TIMBER POTENTIAL VALUE IN THE EASTERN-ARC MOUNTAINS, TANZANIA: NYANGANJE FOREST RESERVE

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN FORESTRY OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

The study was conducted to determine the quantity of timber and extent of illegal timber harvesting in Eastern Arc Mountains. Data were collected using three techniques: desktop review which was used to collect information on timber stocks from two studies in EAMs while socio-economic and ecological surveys were employed to collect information on timber disturbances and timber stocks harvested illegally in NFR. Data analysis involved use of Microsoft excel and Statistical Package for Social Sciences (SPSS). A t-test analysis showed that, the EAMs have high potential in terms of timber tree stocks (p (t) = 0.047 d.f = 39) for stems per ha and (p (t) = 0.001 d.f = 39) for volume per ha). Also linear regression analysis showed that, extraction of timber trees in NFR mostly occurs illegally at the roadside (R^2 = 0.19, p = 0.015). A total of 135 600 000 stems and 74 400 000 m^3 (an equivalent of 0.6 m^3 per tree) composed of 180 different timber species were identified in EAMs. The major timber species contributed 47 000 000 m^3 (63%) of total wood volume. Taking the royalty and volume of each timber classes for indigenous and exotic species, the value of timber in EAMs was USD 5576 million. The harvestable timber was about USD 4461 million for trees sizes of greater than 40 cm DBH. The mean annual quantity of wood harvested illegally was estimated to be 6.2 m^3 per ha, of which 2.7 m^3 per ha was due to timber harvesting. If extraction is done in every hectare in NFR, each year the government could lose USD 0.36 million. Though the EAMs have high potential of timber species, this potentiality will be depleted if effective measures are not taken due to the fact that currently these forests are under pressure for timber extraction. The timber trees species thus need to be well managed and conserved, to ensure sustainability.

DECLARATION

I, **JOSEPH SITIMA MAKERO**, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been nor concurrently being submitted for a higher degree award in any other University.

Joseph S. Makero (MSc. Candidate) Date

The above declaration is confirmed

Professor R.E. Malimbwi (Supervisor) Date

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DEDICATION

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LIST OF ABBREVIATIONS AND SYMBOLS

BD	-	Basal Diameter
CO_2	-	Carbon dioxide
DBH	-	Diameter at Breast Height
EAMs	-	Eastern-Arc Mountains
e.g.	-	Example
FAO	-	Food and Agriculture Organisation of the United Nations
FBD	-	Forest and Beekeeping Division
G	-	Basal area per hectare
ha	-	Hectare
INCO_DEV	-	International Cooperation with Developing Countries
IUCN	-	World Conservation Union
i.e.	-	That is
JFM	-	Joint Forest Management
km	-	Kilometre
MNRT	-	Ministry of Natural Resources and Tourism
m^3	-	Cubic Metre
N	-	Number of stems per hectare
NFR	-	Nyanganje Forest Reserve
NGOs	-	Non Government Organizations
PRA	-	Participatory Rural Appraisal
SUA	-	Sokoine University of Agriculture
TANWAT	-	Tanzania Wattle Company
TShs	-	Tanzanian Shillings
UK	-	United Kingdom

URT	-	United Republic of Tanzania
USD	-	United States of America Dollar
V	-	Volume per hectare
VTA	-	Valuing The Arc
WWF	-	Wildlife World Fund

CHAPTER ONE

INTRODUCTION

1.1 General Overview

Tanzania has an area of 945 000 km^2. About 38.8 million ha or 40.4% is covered by forests and woodlands. Out of 38.8 million ha classified as forest land, almost two third consists of woodlands and general (public) land (Dallu, 2002 cited by Silayo, 2004). According to Mugasha *et al*. (2004), the main vegetation types found in Tanzania include Afroalpine health and moorland, forests, woodlands and grasslands, bushlands and thickets, swamps, mangroves and man made forests. About 13 million ha of this total forest area have been gazetted as forest reserve. Over 80 000 ha of the gazetted area is under plantation forestry and about 1.6 million ha are under water catchment management (Mugasha *et al*., 2004).

The total forested area in Tanzania is classified on the basis of forest types, use and legal status (URT, 1998). The forest estate has productive, protective and scientific functions. Productive benefits include: structural timber, roundwood, woodfuel etc. Protective functions include: soil conservation, environment amelioration, habitat for fauna and flora and water catchment area. Scientific functions include: unique flora and fauna and also high levels of endemism (URT, 1998). The central government owns most of the forest resources in Tanzania through FBD. It owns the gazetted forests, the woodlands in national parks, the plantations and general lands. Local governments own some forest resources which are mainly protective in function (URT, 1998). Corporations own small area of plantation forest, e.g. TANWAT Company Limited and Kilombero Valley Teak Company, private individuals and NGO’s (URT, 1998 cited by Mugasha *et al.*, 2004). The area under private and community is estimated to be 70 000-150 000 ha (FBD and IUCN, 2005).

Despite this huge natural resource base, pressure on natural resource has progressively escalated and ecological degradation has become evident especially in arid and semi-arid area in the country (Mascarenhas, 1991; FBD and IUCN, 2005). Timber trees as among the natural resource in the forests face risk of degradation. According to Iddi (2002) cited by Augustino (2006), the underlying causes include; population growth, shifting cultivation, overgrazing, wild fires and uncontrolled harvesting of trees. Equally, the influx of refugees from the neighbouring countries of Rwanda and Burundi has had devastating effects on timber trees of western Tanzania. FAO (2001) cited by Augustino (2006) estimated that Tanzania lost approximately 92 000 ha or 0.2% of its forest land in recent years, through deforestation resulting from encroachment, especially in forest reserves, due to unsustainable management by central and local government.

1.2 The Eastern-Arc Mountains

The term "Eastern-Arc" was introduced in 1985 to describe an exceptionally rich area of restricted range plant species on the crystalline mountains of eastern Tanzania and south-east Kenya (Lovett, 1990). About one third of the Eastern-Arc flora is composed of restricted range species. Lovett (1990) defined Eastern-Arc Mountains (EAMs) as a chain of isolated mountains surrounded by arid woodland influenced by the Indian Ocean. Its' forests are very important since they contain 30 to 40% of Tanzania plants used by many people for timber, building materials, fuel wood, medicinal plants and food (Munishi *et al.,* 2007). The EAMs are essential to urban populations as they are sources of rivers supplying water to Dar es Salaam, Tanga and Morogoro and also secure water supply for hydroelectric power plants. The EAMs comprise only 0.1% of tropical Africa's land area yet contains a staggering 13% of the entire continent's vascular plants. Over 25% (800 species) of the Eastern-Arc plant species are endemic while 60% of all Tanzania endemic plants occur in the EAMs (Rodgers, 1993). Nine endemic primate species, like the critically endangered Highland Mangabey (*Lophocebus kipunji*), and the African violets (*Saintpaulia* spp.) are among the region's best known endemic species. Also the EAMs forests are rich in commercial valuable timber species such as *Afzelia quanzensis, Khaya anthotheca, Milicia excelsa* and *Pterocarpus angolensis* (Malimbwi *et al*., 2005). In addition, the forests of EAMs, on the slopes and valleys are rich in species of restricted distribution, though in many places these forests have been replaced by cultivation or are heavily disturbed by timber extraction and pole cutting (Madoffe and Munishi, 2005).

The forests of the Eastern-Arc Mountains are undergoing an accelerated rate of destruction (Madoffe and Munishi, 2005) and that there is an urgent need for documentation of the problem, if changes are to be made to reverse or slow the degradation process. The authors further argue that, the growing human population in the area is leading to increased pressure on the remaining natural forests and represents the main threat to their survival. This threat compromises efforts towards forest sustainability and biodiversity conservation causing great concerns among government authorities, local and international researchers and conservation agents.

1.3 Problem Statement and Justification

The Eastern-Arc Mountains are one of the biodiversity hotspots in the world, rich in diversity of species both fauna and flora such as birds, animals and plants (Lovett, 1998). Most of the plants are trees and shrubs, which are used as source of medicine and timber. The EAM's forests provide a number of resources for the people. Sustainable management of these forests is a major concern due to the fact that currently they are under pressure for durable timber extraction. Inventories have shown that timber harvesting is taking place even in catchment forests despite being prohibited by laws (Malimbwi *et al.,* 2005).

In Tanzania, the majority of people can not afford or have no access to furniture or building materials other than wood. According to the present economic forces, the majority of urban population in Tanzania will continue to depend on timber for a long time to come. There is evidence of pressure on the natural forests from where most hardwood timber species are exploited (Malimbwi *et al.,* 2005). Commercial timber extraction for furniture making and building materials require large volume of wood which in turn depletes tree stocks. Charcoal which is the major energy source for urban dwellers doesn't exclude timber trees during production.

Little is known about the physical quantity of timber and rate of extraction in Eastern-Arc forests because in some of the forests inventory has not been done. Furthermore information about physical quantity of timber is scattered and not well organized. It is known that rational decision in management of natural forests depends on information available on their growing stock. Also, the acquisition of forest growth information is a prerequisite to any forest management system and sustainable land use (Mgeni and Malimbwi, 1990).

The intention of this study was to find out the potential of timber in Eastern-Arc Mountain's forests and also to assess the extent of its exploitation in Nyanganje Forest Reserve. The results of this study will contribute to the knowledge on quantity of timber stocks, trend of timber exploitation and also estimation of value of timber in EAMs.

1.4 Objectives

1.4.1 General objective

To determine quantity and assess the extent of timber exploitation in Eastern-Arc Mountains.

1.4.2 Specific objectives

- To quantify timber resources by species and size class distribution for all forests where inventories have been done in EAMs.
- To assess the extent of illegal timber harvesting by species and size class in NFR.
- To assess the trend in timber prices (e.g. dry/rain season) and harvesting costs in villages around NFR.

1.5 Key assumptions in the Study

The study was carried out based on the following key assumptions;

- The Eastern-Arc Mountains forests have high potential in terms of timber tree stocks of different size classes.
- Extraction of timber trees in NFR mostly occurs illegally at the edge of the forest (roadside) where accessibility is easy.

1.6 Limitation of the Study

This study has the following limitations which need to be taken into account when interpreting the results;

(i) Due to time limitation some of the tree species were not translated into botanical names because most of the findings reviewed and websites visited failed to give their botanical names, and also there was no voucher specimen of those species for further identification, thus no utilization knowledge about these species. Thus, they have been left and categorized as lesser known timber species.

(ii) Data collection is limited to two findings i.e. Malimbwi *et al*. (2005), 11 districts inventory and Munishi *et al*. (2007), 14 regions inventory which provide large information of EAMs compared to other single inventories done in one or two forest (s) which cost time and money to gather information.

(iii) Because of the shortage of time and funds, only one forest was selected to present other EAMs on assessment of illegal timber harvesting which is among the threats of potential of timbers in EAMs.

CHAPTER TWO

LITERATURE REVIEW

2.1 Timber Trees and Their Utilization

According to Hilmi *et al.* (1996), timber is defined as wood strictly called xylem, from the stem of any tree excluding palms, grass, herbs and bamboo which is proper for buildings or for tools, utensils, furniture, carriages, fences, ship and the like; usually said of felled trees, but sometimes of those standing. In the context of this study, timber is defined as wood strictly called xylem, from the stem of standing tree which can be sawn into boards and has desirable properties for furniture or construction or carriages or ship excluding the grass, herbs, palm and bamboo. Timber is a valuable product, which is generally used in house construction (rafters, doors, and frames), for furniture, and other constructed items.

In tropical forests, about 220 widely known commercial timber species are utilized (Supin, 1996). The author further argued that, the tropical forests include about one hundred species which occur more or less regularly on world timber markets. This signifies that, few well known timber species are commercially utilized. Due to high demand for durable timber in the world, promotion of lesser known but equally suitable and cheaper timber species should be encouraged (Supin, 1996). The term “lesser known timber species” referred by various researchers, Yeon (1984); Smith *et al*. (1994) cited by Bangura (1998), are those species which are not widely known and fully utilized commercially. A number of studies have been done to document the properties of different lesser known and lesser utilized timber species by comparing with those with highly known and already in the market in order to suggest alternative timber species which have suitable properties and which could be utilized as substitutes to the highly durable timber tree species (Supin, 1996).

2.2 Timber Trees in the Eastern-Arc Mountains

The forests of EAMs are very important source of timber and home of rare and endangered plants species. The vegetation of the EAMs contain a number of different types of forests such as woodland, lowland, sub montane, montane and upper montane (Lovett, 1998). According to Rodgers (1998), the variation in these types of forests comes not only from the 13 main separate blocks but also from changes within each block due to; wet and dry sides (East and West), low (hot) and high (cold) areas, ridges, slopes and valleys, steep and gentle slopes with relatively flat plateau’s on top. These variations give a great range of forest communities and timber tree species in the EAMs.

The forests of Eastern-Arc have been dependable sources of timber for various saw mills supporting the construction and lumber industries and contribute to regional timber trade (Kowero and O’Kting’ati, 1990). However, timber production in these forests has been banned since 1990. The valuable timber species that are found in EAMs include; *Allanblackia stuhlmannii, Beilschmedia kweo, Brachylaena huillensis, Brachystegia* spp, *Cephalosphaera usambarensis, Cordia africana, Entandophragma excelsum, Fagaropsis angolensis, Ficalhoa laurifolia, Greenwayodendron* spp, *Juniperus procera, Khaya anthotheca, Manilkara discolour, Milicia excelsa, Ocotea usambarensis, Olea capensis, Podocarpus usambarensis, Prunus africana, Pterocarpus angolensis, Rapanea melanophloeos, Uvariodendron usambarensis* and many others (Malimbwi *et al*., 2005).

2.3 The Importance of Forests of the EAMs

Globally, besides offering some products like timber, the significance of Eastern-Arc Mountain’s forests are known for their high species richness, endemism and a large number of restricted range species and genera (Newmark, 1998 cited by FBD, 2006). At least 800 vascular plant species are endemic; almost 10% of these being trees. Also out of the Tanzania’s 450 indigenous tree species which are above 20 m height, 150 occur exclusively in Eastern-Arc catchment’s forests and 38 of them are endemic to these forests (Lovett, 1998). These mountains are also major national, regional and local sources of water for agricultural, hydropower and industrial use, a wide array of forest products and agricultural production.

2.4 Timber trees and Livelihood of People

Rural households in developing countries have three broad options to improve their livelihood, this includes natural resource based activities and non-natural resource based activities and migration to other agricultural areas or to urban areas (Carney, 1998). The livelihood of the rural communities bordering the centres of forest biodiversity to varying extents depends on the diverse products accruing from the forest. Wood (mainly building poles and fuel wood) are the important necessities sought from the forest biodiversity almost on a daily routine by the rural communities.

According to Abdallah and Monela (2007), in Eastern Tanzania, local people have eleven types of uses for timber trees including lumbers, poles, firewood, charcoal, medicine, withies, ropes (fibres), live fences, carving and rituals. An estimated 80% of Tanzania’s which approximate 24 million people are living in rural areas where forest resources are central for their livelihood (Augustino, 2006). The industrial and services sector jobs which could save as alternative source of income through employment in the rural areas is growing slowly and poorly developed (World Bank, 2000). Despite the fact that many people in Tanzania use timber trees to sustain livelihoods, the overall value of the forest and timber to national economies are consistently under valued (World Bank, 2000). Timber trees are important tool in addressing poverty issues for marginalized, forest dependant communities, by contributing to livelihood outcomes, income which in turn assist to combat food and health security, as well as well being (Falconer, 1997).

2.5 Exploitation of Timber Trees

According to Milledge *et al.* (2007), high urban demand for timber within Dar es Salaam has depleted most nearby supplies of hardwood whereby the Eastern-Arc Mountains is inclusive. At least 27 hardwood species with commercial timber qualities were harvested from miombo woodlands and coastal forests. Out of 13 species targeted for hardwood exports in mid-2004 over 80% constituted just three species mainly; *Milletia stuhlmannii, Baphia kirkii* and *Swartzia madagascariensis.* Timber trade which is one of the factors contributing to over exploitation of forest products in Tanzania stayed high through out 2003 and up to mid 2004 when enactment of new forest legislation banned the export of round wood from natural forests. It was estimated that over 500 000 m^3 of timber were harvested for commercial purposes from southern Tanzania. This volume is equivalent to over 830 000 trees, with harvesting intensity reaching 91 m^3 of timber per km^2 of forest (Milledge *et al.*, 2007).

Illegally obtaining and utilizing resources in the protected area or in other words poaching is a main challenge for many tropical forests including the Eastern-Arc Mountains (Lulandala, 1998). The main poaching activity in the Eastern-Arc Mountains is timber lumbering, followed by firewood collection. FBD (2006) reported that, among the incidences of poaching offences committed for a period of ten years, illegal lumbering (48%) was more commonly committed in Udzungwa Mountain forest block. Pimm and Raven (2000), reported that, fragmentation of tropical forest has been described as the single greatest threat to global biological diversity.

2.6 Stand Stocking in Eastern-Arc Mountains

Forest inventories have been carried out for some forests in the Eastern-Arc Mountains. Inventory in 11 districts of Tanzania was carried out in 2005 (Malimbwi *et al*., 2005). During this inventory 33 forests across Eastern-Arc Mountains were inventoried in four districts namely; Handeni, Kilombero, Mvomero and Ulanga. The inventory in these four districts involved registered forests reserve under central, local and village governments. The information provided from this inventory included; list of forests and their areas, harvestable quantity and stand stocking in different diameter classes. According to Malimbwi (1997), the common parameters used to describe forest stand are number of stems per ha (N), basal area per ha (G) and tree volume per ha (V). Malimbwi *et al.* (2005) observed the mean stocking of 844 stems per ha, basal area of 21 m^2 per ha and 302 m^3 per ha of standing volume from 4 districts across EAMs. This implies that the forests of EAMs have high standing timber stocks.

Another forest inventory in 14 regions of Tanzania was conducted in 2007 (Munishi *et al*., 2007), in four regions where Eastern-Arc Mountains are found. These regions were Dodoma, Iringa, Morogoro and Tanga where about 50 forests were inventoried. The average stocking of 833 stems per ha, basal area of 27 m^2 per ha and volume of 371 m^3 per ha were observed from 50 forests in 4 regions across EAMs (Munishi *et al*., 2007).

2.7 Harvesting Costs of Timber

Estimation of costs and benefits of timber harvesting are necessary to ensure the profitability of the operation (Long, 2001). The author argued that, the factors that increase harvest costs will decrease timber value. In essence, the costs are divided into two categories; fixed and variable costs. The fixed costs build up on a constant time basis when the machine is owned, whether actually working or not. The variable costs accrue only when the machine is actually working. In timber harvesting, costs are affected by many factors including; machine, socio-economic, climatic condition, operation and management (Staff and Wikstein, 1984).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Areas

This study was conducted using inventory data collected in Eastern-Arc Mountains of Tanzania, stretching in five regions namely; Kilimanjaro, Tanga, Morogoro, Dodoma and Iringa. Further more some field data were collected in Nyanganje Forest Reserve, which covers the South East foot hills of the Udzungwa Mountains.

3.1.1 Eastern-Arc Mountains

Geographical location

The EAMs are chains of crystalline mountains near the Indian Ocean coast stretching from southern Kenya to southern Tanzania. The EAMs are located between latitude 3^{o} 2' to 8^{o} 51' South and longitude 34^{o} 49' to 38^{o} 20' East. Thirteen separate mountain blocks comprise the Eastern-Arc namely; Taita Hill in Kenya, Malundwe, Mahenge, Nguu, Nguru, North and South Pare, Rubeho, Udzungwa, Ukaguru, Uluguru, East and West Usambara in Tanzania (Fig. 1). According to Mbilinyi and Kashaigili (In press) cited by Burgress *et al*. (2006), the Eastern-Arc occupies an area of about 3241.7 km^2 and contains more than 150 Forest Reserves (Appendix 1) under various categories of management (central government, local authority, village government and private).

Figure 1: Map showing the 13 crystalline blocks of the EAMs.

Climate

The EAMs stand out by being under the direct climatic influence of the Indian Ocean monsoon (Lovett, 1993; Lovett, 1996). Being on mountain blocks the forests of the Eastern-Arc are important sources of water for major rivers such as the Kilombero, Pangani, Wami and Ruvu which supply water to Dar es Salaam, Tanga and Morogoro (Lovett, 1998).

Soil and geology

The forests formation of EAMs have been divided into lowland, miombo woodlands, sub montane (800-1250 m), montane (1250-1800 m) and upper montane (1800-2635 m) forests. The highest peak in altitude is Kimhandu in the Ulugurus (i.e. 2635 m) (Burgress *et al.*, 1998). The EAMs occur on a variety of soil types, the crystalline rocks of the Mozambique belt, of which the Eastern-Arc is formed, abut against mid-Jurassic sediments on their eastern side where the mountains meet the coastal plain, forming metamorphic limestone (Griffiths, 1993; Hawthorne, 1993).

Natural vegetation

The EAMs are unique as the only part of forests in Tanzania having closed canopy and unspoilt forests. According to Lovett (1999), there are five major vegetation types found in EAMs; lowland, woodland, sub montane, montane and upper montane vegetation which contain different varieties of small and large plant species. Also the Eastern-Arc is the richest in terms of large trees and as well as small trees.

3.1.2 Nyanganje Forest Reserve

Geographical location

The forest is owned by the central government under the JFM system. It was declared forest reserve on 19 December 1958 under the General Notice Number 555 with a total area of 18 980 ha. The forest is located between latitude 7° 56' to 8°4' South and longitude 36°39' to 36° 50' East, 15 km North East of Ifakara town (MNRT, 2004). Its status is protective forest. There are six villages in proximity to NFR; Kiberege, Signali, Sagamaganga, Lungongole, Kilama and Kibaoni. Specifically, the study was conducted in Lungongole, Sagamaganga and Signali (Fig. 2).

Climate

Climate of the area is governed by oceanic rainfall with oceanic/continental temperature. Estimated rainfall is 2000 mm per year with mist effect at high altitude. The dry season is from June to October and the temperature range from 19° C to a maximum of 27° C. NFR harbours various sources of rivers namely Nangonji, Kiberege, Lungongole, Lumemo, Sululu, Sagamaganga and Ikwambe. These rivers supply water to Ikwambe, Signali, Kiburubutu, Lungongole and Sululu villages surrounding the reserves. Water is used for domestic consumption, small-scale fishing and irrigation schemes (MNRT, 2004).

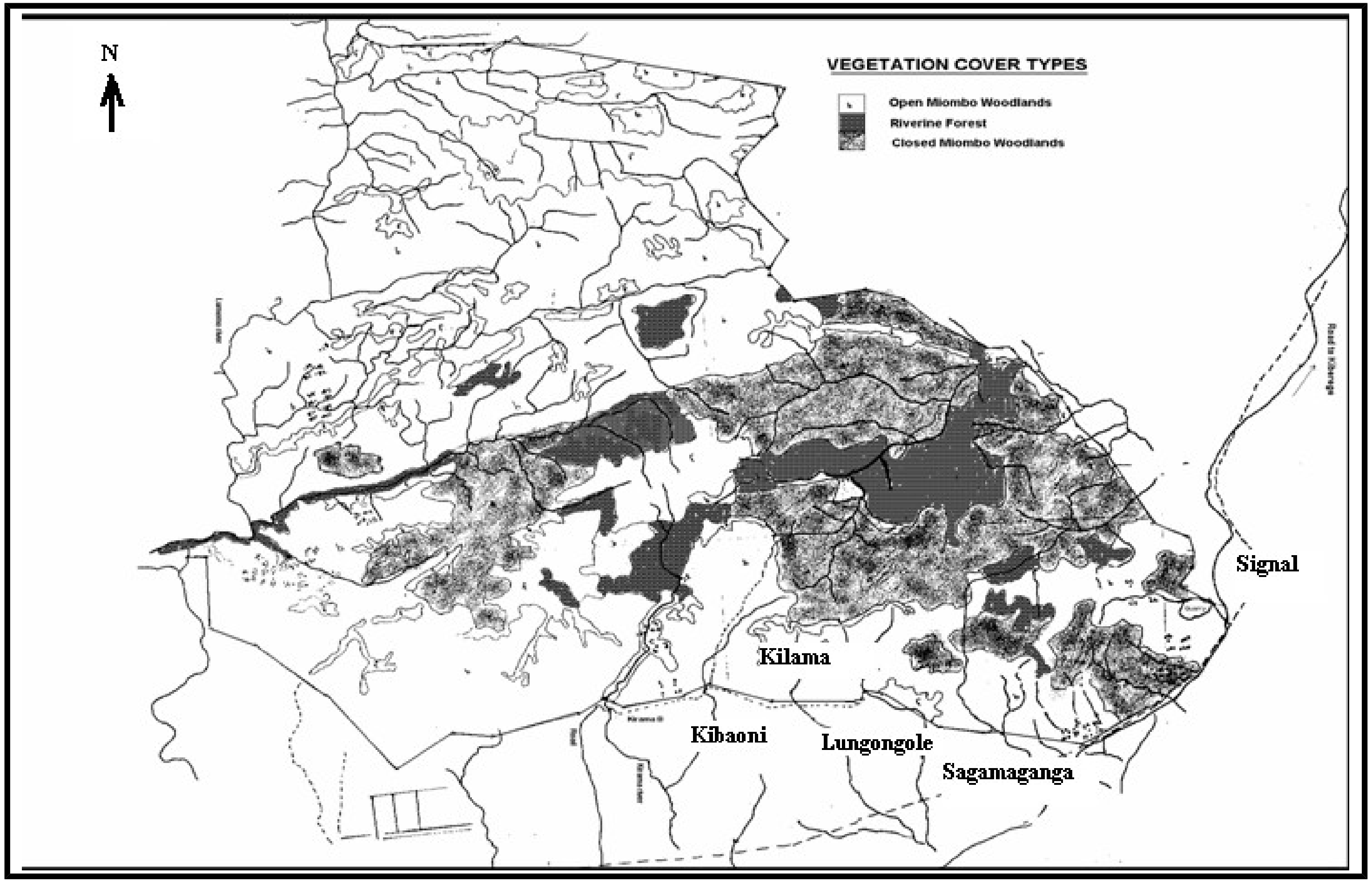

Figure 2: Types of vegetation cover in Nyanganje Forest Reserve and the surrounding villages

Source: Malimbwi *et al*. (2002)

Soil and geology

Nyanganje Forest Reserve is characterized by undulating landscape which forms a component of the Udzungwa ranges of mountains. The altitude ranges from 270 to 962 m above sea level in valley bottoms and mountain peaks respectively. Soils are mainly red and brown ferralitic latosoils over Precambrian crystalline base rock. Not much literature on the geology of this area (MNRT, 2004).

Natural vegetation

According to Lovett and Pocs (1993); Malimbwi *et al.* (2002), there are two main vegetation types found in NFR; miombo woodland and riverine forests (Fig. 2). The woodland is dominated by *Annona senegalensis, Brachystegia boehmii, B. spiciformis, Combretum molle, Diplorynchus condylocarpon, Markamia obtusifolia* and *Pterocarpus angolensis*, with patches of bamboo (*Oxytenanthera abyssinica*). At higher altitudes, there is dry evergreen forest with *Brachylaena huillensis*. The dominant tree in riverine forest is *Breonardia salicina*, accompanied by *Albizia* c.f. *gummifera, Anthocleista grandiflora, Erythrophloeum suaveolensis, Ficus thonningii, Sorindeia madagascariensis* and *Sterculia appendiculata*. The woody climber *Entada pursaetha* is common in the canopy. In the ground layer a woody herb, *Mellera lobulata* (*Acanthaceae*) is dominant in many places (Malimbwi *et al.*, 2002).

3.2 Data Collection Methods

Both primary and secondary data were collected to address the specific study objectives. Data were collected from August to November 2008 using three major data collection methods namely; desktop review method, ecological and social economic surveys.

3.2.1 Desktop review method

This method involved collection of information from two studies in the EAMs (Malimbwi *et al.,* 2005; Munishi *et al.*, 2007) (Appendix 1). The two studies provided data in terms of number of stems, basal area and volume per ha basis according to vegetation types (i.e. woodland, lowland etc), species and diameter size classes. Other information which was collected includes; location, area, ownership and vegetation type of the forest.

3.2.2 Ecological survey

This survey was done using inventory techniques. The aim was to determine the extent and quantity of timber species removed illegally from the study area.

Inventory and sampling

The methodology used for illegal timber harvesting assessment was adopted from Madoffe and Munishi (2005), but slightly modified because of the information required, limitation of time and fund. Eight transects were established from a randomly chosen starting point on the forest edge with the maximum length of 4.5 km and 1 km apart. Plots of 10 m x 50 m were laid at an interval of 300 m in the transect (Fig. 3).

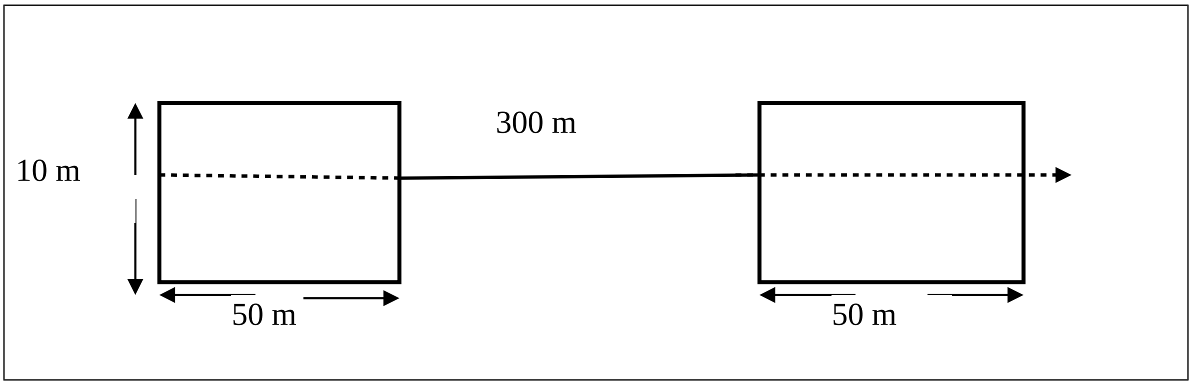

Figure 3: Plots for timber exploitation assessment in NFR

In each plot basal diameters (BD) of the stumps were measured; species identification and main purpose of being removed were done with the aid of two local people well acquainted with ethnobotany and aspects of wood utilization in the study area. Newly harvested stumps (i.e. stumps extracted within this year) and old harvested stumps (i.e. stumps extracted more than one year ago) were recorded. The difference between the new and old stumps was established by colour and freshness of exposure wood.

The following criteria were used to determine the reason for being harvested: species, size, proximity of charcoal kiln and sawing platform to the stump. In this study, individuals of 1 to ≤ 15 cm are defined as small trees for poles while >15 are trees for charcoal and timber depending on species and proximity of sawing platform or charcoal kiln.

A total of 74 standing trees were identified (i.e. one tree in each plot); basal diameter (BD cm), diameter at breast height (DBH cm) and height were measured to establish DBH/BD relationship. The criteria used to select tree for measurement in each plot was based on a tree nearest to the plot centre. Other information collected in each plot were; transect number, plot number, distance from forest edge/roadside, vegetation type and slope (steep/gentle) (Appendix 2).

3.2.3 Socio-economic survey

This involved PRA techniques, questionnaires with key informants and participatory observations (Appendix 3). The survey aimed at collecting information concerning with illegal timber harvesting, market prices, cost of processing and transporting timber in the study area.

3.2.3.1 Participatory rural appraisal

Participatory rural appraisal (PRA) techniques are useful in the valuation of savanna resources (Campbell *et al*., 1997 cited by Kisoza, 2006). PRA techniques were applied to 15 participants in each of the three villages of Signali, Sagamaganga and Lungongole. Stratified random sampling procedures was adopted aiming to include groups of people with different economic status, power in decision-making, gender, educational backgrounds, attitudes, perceptions, experiences, location (nearby and far from the Nyanganje Forest Reserve).

3.2.3.2 Interviewing key informants

Both formal and informal interview were conducted with three village officials from the three villages, seven carpenters and five timber sawyers. Some people were reluctant to respond because they knew that obtaining timber from NFR is an illegal.

3.2.4 Participant observation

This method involved actual observation made by the researcher during the field visits. Documentation by use of visual aids such as digital camera helped to include photographs as evidence of timber uses, illegal activities, economic activities and other related activities happening in the visited area.

3.3 Data Analysis

3.3.1 Desktop review data

Inventory data collected from reports of Malimbwi *et al*. (2005) and Munishi *et al*. (2007) were used to identify timber species and quantity in the EAMs. Since the purpose of this study was to identify timber species relevant to EAMs, forests which are not found in EAMs were not considered.

The procedures used by Green (2008) to sort out the inventory data of 99 forest reserves of Tanzania mainland was adopted in this analysis. In the first step the input data which were provided in terms of number of stems, basal area and volume per hectare basis in different diameter size classes were put in excel spreadsheet for spelling correction and translation using references relevant to local languages found in Tanzania. Green (2008) used 26 references to correct spelling mistakes and also to translate local names into botanical names. In this study 14 more references were integrated and used in order to increase the confidence of accepting the translated tree species. Before analysis, the tree species were divided into 2 groups; the first group included tree species which had already been translated into botanical names while the second group included tree species which had not been translated. The first group was checked and corrected for spelling mistakes while in the second group, the tree species were checked and translated into botanical names. Non timber species were not considered.

In the second step data analysis involved development of quantity of individual timber species. The stocks per area of individual timber species were obtained by multiplying the stocks per hectare basis of individual timber species by the areas of the forests on which the timber species were found. Since basal area is always expressed per hectare, the parameters that changed for each forest were; number of stems and volume, which was given by;

Number of stems = stems per ha × area (ha)

Volume = volume per ha × area (ha)

The total quantities of individual timber species were obtained by summing up their stocks per area from different inventoried forests, while the overall quantity of timber species were obtained by summing the stocks of all individual timber species.

The analysis also involved the classification of timber species in their respective size classes by sorting the timber species from non plantation and plantation forest based on the Forest Act 14 of 2002 Cap 323 (Made under section 106) amended in 2007. The total volume and harvestable volume (i.e. volume of trees with DBH >40 cm) was calculated in each timber class and then multiplied by its royalty per m^3 to get the monetary value of timber species in EAMs.

3.3.2 Ecological data

3.3.2.1 Relative level of disturbance (RLD)

The relative level of disturbance was determined by dividing the number of plots containing a form of disturbance (n_{pi}) by the total number of plots recorded along a transect (N_p) and it is given as percentage (Frontier-Tanzania, 2005);

$$\%RLD = \frac{n_{pi}}{N_p} x100$$

3.3.2.2 Relative abundance of disturbance category (RA)

The relative abundance was calculated from observations made for human cut, natural mortality, sawing platform, bamboo cut, charcoal kiln, thatch grasses cut, fires, foot paths and vehicle paths. It was determined by dividing the number of individuals of particular category (n_i) by the total number of individuals recorded in an area (N), and it is given as percentage (Frontier-Tanzania, 2005);

$$\%RA = \frac{ni}{N} x100$$

3.3.2.3 Estimation of illegally harvested timber stocks

The basal diameters of the stumps (BD) was converted to the diameters at breast height (DBH) of standing trees before harvesting using a linear relationship developed for all species;

$$DBH = 0.7255 + 0.848\ BD \quad (R^2 = 0.99;\ SE = 2.8;\ n = 74)$$

Since height parameter is usually measured for few represented trees, a height/diameter was developed using the sampled trees whose height were measured. This equation was also used to estimate the height of trees that were only left as stumps;

$$Ht = 1.1761 \times DBH^{0.6928} \quad (R^2 = 0.93;\ SE = 0.17;\ n = 74)$$

The total volume of timber stock harvested illegally was calculated using regression equation developed for miombo woodlands at Kitulanghalo Forest Reserve by Malimbwi *et al*. (1994) cited by Luoga *et al*. (2002). This equation was chosen because the vegetation type in the study area is also miombo woodland.

$$V = 0.0001\ DBH^{2.032}\ H^{0.659}$$

3.3.2.4 Annual quantity of harvested timber

Annual quantity of timber species extracted illegally was calculated by dividing the total volume harvested illegally from the field by the period lapsed since the tree was cut;

$$V_a = \frac{V_t}{n}$$

Where:

V_a = Annual quantity (m^3/ha/year)

V_t = Total volume harvested (m^3/ha)

n = Number of years lapsed since the tree was cut

3.3.3 Socio-economic data analysis

3.3.3.1 Qualitative analysis

The components of verbal discussion collected through PRA were analysed. The recorded conversations with respondents were broken down into smallest meaningful units of information to ascertain values and attitudes of the respondents. Kajembe (1994) stated that structural functional analysis seek to explain social facts, related to each other within the social system and by manner in which they are related to physical surrounding.

3.3.3.2 Quantitative analysis

The average retail price of timber per m^3 (i.e. 35 boards[1] of 1”×12”×12ft[2]) in the villages around NFR was calculated by dividing the mean timber price by size of sawn wood.

1

[1] 35 boards were calculated by dividing 1 m^3 by 0.0283 m^3 volume of a board of 1’’x 12’’x 12ft

[2] Size of a board of 1 inch thick, 12 inch width and 12 feet length

The average retail price was used to find the annual income of the timber harvested from the study area.

Analysis was also done to determine the costs required in the extraction process of timber, in terms of costs for harvesting, processing, transportation, labour and tools in use. For the purpose of this study, sawing tools and domestic utensils were assumed to have a useful life of three years without scrap value. They were depreciated using the straight line method. Thus the annual depreciation was computed as;

$$D = \frac{P}{L}$$

Where;

D = Depreciation (TShs/year)

P = Purchase price (TShs)

L = Useful life (years)

Labour was invariably used and as such opportunity cost of labour was assumed to be zero, due to widespread unemployment in the study area. Processing costs involved costs incurred when converting a log into lumber (sawing process), this included inputs such as food. Transportation cost involved costs of moving away the product to the market. The total costs for extraction process of timber in the study area were given by the following formula;

$TC = HC + PC + TPC$

Where;

TC = Total cost (TShs)

HC = Harvesting costs (TShs)

PC = Processing cost (TShs)

TPC = Transportation cost (TShs)

The Net benefit was also calculated as a difference in annual income from timber and annual cost of timber production. The net benefit (a) was thus estimated as:

$a = I_t - C_t$

Where;

I_t = Annual income (TShs)

C_t = Annual cost (TShs)

The underlying assumptions of cost of production and prices of timber were;

- There was no money inflation throughout the year of study hence the same marginal product cost and timber selling price.
- Two persons were involved in the sawing process and produce one cubic metre of lumber in six days.

3.3.4 Statistical analysis

A two tailed t-test at 0.05 probability levels of significance was used in this study to compare mean stocks of timber between forests in EAMs and those outside the EAMs.

This was used as display in understanding if EAMs have high potential in terms of timber stocks. According to Jayaraman (2000), the t-test is often desired in comparing means of two groups of observations representing different populations to find out whether populations differ with respect to their location. Likewise, in order to derive the general relationships among dependent and independent variables, linear regression analysis was used in order to determine the impact of distance from focal disturbance point on harvested intensity.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Timber Species and Quantity in Eastern-Arc Mountains

4.1.1 Major timber species

In this study, a total of 180 timber species representing more than 15 families were identified in the 50 inventoried forests among 6 vegetation strata. The total area of the inventoried forest was 269 410 ha. The 20 dominant timber species identified are listed in Table 1 which include *Ocotea usambarensis, Albizia petersiana, Newtonia buchananii, Syzygium guineense* and *Synsepalum ceraciferum*. The Caesalpiniodeae family dominates the forests of EAMs with about 9.4% of all counted individual timber species. The other dominant families based on number of counts included; Papilionoideae (8.3%), Mimosoideae (6.7%), Combretaceae (6.1%) and Euphorbiaceae (5%) (Table 2). The complete list of tree species identified during desktop review is provided in Appendix 4 and Appendix 5.

The study shows that, distribution of timber species varied widely in blocks, for example; *Newtonia buchananii* and *Brachystegia spiciformis* were observed to be the widespread species occurring in 6 out of the 9 blocks (Table 1). The wide distribution of these species might be attributed to natural climatic conditions which favour the growth of these species, high survival of seedling and or low rate of harvesting for firewood, charcoal and or timber. *Cephalosphaera usambarensis* is less spread compared to other major timber species.

Table 1: Major timber species in the Eastern-Arc Mountains

Major timber species	**Frequency of occurrence in 9 blocks**	**Total volume (m^3)**	**Volume contribution (%)**
Ocotea usambarensis Engl.	2	6 700 000	9.0
Albizia petersiana (Bolle) Oliv.	5	5 700 000	7.7
Newtonia buchananii (Baker) Gilbert & Boutique	6	4 400 000	5.9
Syzygium guineense (Wild.) DC	4	3 400 000	4.6
Synsepalum cerasiferum (Welwitsch) T.D. Penn	2	2 800 000	3.8
Allanblackia stuhlmannii (Eng.)Eng.	4	2 700 000	3.6
Brachystegia spiciformis Bench.	6	2 600 000	3.5
Khaya anthotheca Stapf. ex Baker	5	2 300 000	3.1
Brachystegia boehmii Taub.	4	2 200 000	3.0
Pteleopsis myrtifolia (laws) Engl. & Diels	4	2 000 000	2.7
Brachystegia microphylla (Harms)	5	1 700 000	2.3
Cephalosphaera usambarensis Warb.	1	1 400 000	1.9
Strombosia scheffleri Engl.	5	1 300 000	1.7
Pericopsis angolensis (Baker) Harms.	5	1 300 000	1.7
Ficalhoa laurifolia Hiern.	2	1 200 000	1.6
Albizia gummifera (Gmel.) C.A.Sm.	4	1 100 000	1.5
Podocarpus usambarensis Pilger	4	1 100 000	1.5
Pterocarpus angolensis DC.	4	1 100 000	1.5
Vitex doniana Sweet	3	1 000 000	1.3
Sterculia quinqueloba (Garcke) K. Schum.	5	1 000 000	1.3
Others		27 400 000	36.8
Total		**74 400 000**	**100.0**

Table 2: Dominant timber families in Eastern-Arc Mountains

Timber species family	Count (%)
Caesalpiniodeae	9.4
Papilionoideae	8.3
Mimosoideae	6.7
Combretaceae	6.1
Euphorbiaceae	5.0
Meliaceae	4.4
Sapotaceae	4.4
Clusiaceae(Guttiferae)	3.9
Anacardiaceae	3.3
Oleaceae	3.3
Ericaceae	2.2
Myrtaceae	2.2
Sterculiaceae	2.2
Annonaceae	1.7
Bignoniaceae	1.7
Others	35.0

4.1.2 Rare timber species

The EAMs have a potential for supplying timber, building posts and poles in the miombo woodland, lowland, sub-montane, montane and upper-montane forests adjustment communities. The study has found that some timber species are least represented in terms of number of stems and volumes and hence implying to be rare in the EAMs (Appendix 4). These includes; *Garcinia smeathmannii*, *Diospyros kirkii*, *Annona squamosa*, *Cordyla africana and Swatzia madagascariensis*. The results are slightly close to that of Malimbwi *et al*. (2002) in Nyanganje Forest Reserve who reported lack of *Swatzia madagascariensis* species in almost all plots despite stumps availability indicating that, it might have been overexploited. Milledge *et al*. (2007) in "Lesson learned from a logging boom in southern Tanzania" reported that, *Swartzia madagascariensis* was among the 13 targeted species for hardwood exports in mid-2004. This could probably be make the reasons to the species threaten.

4.1.3 Quantity of timber species

The quantities of timber are given on the basis of the 50 inventoried forests (269 410 ha) i.e. 42% of the EAM (Appendix 1).

Stem numbers

A total of 135 600 000 stems composed of 180 different timber species were identified in EAMs (Appendix 4). The minimum diameter at breast height (DBH) of these timber species identified was 1 cm. The *Ocotea usambarensis* species contributed about 2 100 000 stems, *Albizia petersiana* about 3 900 000 stems and *Newtonia buchananii* about 2 800 000 stems.

Fig. 4 shows reversed ‘J’ shape which is common for natural forest with active regeneration and recruitment (Philip, 1983). Accordingly, active regeneration and recruitment in natural forests of the EAMs as depicted in this study is a good sign of sustainability of the EAMs stock which has chances of ensuring sustainable supply of products and services: and hence sustained livelihoods of the EAMs dependents.

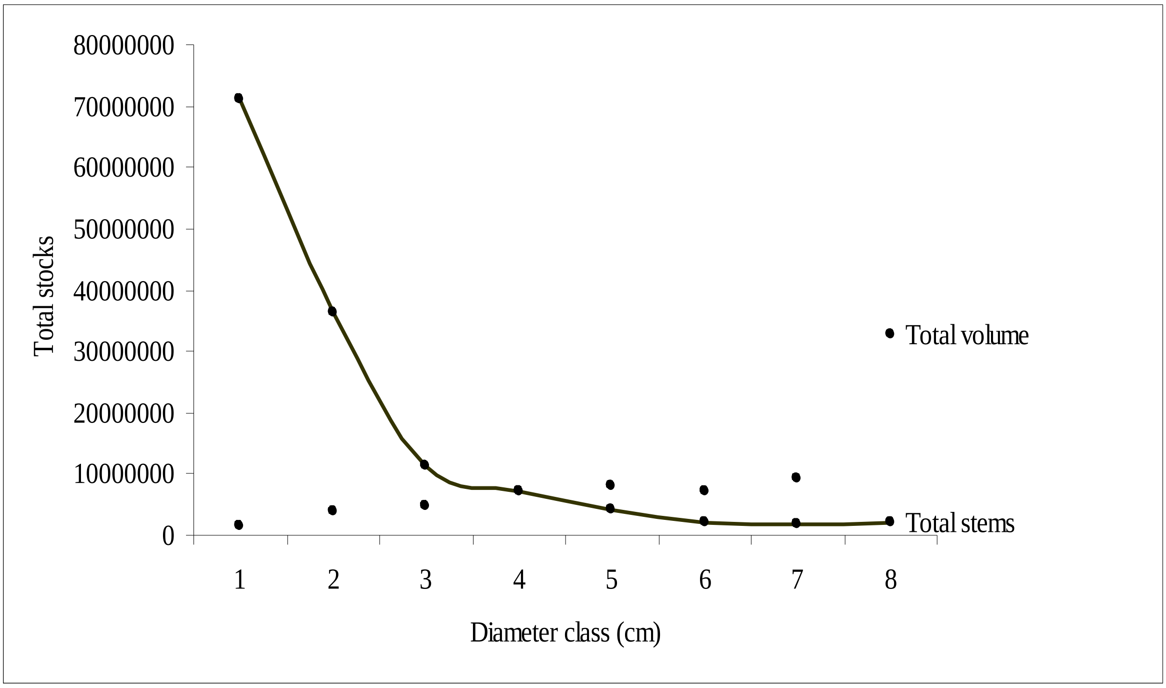

Figure 4: Size class distributions of standing stocks of timber species in EAMs

Volume

The total volumes from the inventoried forest was 74 400 000 m^3 (Table 1). This is an equivalent of 0.6 m^3 per tree. Furthermore Table 1 shows that, the distribution of volume among species is highly skewed, the major timber species (20 out of 180 timber species) contributed 47 000 000 m^3 (63 %) of total wood volume. The distribution of volume in EAMs show a J-shaped trend (Fig. 4) indicating the significant contribution of large trees to volume. Although the small trees are in millions their volume contribution is minimal (Fig. 4).

In order to test the variation of timber potential between EAM's forests and those outside the EAMs, random selection was adopted in both forests. The information in forests outside the EAMs was collected from two studies conducted in Coast, Iringa, Lindi, Mbeya, Morogoro, Rukwa Ruvuma and Tanga regions (Malimbwi *et al*., 2005; Munishi *et al*., 2008). The data extracted from these two studies includes; vegetation type (woodland, lowland, montane etc), altitude (metres above sea level), management regime (reserved or productive forests) and timber stocks (N, G and V) (Appendix 6). Eighty forests (i.e. fourty forests from each part) were paired to test the potentiality of timber between EAMs' forests and outside the EAMs. The criteria used to pair these forests were vegetation type, altitude and management regime. In this investigation two variables was tested; number of stems and volume per ha.

The stems and volume per ha in the EAMs were found to be much higher than those outside the EAMs. The number of stems per ha were slight statistically significantly different (p (t) = 0.047 d.f = 39). Similarly volume were statistically significantly different (p (t) = 0.001 d.f = 39). This means that EAMs forests have high potential in terms of timber tree stocks.

The proportion of timber species and non timber species in EAMs is 9:1. The study revealed about 35 700 000 stems of different non timber species with a total volume of 12 200 000 m^3 (Appendix 8). The dominant tree species included; *Ficus sur, Cylicomorpha parviflora* and *Diplorynchus condylocarpon*. This implies that EAMs is mostly dominated by timber species and hence a big potential to contribute to world timber trade (Kowero and O'Kting'ati, 1990).

4.1.4 Monetary value of timber species

Based on this study it is clear that the Eastern-Arc Mountains have valuable timber species. Most common timber species include *Afzelia quanzensis, Brachylaena huillensis, Brachystegia spp, Dalbergia melanoxylon, Milicia excelsa, Milletia stulhmannii, Pterocarpus angolensis* and *Swartzia madagascariensis.* Normally, FBD sells raw materials as log or poles to the customers and the royalty of the timber tree species are charged according to species classification as listed in Table 3.

Table 3: Species classification in relation to royalty charges in Tanzania

Timber Class	I	II	III	IV
Royalty/m^3 TShs	160 000	120 000	80 000	50 000

Source: Government Notice No 231 (2007)

Plantation species are sold in diameter class as classified in species group, either softwood or hardwood. According to the Government Notice Number 231 (2007), softwood species have not been classified into distinct groups. *Juniperus procera* is grouped separately from other softwood species and is charged at TShs. 50 000/= per m^3 for all sizes. Royalty for other species is set according to diameter classes as shown in Table 4.

Table 4: Prices for plant softwood in different classes in relation to diameter classes in Tanzania

DBH class (cm)	11-20	21-25	26-30	31-35	>35
Royalty/m^3 (TShs)	2000	4000	10 000	17 300	19 200

Source: Government Notice No 231 (2007)

Plantation hardwoods are classified in four groups and are sold in diameter classes (Table 5). *Tectona grandis* and *Cinamomum camphora* are grouped in class I, all *Eucalyptus* spp is grouped in class II, *Grevillea robusta*, *Cederela odorata*, *Acacia melanoxylon*, *Acrocarpus flaxinifolius* and *Maesopsis eminii* are grouped in class III, all other hardwood species not mentioned above are grouped in class IV.

Table 5: Royalty for plantation hardwood in relation to class group and diameter classes in Tanzania

		Royalty/m^3(TShs)			
Timber class	**Species**	**11-20**	**21-30**	**31-35**	**>35**
I	Teak	32 000	80 000	120 000	160 000
III	*Cederella, Grevillea, Acacia, Acrocarpus and Maesopsii*	4 000	8 000	15 000	20 000
IV	All other hardwood	3 000	6 000	12 000	15 000
II		**11-20**	**21-30**	**>30**	
	Eucaliptus saligna& grandis	6 400	16 000	28 000	

Source: Government Notice No 231 (2007)

Taking the royalty and quantity of each timber classes, timber species in the EAMs is worth TShs. 7 249 129 million (USD 5576 million)[1] for all diameter classes in indigenous species and for diameter above 11 cm for exotic species. Table 6 shows that, the value of harvestable timber in the EAMs was about 57 020 345 m^3 at harvestable dbh of greater than 40 cm. This is an equivalent value of TShs. 5 799 047 million (USD 4461 million) for the harvestable sizes of the timber trees.

2

[21] 1 USD was equivalent to Tsh. 1,300/= in March, 2009

Table 6: Quantity and monetary value of timber classes in the Eastern-Arc Mountains forests

Timber Class	Royalty/m^3 (TShs)	Harvestable timber[1]		Total Standing Timber[2]		Harvestable value per volume (TShs)[3]	Total value per volume (TShs)[4]
(i) Non Plantation species		Total stems	Total volume	Total stems	Total volume		
I	160 000	900 000	9 600 000	8 500 000	10 800 000	1 536 000 000 000	1 728 000 000 000
II	120 000	4 900 000	25 700 000	39 700 000	31 900 000	3 084 000 000 000	3 828 000 000 000
III	80 000	700 000	3 200 000	2 900 000	3 800 000	256 000 000 000	304 000 000 000
IV	50 000	3 400 000	18 400 000	84 200 000	27 700 000	920 000 000 000	1 385 000 000 000
Sub Total		**10 000 000**	**56 900 000**	**135 400 000**	**74 200 000**	**5 796 000 000 000**	**7 245 000 000 000**
(ii)Plantation species							
Soft wood group	19 200	118	345	252	471	6 624 000	9 043 200
-Hardwood Plantation						0	0
II	28 000	38 000	80 000	100 000	90 000	2 240 000 000	2 520 000 000
III	20 000	9 000	40 000	90 000	80 000	800 000 000	1 600 000 000
Sub Total		**47 118**	**120 345**	**190 252**	**170 471**	**3 046 624 000**	**4 129 043 200**
Total		**10 047 118**	**57 020 345**	**135 590 252**	**74 370 471**	**5 799 046 624 000**	**7 249 129 043 200**

3

[31] Sub total and total harvestable timber (stems and m^3 at dbh >40cm) in different classes of non-plantation and plantation timber species
[2] Sub total and total timber (in all diameter classes. In stems and m^3) in different classes of non-plantation and plantation timber species
[3]. Monetary value (TShs) of harvestable timber species (Royalty*harvestable total volume). [4] Monetary value (TShs) (Total volume*royalty)

4.1.5 Lesser known timber species

About 190 tree species with 30 800 000 stems and 14 900 000 m^3 were locally identified in different languages such as Sambaa, Nguru, Pogoro, Nyamwezi, Luguru etc. but could neither be identified botanically nor according to their use (Appendix 7). Some of the species have big diameter that could provide saw logs, e.g. Mbeja, Mhankho, Mkavi, Mlombwa, Mnulu, Msambubwinhe, Msinga, Msunguti, Mtumba and Nyandege. These tree species seem to be lesser known scientifically, thus, there is a need for research on their identity, properties and practical aspects of utilization.

4.2 Illegal Timber Harvesting in Nyanganje Forest Reserve

4.2.1 Relative abundance of disturbance

During the transect survey disturbances in terms of tree cut, fire damage, vehicle path and other forms of disturbance were recorded (Fig. 5). Out of 74 plots, 41 (55%) were found to be free from any disturbance while 33 plots (45%) were found to have some form of disturbance.

Tree cutting

In this study, tree cut was the most common type of disturbance representing 73.5% of all disturbances. The main drivers for this were timber harvest, pole cut for house construction, fuel wood removal and charcoal production. About 11.7% of the tree species harvested in the study were bamboo (Fig. 5). Bamboo is harvested for house construction and as weaving materials. Depending on the species available, other uses of bamboo may range from building materials to being used as nutritive wild vegetable (Kumar and Sastry, 1999).

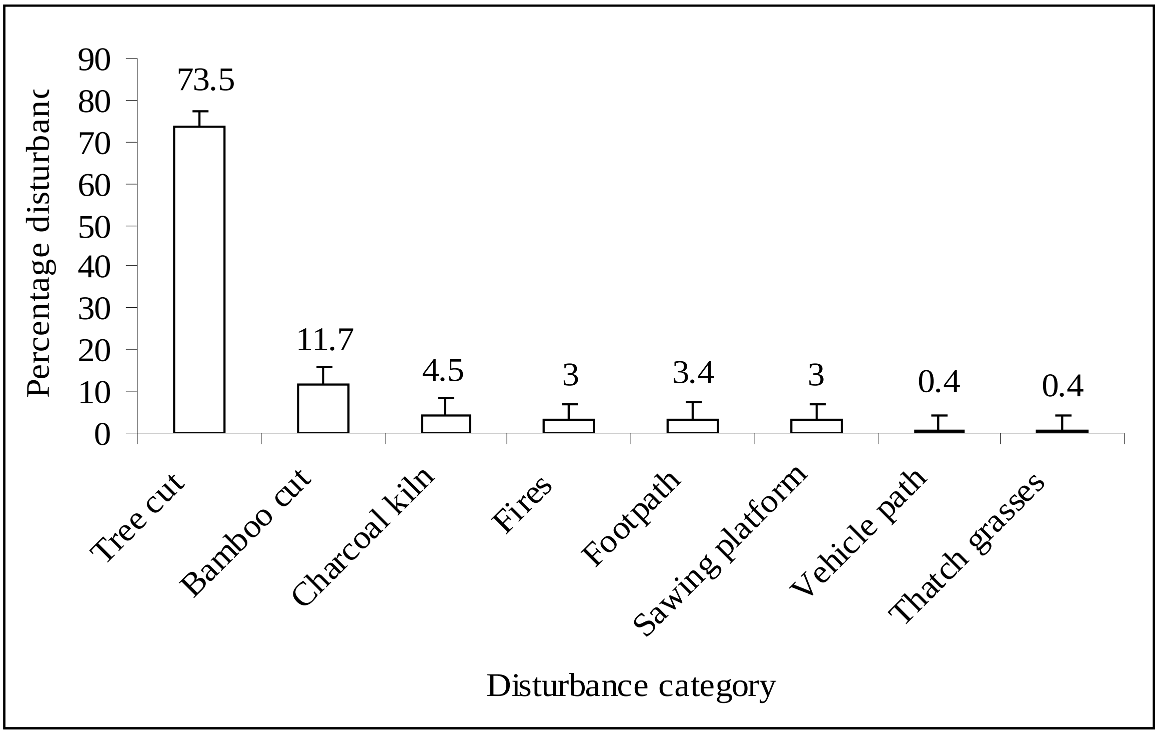

Figure 5: Percentage of disturbance by different forms of human causes along transects in NFR.

Timber sawing

Sawing platforms were also found to be widespread in the area. At least one sawing platform was observed in each transect surveyed. Fig. 5 shows that 3% of disturbance was due to timber sawing on platforms. Evidence of sawing platforms and leftovers of slabs (Plate 1) indicate that there is still illegal timber harvesting in the reserve. Incidentally, pit-sawing was not practiced in the study area because the area is in mountain therefore it is more difficult to dig a pit than making a platform.

Plate 1: Sawing platforms and slabs left after sawing in NFR

Charcoal production

This study revealed an average of 2 charcoal kilns per ha, an equivalent of 4.5% of all disturbances in Nyanganje Forest Reserve. According to Malimbwi *et al*. (2002), charcoal production has become one of the major sources of income for poor people in rural areas. In the production areas this income is more important than income from alternatives such as agriculture. Hence charcoal production is one of the means to reduce poverty among the people. Charcoal is used by the urban dwellers by providing a reliable, convenient, accessible and affordable source of energy for cooking.

Fire

Fire was another particularly destructive form of disturbance observed. About 3% of the disturbance was due to fire scorch. The most affected sides of the forest reserve are those bordered with Sululu hamlet and Lungongole village. Forest fires are increasingly becoming a major problem for many tropical forests, not only affecting ecosystems but also contributing to climate change through carbon emissions.

Foot paths

Footpaths contributed about 3.4% of the disturbances; footpaths can be used as shortcuts toward forest products extraction. Trespassing sometimes results in unplanned activities, such as tree debarking and creating resting areas, where forest fires may start.

Others disturbances

Other disturbances which have been recorded in small percent include; vehicle path 0.4% and thatch grasses cut 0.4%.

4.2.2 Drivers of tree cutting

In the villages around NFR the main food crops are rice, maize, sorghum, cassava and sweet potatoes for personal consumption and only a limited excess is produced to be sold or converted to secondary products such as local brew made from maize and millet. Savings from agricultural production are quite low and do not provide for much improvement in the living standard. To overcome this shortage communities living adjacent to this reserve depend much on the forest for poles, firewood and wild fruits for household use, timber, charcoal, medicine, honey collection for business where most of these products are extracted illegally from NFR.

Table 7: Purposes for tree cutting and their respective contributions (%) to overall cutting in Nyanganje Forest Reserve

Purposes	Stumps sampled Number	%	Stems ha^{-1}	Basal area ha^{-1}	Volume ha^{-1}
Timber	28	14.3	7.6	0.9	8.1
Charcoal	44	22.5	11.9	1.0	8.5
Building posts	9	4.6	2.4	0.1	0.8
Poles	71	36.2	19.2	0.2	0.9
Natural mortality	21	10.7	5.7	0.3	2.4
Unknown*	23	11.7	6.2	0.3	0.5
Total	**196**	**100.0**	**53.0**	**2.8**	**21.0**

*Unknown means no proximity of charcoal kiln or sawing platform and DBH > than 15 cm

Field observations noted 7 timber species which have been cut with an average of 7.6 stems per ha and volume of 8.1 m^3 per ha. The mean diameter of the cut trees was 45.5 cm, and the species included; *Brachystegia boehmii, Brachystegia bussei, Brachystegia spiciformis, Breonadia salicina, Burkea africana*, *Pterocarpus angolensis* and *Uapaca nitida*. Formal discussions with local people revealed further 10 species that are commonly used for timber to make furniture and in buildings (Table 9). The quality timber species, e.g. *Milicia excelsa,* was reported to have been abundant in the past, but is now almost extinct. Others dwindling timber species include *Khaya anthotheca* and *Swatzia madagascariensis*.

Table 7 shows that 36.2% of the tree species were cut for poles. Several species collected for poles were identified and this include *Brachystegia boehmii, Brachystegia bussei, Brachystegia spiciformis, Breonadia salicina, Burkea africana, Combretum molle, Diplorhynchus condylocarpon* and *Flueggea virosa*. These species were mostly preferred probably due to their durability, straightness, length and resistance to insects.

Nduwamungu (2001) reported similar poles species from miombo woodlands of Kilosa district. Though pole cutting constitutes the highest percentage of all cut trees, the number was underestimated because stumps with DBH > 15 cm were considered not suitable for poles. But through reports by Malimbwi *et al*. (2002), big trees can be split into smaller dimensions suitable for poles as the case in this study (Plate 2).

Plate 2: Splitting of big tree into smaller dimensions suited for poles in NFR

Building post cutting contributed 4.6% of all cut trees. Tree species mostly preferred for posts in the village around NFR was *Uapaca nitida.* Although in the reserves there are many species suitable for posts, only this tree species had been targeted probably due to its availability, suitability and resistance to rot and attack by termites.

In the study area charcoal is produced in earth mound kilns made by covering a pile of logs with earth blocks, igniting the kiln and allowing carbonization to take place under limited air supply. According to Zahabu (2001), charcoal makers often spend 13, 10 and 14 days for wood cutting, kiln preparation and carbonization, respectively. Unloading the charcoal kiln takes only about 4 days. About 22.5% of all cut trees in NFR were for charcoal production. The most preferred tree species for charcoal in this area are listed in Appendix 8 which include; *Brachystegia boehmii* (3 m^3) seem to be the most used tree species followed by *Brachystegia spiciformis* (2 m^3), *Burkea africana* (2 m^3), *Combretum molle* (1 m^3), *Pterocarpus angolensis* (0.3 m^3) and *Flueggea virosa* (0.2 m^3). These results are in line with those of Zahabu (2001); Malimbwi *et al*. (2005) with addition of some few tree species. Selection of tree species for charcoal making is based on the species property to produce suitable charcoal; with high recovery, high calorific value and which do not break easily during transport. In this respect, where charcoal production is in progress, prime timber species such as *Pterocarpus angolensis* are not excempted from the kiln. According to Abdallah and Monella (2007), charcoal makers can generate a profit of up to TShs. 8000/= from one bag of charcoal. The business is likely to continue in the future because of inability of many consumers to switch over to alternative energy sources. The fact that prices of electric appliances and electric tariff are unaffordable by many households, compared to cost of charcoal and firewood, which is regarded as a free commodity, could be the contributing factor for dependence on wood fuel. Forests remain to be the main source of fuel for unforeseeable future in Tanzania.

Natural mortality contributes 10.7% of the total tree removal. Most of the firewood collected from the NFR was said to be obtained from dead trees and branches. Natural mortality is very important in stabilizing the old growth forests (Spies, 2004).

The cuts with no evidences supporting their cause were termed as unknown cuts which present 11.7% of the total tree cuts. The unknown cuts could have been used in making home items such as cooking utensils, tool handles and ropes. Handles may be for hoes, local weapons called *nyengos,* spears, or axes. In this study species belong to unknown group include; *Brachystegia bussei, Brachystegia spiciformis, Burkea africana, Diplorhynchus condylocarpon, Markhamia obtusifolia, Pterocarpus angolensis* and *Syzygium guineense*. According to Frontier-Tanzania (2005), tree species used for the handles for hoes and *nyengos* include *Albizia gummifera, Xymolos monospora, Ochna holstii* and *Markhamia obtusifolia.* Spear handles are made of *Englerophyton natalensis* and *Vepris* spp. Mortars and pestles are very important utensils in every household in the study area. They are used for pounding various foodstuffs. Mortars are made from tree species like *Albizia gummifera* and *Syzygium guineense.* The species used for making pestles are *Englerophyton natalensis* and *Milicia excela*, as well as, *Combretum* spp and *Dalbergia* spp. Frontier-Tanzania (2005) in Mtwara reported nearly similar tree species used to make handles for hoes, *nyengos* and mortars.

The tree species that contributed the highest harvested stock are presented in (Fig. 6) which include; *Burkea africana, Pterocarpus angolensis, Brachystegia boehmii, B. spiciformis, B. bussei, Breonadia salicina* and *Combretum molle*.

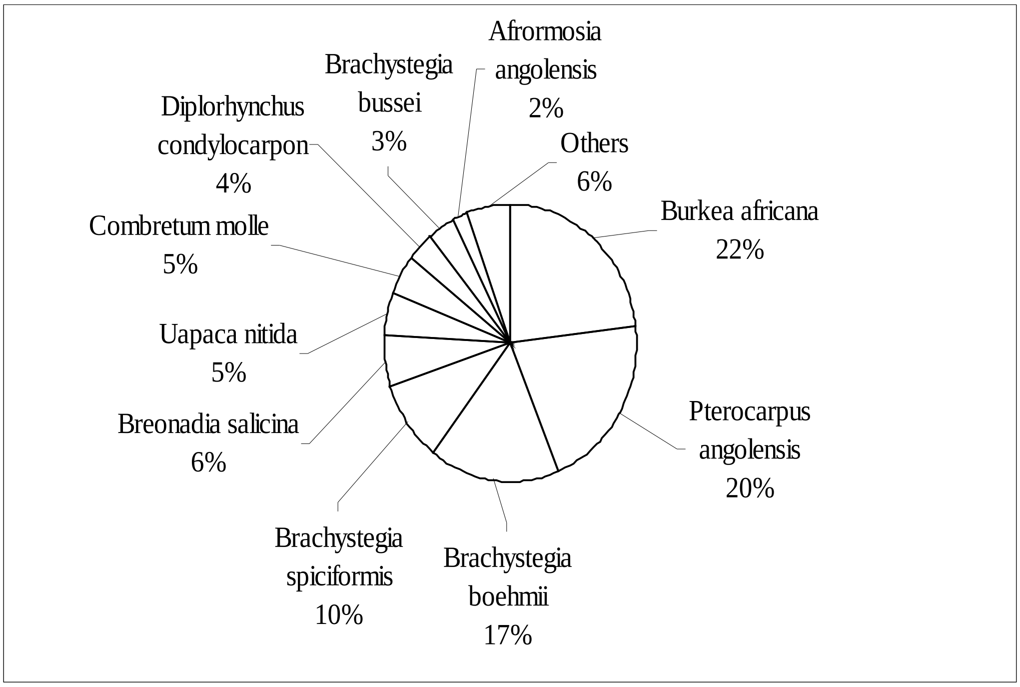

Figure 6: Percentage volume of tree species harvested illegally in NFR

Nearly all these are timber trees but they can also produce charcoal (Luoga *et al*., 2000 cited by Zahabu, 2001). During ecological survey, it was noted that whenever there were more than one big stump cut in a plot and depending on the tree species, there were either a sawing platform or a charcoal kiln nearby.

4.2.3 Comparison between human disturbances and natural mortality

In this study, tree cuts represented a basal area of 2.5 m^2 per ha compared to 0.3 m^2 per ha caused by natural mortality. The volume of newly cut trees was 9.7 m^3 per ha compared to 0.5 m^3 per ha due to natural mortality. Considering stem numbers, basal area and volume per ha, human disturbances in terms of tree cuts is eight time higher than natural mortality, this Signify the magnitude of removals through illegal harvesting in the forest (Table 8).

Table 8: Comparison between trees cut and natural mortality in Nyanganje Forest Reserve

Age	Parameter	Trees cut	Natural mortality	Total cut
New	Stem ha^{-1}	29.2	0.8	30.0
	Basal area ha^{-1}	1.4	0.1	1.4
	Volume ha^{-1}	9.7	0.5	10.9
Old	Stem ha^{-1}	18.1	4.9	23.0
	Basal area ha^{-1}	1.7	0.3	1.4
	Volume ha^{-1}	9.0	1.9	10.9
All	Stem ha^{-1}	47.3	5.7	53.0
	Basal area ha^{-1}	2.5	0.3	2.8
	Volume ha^{-1}	18.7	2.4	21.0

According to Malimbwi *et al*. (2005), the standing volume in Nyanganje Forest Reserve was around 119 m^3 per ha. The Figure represent removal/standing (R/S) stock of 19/119 per ha due to human and 2/119 per ha due to natural mortality. The species with the target volume of felled individual by human include; *Burkea africana*, followed by *Pterocarpus angolensis* while *Pteleopsis myrtifolia* and *Mallotus mauritarium* were less removed (Appendix 9).

Assuming that fresh stumps (those without coppices or are just sprouting and not yet decomposed), which were inventoried were not more than three years old, the annual harvesting intensity can be estimated to be 6.2 m^3 per ha in NFR (Table 8). This removal intensity is far greater than the most common mean annual increment (MAI) reported in miombo woodlands which range from about 1 to 3 m^3 per ha per year (Zahabu, 2001).

Since NFR represent other Eastern-Arc Mountain's forests, EAMs lose 6.2 m^3 per ha each year. The total annual removal in the EAMs is estimated to be 3 800 142 m^3. This removal is very high; therefore, management intervention is necessary to ensure sustainability of these forests.

4.2.4 Tree cut change with distances from the roadside

Analysis of diameter distribution indicated that there was large number of individuals of diameter class 1, 2, 3 and 4 removed from the forest compared to large diameter class 5, 6, 7 and 8 (Fig. 7). This implies that the NFR might have no many large trees in the distance up to 5 km from roadside due to past exploitation of timber.

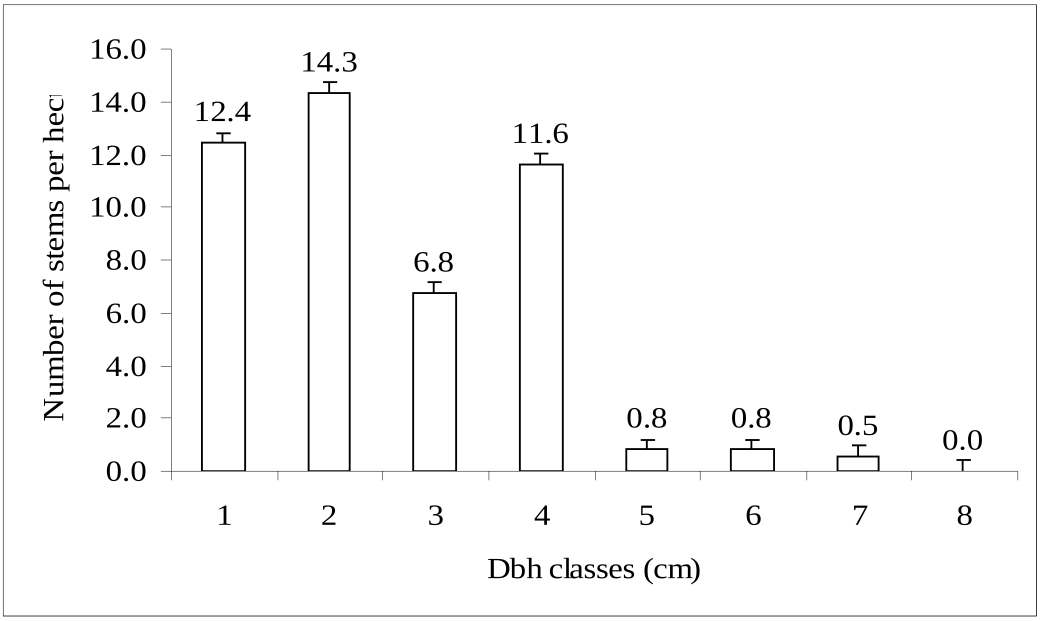

Figure 7: Number of cut trees per ha in different diameter classes in NFR

The number of trees harvested in relation to distance from the road along the Ifakara-Mikumi road is shown in Fig. 8. The trend suggests that harvesting is more intensive up to 3 km from roadside because of accessibility compared to far distance. At 1 km distance from the roadside the number of stumps sampled was 60 compared to 1 stump found at 5 km distance from roadside. The estimated rate of removal of 6.2 m^3 per ha per year, may therefore be on the higher side since the length of transects was only 4.5 km.

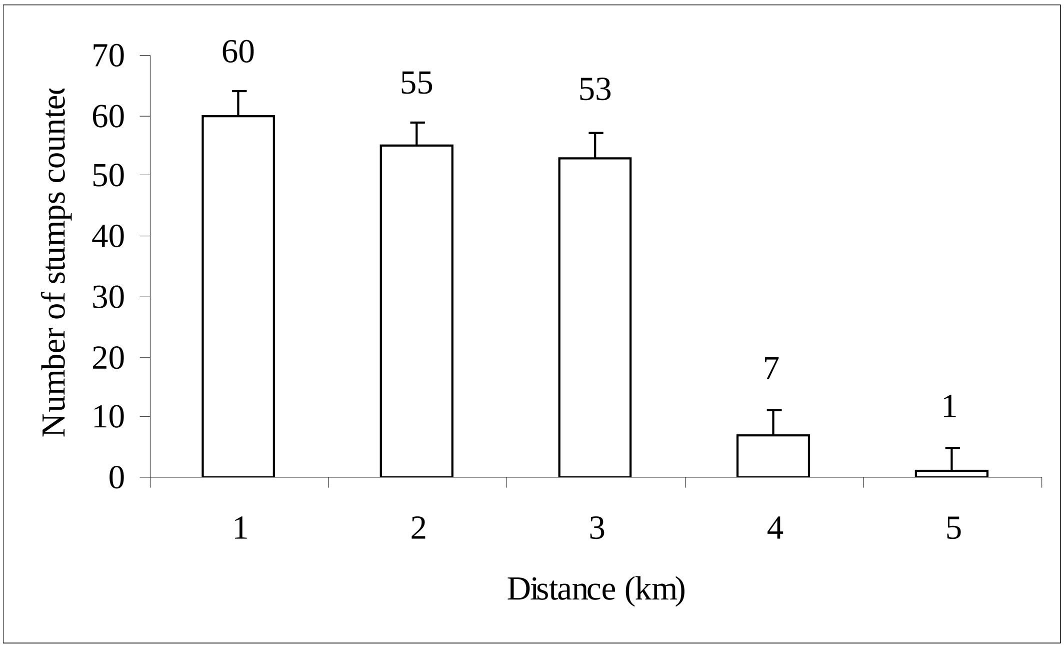

Figure 8: Number of stumps sampled in different distance from the roadside in NFR

Fig. 9 shows that, harvesting intensity tended to decline with increasing distance from roadside (R^2 = 0.19). The equation generated in Fig. 9 indicates that, distance has negative relationship with harvesting intensity, the number of cuts tended to decrease with increasing distance from roadside to the forest interior.

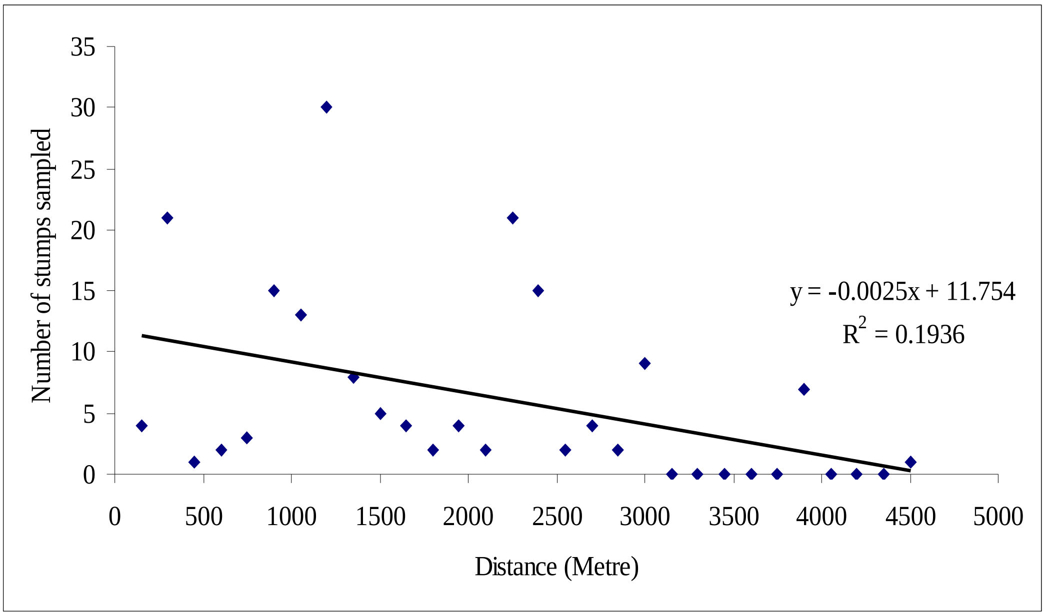

Figure 9: Distribution of tree cut by distance from roadside

4.2.5 Tree species preference for various uses

The trend of tree species preferences for the various uses in the villages around NFR confirms the importance of the forest to the livelihood of the people living adjacent to the forest. Table 9 shows 16 different tree species in the order of their importance to the households in the surveyed villages. *Burkea africana*, *Pterocarpus angolensis* and *Brachystegia spiciformis* appeared to be the most important tree species to the community in the surveyed villages. The respondents ranked *Burkea africana*, to be the first in furniture and building followed by *Pterocarpus angolensis*, and *Brachystegia spiciformis* (Table 9). *Brachystegia spiciformis* was ranked first in firewood followed by *Burkea africana* and *Pterocarpus angolensis*. Preference varies from place to place especially in relation to the abundance of preferred species for specific uses. For example in the case of timber, scarcity of the preferred species compels people to use any other species, providing it has high strength properties, high working properties and high natural durability.

Table 9: Ranking scores for the main tree species in three uses in the villages around Nyanganje Forest Reserve

	Uses*			Total score**	
Species	**Furniture**	**Building**	**Firewood**	**(Point)**	**Rank*** **
Burkea africana Hook	45	46	36	127	1
Pterocarpus angolensis DC	44	41	33	118	2
Brachystegia spiciformis Bench	32	32	48	112	3
Milicia excelsa (Welw) Benth & Hook.f.	32	31	25	88	4
Afzelia quanzensis Welw	30	26	30	86	5
Khaya anthotheca Stapf.Ex Baker	31	29	26	86	5
Brachystegia bussei Harms	28	28	28	84	7
Mangifera indica L	25	26	33	84	7
Selerocarya birrea Hochst	26	29	25	80	9
Bombax rhodognaphalon K.Schum	20	21	22	63	10
Breonadia salicina Vatil.	16	24	22	62	11
Diplorhynchus condylocarpon Wight & Arn.	21	18	19	58	12
Pterocarpus rotundifolius (Sond.) Druce	17	19	21	57	13
Terminalia sambesiaca Diels	19	16	14	49	14
Vitex doniana Sweet	11	11	16	38	15
Tectona grandis L.K	11	11	10	32	16

*In each use (i.e. Furniture, Building and Firewood) the highest score is 48 points

**The total score is given by adding the scores of species in all uses

***The highest rank is based on the species with highest total score (points)

Fuel wood is the primary source of energy in rural households. During PRA in three villages around NFR, people mentioned that fuel wood was a source of energy for cooking while charcoal rated the second. Proximity to natural forest of these villages may influence use and management of forest resources. In addition, people living adjacent the forest reserve obtained timber, charcoal, wild meat and honey from the informal markets i.e. most of these forest products are mainly extracted illegally from the forest. During the fieldwork several charcoal kilns and sawing platforms (old and new) were observed (Plate 3 and 4); this appears to be an indication that most of the forest products used in villages is extracted from NFR.

Plate 3: Charcoal kilns (new and old) in NFR

Plate 4: Sawing platforms (new and old) in NFR

4.3 Local Market Prices and Revenue Lost Around Nyanganje Forest Reserve

4.3.1 Timber sawing process

The timber sawyers in this study were all males and belonging to the ages between 23 and 53 years. The mainstay of the livelihood of people in these studied villages is agriculture i.e. rice, sweet potatoes, maize and bananas. Timber sawing is just a subsidy their income. Usually timber sawing in this area is done illegally by using sawing platform. Source of labour for timber sawing activities is mainly household labour. Lumber production involves, trees felling, delimbing, crosscutting, sawing platform construction, skidding or rolling log, lines marking on the log and finally timber sawing (Table 10).

Table 10: Number of days required in the timber sawing process

Activity	Day
Trees felling, delimbing and cross cut	1
Sawing platform construction	1
Skidding or rolling log and lines marking on the log	1
Timber sawing	3

Generally the work is musculine and time consuming. The average number of days spent by 2 persons to cut and saw a log(s) of diameter range from 25 to 50 cm and produce 29 to 35 boards of 1”×12”×12ft is six days. They spend many days because they can work for 4 to 6 hours per day to ensure their safety against forest officers. If they want to work for the whole day they must establish their camps more than 10 km inside the forest. Transportation of lumber from sawing site takes place immediately after producing one or two pieces of lumber to avoid being caught; when they are caught the timber is confiscated and hence, lost efforts.

During rain season some timber sawyers concentrate more in agriculture while others continue to make lumber. During this period timber sawing process becomes difficult because of dangerous wild animals such as buffalos, elephants, lions, and leopards which migrate from Selous Game Reserve to Nyanganje Forest Reserve escaping floods in Kilombero valley.

4.3.2 Suitable tree species for timber

Selection of tree species for timber production is based on the species properties to produce suitable timber; with high strength, natural durability, straight grain, devoid of knots, easy to machine, good appearance, available in large widths, easy to work and polish. Lumber with high strength, high durability and easy to machine, work and polish attracts market and hence income to timber sawyers. The preferred tree species for timber in this area are listed in Appendix 9. The timber species preferred determination was based on contribution of species to total tree volume. Other tree species mentioned to be used but not found in the study area are *Milicia excelsa, Afzelia quanzensis, Khaya anthotheca, Mangifera indica, Tectona grandis, Terminalia sambesiaca* and *Bombax rhodognaphalon.*

4.3.3 Timber pricing in villages around Nyanganje Forest Reserve

The average price for timber is given in Table 11. The price was about TShs. 8378/= (USD 6.4) per board of 1”×12”×12ft at village sites. There was a decline in real price of timber at village site across the season (i.e. TShs. 9009/= during dry season and TShs. 7746/= in rain season).

Table 11: Average timber price per lumber (1”×12”×12ft) in surrounding villages around Nyanganje Forest Reserve

Season	Village			Mean
	Lungongole	Sagamaganga	Signali	
Dry	7583	12 000	7444	9009
Rain	6750	10 600	5889	7746
Mean(TShs)	**7167**	**11 300**	**6667**	**8378**

The difference in timber prices with seasons are due to decline of purchasing power of the buyers (local people) and also during rain season most of the people concentrate in agricultural activities as a result the demand for timber becomes low and in turn force the timber producers to sell at low price. This trend follows the theory of demand; “the higher the demand the higher the price while the lower the demand the lower the price”. The season used to produce timber is nearly the same as that used to make charcoal. It was observed that there are special months for charcoal production. These are off-season months for agriculture and cover the period of June through November. Charcoal production is usually done to supplement farm income which is the major economic activity. Different from timber prices, charcoal prices in villages around NFR fluctuated significantly over the season. During the wet season it is sold at higher price than during dry season. Similar observation in charcoal prices was observed by CHAPOSA (2002) in Dar es Salaam and other cities in Southern Africa. The probably reasons for difference between charcoal and timber prices in villages around NFR might be an indication of the higher demand for charcoal compared to timber, people opted to use more charcoal than firewood because of unavailable of enough and dry firewood, and/or civilization of the people not like to cook inside their house using firewood during rain season.

Illegal timber harvesting was reported during PRA and key informant survey and also observed during ecological survey. The study revealed that the initial cost for timber production was TShs. 112 000/= which is equivalent to USD 86 (Appendix 10). These costs are mainly for purchasing tools and equipment for beginners who want to engage in timber production. Labours and raw materials are free since household members are engaged themselves in the production. As shown in Table 9, the mean annual quantity of timber harvested illegally was estimated to be 2.7 m^3 per ha. The annual quantity found on merchantable volume of 50% was 1.36 m^3. The study found that, 90% of the key informants interviewed, concurred that they obtained about one third of the volume from the cut log (merchantable volume). This was probably due to avoiding forest officers, poor condition and maintenance of the equipments (i.e. saw blades), large kerf width, sawing variation, sawing method and lack of sawing skills. Therefore the convention rate of 2 by 1 (i.e. 2 for wastes and 1 for lumber) was used to determine lumber recovery in the study area. Base on this information from key informants from villages around NFR, lumber recovery at 33.3% of merchantable volume was estimated to be 0.46 m^3 (an equivalent of 16 boards of 1”×12”×12ft[1]) (Table 12) whose mean unit value based on farm gate price was TShs. 8378/= per board, giving a total income of TShs. 402 144/= (an equivalent to

TShs. 134 048/= per ha per year). The total timber production cost was TShs. 329 000/= (an equivalent to TShs. 109 667/= per ha per year) when obtained illegally (Table 13). Therefore, timber sawyers realised a total net benefit of TShs. 24 381/= per ha per year. If extraction is done in every hectare in NFR, each year the government could lose TShs. 462 751 380/= (USD 355 963)[2]. This worth signify the profitability of illegal timber business to dealers as they neither pay tax nor fee to the government. Illegal logging not only lose revenue but also leads to lose forests, drains government coffers and hurts the livelihoods of communities living adjacent the forests.

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[41] 1’’×12’’×12ft means a board of 1 inch by 12 inch by 12 feet
[2] 1 USD was equivalent to TShs. 1,300/= in March, 2009

Table 12: Summary of Costs and Benefits of timber quantity extracted illegally from Nyanganje Forest Reserve

Costs	***Annual harvest (m^3)/ha***	***Merchantable volume 50%***	***Wastes 66.7% of merchantable volume***	***Recovery 33.3% of merchantable volume***	***Number of. boards***	***Costs (TShs)/ board***	***2006 year***	***2007 year***	***2008 year***
Harvesting cost	2.71	1.36	0.91	0.46	16		112 000	74 667	37 333
Processing cost	2.71	1.36	0.91	0.46	16		27 000	27 000	27 000
Transportation cost	2.71	1.36	0.91	0.46	16	500	8 000	8 000	8 000
Total annual costs							**147 000**	**109 667**	**72 333**
Benefits						**Price (TShs)/board**			
Benefits	2.71	1.36	0.91	0.46	16	8 378	134 048	134 048	134 048
Annual benefits							**134 048**	**134 048**	**134 048**
Net annual benefit							**-12 952**	**24 381**	**61 715**

Table 13: Net benefit (TShs) of timber quantity extracted illegally from Nyanganje Forest Reserve

Year	*Costs*	*Benefits*	*Net benefits*
2006	147 000	134 048	-12 952
2007	109 667	134 048	24 381
2008	72 333	134 048	61 715
TOTAL	**329 000**	**402 144**	**73 144**

4.4 Trend of Timber Trees and Level of Afforestation in the Villages Around Nyanganje Forest Reserve

The majority of respondents (90%) during PRA concurred that the timber trees have increased in NFR during the past ten years because local people have been involved in managing forest resources compared before 2000 when government alone was responsible for forest management. Kajembe *et al.* (2000) reported that, tree planting and retention in the farms is a widespread coping strategy against deforestation. In villages around NFR planting trees species is a major problem. Few people have planted trees in their home gardens and in farms. Furthermore the author observed that, people living far away from natural forest resources plant more trees than those living close to. The major tree species planted in the villages around NFR are presented in Table 14. The average total number of trees per household was estimated to be 20 trees per household.

Table 14: Tree species planted in home garden and in the farm at the villages around Nyanganje Forest Reserve

Local name	Botanical name
Mtiki	*Tectona grandis* L.K
Mvule	*Milicia excelsa* (Welw) Benth & Hook.f.
Mkongo/Mkola	*Afzelia quanzensis* Welw.
Mkangazi	*Khaya anthotheca* Stapf. Ex Baker
Mwarobaini	*Azadirachta indica* A. Juss
Mninga	*Pterocarpus angolensis* DC
Mpingo	*Dalbergia melanoxylon* Guill & Perr.
Msonobari	*Senna siamea* Lam
Mlusina	*Leucaena leucocephala* (Lam.) de Wit
Muakashia	*Acacia* spp
Mualbizia	*Albizia* spp

The major constraints to tree planting as reported during PRA were lack of seedlings and specified planting sites.

4.5 Forest Protection, By-Laws, Regulation and Rules

There are by-laws and regulations that govern the utilization of forests under the Joint Forest Management in villages around NFR. During PRA about 70% of respondents living around this forest confirmed that they were aware of such by-laws and regulations. In spite of this awareness, illegal activities seem to be continuing in the reserve and could probably be due to laxity and inadequate enforcement of the protection laws and regulations. During PRA survey the people living in the villages around this reserve suggested strategies toward reducing forest destruction, which included;

- proper monitoring of entrance or access to the forest to curb illegal activities.
- plant more useful and fast growing trees for firewood, charcoal, building and timber.
- introduce or reduce the price of alternative sources of energy (e.g. kerosene, electricity and solar powers).
- prescribe and execute severe punishment to culprits.
- enforce forest protection law by carrying out more sensitization and educating village meeting.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study intended to determine quantity and assess the extent of timber exploitation in EAM's forests. The study revealed that the EAMs has 180 timber species with a total of 135 600 000 stems and 74 400 000 m^3 of timber (an equivalent of 0.6 m^3 per tree. Furthermore, t-test analysis employed in this study showed that, (p (t) = 0.047 d.f = 39) for stems per ha and (p (t) = 0.001 d.f = 39) for volume per ha). This implies that, the EAMs forests have high potential in terms of timber tree stocks. Generally speaking, the stocking of the EAMs was found to be good, stems number depicted an inverted 'J' shape which is common for natural forests with active regeneration and recruitment; this indicates a good sign of sustainability of the EAMs timber stock which has chances of insuring sustainable supply of products and services.

The study showed that, about 6.2 m^3 per ha of wood resources is extracted each year from NFR of which 2.7 m^3 was contributed by timber. Wood resources in diameter classes 1, 2, 3, and 4 are most extracted compared to large diameter class 5, 6, 7. This implies that the NFR might have no many large trees in the distance up to 5 km from roadside due to past exploitation of timber species. The linear regression analysis showed that, extraction of timber trees in NFR mostly occurs illegally at the edge of the forest (roadside) ($R^2 = 0.19$, p = 0.015), thus, the null hypothesis was accepted. Mean annual increment is important in deciding amount of wood remove. Zahabu (2001) reported that; mean annual increment (MAI) in woodland range between 1 to 3 m^3. This shows that, an estimated annual wood remove of 6.2 m^3 in the study area is higher than the mean annual increment reported in woodland. This may therefore lead to extinction of some species or overexploitation of some size classes hence eventually unsustainable. The consequences of this rapid conversion of native habitat is the loss of biodiversity (Myers *et al*., 2000) and degraded livelihood of the people living adjacent to this reserve because the extinction of plant species not only decrease forest products but also result climatic change. Therefore timber trees should be well manage and conserved because trees in landscape mosaics enhance the ecological quality of the landscape matrix and provide habitat and greater landscape connectivity for dispersal of plant and animal species (Perfecto and Vandermeer, 2002).

5.2 Recommendations

The study manifest the important of the EAMs to the livelihood of the communities living adjacent to them. It is suggested that people living around these mountains should be allowed, under agreed regulations to continue extract some resources such as; medicinal plants, mushroom, wild vegetable and fuel wood from dead wood. Fuel wood collection is a fuel management technique that temporarily reduces damage from wildfire by removing a portion of the accumulated dead, hence facilitates fire control efforts by reducing the intensity, size and damage of wildfires (Liu, 2004). Fuel wood collection techniques may also result in a reduction of greenhouse gas (GHG) emissions from biomass burning.

Agro-forestry is also recommended, along with the planting of some desirable indigenous tree species to the respective areas after assessing the suitability of such species to the given area. Agro-forestry can contribute to reducing pressure of local communities on adjacent forest areas (Boffa *et al.*, 2008). Other income generating activities such as animal husbandry and small-scale industries should be encouraged as well. This would reduce people's dependency on forest products as a source of income and thus reduce the pressure on the natural forest.

Other recommendations which must be adhere and taken into consideration by main stakeholders such as Government and NGO's include;

- stipulation of appropriate rights as incentives for protecting resources in the reserve.
- equipping local people with the formal skills and knowledge needed to manage natural resources.
- acknowledgement of constructive indigenous management system and applying them in sustainable resource management.
- promotion of the use of substitute energy sources to reduce pressure on the woodlands.
- participation in protection against illegal exploitation in the forest reserve.
- formulation and enforcement of by-laws.
- involving in social forestry i.e. establishment of woodlots to reduce pressure on the woodlands.

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APPENDICES

Appendix 1: List of Forest Reserve in the Eastern-Arc Mountains and inventory data considered in this study

(a): List of Forest Reserves in the Eastern-Arc Mountains

P-Proposed forest, **CG**-Central Govt, **LG**-Local Govt, **VG**-Village, **CL**-Clan, **TANAP**A-Tanzania National Park,

Block	No.	Name of Reserve	Area(ha)	Location	Type of vegetation	Ownership
Malundwe	1	Malundwe hill	400	37° 18' E, 07° 24' S	Montane	TANAPA
Mahenge	2	Ligamba	15.8	36° 26' E, 9° 02' S		CG
	3	Mahenge scarp	500.0	36° 42' - 36° 44', 8° 37' - 8° 38' S	Woodland	CG
	4	Mselezi	2,245.0	36° 43' - 36° 44' E, 36° 42' - 36° 44'S	Evergreen or Sub montane, woodland	CG
	5	Muhulu	615.0	36° 41' E, 8° 51' S	Sub montane, woodland	CG
	6	Myoe	93.1	36° 37' E, 8° 39' S		
	7	Nawenge (Kwiro)	623.0	36° 43 E, 8° 42' - 8° 43' S	Evergreen or Sub montane	CG
	8	Sali	991.0	36° 37' - 36° 41' E, 8° 54' - 8° 57' S	Evergreen or Sub montane	CG
Nguru	9	Kanga	6,664.2	37° 40' - 37° 45' E, 5° 53' - 6° 03' S	Evergreen/Woodland	CG
	10	Magotwe	709	37° 39' E, 6° 02' S	Lowland (Converted to farmland)	VG
	11	Mkindu (Mkindo)	5,244.0	37° 28' - 37° 34' E, 6° 12' - 6° 16' S	Woodland	CG
	12	Nguru South	18,800.0	37° 26' - 37° 37' E, 6° 01' - 6° 13' S	Evergreen or Montane, Woodland, Lowland	CG
Nguu	13	Derema	344.0	37° 32' - 37° 27' E, 5° 42' - 5° 37' S	Evergreen or Sub montane	CG
	14	Jungu	261.0	9410382E and 348289N	Semi evergreen or Dry sub montane	CG
	15	Kilindi	5128.0	37° 33' - 37° 36' E, 5° 33' - 5° 40' S	Woodland	CG
	16	Kwediboma	284.0	37° 33' E, 5° 26' S	Woodland	LG
	17	Mbwegere	363.5	37° 29' E, 5° 45' S	Woodland	CG
	18	Mkongo	945.0	37° 33' E, 5° 27' - 5° 29' S	Woodland	CG
	19	Mkuli extn	2,931.0	37° 28' E, 5° 47' S	Woodland	CG
	20	Mkuri/w river	599.8			?
	21	Nguru North	14,041.0	37° 36' - 37° 32' E, 5° 27' - 5° 38' S	Dry montane, Sub montane and Montane	CG
	22	Pumula	1,061.0	37° 32' - 37° 28' E, 5° 40' - 5° 44' S	Evergreen	CG
	23	Rudewa South	555.6	37° 37' E, 5° 47' S	Woodland	CG

North Pare	24	Kamwela I(P)	199.0	37° 45’ E, 03° 45’ S		
	25	KamwelaII(P)	293.0	37° 45’ E, 03° 45’ S		
	26	Kindoroko	885.0	37° 45' E, 3° 43' - 3° 46' S		CG
	27	Kiverenge(P)	2,155.0	37° 37' - 37° 40' E, 3° 48' - 3° 50' S		
	28	Minja	520.4	37° 45' E, 3° 43' - 3° 46' S		CG
	29	Mramba	3,355.0	37° 33' - 37° 36' E, 3° 31' - 3° 39' S		CG
South Pare	30	Chambogo	5,466.6	37° 45' - 37° 51' E, 4° 04' - 4° 08' S		CG
	31	Chome	1,4282	37° 53' - 38° 00' E, 4° 10' - 4° 25' S		CG
	32	Chongweni	92.3	37° 50' E, 04° 20' S		LG
	33	Dido(P)	?	?		VG
	34	Ishereto(P)	?	?		VG
	35	Kwamwenda(P)	583	37° 50' E, 04° 20' S		
	36	Kankoma	74	37° 50' E, 04° 20' S		LG
	37	Kiranga Hengae	321	37° 50' E, 04° 20' S		LG
	38	Kwizu	3070	37° 50' E, 04° 20' S		LG
	39	Maganda	28	37° 50' E, 04° 20' S		LG
	40	Mambugi(P)	?	?		VG
	41	Mwalla(P)	1373	37° 50° E, 04° 20' S		
	42	Vumari	1829	37° 50' E, 04° 20' S		LG
Rubeho	43	Mafwomero	3,237.0	36° 35' E, 06° 49' S	Evergreen or montane	CG
	44	Mangalisa	4,988.0	36° 25' E, 07° 10' S	Evergreen or montane	CG
	45	Pala-ulanga	10,610.3	36° 47' - 36° 50' E, 7° 12' - 7° 22' S	Evergreen or Sub Montane	CG
	46	Ukwiva	54,634.0	36° 34' - 36° 51' E, 6° 58' - 7° 21' S	Evergreen or Sub MontaneWoodland	CG
	47	Ilole forest				
	48	Wotu	1,024.0		Evergreen?	CG
Udzungwa	49	Brook bond	12,000.0	?		Private(Unilevel)
	50	Duma	11.0	?	?	LG
	51	Idewa	291.0	35° 46' 40" - 35° 48' 00" E, 08° 16' 07" - 08° 17' 15" S		LG
	52	Igoda	33.0	?	?	LG
	53	Ihanga	3,468.0	0235000 - 0241000 E and 9112000 – 9106000S	Woodland Lowland	CG
	54	Ihang’ana	1,206.0	35°42' 20" - 35° 44' 50"E, 08° 16' 45" - 8° 18' 38" S	Evergreen	CG
	55	Image	8,919.0	36° 08' 15" - 36°12'25"E, 07° 22' 15" - 07° 33' 15"S	Evergreen	CG

	56	Ipafu	88.0	?	?	LG
	57	Iwonde	?2,581.0	36° 32 - 36° 42' E, 7° 55' - 8° 00' S	Evergreen/Woodland	TANAPA
	58	Iyondo/Iyonde	27,972.0	36° 06' - 36° 22' E, 8° 00'- 8° 16' S	Woodland, Lowland	CG
	59	Kawemba(P)	69.0	36° 00' 50" - 36° 01' 15" E, 8° 08' 10", 8° 08' 50" S		CG
	60	Kibao	440.0	35° 17' 50" - 35° 18' 05" E, 8° 34' 00" - 8° 35' 25" S		CG
	61	Kidegema Msitu	218.0	?	?	LG
	62	Kidete	105.0	35° 27' 08" - 3° 28' 33" E, 8° 29' 15" - 8° 29' 45" S		LG
	63	Kigogo	2,522.0	35° 11' 45" - 35° 16' 30" E, 08° 37' 40" - 08° 41' 40" S		CG
	64	Kimala (P)	1,000.0	?		
	65	Kilanzi kitungulu(P)	1,099.0	36° 02' 50" - 36° 04' 30" E, 8° 06' 00", 8° 08' 35" S		CG
	66	Kisinga Lugalo(P)	14,164.0	35° 53' 52" - 36° 03' 40" E, 07° 44' 25" - 07° 53' 00"S	Evergreen	CG
	67	Kitemele(P)	273.0	36° 01' 30" - 36° 02' 45" E, 8° 9' 15" - 8° 10' 25" S		CG
	68	Kitonga (P)	629.0	37° 07' - 37° 10' E, 07° 35' - 07° 43' S	Woodland	
	69	Kitwile	69.0	?	?	LG
	70	Kyfulilo farm	50.0	?		Private
	71	Lufuna	350			
	72	Lugoda Lutali	108.0	35° 25' 15 - 35° 31' 30"E, 8° 32' 30" - 8° 34' 15" S		LG
	73	Luhunga	252.0	?	?	LG
	74	Lulanda	197.0	35° 36' 50" - 35° 38' 15" E, 08° 35' 15" - 08° 17' 07" S		VG
	75	Madisi	84.0	?	?	LG
	76	Malenda farm	400.0	?		Private
	77	Mkonge	97.0	?	?	LG
	78	Mufindi scarp east	16,737.0	35°11'55"E - 35°36'05"E, 8° 34' 05" S - 08° 42' 40" S		CG
	79	Mufindi scarp west	1,852.0	35°07'40"E - 35°10'50"E, 08° 41' 15" S - 08° 43' 50" S		CG
	80	Mufindi tea	1,000.0	?		Private

	81	Myangala	35.0	35°19' - 35°20'E, 8° 18' 15" - 8° 19' 00" S		LG
	82	Ndynduli	5.0	?	?	LG
	83	New Dabaga (P)	3,732.0	35°54'07" - 35°56'52" E, 08° 03' 15" - 08° 06' 46"S		
	84	Njerera Luhega	2,833.0	?		CG
	85	Nyanganje	17,767.0	36° 39' - 36° 50' E, 7° 56' - 8° 4' S	Lowland, woodland	CG
	86	Udzungwa park (Mwanihana, Kilombero river)	190,000.0	36° 45' E, 07° 50' S	Woodland, lowland, sub montane montane?	TANAPA
	87	Udzungwa scarp(Kilombero)	20,720.0	35° 51' - 36° 02' E, 8° 14' - 8° 32' S	Lowland, sub montane, montane?	CG
	88	Udzungwa scarp(Kilolo)	23,000			
	89	Ukami	85.0	36° 24' E, 7° 53' S		VG
	90	Ulagambi(P)	2,057.0	35° 54' 04" - 35° 56' 48 " E, 08° 00' 07" - 08° 03' 50" S		CG
	91	West Kilombero scarp(P)	105,000.0	36° 05' 45" - 36° 58' 30" E, 07° 38' 30" - 08° 17' S		CG
Ukaguru	92	Ikwamba	899.0	36° 57' - 36° 59' E, 6° 19' - 6° 21' S		CG
	93	Mamboto	137.0	36° 55' E, 06° 20' S		CG
	94	Mamboya	503.0	37° 03' - 37° 04' E, 6° 13' - 6° 15' S	Evergreen or Montane	CG
	95	Mamiwa Kisara North	6,775.0	36° 53' - 37° 03' E, 6° 21' - 6° 30 S	Evergreen or Upper Montane	CG
	96	Mamiwa Kisara South	6,266.4	36° 54' - 37° 00' E, 6° 26' - 6° 35' S	Evergreen or Upper Montane	CG
	97	Mlali	6,216.0	?		CG
	98	Uponera	375.0	36° 55' E, 06° 20' S		CG
Uluguru	99	Bunduki I	106.6	37° 38' E, 7° 01' S	Montane	CG
	100	Bunduki II	2.8	37° 38' E, 7° 01' S	Plantation(Pines, *Eucalyptus and Cedrella*)	LG
	101	Bunduki III	3.0	37° 38' E, 7° 01' S	Evergreen or Montane	CG
	102	Bunduki IV	6.1			CG
	103	Bunduki V	3.7			CG
	104	Bunduki VI	2.6			CG
	105	Dindili	1,006.9	37° 52' E, 6° 42' S	Lowland-woodland	CG
	106	Kasanga	70.0	37° 45' E, 07° 10' S	Evergreen or Sub montane(completely encroached)	CG
	107	Kitulang'halo	2,638.0	37° 57' - 38° 01' E, 6° 39' - 6° 43' S	Woodland	CG
	108	Mindu	2,285.0	37° 35' E, 6° 50' S	Woodland	CG

	109	Mkungwe	1,966.8	3° 53' - 37° 57' E, 6° 51' - 6° 55' S	Lowland-woodland	CG
	110	Mlaliwila	12.8	37° 45' E, 06° 59' S		LG
	111	Nguru ya ndege	3,614.0	37° 35' - 37° 37' E, 6° 41' - 6° 44' S	Woodland(-), lowland	CG
	112	Shinkurufumi/Shukuru fumu	260.0	37° 31' E, 07° 09' – 07° 11' S	Evergreen or Sub Montane	CG
	113	Tongeni river/Nongeni	231.5		Woodland	CG
	114	Uluguru North	8,356.7	37° 37' - 37° 45' E, 6° 51' - 7° 01' S	Evergreen or Sub montane	CG
	115	Uluguru South	17,292.7	37° 36' - 37° 45' E, 7° 01' - 7° 12' S	Evergreen or Montane, Upper montane	CG
East Usambara	116	Handei	156.0	?		VG
	117	Kambai	1,050.0	38° 42'E, 5° 00'S		CG
	118	Kizangata	6..2	?		VG
	119	Kizee	39.4	?		VG
	120	Kwamkoro	2,209.0			
	121	Kwamgumi	1,149.0	38° 44'E - 38 ° 47'E, 4° 55' S - 4° 57' S	Evergreen	CG
	122	Longuza teak plantation	1541.3	38° 41'E, 5° 02'S		CG
	123	Magrotto(estate)	591.0	38° 45'E, 5° 07'S		Private
	124	Manga	1,635.0	38° 45'E - 38° 47'E; 5° 00' S – 5° 02' S		CG
	125	Mfundia	786.4	E 38° 35' 49.7", S 4° 54' 41.4"		VG
	126	Mlinga	840.0	E 38° 44' 30'' - 38° 46' 00'' E, S 05° 04' 00'' – S 5° 05' 00''		CG
	127	Mlungui	200.0	38° 42'E, 5° 00'S		CG
	128	Mtai	3,107.0	38° 44'E - 38° 48'E, 4° 51'S – 4° 54'S	Evergreen	CG
	129	Nilo	6,025.0	E 38° 37' – 41', S04° 50' – 59'S		CG
	130	Segoma	1,100.0	38° 43'E –38° 47'E, 4° 57 S - 5 ° 01 S		CG
	131	Semdoe/Msige	980.0	38°41'E - 38°43'E, 4°56' - 4°58' S		CG
West Usambara	132	Ambangulu	772.0	?		Private
	133	Baghoi	334.7	?		LG
	134	Balangai East	325.8	38° 31' 0 E, 4° 55' 60 S	Montane	CG
	135	Balangai West	1,003.3	?		CG
	136	Banga II	1,459.2	?	Evergreen or Upper montane	CG
	137	Bombo Makole	263.0	?		LG
	136	BumbaMavumbi	1,044.0	38° 38' E, 4° 43' S	Evergreen or Montane	CG

	139	Chambogo(P)	605.0	?		VG
	140	Deai(P)	100.0	?		VG
	141	Dindira(P)	80.0	?		VG
	142	Kifulio(P)	130.0	?		VG
	143	Kikongoli	245.2	?		
	144	Kisima Gonja	1,440.3	38° 29' E, 4° 49' - 4° 57' S	Evergreen or Montane	CG
	145	Kitara Ridge	388.0	?	Almost is completely cleared	LG
	146	Kwamongo(P)	142.0	?		VG
	147	Kwebagu/Hebangue	33.6	?		LG
	148	Kwenyashu	16.2	?		LG
	149	Lutindi(KKKT)	2,150	38° 37' - 38° 39' E, 4° 51' - 4° 55' S		Private
	150	Mafi hill	4,508.0	38° 11' - 38° 06' E, 4° 53' - 4° 57' S	Evergreen	CG
	151	Mahenzangulu	325.8	38° 31' E, 4° 57' S	Evergreen or Dry montane	CG
	152	Manka	133.6	?		CG
	153	Mgombani	95.0	38° 30' E, 4° 58' S		CG
	154	Mkusu	3,674.0	?	Evergreen or Upper montane	CG
	155	Mtumbi	304.0	?		LG
	156	Mweni Gombelo	1,029.0	38° 33' - 38° 37' E, 4° 38' - 4° 42' S		CG
	157	Mzashai(P)	350.0	?		VG
	158	Mzinga	355.5			
	159	Mzongoti(P)	154.0	?		VG
	160	Ndelemai	1,421.0	?	Evergreen or Montane (Suffered from extensive clearance)	CG
	161	Ndolwa	1,159.3	?		CG
	162	Sekigoto(P)	100.0	?		VG
	163	Shambalai	21.0	?		LG
	164	Shangayu	7,834.0	?	Evergreen or Montane, upper montane	CG
	165	Shukilai(P)	100.0	?		VG
	166	Shume Magamba	12,225.0	?	Evergreen or Upper montane	CG
	167	Shume Extn	48.9			
	168	Tanda (P)	100.0	?		VG
	169	Vugiri	40.8	38° 27' E, 5° 04' S		CG
	170	Yumbu(P)	350.0	?		VG

Source: Malimbwi *et al.* (2005); Munishi *et al.* (2007); Howell *et al.* (2007)

(b): Summary of inventory data considered in this study

Block	Forest name	Area(ha)	Vegetation type	Dbh classes(cm)						Total/ha		
				Less than 40			Above 40					
				N	G	V	N	G	V	N	G	V
Mahenge	Mselezi	2245	sub montane/woodland	343	5	28	7	1	18	350	6	46
	Sali	991	sub montane	147	4	49	25	9	184	172	13	233
	Nawenge	623	sub montane	204	204	36	14	14	34	219	219	70
	Mahenge scarp	500	woodland	337	4	25	27	5	70	364	9	95
Nguru	Kanga	6664.2	sub montane/woodland	185	3	27	40	22	360	225	25	387
	Mkindo	5244	woodland	201	3	29	14	9	160	215	13	188
	Nguru south	18800	Lowland	54	1	11	24	10	190	78	11	201
	Nguru south		Montane	61	2	24	38	16	316	99	19	340
	Nguru south		Woodland	198	5	43	15	4	77	213	9	120
Nguu	Derema	344	sub montane	628	6	42	64	24	347	692	30	390
	Jungu	261	dry sub montane	1194	8	44	22	4	41	1216	12	86
	Kilindi	5128	woodland	378	4	20	21	9	128	399	13	148
	Kwediboma	284	woodland	333	4	31	38	8	118	371	12	149
	Mbwegere	363.5	woodland	171	4	37	8	1	19	179	6	56
	Mkongo	945	woodland	562	6	40	19	3	37	581	10	77
	Mkuli extension	2931	woodland	276	4	29	8	2	21	284	6	49
	Nguru North	14041	sub montane/montane	271	5	42	41	17	278	312	22	320
	Pumula	1061	sub montane	370	7	49	22	5	63	392	12	112
	Rudewa	555.6	woodland	358	3	14	0	0	0	358	3	14
Rubeho	Palaulanga	10610.3	sub montane	278	6	38	46	10	99	324	17	137
	Ukwiva	54634	sub montane/woodland	391	9	58	19	6	60	410	15	118
Udzungwa	Ihanga	3468	woodland/lowland	22	1	11	27	7	153	49	8	164
	Iwonde	2581	sub montane/woodland	451	5	30	55	11	116	506	16	146
	Iyonde	27972	woodland	152	5	40	33	6	115	185	12	155
	Iyonde		lowland	187	4	24	15	5	64	202	9	88
	Nyanganje	18900	woodland	220	4	30	18	4	48	238	8	78
Ukanguru	Mamboya	503	sub montane/montane	398.6	6	36	35	18	247	434	24	283
	Mamiwa kisara North	6775	sub montane/upper montane	205.6	3	19	3	1	6	208	4	25
	Mamiwa kisara south	6266.4	sub montane/upper montane	444	9	56	21	5	64	465	14	120

Uluguru	Bunduki 1	106.6	montane	299	9	96	23	4	72	322	14	168
	Bunduki II	2.8	plantation	71	6	67	80	26	433	151	32	500
	Bunduki III	3	sub montane/montane	141	4	59	40	8	135	181	12	193
	Dindili	1006.9	lowland/woodland	171	3	22	0	0	0	171	3	22
	Kitulanghalo	2638	woodland	148	3	21	9	1	18	157	5	38
	Mkungwe	1966.8	lowland/woodland	206	4	28	9	2	31	215	6	59
	Nguru ya Ndege	3614	woodland/lowland	85	1	11	8	2	33	93	3	45
	Shikurufumu	260	sub montane	132	5	46	38	19	365	170	24	411
	Uluguru North	8356.7	sub montane	154	7	86	45	14	240	199	21	326
	Uluguru South	17292.7	sub montane/montane/upper montane	112	3	34	13	9	182	125	13	216
	Mindu	2285	woodland	618	3	7	0	0	0	618	3	7
Usambara East	Kwamgumi	1149	sub montane	84	1	11	25	6	69	109	7	80
	Mtai	3107	sub montane	235	4	21	10	4	52	245	8	73
Usambara West	Baga 2	1459.2	sub montane/upper montane	239	4	36	38	32	587	277	36	623
	Balanghai	1003.3	sub montane/upper montane	160	7	84	98	50	960	258	56	1044
	Bumba Mavumbi	1044	sub montane/montane	47	2	21	48	17	262	95	19	283
	Kisimagonja	1440.3	sub montane/montane	79	2	20	56	25	503	135	27	523
	Mahezangulu	325.8	sub montane/dry montane	99	2	21	68	35	603	167	37	624
	Mkusu	3674	sub montane/upper montane	87	4	56	20	4	78	107	8	133
	Shume magamba	12225	sub montane/upper montane	334	7	58	36	14	240	370	21	298
	Ndelemai	1421	sub montane/montane	253	7	75	33	8	146	286	15	221
	Mafi hill	4508	sub montane	286	5	36	17	4	36	303	9	73

Source: Malimbwi *et al.* (2005); Munishi *et al.* (2007)

Appendix 2: Forest inventory forms

Data sheet for recording timber exploitation

Transect ……………Vegetation type....................Date...........................

Plot	Name of species	New cut	Old cut	BD (cm)	Other disturbances	New	Old	Remarks

Data sheet for recording standing trees

Transect……………….Vegetation type……………Date…………………

Plot	Name of species	BD(cm)	DBH(cm)	Ht (m)	Remarks

Appendix 3: Research questions (PRA and Key informants)

A. Participatory rural appraisal

The following questions were employed during PRA in the villages of Signali, Sagamaganga and Lungongole. Though presented in English here, all interviews were conducted in Swahili

Summary of issue and PRA technique used

Issue	PRA
Forest condition	Time line Past eight years, current
Timber resource	Resource mapping
Timber product and price	Matrix pair wise ranking

1 What is the major economic activities/source of income in the village?
2 What type of crops and livestock do you keep in the village?
3 Where do you get firewood, charcoal, poles and lumber?
4 How do you benefit from this forest reserve (NFR)?
5 How people access basic needs from the forest?
6 What is the status of timber species in the forest from 2000 up to 2008?
7 Are bush and / or forest illegal activities a problem in this area? Which part of the forest is most affected, Lower or higher altitude?
8 Who are the main exploiters of the forest reserve?

9 Comparatively, what has been the situation of timber exploitation outbreaks in the area for the past 10 years ago? Has the situation being increasing or decreasing or no change?
10 hich timber species are most targeted for furniture, building materials, fire wood uses?
11 What is the relative abundance of such targeted species in forest?
12 Is there any village by-laws governing illegal activities in this village?
13 What punishment do you consider appropriate for someone found guilt of an offence of illegal activities in this area/ village?
14 On your opinion, what do you think needs to be done to end this problem?
15 What are the prices of such targeted timber species and untargeted timber species over time (dry/rain season)?
16 How many people are involved in the different uses of the forests? Such as lumber, poles, fuel wood (small/medium/many)?
17 Do you plant any timber tree species?
18 If yes how many? Where? Are they exotic or indigenous? Which species?
19 Where do you get the seedlings? Who pays for them?
20 Have you received any training regarding to forest management in this village?

B. Individual Interview

Part 1: Village Executive Officer

Village……………………………Name…………………………..Date…………

1. What is the number of households in your village? Male……….Female………
2. What is the major economic activity in this village?
2. Where do people get firewood, poles and lumber for their daily routine?
3. What is the number of people involving in forest activities? Carpenters……..Timber sawyers...................
4. Which timber tree species are mostly used for house construction and fuel wood?
5. What is the trend of timber exploitation from the forest?
6. What effort have you taken to reduce this problem?
7. Is there any afforestation activity conducted in your village?
8. If yes how many trees are planted? Where? Exotic or indigenous?
9. Which species?
10. Where do you get the seedlings?
11. Who pays for them?
12. On your suggestion, what do you think needs to be done to end the problem of timber exploitation?

Part 2: Carpenters and Timber sawyers

Name....................................Age.................................

Sex............. Occupation……………………………….

Marital status………………….

1. Are you a resident of this area? ....
2. For how long have you been here? ....years
3. Is there any forest harvested? Yes or No, where is your source location (s)?

No	Timber species	Source location	Distance (km)

4**.** How much do you sell/purchase per piece?

No	Timber species	Size	Price/unit (TShs)	
			Dry	Rains
1				

5. What is the preferred timber species?

Ranking	Timber species	Uses
1		

6. What is the capacity of market?

No	Timber species	size	Cubic metres
1			

7a**.** What are the costs of logging/production e.g. time spent/number of man days harvesting timber in a specific area/given volume; wage rates; capital costs, and, other production costs, processing costs and transport costs

Capital cost ($1m^3$ of timber)	Number of labour	Production cost ($1m^3$ of timber)			Transportation cost ($1m^3$ of timber**)**
		Time spent	Labour wages	Other cost (spares, fuel etc)	

7b. What percent/proportional of lumber volume do you get after sawing the log?

8. What is current extraction rates e.g. changes in timber stocks in past 8 years (Low, medium, high)

Timber species	Extraction rate	
	Past 8 years	Current

9. What is the perception towards how much of timber extracted is illegal (Low, medium, high)

Timber species	Illegal	Legal

Appendix 4: Timber species in Eastern-Arc Mountains

No	Timber species	Family	Area (ha)	Total	
				N	V
1	*Acacia nigrescens* Oliv.	Mimosoideae	4897.8	310993.2	20614.9
2	*Acacia nilotica* (L.)	Mimosoideae	33100.0	303956.0	5976.7
3	*Acacia polyacantha*	Mimosoideae	38701.9	537867.4	219144.9
4	*Acacia* spp	Mimosoideae	623.0	9920.4	891.8
5	*Afzelia quanzensis* Weiw.	Caesalpiniodeae	159189.2	381363.2	337567.6
6	*Albizia gummifera* (Gmel.) C.A.Sm.	Mimosoideae	33082.8	1029365.9	1135279.0
7	*Albizia harveyi* Fourn.	Mimosoideae	2285.0	262775.0	3953.1
8	*Albizia petersiana* (Bolle) Oliv.	Mimosoideae	185887.6	3959291.1	5718492.0
9	*Albizia schimperiana* Oliv.	Mimosoideae	363.5	2544.5	3671.4
10	*Albizia versicolor* Welw.ex.Oliv.	Mimosoideae	75895.3	267913.6	55686.5
11	*Allanblackia* spp	Clusiaceae(Guttiferae)	991.0	78901.3	129496.1
12	*Allanblackia stuhlmannii* (Eng.)Eng.	Clusiaceae(Guttiferae)	42958.4	648652.0	2726497.0
13	*Allanblackia ulugurensis*	Clusiaceae(Guttiferae)	25649.4	959122.4	585271.0
14	*Annona senegalensis*	Annonaceae	227260.7	2454255.8	191616.9
15	*Annona* spp	Annonaceae	57379.0	4169158.6	503333.0
16	*Annona squamosa*	Annonaceae	3614.0	7228.0	8962.7
17	*Antiaris* spp	Moraceae	991.0	7890.1	1731.1
18	*Antiaris toxicaria* (Rumph.ex Pers) Lesch.	Moraceae	117018.0	1028070.3	622752.4
19	*Baphia kirkii* Baker	Papilionoideae	5244.0	26220.0	5663.5
20	*Bauhinia petersiana*	Caesalpiniodeae	147440.0	1015341.0	419939.4
21	*Bauhinia thonningii*	Caesalpiniodeae	2506.0	44736.5	6571.4
22	*Beilschmiedia kweo* (Mildbr.)Robyns & Wilczek	Lauraceae	44577.8	255582.9	760935.6
23	*Bersama abyssinica*		102023.6	755593.7	228954.9
24	*Bombax rhodognaphalon* K. Schum.	Bombacaceae	72336.2	180957.2	398318.7
25	*Borassus aethiopum*	Arecaceae	3468.0	20808.0	228506.5
26	*Brachylaena huillensis* Hutch.	Compositae	4517.0	82726.0	49915.6
27	*Brachystegia boehmii* Taub.	Caesalpiniodeae	126107.9	6635109.6	2237792.0
28	*Brachystegia bussei*	Caesalpiniodeae	58275.3	2038687.1	700772.5
29	*Brachystegia microphylla*	Caesalpiniodeae	85197.3	2243146.0	1725515.0
30	*Brachystegia spiciformis* Bench.	Caesalpiniodeae	171330.8	4854485.2	2549281.0
31	*Brachystegia* spp	Caesalpiniodeae	2745.0	83996.8	29317.0
32	*Bridelia micrantha*	Euphorbiaceae	157454.1	1009751.5	320141.2
33	*Bridelia* spp	Euphorbiaceae	10610.3	10610.3	9655.4
34	*Burkea africana* Hook.	Caesalpiniodeae	101506.0	1248820.0	150651.8
35	*Casearia engleri*		2899.5	190229.1	318499.8
36	*Cassia abbreviata*		3614.0	50596.0	6143.8
37	*Cassipoure malosana* (Baker) Alston.	Rhizophoraceae	27259.7	113274.3	25548.9
38	*Casuarina cunninghamiana*		106.6	1705.6	234.52

39	*Cedrela odorata* Roam	Meliaceae	36095.5	112816.8	91336.6
40	*Celtis durandii*	Ulmaceae	35661.4	641516.0	112092.0
41	*Celtis* spp	Ulmaceae	44232.0	334651.0	357618.7
42	*Cephalosphaera usambarensis* Warb.	Myristicaceae	18800.0	37600.0	1357360.0
43	*Chrysophyllum perpulchrum* Mildbr..Ex Hutch. & J.M. Dalz	Sapotaceae	34096.0	1548995.0	894489.1
44	*Chrysophyllum spp*	Sapotaceae	12225.0	12225.0	18582.0
45	*Clerodendrum cephasothum*		25756.0	53217.6	41216.9
46	*Combretum adenogonium* Steud.ex A.Rich	Combretaceae	19774.0	494148.0	88221.5
47	*Combretum collinum* Fresen.	Combretaceae	151555.0	2626223.0	622984.8
48	*Combretum molle* R.Br.ex G.Don	Combretaceae	105253.6	1988624.0	260894.7
49	*Combretum schumannii* Engl.	Combretaceae	11046.0	776963.0	45795.1
50	*Combretum* spp	Combretaceae	204062.7	1298938.7	89035.5
51	*Combretum zeyheri*	Combretaceae	47739.1	495669.6	124350.0
52	*Commiphora africana* (A. Rich.)Engl.	Meliaceae	16271	287097.0	299713.1
53	*Commiphora eminii* Engl.	Meliaceae	18800	18800.0	67116.0
54	*Cordia africana*	Boraginaceae	29699.5	153981.7	213188.3
55	*Cordia monoica*	Boraginaceae	15402	168687.0	126395.2
56	*Cordyla africana* Lour.	Papilionoideae	1006.9	6041.4	2023.869.0
57	*Cornus volkensii*		1966.8	90472.8	51825.2
58	*Croton macrostachys* Hochst.ex.Del	Euphorbiaceae	18798.5	119217.0	94406.5
59	*Croton* spp	Euphorbiaceae	1006.9	13089.7	523.6
60	*Cussonia arborea*	Araliaceae	2618.6	59081.6	17411.9
61	*Dalbergia boehmii* Taub.	Papilionoideae	61096.3	412496.6	44184.4
62	*Dalbergia melanoxylon* Guill.& perr.	Papilionoideae	63471.2	647782.0	49009.9
63	*Dalbergia nitidula* De Wild.	Papilionoideae	82893.4	2518401.6	49326.4
64	*Dalbergia* spp	Papilionoideae	28472	227776.0	9051.6
65	*Dappea carpensis*		5491.5	573570.0	10328.4
66	*Diospyros kirkii*	Ebenaceae	1966.8	9834.0	1711.2
67	*Diospyros mespiliformis* Hochst.ex A.DC.	Ebenaceae	36471.2	632621.4	313151.3
68	*Diospyros* spp	Ebenaceae	22974.6	202505.7	44793.1
69	*Drypetes usambarica*		18800.0	18800.0	170892.0
70	*Entandophragma stolzii* Harms.	Meliaceae	43605.3	224295.1	626188.8
71	*Erythrophleum africanum*	Caesalpiniodeae	22368.0	141144.0	91551.6
72	*Eucalypus* spp	Myrtaceae	17921.5	49985.3	47355.7
73	*Ficalhoa laurifolia* Hiern.	Ericaceae	38351.0	1324025.9	1180160.0
74	*Flacourtia indica* (Burm. F.) Merr.	Flacourtiaceae	6744.6	111498.2	16565.1
75	*Fluegera virosa*	Euphorbiaceae	46872.0	56700.0	69045.5
76	*Garcinia buchananii*	Clusiaceae(Guttiferae)	7671.1	100876.6	209634.4
77	*Garcinia smeathmannii*	Clusiaceae(Guttiferae)	503.0	4024.0	201.2
78	*Garcinia* spp	Clusiaceae(Guttiferae)	991.0	10520.2	11879.4
79	*Grevillea robusta* A.Cunn	Proteaceae	9089.3	14150.0	22175.5
80	*Grewia bicolor* Juss.	Tiliaceae	17437.4	558158.1	111171.5
81	*Grewia* spp	Tiliaceae	15102.0	12967270.0	479720.7
82	*Harungana madagascariensis*	Clusiaceae(Guttiferae)	63766.7	84066.0	402333.7
83	*Ilex mitis* (L) Radlk	Aquifoliaceae	33739.4	449204.3	168599.7
84	*Isoberlinia scheffleri* Greenway	Caesalpiniodeae	6568.3	92130.1	67247.3
85	*Julbernardia globiflora* (Benth) Troupin	Caesalpiniodeae	105629.4	1054050.4	505051.5
86	*Khaya anthotheca* Stapf.ex Baker	Meliaceae	116260.3	459051.8	2284913.0
87	*Kigelia africana*	Bignoniaceae	56919.0	402932.9	336850.3
88	*Lannea schweinfurthii* (Engl.) Engl.	Anacardiaceae	5753.8	71906.4	8388.4
89	*Lonchocarpus bussei*		80843.3	954306.4	200969.8
90	*Lonchocarpus capassa*		2285.0	290195.0	1668.1
91	*Lonchocarpus* spp		2745.0	35888.2	6178.5
92	*Macaranga kilimandscharica* Pax	Euphorbiaceae	14623.1	313324.5	210805.2

93	*Macaranga* spp	Euphorbiaceae	108557.1	1405122.1	335557.2
94	*Maerua cylindricarpa*	Capparidaceae	34585.4	17292.7	22653.4
95	*Maesa lanceolata*		17552.7	146008.9	138753.6
96	*Maesopsis eminii Engl.*	Rhamnaceae	5095.0	22390.0	14202.3
97	*Mangifera indica* L.	Anacardiaceae	9532.2	220758.1	16880.5
98	*Manilkara discolor*	Sapotaceae	3674.0	124916.0	392603.6
99	*Manilkara sansibarensis*	Sapotaceae	1149.0	5745.0	10570.8
100	*Manilkara* spp	Sapotaceae	7830.0	164430.0	83076.3
101	*Manilkara sulcata*	Sapotaceae	47305.4	1293688.0	276754.7
102	*Margaritaria discoidea*		28520.4	193175.7	40395.6
103	*Margaritaria* spp		500.0	3500.0	1280.0
104	*Markhamia obtusifolia*	Bignoniaceae	99281.2	1846179.2	130519.6
105	*Markhamia zanzibarica*	Bignoniaceae	108247.0	2237932.0	108843.0
106	*Milicia excelsa* (Welw.) Benth & Hook.f	Moraceae	85070.8	439965.6	834553.7
107	*Milletia dura*	Papilionoideae	34572.0	635970.0	48979.2
108	*Millettia sacleuxii*	Papilionoideae	74817.2	1898054.2	195987.4
109	*Millettia usambarensis*	Papilionoideae	54634.0	437072.0	125658.2
110	*Mitragyna rubrostipulata* (K.Schum) Havil.	Rubiaceae	25909.4	36086.1	147440.9
111	*Myrica salicifolia*		7830.0	39150.0	24038.1
112	*Myrsine holstii*	Myrsinaceae	7278.0	56342.9	17801.9
113	*Myrsine melanophloeos*	Myrsinaceae	73239.7	579292.2	373676.3
114	*Neoboutonia macrocalyx* Pax	Euphorbiaceae	24775.8	416953.2	43056.5
115	*Newtonia buchananii* (Baker) Gilbert & Boutique	Mimosoideae	75959.1	2732228.8	4363574.0
116	*Newtonia* spp	Mimosoideae	12225.0	73350.0	43398.8
117	*Ocotea* spp	Lauraceae	60900.4	173695.6	298446.5
118	*Ocotea usambarensis* Engl.	Lauraceae	62072.9	2105361.3	6740112.0
119	*Odyendea zimmermannii* Eng.	Simaroubaceae	2484.3	62861.7	197457.9
120	*Olea africana* Mill	Oleaceae	7830.0	477630.0	79552.8
121	*Olea capensis* Baker..	Oleaceae	13286.0	32938.0	22448.3
122	*Olea europaea*	Oleaceae	6252.0	33898.0	1457.5
123	*Oxystigma msoo* Harms.	Caesalpiniaceae	7830.0	461970.0	107584.2
124	*Ozoroa insignis* Del.	Anacardiaceae	87096.0	3941913.7	755547.2
125	*Parinari curatellifolia*	Chrysobalanaceae	49640.3	1140975.6	545490.9
126	*Parinari excelsa* R.Grah.	Chrysobalanaceae	34190.0	298175.4	299878.0
127	*Parinari* spp	Chrysobalanaceae	991.0	52600.9	79180.7
128	*Pericopsis angolensis* (Baker) Harms.	Papilionoideae	251862.0	913198.3	1311810.0
129	*Pinus spp*	Pinaceae	2.8	254.8	471.5
130	*Podocarpus falcatus* Mirb	Podocarpaceae	25649.4	34006.1	22422.5
131	*Podocarpus usambarensis* Pilger	Podocarpaceae	134714.9	1163633.7	1083378.0
132	*Polyscias fulva*		25649.4	42362.8	57680.3
133	*Prunus africana* Hook. F.	Rosaceae	13684.2	169139.4	55788.4
134	*Pseudolachnostylis maprouneifolia*		163828.5	2763388.8	753418.6
135	*Pteleopsis angolensis*		13959.9	347529.4	12268.21
136	*Pteleopsis myrtifolia (laws) Engl. & Diels*	Combretaceae	135984.9	1079890.4	2002097
137	*Pterocarpus angolensis DC.*	Papilionoideae	185184.5	3059660.7	1054696
138	*Pterocarpus rotundifolius Druce*	Papilionoideae	38545.4	397380.6	81305.48
139	*Pterocarpus* spp	Papilionoideae	1055.6	25389.2	2174.544
140	*Rapanea melanophoea* (Gilg.) Mez	Myrsinaceae	20055.0	464145.0	158507.7
141	*Rauvolfia caffra*		28475.0	7545.0	30394.78
142	*Rauvolfia* spp		2245.0	176756.0	20025.83
143	*Rhus natalensis*	Anacardiaceae	36328.7	316048.7	21804.2
144	*Rothmannia fischeri*	Rubiaceae	25649.4	959455.2	396314.7
145	*Sclerocarya birrea* Hochst	Anacardiaceae	79902.3	313945.7	304384.9

146	*Scorodophloeus fischeri*		53481.5	2565459.2	831515.7
147	*Senna siamea*	Caesalpiniaceae	18800.0	112800.0	33464
148	*Senna* spp	Caesalpiniaceae	2245.0	178742.0	4302.802
149	*Sorindeia madagascariensis*	Anacardiaceae	91009.6	2356470.0	569926.5
150	*Sterculia appendiculata*	Sterculiaceae	12292.2	25584.4	297993.7
151	*Sterculia quinqueloba* (Garcke) K. Schum.	Sterculiaceae	119007.2	1999256.4	1006560
152	*Sterculia spp*	Sterculiaceae	4508.0	36064.0	11360.16
153	*Strombosia scheffleri* Engl.	Olacaceae	90768.1	4091848.7	1317226
154	*Strombosia* spp	Olacaceae	1003.3	8026.4	1143.762
155	*Strychnos spinosa*	Loganiaceae	29525.4	60797.8	36705.26
156	*Strychnos* spp	Loganiaceae	500.0	40000.0	975
157	*Swartzia madagascariensis*	Caesalpiniodeae	10610.3	10610.3	2864.781
158	*Symphonia globulifera*		43308.7	877976.4	322699.5
159	*Synsepalum ceraciferum*	Sapotaceae	43169.8	286456.6	2763318
160	*Synsepalum msolo*	Sapotaceae	58642.6	926482.7	216114.8
161	*Syzygium cuminii* (Willd.)DC.	Myrtaceae	32531.0	381823.3	222763.3
162	*Syzygium guineense*	Myrtaceae	74752.4	1312435.6	3366809
163	*Syzygium* spp	Myrtaceae	7830.0	54810.0	8926.2
164	*Tamarindus indica* L.	Caesalpiniodeae	15558.1	126055.0	53093.14
165	*Tarenna nigrescens*		8619.7	51844.2	128840.8
166	*Teclea nobilis*		85395.8	2665393.5	557677.8
167	*Terminalia brownii* Fries	Combretaceae	263.0	6321.0	3390.39
168	*Terminalia mollis* Laws.	Combretaceae	77170.7	255341.7	274935.5
169	*Terminalia sambesiaca* Engl.&Diels.	Combretaceae	74003.5	684616.1	196948.4
170	*Terminalia sericea* Burch.ex DC.	Combretaceae	27972.0	27972.0	42237.72
171	*Trichilia dregeana*	Meliaceae	1329.1	83666.5	36257.86
172	*Trichilia emetica* (Forssk) Chiov.	Meliaceae	56624.2	2757249.5	423839.9
173	*Trichilia* spp	Meliaceae	503.0	32041.1	1609.6
174	*Uapaca kirkiana*	Euphorbiaceae	74834.0	1075710.0	511921.8
175	*Vitex doniana* Sweet	Verbenaceae	158665.0	1935240.8	1009575
176	*Vitex mombassae*	Verbenaceae	93216.3	1931555.6	452456.4
177	*Xeroderris* spp	Papilionoideae	500.0	28000.0	1265
178	*Xeroderris stuhlmannii* (Taub.) Dunn ex Baker f.	Papilionoideae	87075.3	174150.6	173167.4
179	*Ximenia caffra*	Olacaceae	27972.0	55944.0	17342.64
180	*Xymalos monospora*	Monimiaceae	13544.4	75382.5	13347.43
	Sub Total			**136966673**	**74369910**

Appendix 5: List of timber classes in Eastern-Arc Mountains

A: Non plantation timber species

Class	No	Timber species	Class	No	Timber species
I	1	*Afzelia quanzensis*	IV	36	*Dalbergia nitidula*
	2	*Allanblackia stuhlmannii*		37	*Dalbergia* spp
	3	*Beilschmiedia kweo*		38	*Dappea carpensis*
	4	*Brachylaena huillensis*		39	*Diospyros kirkii*
	5	*Cephalosphaera usambarensis*		40	*Diospyros* spp
	6	*Combretum schumannii*		41	*Drypetes usambarica*
	7	*Dalbergia melanoxylon*		42	*Erythrophleum africanum*
	8	*Diospyros mespiliformis*		43	*Flacourtia indica*
	9	*Entandophragma stolzii*		44	*Fluegera virosa*
	10	*Khaya anthotheca*		45	*Garcinia buchananii*
	11	*Milicia excelsa*		46	*Garcinia smeathmannii*
	12	*Olea africana*		47	*Garcinia* spp
	13	*Olea capensis*		48	*Grewia bicolor*

	14	*Olea europaea*		49	*Grewia* spp
	15	*Pterocarpus angolensis*		50	*Harungana madagascariensis*
	16	*Pterocarpus rotundifolius*		51	*Ilex mitis*
	17	*Pterocarpus* spp		52	*Isoberlinia scheffleri*
	18	*Swartzia madagascariensis*		53	*Kigelia africana*
II	1	*Acacia nigrescens*		54	*Lannea schweinfurthii*
	2	*Albizia gummifera*		55	*Lonchocarpus bussei*
	3	*Albizia harveyi*		56	*Lonchocarpus capassa*
	4	*Albizia petersiana*		57	*Lonchocarpus* spp
	5	*Albizia schimperiana*		58	*Macaranga capensis*
	6	*Albizia versicolor*		59	*Macaranga* spp
	7	*Baphia kirkii*		60	*Maerua cylindricarpa*
	8	*Brachystegia boehmii*		61	*Maesa lanceolata*
	9	*Brachystegia bussei*		62	*Mangifera indica*
	10	*Brachystegia microphylla*		63	*Manilkara discolor*
	11	*Brachystegia spiciformis*		64	*Manilkara sansibarensis*
	12	*Brachystegia* spp		65	*Manilkara* spp
	13	*Burkea africana*		66	*Manilkara sulcata*
	14	*Chrysophyllum perpulchrum*		67	*Margaritaria discoidea*
	15	*Chrysophyllum* spp		68	*Margaritaria* spp
	16	*Julbernardia globiflora*		69	*Milletia dura*
	17	*Markhamia obtusifolia*		70	*Millettia sacleuxii*
	18	*Markhamia zanzibarica*		71	*Millettia usaramensis*
	19	*Newtonia buchananii*		72	*Mitragyna rubrostipulata*
	20	*Ocotea usambarensis*		73	*Myrica salicifolia*
	21	*Parinati curatellifolia*		74	*Myrsine holstii*
	22	*Pericopsis angolensis*		75	*Myrsine melanophloeos*
	23	*Podocarpus falcatus*		76	*Neoboutonia* spp
	24	*Podocarpus usambarensis*		77	*Newtonia* spp
II	25	*Sterculia appendiculata*	IV	78	*Ocotea* spp
	26	*Sterculia quinqueloba*		79	*Odyendea zimmermannii*
	27	*Sterculia* spp		80	*Oxystigma msoo*
	28	*Syzygium cuminii*		81	*Ozoroa insignis*
III	1	*Bombax rhodognaphalon*		82	*Parinari curatellifolia*
	2	*Cassipoure malosana*		83	*Parinari excelsa*
	3	*Cordia africana*		84	*Parinari* spp
	4	*Cordyla africana*		85	*Polyscias fulva*
	5	*Ficalhoa laurifolia*		86	*Prunus africana*
	6	*Pteleopsis myrtifolia*		87	*Pseudolachnostylis maprouneifolia*
	7	*Xymalos monospora*		88	*Pteleopsis angolensis*
IV	1	*Acacia nilotica*		89	*Rapanea melanophoea*
	2	*Acacia polyacantha*		90	*Rauvolfia caffra*
	3	*Acacia* spp		91	*Rauvolfia* spp
	4	*Allanblackia* spp		92	*Rhus natalensis*
	5	*Allanblackia ulugurensis*		93	*Rothmannia fischeri*
	6	*Annona senegalensis*		94	*Sclerocarya birrea*
	7	*Annona* spp		95	*Scorodophloeus fischeri*
	8	*Annona squamosa*		96	*Senna siamea*
	9	*Antiaris* spp		97	*Senna* spp
	10	*Antiaris toxicaria*		98	*Sorindeia madagascariensis*
	11	*Bauhinia petersiana*		99	*Strombosia scheffleri*
	12	*Bauhinia thonningii*		100	*Strombosia* spp
	13	*Bersama abyssinica*		101	*Strychnos spinosa*

	14	*Borassus aethiopum*		102	*Strychnos* spp
	15	*Bridelia micrantha*		103	*Symphonia globulifera*
	16	*Bridelia* spp		104	*Synsepalum ceraciferum*
	17	*Casearia engleri*		105	*Synsepalum msolo*
	18	*Cassia abbreviata*		106	*Syzygium guineense*
	19	*Casuarina cunninghamiana*		107	*Syzygium* spp
	20	*Celtis durandii*		108	*Tamarindus indica*
	21	*Celtis* spp		109	*Tarenna nigrescens*
	22	*Clerodendrum cephasothum*		110	*Teclea nobilis*
	23	*Combretum adenogonium*		111	*Terminalia brownii*
	24	*Combretum collinum*		112	*Terminalia mollis*
	25	*Combretum molle*		113	*Terminalia sambesiaca*
	26	*Combretum* spp		114	*Terminalia sericea*
	27	*Combretum zeyheri*		115	*Trichilia dregeana*
	28	*Commiphora africana*		116	*Trichilia emetica*
	29	*Commiphora eminii*		117	*Trichilia* spp
	30	*Cordia monoica*		118	*Uapaca kirkiana*
	31	*Cornus volkensii*		119	*Vitex doniana*
	32	*Croton macrostachys*		120	*Vitex mombassae*
	33	*Croton* spp		121	*Xeroderris* spp
	34	*Cussonia arborea*		122	*Xeroderris stuhlmannii*
	35	*Dalbergia boehmii*		123	*Ximenia caffra*

B**:** Plantation timber species

Class	**No**	**Timber species**
(i) Softwood Plantation species		
	1	*Pinus* spp
(ii) Hardwood Plantation species		
II	1	*Eucalypus* spp
III	1	*Cedrela odorata*
III	2	*Grevillea robusta*
III	3	*Maesopsis eminii*

Appendix 6: Comparison of timber stocks between Eastern-Arc Mountains and outside the Eastern Arc Mountains

Eastern-Arc Mountains Forests						Forests outside Eastern-Arc Mountains					
Forest name	**Vegetation type**	**Altitude (m)**	**N**	**G**	**V**	**Forest name**	**Vegetation type**	**Altitude (m)**	**N**	**G**	**V**
Mahenzangulu	Dry montane	1012	816.5	57.3	843.4	Bondo	Dry lowland	685-707	2399.2	16.6	88.9
Jungu	Dry montane	953-1007	3331.0	17.0	108.0	Mduguyu	Dry montane	1366-1461	1308.4	2.6	13.9
Mindu	Dry woodland	300-1000	993.0	5.5	14.6	Mohoro	Dry woodland	60	1201.7	11.1	60.8
Mvuha	Lowland	110-1520	638.0	22.5	230.4	Kwasumba	Lowland	610	3185.4	11.2	58.9
Iyonde	Lowland	300-921	403.0	14.4	142.6	Kazimzumbwi	Lowland	110-214	598.0	4.9	31.9
Nguru south	Lowland	619-724	161.0	27.7	515.3	Pugu	Lowland	110-267	1181.0	7.6	41.0
Pumula	Lowland	790-1348	2149.7	25.0	217.1	Pagwi	Lowland	1213-1385	1897.6	29.8	276.2
Mbwegere	Lowland	802-850	572.4	8.8	83.2	Kwamjali	Lowland	1250-1380	2004.6	6.2	18.3
Mkongo	Lowland	900-1008	990.8	13.1	94.6	Ruvu south	Lowland	128-238	1114.0	7.5	34.4
Ruvu	Lowland-woodland	250-480	921.0	19.3	244.2	Masanganya	Lowland/woodland	142-192	1020.0	12.1	90.5
Mkungwe	Lowland-woodland	278-1100	572.0	11.8	116.1	Mbwego	Lowland-sub montane	809-836	1820.6	19.6	127.8
Kimboza	Lowland-woodland	300-400	716.9	18.0	231.7	Utete	Lowland-woodland	0-68	769.6	7.9	35.0
Mkindo	Lowland-woodland	300-800	570.0	26.7	372.8	Vigoregore	Lowland-woodland	127-180	1134.1	15.3	85.8
Ihanga	Lowland-woodland	330-358	261.0	10.4	175.9	Itundufura	Lowland-woodland	430-680	267.0	14.7	141.8
Kitulangalo	Lowland-woodland	363-553	428.0	8.6	59.6	Magambazi	Lowland-woodland	550-651	1499.5	19.1	190.4
Tongeni	Lowland-woodland	400-1000	647.0	5.1	40.1	Handeni hill	Lowland-woodland	729-829	572.4	8.8	76.7
Kanga	Lowland-woodland	435-821	521.0	33.8	480.1	Msinko	Lowland-woodland	744-867	1610.9	19.3	154.3
Dindili	Lowland-woodland	465-765	340.0	5.8	37.7	Lubalanzi	Woodland	162-490	716.9	18.0	231.7
Nguru ya ndege	Lowland-woodland	599-947	353.0	8.9	101.9	Rungo	Woodland	165-244	815.0	8.8	76.1
Rudewa	Lowland-woodland	764-974	2101.5	29.5	321.0	Kikale	Woodland	18-25	840.4	7.5	40.1
Kilindi	Lowland-woodland	779-1003	2101.5	29.5	321.0	Kiwengoma	Woodland	198-580	1639.1	22.1	162.4
Mkuli	Lowland-woodland	937-975	663.5	10.4	82.8	Tamburu	Woodland	21-102	1187.2	17.9	134.1
Iwonde	Lowland-woodland-submontane	460-810	657.0	18.3	159.8	Mitundumbea	Woodland	221-345	1423.0	16.9	92.3
Bunduki II	Montane	1276	171.0	32.8	509.3	Toga	Dry montane-montane	1436-1624	2195.7	18.8	142.4
Balangai	Montane	1381	452.1	65.7	1184.2	Mbinga	Dry sub montane	900-1150	1257.0	20.4	182.0
Bunduki I	Mmontane	1250-1800	436.0	21.6	273.5	Mbalu	Dry sub montane-sub montane	948-1048	1514.5	27.2	322.2
Sali	Sub montane	1050-1300	959.8	19.0	283.7	Tongoma	Sub montane	320-1200	1166.0	16.9	140.5
Delema	Sub montane	1107-1322	2320.4	61.0	723.1	Kilihili	Sub montane		572.4	13.8	91.2

Mvuha	Woodland	110-1521	1100.0	11.7	65.8	Mulele	Woodland	1050-1500	460.0	9.1	55.6
Kilangwe	Woodland	182-228	788.0	14.9	127.0	Tongwe	Woodland	1068-1570	525.0	10.5	76.9
Matundu	Woodland	298-462	397.0	12.0	132.8	Mohoro river	Woodland	12-22	634.3	12.8	93.4
Nyanganje	Woodland	300-900	521.0	12.5	119.1	Mchungu	Woodland	12-32	1310.2	18.0	128.9
Iyonde	Woodland	300-920	309.0	14.9	181.7	Ruhoi	Woodland	135-210	842.0	9.9	60.1
Palaulanga	Woodland		463.8	17.8	142.4	Pangawe East	Woodland	150-650	552.9	11.4	116.6
Mselezi	Woodland-sub montane	560-890	762.6	13.6	117.3	Ipinde	Woodland	300-620	668.0	7.1	62.3
Banga	Woodland		1131.2	27.0	244.5	Lionja	Woodland	350-450	820.0	10.0	68.3
Bombo	Woodland		970.3	10.4	45.1	Muhuwesi	Woodland	350-900	658.0	10.0	67.3
Kwamgumi	Woodland		845.7	26.6	259.7	Nyera kiperere	Woodland	400-450	487.0	6.3	42.7
Mafi hill	Woodland		1076.3	18.5	132.0	Katundu	Woodland	41-72	440.1	6.6	68.4
Mtai	Woodland		604.2	19.9	169.9	Chang'andu	Woodland		1737.8	11.0	40.1

Appendix 7: Lesser known timber species in Eastern-Arc Mountains

No	Lesser known species	Area (ha)	Total	
			N	V
1	Untranslated_Afdok	2.8	8.4	7.1
2	Untranslated_Afraia	18800.0	37600.0	3008.0
3	Untranslated_Chibangu	5244.0	10488.0	19035.7
4	Untranslated_Chidung'unda	13041.4	84681.8	11322.2
5	Untranslated_Chitenu	17292.7	0.0	23691.0
6	Untranslated_Dwayo	3674.0	113894.0	30053.3
7	Untranslated_Ganga	261.0	2088.0	180.1
8	Untranslated_Gasu	1061.0	4244.0	954.9
9	Untranslated_Haghanguku	7830.0	23490.0	9004.5
10	Untranslated_Hazara	5128.0	82048.0	9333.0
11	Untranslated_Hetambobo	14041.0	8719461.0	80876.2
12	Untranslated_Kavi	8579.0	132243.0	19679.7
13	Untranslated_Kavumochai	7830.0	227070.0	99754.2
14	Untranslated_Keampindi	1459.2	208665.6	7602.4
15	Untranslated_Kiange	17292.7	86463.5	14180.0
16	Untranslated_Kibangangwalu	1966.8	9834.0	1042.4
17	Untranslated_Kidunguda	6266.4	100262.4	13723.4
18	Untranslated_Kifuru	260.0	16640.0	6890.0
19	Untranslated_Kigogoeka	3674.0	11022.0	22742.1
20	Untranslated_Kigwandi	23729.0	1390284.0	165738.3
21	Untranslated_Kigwe	325.8	14986.8	9086.6
22	Untranslated_Kihakio	12225.0	24450.0	1222.5
23	Untranslated_Kihale	1006.9	6041.4	1107.6
24	Untranslated_Kikulu	260.0	1560.0	122.2
25	Untranslated_Kilungundumbi	945.0	3780.0	888.3
26	Untranslated_Kimungwe	1044.0	90828.0	14073.1
27	Untranslated_Kimwere	2581.0	20648.0	3226.3
28	Untranslated_Kinhongolo	12225.0	24450.0	1956.0
29	Untranslated_Kiongoa	15899.0	952347.0	392225.5
30	Untranslated_Kisime	17292.7	311268.6	10375.6
31	Untranslated_Kisulu	260.0	3120.0	2173.6
32	Untranslated_Kivumba	8356.7	41783.5	131952.3
33	Untranslated_Koho	2484.3	28912.5	47018.8
34	Untranslated_Kyabe	12944.3	62964.1	299228.4
35	Untranslated_Liluti	27972.0	0.0	3356.6
36	Untranslated_Limpulu	27972.0	55944.0	59860.1
37	Untranslated_Linyenze	27972.0	223776.0	220699.1
38	Untranslated_Mamata	3674.0	11022.0	4078.1
39	Untranslated_Mandai	1421.0	110838.0	40200.1
40	Untranslated_Masasani	3674.0	312290.0	205597.0
41	Untranslated_Masukemengi	945.0	7560.0	349.7

42	Untranslated_Mbabara	17292.7	103756.2	13142.5
43	Untranslated_Mbane	37600.0	112800.0	220524.0
44	Untranslated_Mbeja	25649.4	118152.4	484099.6
45	Untranslated_Mbeta munda	17292.7	0.0	14525.9
46	Untranslated_Mbiriti	106.6	426.4	264.4
47	Untranslated_Mbombo	37600.0	263200.0	202100.0
48	Untranslated_Mbombwe	555.6	2222.4	32235.9
49	Untranslated_Mbukwe	7830.0	23490.0	3445.2
50	Untranslated_Mbwimbwi	17292.7	34585.4	33547.8
51	Untranslated_Mdananda	22935.2	951054.8	115026.9
52	Untranslated_Mdendelu	624.5	42953.0	1486.1
53	Untranslated_mdikodiko	1044.0	4176.0	6598.1
54	Untranslated_mdyafuno	344.0	2752.0	206.4
55	Untranslated_Mfati	8356.7	33426.8	5766.1
56	Untranslated_Mfumbati	12225.0	354525.0	43276.5
57	Untranslated_Mgeremanando	25649.4	144381.1	100620.6
58	Untranslated_Mgoto	1061.0	42440.0	1453.6
59	Untranslated_Mgualo	37600.0	75200.0	295724.0
60	Untranslated_Mgunku	5128.0	46152.0	11332.9
61	Untranslated_Mhagahaga	5244.0	57684.0	11169.7
62	Untranslated_Mhamiladuma	5244.0	10488.0	27845.6
63	Untranslated_Mhanga	325.8	1303.2	8148.3
64	Untranslated_Mhangehange	17292.7	17292.7	2421.0
65	Untranslated_Mhankho	18800.0	150400.0	1577132.0
66	Untranslated_Mhawawa	54634.0	54634.0	113638.7
67	Untranslated_Mhegesha	12225.0	12225.0	6479.3
68	Untranslated_Mhendele	3674.0	209418.0	35564.3
69	Untranslated_Mhiza	18800.0	37600.0	7520.0
70	Untranslated_Mhuhu	27972.0	0.0	9510.5
71	Untranslated_Mhumbi	503.0	23590.7	4074.3
72	Untranslated_Mhunungu	6266.4	12532.8	14851.4
73	Untranslated_Minga	18900.0	18900.0	4536.0
74	Untranslated_Mjambewa	17292.7	34585.4	20751.2
75	Untranslated_Mjeja	3215.0	82545.0	2480.1
76	Untranslated_Mjikojiko	1440.3	11522.4	907.4
77	Untranslated_Mkavi	39216.6	107729.6	583165.4
78	Untranslated_Mkeakiindi	1149.0	36768.0	5296.9
79	Untranslated_Mkengelechuma	37800.0	94500.0	10773.0
80	Untranslated_Mkesi	27972.0	195804.0	30489.5
81	Untranslated_Mkeweo	6775.0	65040.0	6097.5
82	Untranslated_Mkisigizi	12225.0	24450.0	3300.8
83	Untranslated_Mkoberenga	54634.0	54634.0	2731.7
84	Untranslated_Mkogho	3674.0	22044.0	8082.8
85	Untranslated_Mkombelo	3614.0	7228.0	47126.6
86	Untranslated_Mkomwa	8356.7	8356.7	23900.2

87	Untranslated_Mkonde	21954.1	320686.5	121208.1
88	Untranslated_Mkoya	54634.0	0.0	90692.4
89	Untranslated_Mkuguta	3468.0	20808.0	936.4
90	Untranslated_Mkulu	18800.0	225600.0	39856.0
91	Untranslated_Mkumbambega	7830.0	23490.0	8613.0
92	Untranslated_Mkumbiti	2638.0	7914.0	4642.9
93	Untranslated_Mkumbu	18900.0	37800.0	3591.0
94	Untranslated_Mkunguga	18900.0	132300.0	22869.0
95	Untranslated_Mkungunijike	1459.2	5836.8	70975.5
96	Untranslated_Mkuvi	8359.7	8377.7	36868.4
97	Untranslated_Mkuwiwira	503.0	25351.2	3772.5
98	Untranslated_Mkwayala	17292.7	17292.7	864.6
99	Untranslated_Mkwayanga	17292.7	34585.4	14871.7
100	Untranslated_Mlawilila	54634.0	437072.0	118555.8
101	Untranslated_Mlengwalengwa	17292.7	121048.9	18503.2
102	Untranslated_Mlengwe	18900.0	661500.0	17199.0
103	Untranslated_Mlewelewe	3.0	45.0	62.0
104	Untranslated_Mlilo	24044.0	246076.0	29820.2
105	Untranslated_Mlindimila	18900.0	75600.0	50085.0
106	Untranslated_Mlingalinga	4508.0	9016.0	13794.5
107	Untranslated_Mlombwa	14041.0	1572592.0	588879.5
108	Untranslated_Mmamata	325.8	3909.6	2867.0
109	Untranslated_Mmandai	1003.3	4013.2	13113.1
110	Untranslated_Mmandali	18800.0	37600.0	3572.0
111	Untranslated_Mmogho	3674.0	11022.0	80313.6
112	Untranslated_Mmungi	17292.7	69170.8	183648.5
113	Untranslated_Mnaila	6664.2	53313.6	9996.3
114	Untranslated_Mnemela	25464.2	349834.6	65269.7
115	Untranslated_Mnenebewa	54634.0	54634.0	2185.4
116	Untranslated_Mng'eng'emambewa	3614.0	7228.0	2782.8
117	Untranslated_Mng'eng'ena	8356.7	16713.4	5849.7
118	Untranslated_Mnkunguni	363.5	1454.0	836.1
119	Untranslated_Mnulu	25111.6	91477.2	308623.1
120	Untranslated_Mnyungapembe	284.0	9940.0	247.1
121	Untranslated_Momboa	12225.0	12225.0	29829.0
122	Untranslated_Mpangusawana	284.0	2272.0	380.6
123	Untranslated_Mpapata	1003.3	72237.6	5116.8
124	Untranslated_Mpazaza	27972.0	0.0	4195.8
125	Untranslated_Mpembeza	18900.0	831600.0	285768.0
126	Untranslated_Mpumu	27972.0	139860.0	3076.9
127	Untranslated_Msadasada	18900.0	18900.0	9828.0
128	Untranslated_Msagusa	555.6	2222.4	4389.2
129	Untranslated_Msai	18800.0	56400.0	25944.0
130	Untranslated_Msalala	27972.0	27972.0	5874.1
131	Untranslated_Msambubwinhe	37600.0	883600.0	1770960.0

132	Untranslated_Msesewe	1061.0	14854.0	20604.6
133	Untranslated_Msheitundu	7830.0	109620.0	15503.4
134	Untranslated_Mshembuzi	7830.0	7830.0	28814.4
135	Untranslated_Mshia	3107.0	15535.0	13546.5
136	Untranslated_Msia	344.0	6536.0	11826.7
137	Untranslated_Msilasi	6775.0	40650.0	23712.5
138	Untranslated_Msimba	5221.0	34039.0	5684.1
139	Untranslated_Msimbolanga	17292.7	69170.8	15563.4
140	Untranslated_Msinga	37600.0	188000.0	830960.0
141	Untranslated_Msonjo	19144.0	21552.0	241717.6
142	Untranslated_Msunguti	6266.4	119061.6	604770.3
143	Untranslated_Mswaswa	8359.7	8437.7	29943.8
144	Untranslated_Mswe	7830.0	23490.0	30302.1
145	Untranslated_Mtandala	1421.0	22736.0	2159.9
146	Untranslated_Mtei	1003.3	4013.2	4575.5
147	Untranslated_Mtelele	5244.0	47196.0	3041.5
148	Untranslated_Mtendele	7830.0	23490.0	2114.1
149	Untranslated_Mtiki pori	5244.0	534888.0	23807.8
150	Untranslated_Mtikitiki	27972.0	0.0	13706.3
151	Untranslated_Mtoamaghasa	1329.1	15349.4	17735.7
152	Untranslated_Mtobwe	555.6	23890.8	1700.1
153	Untranslated_Mtugutu	503.0	4024.0	150.9
154	Untranslated_Mtumba	54634.0	327804.0	405930.6
155	Untranslated_Mtumbakutumbaku	27972.0	27972.0	2517.5
156	Untranslated_Mtundankunguu	15899.0	23247.0	40346.1
157	Untranslated_Mturu	991.0	47340.8	3198.0
158	Untranslated_Mualasindi	17292.7	0.0	5706.6
159	Untranslated_Muengeenge	17292.7	17292.7	9511.0
160	Untranslated_Muhange	17292.7	103756.2	47382.0
161	Untranslated_Muhekela	18900.0	226800.0	28728.0
162	Untranslated_Mumbala	27972.0	0.0	48951.0
163	Untranslated_Mumemena	54634.0	109268.0	14204.8
164	Untranslated_Mumwemba	13041.4	69101.2	99342.7
165	Untranslated_Muomboa	7830..0	297540.0	304587.0
166	Untranslated_muswa	17292.7	0.0	8473.4
167	Untranslated_mvungaliza	1966.8	108174.0	12115.5
168	Untranslated_Mvutiwanda	20055.0	44505.0	47029.4
169	Untranslated_Mwalimng'andu	17292.7	34585.4	5014.9
170	Untranslated_Mwamba	8356.7	8356.7	44123.4
171	Untranslated_Mwanganapala	17292.7	0.0	17292.7
172	Untranslated_Mwasumihage	17292.7	259390.5	10202.7
173	Untranslated_Mwefu	15899.0	46494.0	7283.3
174	Untranslated_Mwela	8356.7	8356.7	13203.6
175	Untranslated_Mweleti	555.6	4444.8	255.6
176	Untranslated_Mwemba	17292.7	69170.8	189873.9

177	Untranslated_Mwenga	7830.0	23490.0	96152.4
178	Untranslated_Mweti	1003.3	7023.1	18711.6
179	Untranslated_Mzongonene	18800.0	18800.0	46812.0
180	Untranslated_Mzonozono	7830.0	854913.9	84082.9
181	Untranslated_Nekazito	1616.6	227070.0	18165.6
182	Untranslated_Ngomoka	3674.0	30869.4	28180.8
183	Untranslated_Nkiongoo	12225.0	235136.0	15871.7
184	Untranslated_Ntakua	15899.0	183375.0	88631.3
185	Untranslated_Ntendeule	5128.0	156584.0	40269.7
186	Untranslated_Nyandege	12225.0	10256.0	554644.5
187	Untranslated_Shiuvundo	18900.0	1271400.0	67115.3
188	Untranslated_Tondolo	1459.2	113400.0	129276.0
189	Untranslated_Tondoti	284..0	5836.8	32277.5
190	Untranslated_Ungo	4269.3	2272.0	159.0
	Sub Total		**30325007.7**	**14749878.0**

Appendix 8: Non timber species in Eastern Arc Mountains

Non Timber species	Family	Total	
		N	V
Acacia goetzei Harms.	Fabaceae	87067.7	621797.3
Acacia microphylla Willd.	Fabaceae	3619.2	5052.5
Acacia robusta Burch.	Fabaceae	56662.9	30323.6
Acacia seyal Chev.	Fabaceae	6041.4	332.3
Acacia spp	Fabaceae	59766.6	8067.9
Adenia gummifera Burtt Davy	Passifloraceae	11632.0	10.9
Afrocrania spp		34585.4	185723.6
Afroselsalisia cerasifera		167832.0	401957.6
Afrosersalisia spp		17292.7	1383.4
Allophylus abyssinicus (Hochst.) Radlk	Sapindaceae	535881.6	219573.1
Alsodeiopsis schumannii (Engl.) Engl.	Icacinaceae	18800.0	40420.0
Anthocleista grandiflora Gilg.	Loganiaceae	75200.0	232615.9
Aphloea theiformis		1000101.6	321917.3
Apodytes dimidiate E. Mey. ex Arn	Icacinaceae	34585.4	10548.6
Aspilia mossambicensis		8356.7	2172.7
Balthasaria schliebenii (Melch.) Verdc	Theaceae	0.0	23691.0
Bertiera pauloi Verdc.	Rubiaceae	0.0	16255.1
Boscia salicifolia (Melch.) Verdc	Theaceae	29702.0	2463.5
Bridelia cathartica G. Bertol	Euphorbiaceae	192415.0	18126.6
Calycosiphonia spathicalyx (K. Schum.) Robbr.	Rubiaceae	111888.0	279.7
Canthium oligocarpum Hiern	Rubiaceae	47997.6	2383.8
Carissa edulis (Forssk.) Vahl	Apocynaceae	662985.6	51220.6
Cassia burtii		473055.0	2669.1
Cassine aethiopica Thunb.	Celastraceae	144560.0	20455.2
Catha edulis (Vahl) Endl.	Celastraceae	24450.0	5012.3
Catunaregam spinosa (Thunb.) Tirveng	Rubiaceae	618831.7	10516.4
Celtis Subgen. *Celtis* L	Ulmaceae	16052.8	46733.7
Celtis gomphophylla Barker	Ulmaceae	36725.1	4454.3

Chassalia discolor K. Schum	Rubiaceae	20019.4	1006.0
Clerodendrum cephasothum		53324.2	41217.0
Coffea mufindiensis A. Chev	Rubiaceae	21496.0	85424.8
Commiphora pteleifolia Engl.	Burseraceae	26131.2	178.7
Conopharingia spp		325949.4	43051.3
Crossopteryx febrifuga (Afzel. ex G. Don) Benth	Rubiaceae	125880.0	46901.5
Cussonia spicata Thunb	Alariaceae	17292.7	3285.6
Cyathea dregei Kunze	Cyatheaceae	17292.7	3285.6
Cylicomorpha parviflora Urb.	Caricaceae	230444.0	2721771.7
Dappea carpensis		573570.	10328.4
Daslepis integra		128470.5	54730.5
Deinbollia kilimandscharica Taub.	Sapindaceae	22023.2	3160.2
Deinbollia spp	Sapindaceae	63121.0	39.0
Dichatepetalum stuhlmani		214490.5	813.9
Dichrostachys cinerea Miq.	Fabaceae	57125.0	0.0
Didymosalpinx norae (Swynn.) Keay	Rubiaceae	223776.0	2517.5
Diosperus spp		71496.8	5543.0
Diospyros consolatae Chiov.	Ebenaceae	6041.4	1298.9
Diospyros kirkii Hiern	Ebenaceae	9834.0	1711.1
Diospyros spp		185213.0	44793.1
Diplorhynchus condylocarpon (Müll. Arg.) Pichon	Apocynaceae	8356656.6	531052.4
Dombeya spp		54634.0	3824.4
Dombeya rotundifolia Bojer	Sterculiaceae	2300276.0	183671.9
Dombeya shumpangae		17874.2	2886.9
Dovyalis abyssinica Warb.	Flacourtiaceae	46694.4	1940.7
Drypetes spp		93960.0	1487.7
Drypetes usambarica (Pax) Hutch.	Euphorbiaceae	37600.0	170892.0
Ehretia amoena Klotzsch	Boraginaceae	25172.5	412.8
Englerophytum natalense (Sond.) T.D. Penn	Sapotaceae	1696000.7	17110.3
Erythrina abyssinica Lam.	Fabaceae	258135.3	155311.3
Euclea divinorum Hiern	Ebenaceae	226800.0	28728.0
Euclea spp		437072.0	67199.8
Ficus bussei Warb. ex Mildbr. & Burret	Moraceae	0.0	6433.6
Ficus exasperate Vahl	Moraceae	124897.7	35692.3
Ficus glimosa		643566.8	256714.0
Ficus spp		409383.8	771595.3
Ficus sur		356630.8	3132308.4
Ficus Sycomorus L.	Moraceae	49632.2	58572.8
Garcinia smeathmannii (Planch. & Triana) Oliv.	Clusiaceae	4024.0	201.2
Garcinia spp		10520.2	11879.4
Gelonium zanzibarensis		25056.0	276.7
Harrisonia abyssinica Oliv.	Simarouceae	83916.0	4755.2
Hymenaea verrucosa Gaertn.	Fabaceae	5745.0	11110.8
Indigofera garckeana Vatke	Fabaceae	1958896.0	666.6
Lannea schimperi (Hochst. ex A. Rich.) Engl	Anacardiaceae	62986.0	7118.1
Lannea spp		12532.8	3195.9
Lannea welwitschii (Hiern) Engl.	Anacardiaceae	10136.4	15201.3
Lasianthus kilimandischarious		8356.7	5181.2
Lasianthus microcalyx K. Schum	Rubiaceae	3321027.5	22208.8

Lecaniodiscus flaxinifolia		166605.0	52580.5
Lecaniodiscus spp		10425.6	439.8
Lettowianthus stellatus Diels	Annonaceae	569494.2	93490.1
Lonchocarpus bussei Harms	Fabaceae	201407.4	45365.1
Monodora grandidieri Baill	Annonaceae	491706.0	58458.4
Niaytenus senegalinsis		89148.0	85949.2
Nuxia floribunda Benth.	Loganiaceae	8356.7	23900.2
Ochna leptoclada Oliv.	Ochnaceae	262109.2	115329.5
Ochna schweinfurthiana Aubrév	Ochnaceae	21220.6	1697.7
Oncoba spinosa Forssk.	Flacourtiaceae	166759.4	80338.1
Ormocarpum kirkii S. Moore	Fabaceae	146029.0	8575.3
Oxyanthus speciosus DC.	Rubiaceae	223776.0	559.4
Oxytenanthera abyssinica (A. Rich.) Munro	Poaceae	17292.7	1210.5
Pachystela brevipes (Baker) Baill. ex Engl.	Sapotaceae	16976.0	2164.4
Paulinia spp		97315.1	4063.7
Pavetta stenosepala K. Schum	Rubiaceae	121048.9	10721.5
Polaina spp		87496.8	2367.0
Polyscias stumanii		302771.6	16456.7
Polysphaeria spp		391608.0	19580.4
Psychotria riparia (K. Schum. & K. Krause) E.M.A. Petit	Rubiaceae	34706.0	54638.2
Psycotria spp		96427.6	5008.7
Psychotria megalopusi		18900.0	7749.0
Rawsonia reticulate Gilg	Flacoutriaceae	69170.8	9683.9
Ricinus communis L.	Euphorbiaceae	17755.9	1659.9
Rinorea angustifolia (Thouars) Baill.	Violaceae	31165.0	4742.5
Rutidea fuscenscens		63373.2	6351.7
Rytiginia spp.		152727.5	22394.4
Sapium ellipticum (Hochst.) Pax	Euphorbiaceae	82606.0	104086.7
Scolopia zeyheri (Nees) Szyszyl	Flacourtiaceae	86700.0	1179.1
Steganotaenia araliacea Hochst.	Apiaceae	10256.0	2615.3
Stereospermum kunthianum Cham.	Bignoniaceae	1284715.0	101918.7
Stereospermum spp		40000.0	4605.0
Strychnos innocua Delile	Loganiaceae	566817.0	23459.0
Tabernaemontana spp		450595.1	79095.3
Taremma spp		6516.0	1185.9
Thespesia danis Oliv.	Malvaceae	130688.0	7139.4
Trema orientalis (L.) Blume	Ulmaceae	202120.2	9695.6
Trilepisium madagascariens		307692.0	180419.4
Turraea holistii		340536.0	1151.4
Vangueria infausta Burch.	Rubiaceae	363042.9	35469.2
Vangueria madagascariensis J.F. Gmel.	Rubiaceae	11360.0	380.6
Vangueria spp		113400.0	1134.0
Vepris ngamensis I. Verd.	Rutaceae	16713.4	3342.7
Vernonia spp.		123102.0	2081.0
Xylopia aethiopica (Dunal) A. Rich	Annonaceae	8356.7	2172.7
Xymalus spp		1303.2	544.1
Zanha africana Exell	Sapindaceae	**202425.0**	**69099.6**

Appendix 9: Illegal timber harvested in Nyanganje Forest Reserve

TIMBER

Code	Local Name	Botanical Name	Total ha[1]		
			N	G	V
7	Mgelegele/Mtelela	*Brachystegia bussei*	0.81	0.06	0.46
8	Mgwina	*Breonadia salicina*	1.08	0.15	1.28
9	Mhekela/Muhekera	*Uapaca nitida*	0.27	0.02	0.10
10	Mkarati	*Burkea africana*	2.16	0.30	2.71
19	Mninga/Mtumbati	*Pterocarpus angolensis*	2.70	0.37	3.39
32	Myombo	*Brachystegia boehmii*	0.27	0.01	0.07
33	Myombo dume/Mtondoo	*Brachystegia spiciformis*	0.27	0.02	0.12
		Grand Total	**7.57**	**0.92**	**8.13**
CHARCOAL					
6	Mfuru	*Vitex doniana*	0.27	0.02	0.16
9	Mhekela/Muhekera	*Uapaca nitida*	0.27	0.01	0.04
10	Mkarati	*Burkea africana*	1.62	0.19	1.75
14	Mlama	*Combretum molle*	0.27	0.09	0.92
18	Mng'eng'e		0.27	0.03	0.29
19	Mninga/Mtumbati	*Pterocarpus angolensis*	0.54	0.04	0.34
21	Mpingo	*Dalbergia melanoxylon*	0.27	0.02	0.12
25	Msegese	*Piliostigma thornningii*	0.27	0.01	0.03
26	Msolwa/Mkwambikwambi	*Flueggea virosa*	0.81	0.03	0.23
29	Mtogo	*Diplorhynchus condylocarpon*	0.54	0.02	0.1.0
31	Muwanga/Mwanga	*Afrormosia angolensis*	0.54	0.05	0.37
32	Myombo	*Brachystegia boehmii*	3.51	0.30	2.57
33	Myombo dume/Mtondoo	*Brachystegia spiciformis*	2.70	0.20	1.53
		Grand Total	**11.89**	**1.00**	**8.45**
POLES					
1	Mbarikila/Mkora	*Afzelia quanzensis*	0.27	0.00	0.00
4	Mfungutua dume/Mfumbi/Mfungwa	*Kigelia africana*	0.27	0.00	0.01
5	Mfupawakuku		0.54	0.00	0.01
7	Mgelegele/Mtelela/Myombo mtelela	*Brachystegia bussei*	1.08	0.01	0.04
9	Mgwina	*Breonadia salicina*	1.89	0.02	0.10
10	Mkarati	*Burkea africana*	0.81	0.01	0.04
11	Mkokonanguruwe		0.54	0.00	0.02
12	Mkondekonde	*Myrianthus arboreus*	0.27	0.00	0.01
13	Mkuyu	*Ficus sycomorus*	0.27	0.00	0.09
14	Mlama	*Combretum molle*	0.54	0.01	0.03
15	Mlelamwana		0.27	0.00	0.09
17	Mnepa	*Pteleopsis myrtifolia*	0.27	0.00	0.00
20	Mpalapala/Chipalapala	*Mallotus mauritarium*	0.27	0.00	0.00
22	Mpululu	*Terminalia sericea*	0.54	0.01	0.02
23	Msada	*Sapium amatum*	0.27	0.00	0.02
24	Msaula	*Parinari curatellifolia*	0.27	0.00	0.01
26	Msolwa/Mkwambikwambi	*Flueggea virosa*	2.16	0.02	0.10
28	Mtalula	*Acacia polyacantha*	0.27	0.00	0.01
29	Mtogo	*Diplorhynchus condylocarpon*	1.89	0.02	0.12

30	Mtopetope	*Annona senegalensis*	0.54	0.01	0.02
32	Myombo	*Brachystegia boehmii*	4.87	0.05	0.22
33	Myombo dume/Mtondoo	*Brachystegia spiciformis*	1.08	0.01	0.05
		Grand Total	**19.19**	**0.18**	**0.86**
BUILDING POST					
9	Mhekela/Muhekera	*Uapaca nitida*	2.43	0.11	0.76
		Grand Total	**2.43**	**0.11**	**0.76**
		Unknown	**6.22**	**0.31**	**0.48**
		Human cut	**47.30**	**2.52**	**18.68**
NATURAL MORTARITY NEW					
7	Mgelegele/Mtelela/Myombo mtelela	*Brachystegia bussei*	0.81	0.06	0.47
		Grand Total	0.81	0.06	0.47
NATURAL MORTARITY OLD					
7	Mgelegele/Mtelela/Myombo mtelela	*Brachystegia bussei*	0.54	0.03	0.21
9	Mhekela/Muhekera	*Uapaca nitida*	0.27	0.03	0.29
10	Mkarati	*Burkea africana*	1.08	0.06	0.46
16	Mlengamashi	*Syzygium cordatum*	0.27	0.02	0.14
19	Mninga/Mtumbati	*Pterocarpus angolensis*	0.27	0.02	0.10
21	Mpingo	*Dalbergia melanoxylon*	0.27	0.00	0.01
22	Mpululu	*Terminalia sericea*	0.27	0.01	0.10
26	Msolwa/Mkwambikwambi	*Flueggea virosa*	0.81	0.05	0.41
29	Mtogo	*Diplorhynchus condylocarpon*	0.54	0.01	0.07
32	Myombo	*Brachystegia boehmii*	0.54	0.02	0.10
		Grand Total	4.87	0.26	1.89
		Natural mortarity	**5.68**	**0.31**	**2.36**
		Total cut	**52.97**	**2.83**	**21.04**

Appendix 10: Cost and benefit on illegal timber harvested in Nyanganje Forest Reserve

Harvesting cost			2006	2007	2008
(i) Sawing tools (Lifespan 3years)	**Uses**	**Cost/unit**			
Sawing blade (8-10feets)	Sawing	28,000	28,000	18,667	9,333
Felling saw (sege)(6feets)	Felling	18,000	18,000	12,000	6,000
Axe	Felling/Delimbing	8,000	8,000	5,333	2,667
Machette	Delimbing	5,000	5,000	3,333	1,667
Hoe	Digging	3,000	3,000	2,000	1,000
Sharping tool(Tupa)	Sharping	3,000	3,000	2,000	1,000
Rope	Skidding	7,000	7,000	4,667	2,333
Scoop	Scooping	10,000	10,000	6,667	3,333
Sub Total			**82,000**	**54,667**	**27,333**
(ii)Domestic utensils (life span 3years)					
Cooking pan (3 items)	Cooking	5,000	15,000	10,000	5,000
Lid (2 items)	Lidding/Covering pan	1,500	3,000	2,000	1,000
Bowl (2 items)	For vegetable	1,000	2,000	1,333	667
Plate (2 items)	For meal	2,000	4,000	2,667	1,333
Bucket or gallon (20Lt) (2 items)	For preserving water	3,000	6,000	4,000	2,000
Sub Total			**30,000**	**20,000**	**10,000**
Total			**112,000**	**74,667**	**37,333**
Processing cost					
(i)Food					
Maize flour (15kg)	For meal	600	9,000	9,000	9,000
Beans (5kg)	For meal	1,400	7,000	7,000	7,000
Dagaa (2.5kg)	For meal	2,000	5,000	5,000	5,000
Cooking oil (2Lt)	For meal	3,000	6,000	6,000	6,000
Sub Total			**27,000**	**27,000**	**27,000**

Transporting cost	103				
Lumber (average 16pcs 1"*12"*12ft)		500	8,000	8,000	8,000
Total costs per 1m3			**147,000**	**109,667**	**72,333**
Benefits		**Price/board**			
Income for 16pcs (1"*12"*12ft)		8,378	134,044	134,044	134,044
Total Benefits per m^3			**134,044**	**134,044**	**134,044**
Net Benefits			**-12,956**	**24,378**	**61,711**