtii (Vatke.)	Asteraceae	CM 119-04
Vernonia poskeana Vatke and Hildeb.	Asteraceae	CM 133-04
Vernonia perrottetii Sch. Bp. ex Walp.	Asteraceae	CM 134-04
Waltheria indica L.	Solanaceae	CM 071-04
Zaleya pentandra (L.) Jeffrey	Aizoaceae	CM 117-04
Ziziphus pubescens Oliv.	Boraginacae	CM 011-04

Appendix 5: Pairwise Ranking Results of the Destructive Harvesting Methods

	Root	Bark	Stem	Leaves	Fruits		Frequency	Rank
Root		Root	Stem	Root	Root	**Root**	3	2
Bark			Stem	Bark	Bark	**Bark**	2	3
Stem				Stem	Stem	**Stem**	4	1
Leaves					Leaves	**Leaves**	1	4
Fruits						**Fruits**	0	5

Appendix 6: Species Preferred For Different Use Categories As Mentioned By Local People

USE CATEGORY	PREFERRED SPECIES		FAMILY NAME	PARTS USED
	LOCAL NAME	BOTANICAL NAME		
1. MEDICINAL	Mokitakita	*Harissonia abyssinica*	Simaroubaceae	Roots
	Mswaki	*Salvadora persica*	Salvadoraceae	Leaves; bark; root
	Mojengojengo	*Ximenia caffra*	Olacaceae	Leaves; roots
	Mduguyu	*Acacia nilotica*	Fabaceae	Bark; roots
	Mlungulungu (utambazi/lawalawa)	Zanthoxylum chalybeum	Rutaceae	Roots
	Mgunga/kikwata	*Acacia senegal*	Fabaceae	Stem/ root bark
	Mkwaju	*Tamarindus indica*	Fabaceae	Leaves; roots; seeds
	Bukoo	*Terminalia brownii*	Combretaceae	
2. FUELWOOD	Mng'arada (ngoja kidogo)	*Acacia mellifera*	Fabaceae	Stem

	Mkole	*Grewia bicolor*	Tiliaceae	Stem (wood)
	Mgunga	*Acacia tortilis*	Fabaceae	Stem (wood)
	Mduguyu	*Acacia nilotica*	Fabaceae	Stem (wood)
	Mokitakita	*Harissonia abyssinica*	Simaroubaceae	Stem branches
	Bukoo	*Terminalia brownii*	Combretaceae	Stem (wood)
	Mojengojengo	*Ximenia caffra*	Olacaceae	Stem (wood)
	Mlungulungu	Zanthoxylum chalybeum	Rutaceae	Stem branches
	Pee/ Mtalawanda	*Manilkara mochisia*	Sapotaceae	Stem (wood)
	Mkwaju	*Tamarindus indica*	Fabaceae	Stem (wood)
	Mswaki	*Salvadora persica*	Salvadoraceae	Stem
	Mgunga	*Acacia tortilis*	Fabaceae	Stem (wood)
	Mduguyu	*Acacia nilotica*	Fabaceae	Stem (wood)
3. CHARCOAL	Mng'arada (ngoja kidogo)	*Acacia mellifera*	Fabaceae	Stem (wood)
	Toto	*Rudbeckia hirta*		Stem (wood)
	Tetekoo (mlama)	*Rhus vulgaris*	Anacardiaceae	Stem (wood)

	Mbolongo (mrura)	*Acacia drepanolobium*	Fabaceae	Stem (wood)
	Mkababu	*Acacia albida*	Fabaceae	Stem (wood)
	Bukoo	*Terminalia brownii*	Combretaceae	Stem (wood)
	Mpingo	*Dalbergia melanoxylon*	Fabaceae	Stem (wood)
	Mlungulungu	*Zanthoxylum chalybeum*	Rutaceae	Stem (wood)
4. BUILDING/ TIMBER	Toto	*Rudbeckia hirta*	Combretaceae	Stem (wood)
	Mng'arada (ngoja kidogo)	*Acacia mellifera*	Fabaceae	Stem (wood)
	Motoo	*Grewia villosa*	Tiliaceae	Stem (wood)
	Tetekoo (mlama)	*Rhus vulgaris*	Anacardiaceae	Stem (Wood)
	Bukoo	*Terminalia brownii*	Combretaceae	
	Mkole	*Grewia bicolor*	Tiliaceae	Stem (wood)
	Mwerema	*Cordia monoica*	Boraginaceae	Stem (wood)
	Mgunga	*Acacia tortilis*	Fabaceae	Stem (wood)
5. FOOD	Osilalei (Mponda)	*Commiphora africana*	Burseraceae	Tea infusions by its bark

	Mkwaju	*Tamarindus indica*	Fabaceae	Fruits
	Mbuyu *Also its fibres are used to make ropes and the tree is preferred for beehives*	*Adansonia digitata*	Bombaceae	Fruits
	Motoo	*Grewia villosa*	Tiliaceae	Fruits
	Toto	*Rudbeckia hirta*	Combretaceae	
	Mkoche	*Hyphaene petersiana*	Arecaceae (Palmae)	Leaves
	Kitete	*Lagenaria siceraria*	Cucurbitaceae	Fruits
6. HANDCRAFT	Engaetete	*Commelina benghalensis*	Commelinaceae	Leaves
	Emuruwa	*Pennisetum mexianum*	Poaceae	Grass
7. RITUAL	Oloiren	*Olea europeae ssp cuspidata*	Oleaceae	

Appendix 7a: List of Useful Plant Species Mentioned By Local People in the Study Area

Species botanical name	Family name	Maasai/Arusha	Mbugwe	Main uses
Acacia albida (Faidherbia albida)	Fabaceae			Beek., Cha, Fi, Fodder, Fo, Me, shade
Acacia drepanolobium	Fabaceae	Eluai	Mbolongo	Me, Fi, Cha
Acacia mellifera	Fabaceae	Oiti	Mng'arada	Fi, Cha, Me, Fe
Acacia nilotica	Fabaceae	Olkiloriti	Barabonyoda (Mduguyu)	Cha, Fi, Fo, Me
Acacia tortilis	Fabaceae		Moonga	Cha, Fi, Constr, shade
Acacia xanthophloea	Fabaceae	Locheda		Cha,
Achyranthus aspera	Amaranthaceae	Monkwalyaro		Me,
Adansonia digitata	Bombaceae	Olimisera	Mwuwiye (Mbuyu)	Fo, Me
Afzelia quanzensis	Fabaceae		(Mkora)	Cha, fi, Me
Albizia anthelminthica	Fabaceae	Emukutani/ Ormukutani		Me
Albizia harveyi	Fabaceae		Musisiviri	Fi, Cha
Albizia petersiana	Fabaceae		Mosisiviri	Fi, Cha
Allophylus spp	Sapindaceae	Enchani empurkei		Me,
Aloe secundiflora (Engler)	Liliaceae	Osukuroi		Local brews
Azanza garckeana	Malvaceae	Motoo	Mutogo	Fo, Fi
Balanites aegyptiaca	Balanitaceae	Orong'oswa	Modorii (Mkikuyu)	Fi, Cha, Fo, Me
Brachistegia spiciformis	Fabaceae			Cha, Fi, Me
Cassia mimosoidae	Fabaceae	Osokonoi		Fi, Po, Me
Combretum zeyheri	Combretaceae	Olmaroroi/ tetekoo	(Mlama)	Fo, Cha, Po, Me
Commelina benghalensis	Commelinaceae	Engaetete		Ritual
Commiphora africana	Burseraceae	Osilalei	Tundulu	Fi, Me, Fodder, Constr,
Cordia monoica	Boraginaceae	Olsiyeki	Mwerema	Fi, Pegs, Po,

Cordia ovalis	Boraginaceae	Ordokoo		Me
Cordia sinensis	Boraginaceae		Mochocho	Fo, Fodder
Dalbergia melanoxylon	Fabaceae	(Mpingo)	Mwinde	Cha, Constr.(Po),
Delonix regia	Fabaceae		(Mjohoro)	Fi
Dichrostachys cinerea	Fabaceae	Endundulu		Po, Fi, Fodder, Me
Enicostema axillave		Motee wa losango		Me,
Erythrina abyssinica	Fabaceae	Olngaboli		Fi, Me, Po
Ficus stuhlmannii	Moraceae	Olkilili		Constr.
Ficus sycomorus	Moraceae	Olng'arboli	(Mkuyu)	Fi, Me,Constr., Fo
Ficus thonningii	Moraceae	Oreteti		ceremonial
Grewia bicolor	Tiliaceae	Ositeti	Musuna-nu-kuu/ Muriwao	Fi, Contr.-Po, (pegs)
Grewia platyclada	Tiliaceae	Olmangulai		Fi, Me, Fo, Fodder. Po
Grewia villosa	Tiliaceae	Olmangulai	Motoo	Fo, Fi
Hagenia abyssinica	Rosaceae	Enjani		Me,
Harissonia abyssinica	Simaroubaceae		Mokitakita	Fi, Fito, Me
Hyphaene coriacea	Palmae		(Mnyaa)	Weav, Ceil,
Hyphaene petersiana	Palmae	Mwangwa	Madala	Ceil, Fo
Kigelia africana	Bignoniaceae		(Mlegea)	Me, Constr., Fo
Lagenaria siceraria	Cucurbitaceae	Kitete		Ceremonial
Lannea schweinfurthii var. stuhlmanii	Anacardiaceae	Orupande	Mong'ong'o	Me,
Lippia kituiensis (ukambensis)	Verbenaceae	Osinoni		Me
Lonchocarpus eriocalyx	Fabaceae		Mweiya	Fi, Cha,
Maesa lanceolata	Myrsinaceae	Olodua	Esenyi	Me
Manilkara mochisia	Sapotaceae	(Mtalawanda)	Pee	Fi
Markhamia platycalyx	Bignoniaceae		Motoo	Fi, Fo, Me
Papaver somnifera var. album	Papaveraceae	Mofene		Me

Pennisetum mexianum	Poaceae	Emuruwa		Me,
Plectranthus barbalis	Labiatae		Motewiwayi	Me,
Podocarpus latifolius	Podocarpaceae	Orpiripiri		Fi, Me, Constr.
Rapanea melanophloeos	Myrsinaceae	Sokoneda		Me,
Rudbeckia hirta	Asteraceae		Toto	Cha
			Modee	
Salvadora persica	Salvadoraceae	Oremit	(Mswaki)	Tb, fibre, Fi, Me
Sansevieria zeylandica	Agavaceae	Njaro		Me
Sclerocarya birrea subsp.				
Caffra	Salvadoraceae	Marula	Monyangu	Fo
			Motowambuye/	
			motongu wa	
Solanum incanum	Solanaceae	Endulelei	mbuye	Me
			Mosinko	
Tamarindus indica	Fabaceae	Olmasambrai	(Mkwaju)	Fo, Constr(Po), Me
Terminalia brownii	Combretaceae	Olbukoi	Bukoo	Me, Fi
Vitex doniana	Verbenaceae		(Mfuu)	Ti, Fo, Fi,
Ximenia americana	Olacaceae	Olamai		Me, Fi
Ximenia caffra	Olacaceae		Mojengojengo	Fo, Me,
			Molongo/	
		Oluisuki/	morongi	
Zanthoxylum chalybeum	Rutaceae	luisukii	(Mlungulungu)	Constr.-Po, Me,
Ziziphus mucronata	Rhamnaceae	Olailaley		Fo, Constr. -Ceil

KEY: Fo= Food Tb= Toothbrush
Ceil= Ceiling Cha= Charcoal
Po= Poles Constr.= Construction
Me= Medicinal Weav= Weaving
Fi= Firewood Fe= Fencing Ti= Timber

** Written in brackets are Swahili names of the given species as given by some respondents*

Appendix 7b: Useful Species Encountered During Inventory

SPECIES NAME	FAMILY	IN	OUT
Acacia drepanolobium	Fabaceae		X
Acacia mellifera	Fabaceae	X	X
Acacia tortilis	Fabaceae	X	X
Achyranthus aspera	Amaranthaceae	X	X
Adansonia digitata	Bombaceae	X	
Albizia anthelmentica	Fabaceae	X	
Balanites aegyptica	Balaniteceae	X	
Cassia mimosoidea	Fabaceae	X	
Commiphora africana	Burseraceae	X	X
Cordia monoica	Boraginacae		X
Cordia ovalis	Boraginacae		X
Dalbergia melanoxylon	Fabaceae	X	
Dichrostachys cinerea (L.) Wight and Arn.,	Fabaceae	X	X
Grewia bicolor	Tiliaceae		X
Grewia platyclada	Tiliaceae		X
Harissonia abyssinica	Simaroubaceae	X	X
Lonchocarpus eriocalyx	Fabaceae		X
Markhamia platycalyx	Bignoniaceae		X
Pennisetum mexianum	Poaceae	X	X
Salvadora persica	Salvadoraceae	X	X
Sclerocarya birrea	Anacardiaceae	X	X
Solanum incanum	Solanaceae	X	X
Terminalia brownii	Combretaceae		X
Ziziphus pubescens	Boraginaceae		X

IN- found inside the National Park

OUT- found outside the National Park

Appendix 8: Importance Value Indices - Overall

SPECIES	FAMILY	IVI-OVERALL
Acacia tortilis	Fabaceae	229.29
Acacia kirkii	Fabaceae	114.58
Adansonia digitata	Bombaceae	76.93
Strychnos potatorum	Loganiaceae	53.70
Acacia melifera	Fabaceae	37.99
Balanites aegyptiaca	Balaniteceae	23.05
Acacia senegal	Fabaceae	13.71
Albizia amara	Fabaceae	10.86
Cordia monoica	Boraginaceae	9.56
Commiphora schimperi	Burseraceae	7.27
Grewia bicolor	Tiliaceae	4.35
Acacia polyacantha	Fabaceae	3.98
Cadaba farinosa	Capparaceae	3.90
Boscia angustifolia	Capparaceae	3.76
Boscia mossambicensis	Capparaceae	3.65
Acacia cinerea	Fabaceae	3.41

Appendix 9: Species Encountered in the Field That Have Multiple Uses

BOTANICAL NAME	FAMILY NAME	USES
Terminalia brownii	Combretaceae	• Construction • Medicinal (stomach disorders) • Fuelwood • Charcoal
Acacia nilotica	Fabaceae	• Medicinal (gonorrhoea) • Food (fruits) • Fuelwood • Construction • Charcoal • Carving wooden spoons
Acacia tortlis	Fabaceae	• Fuelwood • Chacoal • Construction
Grewia bicolor	Tiliaceae	• Construction • Food (fruits) • Fuelwood • Walking sticks • Vihenge
Tamarindus indica	Fabaceae	• Food (fruits) • Medicinal • Fuelwood
Zanthoxylum chalybeum	Rutaceae	• Medicinal • Fuelwood • Construction • Food (spicing tea/ vegetables) • Used for local storage of food
Ximenia caffra	Olacaceae	• Food (fruits) • Medicinal • Fuelwood
Harissonia abyssinica		• Medicinal • Food (fruits) • Fuelwood
Salvadora persica	Salvadoraceae	• Medicinal • Fuelwood • As toothbrush

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Appendix 10: Age of Respondent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	15-24 years	10	12.8	12.8	12.8
	25-34 years	30	38.5	38.5	51.3
	35-44 years	16	20.5	20.5	71.8
	> 44 years	22	28.2	28.2	100.0
	Total	78	100.0	100.0	

DECLARATION

I, Clara Anita Makenya, do hereby declare that, this thesis is a result of my original work and it has not been submitted for any academic degree award to any other University. All sources of materials used for the thesis have been duly acknowledged.

Signature.....

Date.....12th July 2005.....