CHARCOAL PRODUCTION AND ITS IMPLICATIONS ON SUSTAINABILITY OF COMMUNITY-BASED FOREST MANAGEMENT. A CASE OF MBANGALA VILLAGE LAND FOREST RESERVE, SONGWE DISTRICT

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE.

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ABSTRACT

Mbangala Village Land Forest Reserve is a productive forest under Community Based Forest Management being managed by the Mbangala Village Council. The forest reserve was established in 2010, at Songwe District in Songwe Region. Sustainable charcoal production in Songwe District has not received a systematic research assessment. To what extent the so called sustainable charcoal production adheres to sustainability principle is not clear. The aim of this study was to assess charcoal production under Community Based Forest Management and its implications to sustainability of forest resources in Mbangala village land forest reserve. Sixty sample plots each with an area of 0.071 ha was systematically established in 6 transect. Socio-economic data were collected by interviewing charcoal makers and key informants using structured questionnaire, focus group discussion, informal discussion and field observations. Microsoft Excel software was used to analyse quantitative data to generate stand parameters, SPSS was used to analyse qualitative data. A total of 78 woody species belonging to 30 families were identified, compared with 122 species belonging to 46 families in other forest in same district. Tree stocking was 297 stems ha^{-1} while basal area and volume was $5.2m^2ha^{-1}$ and $51.15m^3ha^{-1}$ respectively. NAFORMA report tree stocking of 954 stems ha^{-1}, basal area of $8.9m^2ha^{-1}$ and woody volume of $75.4m^3ha^{-1}$ on Chunya/Songwe district. On average there were 12 201 stems ha^{-1} of regenerants. The Shannon Wierner (3.29) and Simpson (0.064) indices were reasonably average. Charcoal makers accrued high income (between TZS 600 000 to 3 million) from charcoal harvesting compared to other economic activities. Agriculture and petty business (generate income between one TZS 100 000 to 900 000). Revenue from CBFM were used to build Village office, Village Executive office resident, 2 teachers house in village primary school, one classroom as well as teachers office. Compliance of the community to laws and regulations are generally very low, which endanger the existence of Village Land Forest Reserve. Result shows that harvested wood volume was 241 884.04 m^3 equal to 48 376 m^3 per year. This mean harvestable volume in each year is 17 times more than it required. The study concludes that, although tree species richness and diversity are on average high, the reserve has been affected by charcoal harvesting and other human activities, because stocking level were high compared to obtained results. Thus this study recommends the urgent need for appropriate and efficient management strategies to ensure regeneration, so that the remaining woodlands continue to supply charcoal to Mbeya city and other urban areas and deriving other goods and services.

DECLARATION

I, Paulo Moses, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is a result of my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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DEDICATION

This work is dedicated to my beloved mother the late Christina Alexander Mganga (may her soul rest in eternal peace), she sacrificed much and laid down the foundation for my education and to my beloved daughter Anthonia for whose education is vital to her life. I also dedicate this work to my wife Upendo Mwasomola for her support and sacrifice.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

C	Simpson index
CBFM	Community Based Forest Management
CBNRM	Community Based Natural Resource Management
CHAPOSA	Charcoal potential in Southern Africa
DANIDA	Danish International Development Agency
DBH	Diameter at breast height
FAO	Food and Agriculture Organization of United Nations
FINIDA	Finish International Development Agency
GPS	Geographical Positioning System
ha	hectare
IVI	Important Value Index
JFM	Joint Forest Management
KES	Kenya shilling
KFS	Kenya Forest Service
LPG	Liquefied Petroleum Gas
MNRT	Ministry of Natural Resources and Tourism
NAFORMA	National Forest Resources Monitoring and Assessment
NORAD	Norwegian International Development Agency
NWFP	Non wood forest products
SIDA	Swedish International Development Agency
SSA	Sub Saharan Africa
TaTEDO	Tanzania Traditional Energy Development Organization
TFS	Tanzania Forest Service

TZS	Tanzania shilling
UNEP	United Nations Environmental Programme
USD	United States Dollar
VEO	Village Executive Officer
VLFR	Village Land Forest Reserve
VNRC	Village Natural Resources Committee

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Prior to colonialism, traditional land use was in harmony with the environment, because over centuries societies used to develop own social customs and regulations, which ensured sustainable use of land-based natural resources from one generation to the next. Local communities relied on natural resources around them and thus exploited them with restraint (Western and Wright, 1994). In recent decades, Tanzania, like many other eastern and southern African countries, has experienced a number of policy reforms. Most of reforms were devolve the management of common pool resources (a natural or human-made resource system whose size or characteristics makes it costly, but not impossible to exclude others from obtaining benefits from its use) from the state to lower levels (Alden and Mbaya, 2001). These policies underlined the need for community participation and empowerment in the management of natural resources in order to achieve sustainable development.

There is widespread adoption of Community-Based Forest Management (CBFM) approaches including joint or co-management in most SSA countries since the 1990s (FAO, 1999). The management of some CBFMs were modify so as to enable sustainable charcoal harvesting for income generation and improve forest management. CBFM is supposed to focus on community's needs, and to be more locally relevant, pro-poor, equitable, and opposite of the top–down government approaches (Agrawal, 2005; Blaikie, 2006; Ribot, 1999). CBFM is a paradigm shift wherein governments devolve the legal authority and rights for the management and sustainable use of forest resources from top–down, centralized control to bottom–up management by organized communities which have local institutions, economic incentives, and the primary authority for implementation, guided by a forest management plan that has been mutually accepted by key stakeholders (CBNRM Net, 2008).

Despite the potential for CBFM sustainable charcoal production to contribute to poverty alleviation and reduce effects of material deprivation, a critical assessment of charcoal production and its implication to communities' incomes and sustainability of the forest resources under CBFM is important.

1.2 Problem Statement and Justification of the Study

Charcoal production in the Community Based Forest Management is taking place in the country. Some villages in Tanzania have started regulated forest utilization via local licensing of charcoal production, and have reported to have collected adequate revenue to fund local community services and development in largely accountable manner (Lund and Treue, 2008). However sustainable charcoal production in Songwe District has not received a systematic research assessment. To what extent the so called sustainable charcoal practice adheres to sustainability principle is not clear. Songwe District supplies most charcoal used in the fast growing Mbeya City. Information on benefits obtained from charcoal production in the CBFM and how charcoal production and trade improve the economy of local communities as well as sustainability of forest resources is not well - known. In Songwe charcoal production is an important activity aiming to support livelihoods where other economic opportunities are severely limited.

Furthermore, given the current demand of charcoal in the Mbeya City and other nearby towns there is a need of understanding the potential of the forest to supply charcoal over medium time perspective. However such information is limited and if available is scattered and not documented. Thus this dissertation work aim at addressing this knowledge gap. It is anticipated that information generated in this work can be useful in improving, designing and implementation appropriate charcoal production and trade policies that can address sustainability of forests. It is known that a rational decision in management of natural forests depend information on their growing stock. It is also known that the acquisition of forest growth information is prerequisite to any forest management system and sustainable land use.

1.3 Research Objectives

1.3.1 Overall objective

The overall objective of the study was to assess charcoal production under CBFM and its impact on sustainability of forest resource and communities` livelihoods in Mbangala village land forest reserve.

1.3.2 Specific objectives

The specific objectives were to:

i. Assess charcoal production and its implication to standing stock, species diversity, richness and structure.
ii. Assess charcoal production and its economic impact on communities' livelihoods, local community services and development.
iii. Assess compliance of community to harvesting plan, existing laws and regulations on sustainability of the Forest Reserve.

1.3.3 Research questions

The study strove to answer the following questions

a) To what extent charcoal produced benefit to communities?
b) Who benefits from revenue collected and other benefits? Why and how?
c) Is there transparency in distribution of revenue?
d) What changes are due to CBFM invention in communities livelihoods?
e) What are impacts of charcoal production on standing stock, species diversity, richness and structure?

f) What tools are used to manage the forest reserve?

g) Do you have any management plan and/or harvesting plan?

h) Is the harvesting adhering to the forest management plan?

i) Is the community aware of existing village by laws and Forest act?

1.4 Limitations of the Study

Some limitations were encountered during the study, including:

i) Reluctance to give information

Some of the key informants were reluctant to give information mainly on revenue for example village royalty collected from charcoal in past three year. Figure presented is very small compared to number of charcoal bags harvested from forest. The same problem was encountered on charcoal makers interviewed due to the fact that matters related to cash income are regarded as private and sensitive. Most interviewed charcoal makers were unwilling to disclose their real incomes. This problem was minimized by knowing the number of charcoal bags each produced and calculate the amount of money earned.

ii) Poor recall memory by the respondents

In some cases, the respondents were getting difficulties in recalling the past when historical information was required. The shortfalls were reduced by breaking down the questions into manageable, meaningful and easily recalled components. Furthermore, this problem was reduced through additional information obtained from key informants, actual field observation and researcher’s experience in the study area.

iii) Consistency in identifying some plant species

Some plant species were not easily identified in the field. However, this problem was resolved by collecting specimens for identification by a taxonomist from Wildlife Conservation Society in Mbeya town.

iv) Consistency in getting charcoal makers

There were difficulties in getting charcoal makers to interview. In village register there no any charcoal maker registered. Random sampling was very difficult to employ since and there were no any other way to get their name, and most of them were not resident in the village there were just come to work and after finishing their work return back to their native villages. Therefore to overcome this challenge snowball sampling technique was used.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Forest Management in Tanzania

Conservation discourses in Tanzania has long history, the fortress approach that has been implemented before independence, exclude local people in the management of forest resources. Even after independence, the approach has been showpiece management of forests in Tanzania. Change of forest ownership from a traditional/ customary system to centralised regime, among other things, caused old rules that were regulating land tenure, production and distribution on a sustainable basis, begin to break down (Barraclough and Ghimire, 1995), as a result communities' interest to conservation forests and woodlands declined (Akida and Blomley, 2006).

The forest sector in Tanzania is centrally managed through Tanzania Forest Service (TFS) since 2010. Formerly, forest sector was under Forest and Beekeeping Division of the Ministry of Natural Resources and Tourism (MNRT). However, past experience indicates that the sector has not performed to the expectation; this is manifested by forest degradation through illegal activities and human pressure (URT, 1998). Generally forest resources in Tanzania both ecological and socio-economic threat speeding up resource base degradation. According to Luoga *et al.* (2000), forest cover has continually been declining from more than 50% during independence to 45% in late 1970s. In 1990s, the decline in forest cover was reported to be 41%.

In early 1990s, the participatory approach ("Community-Based Forest Management" and Joint Forest Management) was adopted by the Government in order to ensure sustainability of forest resources and generation of benefits to local communities (Monela *et al.,* 2000; Adams and Hutton, 2007). This was a significant step to increase attention to local communities' access rights and improvement of management of forest resources. The participatory approach was introduced in Tanzania with facilitation from Government of Tanzania and various Development Partners such as the World Bank, NORAD, DANIDA, FINIDA and Sida. The Swedish International Development Agency (Sida) facilitated Duru-Haitemba in Babati, Suledo in Kiteto District and Mgori Village Land Forest Reserve in Singida. The facilitations aimed to pilot participatory forest activities through the Land Management Programme (LAMP). Under this programme villages were capacitated to manage forests using their own resources for their own benefit as per the 1998 National Forest Policy, Village Land Act (1999), National Forest Programme (2001) and Forest Act (2002) (Abdallah *et al.*, 2012).

2.2 Participatory Forest Management

2.2.1 Overview of participatory forest management

National Forest Policy of 1998 and the Forest Act 2002, provides the basis for communities in Tanzania to own, manage or co-manage forests (Blomley and Ramadhani, 2007). Two types of PFM are recognized by law; Community Based Forest Management (CBFM) and Joint Forest Management (JFM). The CBFM allows local communities to declare and gazette, village, group or private forest reserves and take full responsibilities of setting and enforcing rules and regulations over forest management and use. In JFM local communities are allowed to enter into agreements with Government.

Early attempt to solve environmental problems without local people involvement have achieved very little success. Today the role of community in the management of natural resources has become a key component in development programs (Kajembe and Mgoo, 1999). Since 1998 the Government has changed Forest Policy from Central Government oriented to participatory management where communities around were given mandate to manage the forests on behalf or under joint management. Various Community Based Forest Management models (CBFM) have been established with success such as Duru-haitemba (CBFM), Urumwa (CBFM) in Tabora, Mgori Joint Forest Management (JFM) in Singida. However, under JFM and CBFM the legal ownership of land remains with the Government. Village committees are co-managers of the forest and are entitled to shares benefits. Village Natural Resource Committee control access to the forests and manage them. These local community institutions are said to proving more effective than State Forest Departments in managing the forest. Regenerating forests now provide more medicinal, fibre, fodder, and dry fuelwood and food products for rural people, whose livelihoods are thereby improved (Abdallah and Monela, 2007).

2.2.2 Impacts of participatory forest management on forest conditions

In India, although there are few studies on ecological impacts of PFM, there are indicators of positive impact of PFM across the country (Murali *et al.*, 2002; Ravindranath and Sundha, 2004). In many states, forests under PFM are regenerating. Remote sensing data shows improvement in productivity and diversity of vegetation (Extension Digest, 2006). This implies that, participatory forest management offers an important survival strategy for threatened Indian forests. In Punjab for example, PFM has shown positive effects whereby the forest is healthier than before and people are satisfied with the products they collect from the forests (Uma *et al.*, 1994). Again, PFM approach for management of degraded forests in the Shiwalik belt of Haryana proved that there is a positive correlation between the period of effective protection and such parameters as tree population/ha and basal area, and the decrease in occurrence of shrubs, with increasing years of protection, reinforces observation that the tree canopy cover has been gradually improving over years (UNEP, 2006).

In Nepal, PFM has a positive impact on total number of stems per unit where an increase of 51% was recorded. In addition, the strategy has led to improved biodiversity and ecological conservation (Branney and Yandav, 1998). Furthermore, CANARI (2002) reported that, in the Caribbean, a review of existing cases gives evidence of some significant positive impacts, as well as unanticipated negative ones. Resource degradation has been reversed and ecosystem health restored through stabilised utilization patterns and control of overuse. In Ethiopia, though PFM has not been institutionalised within the government structure, its impact has been realized through improved forest conditions (Irwin 2004; Amente and Tadesse, 2005).

In Tanzania, Community Based Forest Management (CBFM) initiative has resulted into visible impacts mainly in two areas: first, on the forest resource base and second, on the surrounding community. These impacts are both positive and negative (Kajembe and Mgoo, 1999). In Duru-Haitemba, it was reported that forest cover has increased progressively from 1994, with regeneration increase to 75% from about 50% before the initiative. Kajembe *et al.* (2004), observed a negative PFM impact at Kwizu Forest Reserve in Kilimanjaro Region, where-by despite of PFM strategy, illegal activities in the reserve are still extensive, and that, forest exploitation has increased instead of decreasing. Mohamed (2006) also observed a non-significant positive impact on resource base especially basal area and standing wood volume in Handeni Hill Forest Reserve.

2.2.3 Impacts of participatory forest management on livelihoods

Natural resources, particularly forest resources, play a key role in livelihoods. Previously communities had no access to public forest resources, no rights to take management decisions, no opportunity to obtain technical support from the forest agency, there has been a significant change in the framework of forest management. In many countries, communities that enter into forest management partnerships do so in the knowledge that their rights of access to the resource, and the benefits that may accrue from the time invested in management, are secured by legislation. CANARI (2002) reported that, in the Caribbean, livelihoods of persons who depend on forest resources have become more secured as a result of better managed forests (whose products can be sold at a higher price), increased skills, and the exclusion of competitors.

User groups in Nepal have legal right to manage their local forests and accrue revenue, while village communities in Mali have taken control of local fuel wood markets. Communities in Guatemala have timber - harvesting rights through forest concessions. In West Bengal India, studies have shown that PFM has led to an increased availability of fuel wood and that; communities derive as much as 17% of their annual household income from NWFP collection and sale (Tewari and Campbell, 1995). In Mexico, communities have been able to gain a source of income through timber harvested from community managed forests (Carter and Gronow, 2005). Kahyarara *et al.* (2002), when examining the relationship between poverty and deforestation of Tanzanian’s coastal forests, found clear evidence on the link between deforestation and poverty. This implies that, loss of forests leads to a lower quality of life and vice versa. Forests provide a wealth of indirect environmental benefits as well as direct use benefits for many of the people surrounding them. Further, people may gather medicinal plants, fuel wood or derive food from the forests to support their livelihoods (Bush *et al.,* 2004). PFM aims at contributing to improved local community’s livelihoods and poverty alleviation.

In Tanzania, the few studies done, so far show little positive impact on livelihoods. For example Kigula (2006) reported that people participating in East Usambara forests are inadequately empowered to manage the forest resources, hence reducing their chances to explore potentials for PFM on poverty reduction and enhance livelihoods. The same observation was also made by Jambia and Sosovele (2004) in Amani Nature Reserve and Kajembe *et al.* (2004) in Kwizu Forest Reserve. On the other hand, PFM at Duru-Haitemba observed to have a positive impact on the livelihoods of the rural people as they were satisfied with the products they collect from the forest (Kajembe *et al.*, 2004).

2.3 Charcoal Production Policies and Poverty

The major policy challenge is how to meet the growing demand for charcoal for the majority of Africa's billion people while significantly supporting livelihoods and contributing to poverty reduction, without undermining ecological sustainability. The literature shows that most charcoal production in Africa is unsustainable forest mining of existing natural woodland stocks (Zulu and Richardson, 2012). This ultimately undermines charcoal's poverty-reduction potential. Reasons for over-exploitation include weak, misguided, neglected, underdeveloped, disjointed, overly prohibitive, contradictory or non-existent woodfuel policies and laws, combined with poor enforcement and regulatory capacity (Zulu and Richardson, 2010). A study of East African countries showed that only Sudan and Kenya had explicit policies to promote the sustainable production of charcoal (Mugo and Ong, 2006).

On the supply side, factors that undermine sustainable forest management also undermine charcoal-based poverty reduction. Given current limitations and largely unproven long-term potential of CBFM approaches, it is counterproductive to discount alternative interventions including large-scale plantations, natural forest based production, forest co-management, and private production of charcoal, which together expand opportunities for charcoal-based poverty reduction (Zulu and Richardson, 2012).

2.3.1 Charcoal production worldwide

The global production of wood charcoal was estimated at 47 million metric tonnes in 2009, and increased by 9% since 2004 (FAO, 2010). This increase is strongly influenced by Africa, which produces about 63% of the global charcoal production (FAO, 2010). Charcoal production boosted in the continent by almost 30% since 2004, thus extended Africa's global lead (FAO, 2010). Consequently, the escalating rate of wood charcoal production, particularly in developing countries, will continue to pose severe threats on the remnant woodland resources. Among the top ten wood charcoal producing countries in the world, Brazil, with the largest forest resources in the world, stood first; while Nigeria and Ethiopia are second and third respectively (Fig. 1) (FAO, 2010). The remaining seven countries are: Democratic Republic of Congo, Mozambique, India, China, Tanzania, Ghana and Egypt.

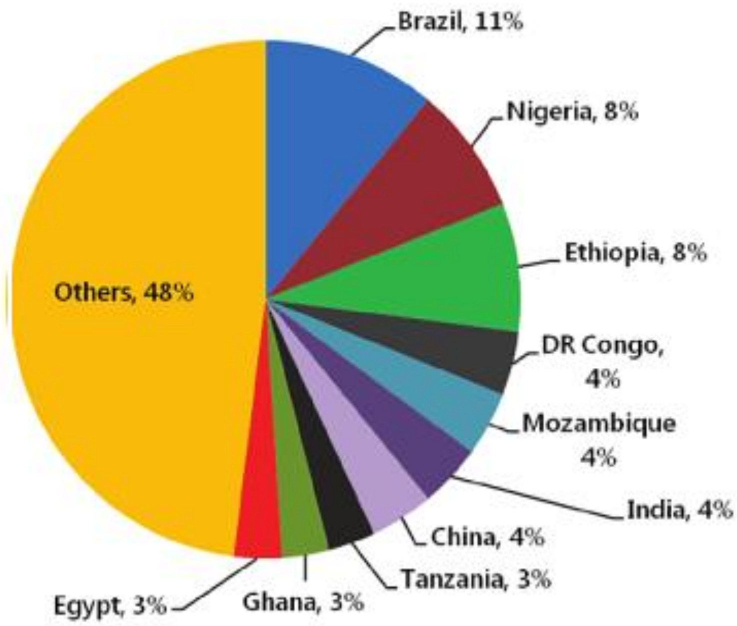

Figure 1: Top ten wood charcoal producing countries in the world

Source: FAO (2010)

2.3.2 Charcoal production and income in Tanzania

2.3.2.1 Charcoal production

Typically involves harvesting mature trees, cutting into billets and pyrolysis done mostly using earthen kilns – is primarily the work of men and older boys in rural villages. The charcoal is primarily produced for sale rather than use, as village wives are usually expected to collect branch wood for firewood for their own cooking and heating (Zulu and Richardson, 2012). Often farmers clear fell forestland for crop farming, and convert the wood into charcoal for sale. Thus, investment costs for charcoal production are low, and in some cases, returns on investment are reported to be high (Osemeobo and Njovu, 2004). However, net gains can be negative if the costs of labour, wood and other raw materials and opportunity costs are included. A cost-benefit analysis of charcoal production in Miombo woodland in eastern Tanzania produced a negative net present value (NPV) of USD 868 per hectare (Luoga *et al*., 2000). The implications of the charcoal economy for rural livelihoods may be significant given the prevalence of charcoal use and high rural poverty rates. However, how charcoal is harvested in the CBFM? Is the harvesting adhering to the forest management plan? Are the sustainable principles adhered? These questions require research attention.

2.3.2.2 Charcoal income

Widespread production and trade of charcoal for income and as a cooking fuel has numerous implications for poverty alleviation throughout Tanzania. Charcoal alone was estimated to contribute USD 650 million to Tanzania's economy, 5.8 times the combined value of coffee and tea production, and the sector provided income to several hundred thousands of households in both urban and rural areas (World Bank, 2009). The World Bank (2001) framework for understanding poverty is used here to examine both the positive and negative impacts of charcoal production, trading and use on poverty through the four dimensions of the framework i.e., (i) material deprivation, (ii) poor education and health, (iii) vulnerability and exposure to risk, and (iv) voicelessness/powerlessness.

2.3.2.3 Charcoal and poverty alleviation through income generation

Three main marketing channels for the production and trading of charcoal (Zulu and Richardson, 2012) are: direct marketing channel involving small-scale producers selling directly to consumers. The wholesale marketing channel involving intermediaries who buy charcoal from small-scale producers and deliver it to consumers for sale. The wholesale-retail marketing channel is more complex; where intermediaries buy charcoal from producers and sell it to secondary intermediaries who transport and package the charcoal for sale to consumers in retail markets (World Bank, 2009).

2.3.2.4 Charcoal production process

Charcoal is usually produced by slow pyrolysis, the heating of wood in the absence of oxygen. During the process, water is driven out first from the wood (drying) and then the pyrolysis starts when the temperature in the kiln is high enough. When the pyrolysis is 17 complete the kiln gradually cools down after which the charcoal can be removed from the kiln (Hofstad, 1995). Charcoal is produced by various methods. The oldest and still the most widely used method for charcoal production is the traditional earth kiln (Malimbwi *et al.,* 2007). Two varieties exist, the earth pit kiln and the earth mound kiln. The earth pit kiln is constructed by first digging a small pit in the ground. Then the wood is placed in the pit and lit from the bottom, after which the pit is first covered with green leaves or metal sheets and then with earth to prevent complete burning of the wood. The earth mound kiln is built by covering arranged piles of wood on the ground with earth. The mound is preferred over the pit where the soil is rocky, hard and shallow or the water table is close to the surface. Mound can also be built over a long period by stacking gathered wood in position and allowing it to dry before covering and burning (Malimbwi *et al.*, 2007). With Earth Mound Kiln the process of charcoal making involves wood cutting, kiln constructions, carbonizations and finally unloading charcoal from the kiln.

Generally, the work is laboured intensive and muscularly done, usually by male members of the family with manual tools (axes, hoes and shovels). For a kiln with about 1.5 tonnes of charcoal it takes an average of about 13, 10 and 14 days for wood cutting, kiln preparation and carbonization respectively. Unloading the charcoal takes an average of 4 days (Malimbwi *et al.*, 2005). Despite the variations in kiln types, the steps for producing charcoal (Table 1) are essentially the same. According to Herd (2007), the main differences arising between regions are the tree species used, the kiln insulation material used and the arrangement.

Table 1: Steps involved in the production of charcoal using the traditional earth kiln

Step	Activity
1. Kiln site identification	1.1. Select site for kiln construction
2. Material Preparation	2.1. Tree felling
	2.2. Cross cutting into short logs
	2.3. Wood drying
3. Kiln construction	3.1. Kiln base structure
	3.2. Stacking logs
	3.3. Kiln insulation with grass & soil
4. Carbonization	4.1. Ignite kiln
	4.2. Carbonization control
	4.3. Cooling period
5. Sorting & selling	5.1. Sorting of charcoal
	5.2. Packing into bags
	5.3. Transport to road

Source: Herd (2007)

The efficiency of the kiln depends on the arrangement of the billets, moisture content of wood and the monitoring of the carbonization process. The efficiency is low when using the traditional earth mound kiln. A study conducted by CHAPOSA (2002) showed that the efficiency of the traditional earth mound kiln ranges from 11 – 30%, however, in other studies the efficiency of the traditional kiln was reported to range between 10 – 20%. The conversion rate ranges from 1 to 2 bags of charcoal taken from one cubic meter of fuel wood (TaTEDO, 2001).

2.3.2.5 Tree species preferred for charcoal

Even though all species of wood can be carbonized to charcoal, the quality of charcoal varies from specie to specie and is dependent on the method of carbonization (KFS, 2013). Large tree species (>20cm diameter) with high caloric values are the most preferred, due to the large quantity of dense and hard charcoal they produce (Monela *et al.,* 1993). *Bachystegia boehmii, B. bussei, Combretum sp, Bauhhinia sp, Acacia nilotica, Fluegea virosa, Swartizia madagacariencis* and *Julbernadia sp*. are some of the species that have been reported to produce high quality charcoal (Msemwa, 2007). Most of these are Miombo woodland species. Tree species preference is based on the species property to produce charcoal with high recovery percentage, high calorific value that attracts customers and hence more income to charcoal dealers since lighter charcoal with low calorific value has a problem of crumbling easily into small pieces or fines during transportation and consequently lowering market value (Zahabu, 2001). In Kenya, most species preferred for charcoal production include *Casuarina equisetifolia*, *Acacia mearnsii*, *Acacia polyacantha*, and *Acacia xanthophloea*, and other *acacia* and *combretum* species (Mugo and Ong, 2006).

2.3.2.6 Effects of charcoal production on forest resources and environment

The direct environmental impact of charcoal production is caused by the felling of trees to produce charcoal. Eleven to twenty per cent of deforestation in developing countries can be attributed to charcoal production (Norconsult, 2002). Since the trend has been that more and more people use charcoal, the tendency to fell more trees has been and will continue to increase in the absence of any affordable alternative. The problems associated with felling trees that are not replaced by regeneration or reforestation activities are well known: depletion of water sources and water catchment areas; reduction of carbon sinks; erosion; and loss of habitat and biodiversity. Several studies in charcoal producing countries have attempted to capture the impacts of charcoal on deforestation and forest degradation. In Malawi, Kambewa *et al*. (2007) analysis of the impact of the charcoal industry on forests revealed a volume equivalent to about 15 000 ha of forestland being cut per year, with close to 60% of the charcoal being produced in Forest Reserves and National Parks. The study also reveals the negative impacts of charcoal making on species composition of forests. In this situation preferred species for charcoal making are removed leaving woodlands of lower quality. The principle cause of deforestation in Tanzania is the felling of trees for the production of charcoal (Van Beukering *et al.,* 2007). According to Kifukwe (2013), Tanzania is one of the largest charcoal producing countries in the world. This has led to charcoal becoming a major cause of deforestation ranking behind shifting land use to agriculture but ahead of forest fires.

2.3.3 Charcoal trading system in Tanzania

2.3.3.1 Charcoal trade arrangements

Trade in charcoal is conducted by formal as well as informal actors. One commercialization begins with government-issued licenses for the exploitation of the forest resources. The product is required to be transported and traded by officially licensed transporters and traders who pay the necessary duties and taxes. A second commercialization begins without official authorization, which is essentially an informal or illegal activity. Charcoal trade through this informal chain is transported and traded clandestinely in attempt to avoid authorities, taxation and eventual penalties (World Bank, 2009). According to Van Beukering *et al.* (2007), the trade of charcoal in Tanzania is primarily informal and it is characterized by a high turnover rate. There is no significant warehousing. All stocks produced are promptly consumed. Abundant evidence of the charcoal trade is visible throughout the cities and surrounding regions. Highways are lined with charcoal bags for sale in the production areas and on the outskirts of towns. Thousands of markets throughout the country offer charcoal for sale. Most of the wood used to burn charcoal is either obtained freely from on-farm sources, or illegally from government sources in charcoal producing areas (KFS, 2013). In urban areas, charcoal dealers sell their charcoal either to charcoal vendors or directly to consumers who buy charcoal in large quantities. Charcoal vendors who are spread all over the urban areas then sell the charcoal to final consumers usually in small quantities (Mndeme, 2008).

2.3.3.2 Transportation and distribution system of charcoal

Almost all charcoal produced in rural areas is transported to the main Tanzanian cities by trucks, motorcycles or bicycles. Although bicycles account for quite a small percentage of the charcoal transported, they are in common use among rural and semi-urban households linked to the chain (Van Beukering *et al.*, 2007). Charcoal producers and business-people trading in smaller amounts primarily use bicycles. The fact that transportation is mainly by bicycles is an indication of their unsteady economic conditions, and consequently, their inability to afford better and safer means of transport (Van Beukering *et al.*, 2007). However, very few producers actually ferry their own charcoal to the cities. Napendaeli (2004) indicated that more than 60% of the charcoal producers do not transport their charcoal to the markets in urban areas and 36% of them use bicycles to ferry charcoal up to nearby main roads where charcoal dealers come to collect the bags. Only 4% of the producers do hire transport and ferry their charcoal up to wholesalers/retailers in Dar es Salaam city. They usually do this only when the charcoal production sites are less than 30km from potential markets and there is the opportunity to retain a higher margin of profit there.

Most of the charcoal produced is ferried to the cities by charcoal dealers. They collect charcoal at the production sites using their own, or in most cases, hired means of transport (i.e. lorries and pick-ups). More charcoal is transported during the dry season for reasons related to the larger quantity produced and the better conditions of the roads. In the case of Dar es Salaam, the highest amount of charcoal usually enters the city during morning hours (6:00 am) through the major routes: Morogoro, Pugu (59%), Kilwa (31%) and Bagamoyo (10%) (Napendaeli, 2004). Transportation of natural resources including charcoal is only allowed during day time between 6.00 am to 6.00 pm. Most of the 23 charcoal passes through checkpoints very early in the morning between 6.00 to 6.59 am and late in the evening between 5.00 and 6.00 pm. This is because most of the vehicles used are more than 10 years old (79%) with many traffic offenses and as such, drivers tend to avoid traffic police (Malimbwi *et al.,* 2007).In Kenya, transporters costs include the movement permit fee payable to KFS at a rate of KES 20/bag, Cess fee of KES 20-50/bag, cost of vehicle hire which varies with the size of the lorry and the distance to the market, the county council charges and the bribes paid to the police and the county council security (KFS, 2013).

2.3.3.3 Charcoal markets and prices

Charcoal is a highly commercialized commodity which can be transported economically over long distances for market. According to KFS (2013), the most common charcoal supply consists of three levels. First the transporters visit the production site or a designated collection points with motorised or non-motorised means of transportation and buy the charcoal in bulk. They then transport the charcoal to wholesalers or retailers mostly in urban areas. In the national survey study findings in Kenya (Mutimba and Baraza, 2005), 56% of producers sold their charcoal to wholesalers or retailers via transporters as well as directly to households, food businesses and other customers including social institutions. Charcoal is sold in different units of various sizes. MNRT (2001) reported different units used by vendors to sell charcoal whereby the smallest unit used was empty paint tin (*kopo*) and the largest unit being a bag (*gunia*). In Dar es Salaam, most vendors sell charcoal at their house yards of which they are not paying taxes (MNRT, 2001).

Charcoal prices often vary depending on production and transportation costs, the quality of charcoal based on the weights and presence or absence of fines, soil particles and unburnt wood and twigs, the market with the towns providing the major market to the charcoal, the 24 season, royalty and on whether there is a ban from the government or not. For example, studies conducted in Kenya by KFS (2013) reported that charcoal prices vary depending on the season with lower prices registered during the dry season and higher prices in the rainy season owing to low supplies and high cost of transport. Charcoal pricing increases from a low of KES 250 per bag at the producer level to a high of KES 2 800 per bag at the consumer level, with the latter being realized where charcoal is sold to households in small 2kg-tins. In Tanzania, Camco (2013) reported that charcoal pricing increases from TZS 7,000 per bag at the producer level to TZS 40 000 per bag at the consumer level. One vital piece of information that producers lack is market price knowledge. Charcoal producers are also lacking business skills. Business development skills would allow the producers to manage their business better and market their product (Blodgett, 2011). Producers sometimes are forced to yield to the demand for low prices by transporters and vendors to raise funds to fend their family needs like food, clothing and school fees, especially during drought. During the wet and planting seasons most producers halt production and engage in agriculture thereby leading to low supplies of charcoal hence higher prices. MNRT (2001) found that the highest price is fetched during wet season when processing and transport is difficult compared to dry season. Tanzanian charcoal market is valued at USD 650 million, nearly ten times the Malawian market due to the higher prices prevalent in Dar es Salaam (World Bank, 2009).

Charcoal vendors sell their charcoal in small units in tins, buckets and small sacks. According to Mndeme (2008) to increase profit margins, the vendors normally manipulate packing, sizes and shapes of tins, buckets and bags they use as the result most of the tins and the buckets used are deformed. The manipulations are also done by producers and transporters of charcoal and finally the effect is most felt by consumers. Malimbwi *et al.* (2007) reported that large scale vendors have to pay for tax, municipal permit, site construction, security and salaries while small scale vendors who sell charcoal at their premises usually have less running costs. In accordance with the Forest Act No. 14 of 2002, the TFS agency is entitled to charge fees and royalty from charcoal, also the Local Government Act No. 9 of 1982 allows the district councils to charge cess fee of 5% of the royalty charged by TFS agency. Fees and permit plus costs of production, packaging, transportation and marketing and other variable costs are incurred by charcoal dealers. Therefore, for charcoal dealers to make profit, the price of charcoal has to be raised above these charges and their respective costs. Thus increase or decrease of these charges are likely to affect positively or negatively the price of charcoal. Blodgett (2011) reported that taxes along the Rwandese charcoal value chain amount to about 7% of the end user price.

2.3.3.4 Charcoal consumption

Charcoal, which covers about 80% of urban households energy needs in Africa, remains one of the prime sources of energy in the continent, particularly in Sub-Saharan Africa (FAO, 2010). And, yet it will remain the main cooking fuel for most people in the region's towns and cities for the foreseeable future because it is accessible and affordable (Mugo and Ong, 2006). With population increase, urbanization, and economic growth, the demand for energy is expected to grow. As the modern energy sources are still beyond the reach of the majority of people in developing countries, dependence on biomass fuel is expected to continue. Household energy use can, generally be categorized as traditional (including agricultural residues and firewood), intermediate (charcoal and kerosene) or modern (LPG, biogas and electricity) (Msuya *et al.*, 2011). In developing countries, energy consumption is still low and limited almost exclusively to biomass fuels: firewood, charcoal and other organic wastes (Malimbwi *et al.*, 2010). At national level 96.6% of Tanzania's total population (Table 3) relies on biomass fuels for cooking of which 71.8% relies on firewood and 24.8% on charcoal (Camco, 2014; MNRT, 2013). Of the estimated total population of 44.94 million people (2012), those relying on biomass (firewood, charcoal and farm residues) for cooking were 43.57 million (Table 2).

Table 2: Sources of energy for cooking in Tanzania

Energy source for cooking	Percent rural	Urban	Total	Population rural	(millions) urban	2012 total
Firewood	90.1	20	71.8	29.96	2.34	32.30
Charcoal	8.5	71	24.8	2.83	8.29	11.12
Crop residues	0.4	0.1	0.3	0.14	0.01	0.15
Biogas	0.1	0.4	0.2	0.02	0.05	0.07
Electricity	0.2	1	0.4	0.07	0.12	0.19
Kerosene	0.4	7	2	0.13	0.82	0.95
LPG	0.1	0.1	0.2	0.03	0.01	0.04
Others	0.2	0.4	0.3	0.07	0.05	0.12
Total	**100**	**100**	**100**	**33.25**	**11.69**	**44.94**

Source: Camco (2014); MNRT (2013)

Charcoal demand in rural areas has increased from 4% in 2000 to 8.5% in 2012 (Camco, 2014) and in Dar es Salaam from 71% in 2007 to 91% in 2012 (Camco, 2014). Charcoal demand in other urban areas has increased from 53.9% in 2007 to 59.1% in 2012 (Camco, 2014). By end of 2012, the population consuming charcoal in Tanzania mainland was 11.12 million people mainly in urban and peri-urban areas (Table 3). Camco (2014) reported that in 2012 Tanzania consumed 2 333 743 tonnes of charcoal whereby rural households consumed 515 740 tonnes, urban households 1 513 602 tonnes and non-households (commercial, institutional, etc) all urban consumed 304 401 tonnes. According to Van Beukering *et al*. (2007), households represent the most accessible source of charcoal demand in urban and peri-urban areas. The second largest consumer of charcoal is the commercial sector, which consists of petty food vendors and restaurants/hotels. Charcoal is also used by small-scale industries which include small textile finishers, food processing industries (breweries, smokeries, etc), agro-processing industries (tobacco curing, tea drying and beeswax processing industries) and industries involved in the production of building materials (burnt bricks, lime, smiths, foundries, pottery and ceramics). Whereas the service sector, which consists of secondary schools, colleges, hospital/health centers and prisons, as well as other institutions, represent a marginal share of the total demand for charcoal.

Recent household budget surveys, census and other data show that, currently, a quarter of all Tanzanians consume charcoal as their primary cooking and heating fuel (Table 3). Dar es Salaam makes up one third of total consumption (Camco, 2014). Several studies have given different estimates on the percentage of Dar es Salaam households depending on charcoal as a source of energy for cooking purposes. Camco (2013) reported that over 90% of the households in Dar es Salaam, and almost all the restaurants and hotels, use charcoal as their only source of cooking energy and buy their charcoal from suppliers where the price differential between suppliers is small. The World Bank's (2009) assessment from 2001 - 07 also showed that the number of households in Dar es Salaam cooking with charcoal grew from 47% to 71%, while the uses of LPG declined from 43% to 12%. Other estimates include TaTEDO (2001) estimated at 85%, and Ishengoma and Ngaga (2001) at 86% of the total demand.

Table 3: Tanzania population using charcoal in 2012 (by area)

Area	Total Pop.	% Pop. Using charcoal	No. using charcoal	%Total charcoal demand
Dar es Salaam	4 364 541	91.0	3 971 732	35.7
Other urban	7 316 739	59.1	4 321 976	38.9
Rural	33 246 720	8.5	2 825 971	25.4
Total	**44 928 000**	**24.8**	**11 119 680**	**100.0**

Source: Camco (2014)

In Kenya, the annual consumption was estimated at between 1.6 - 2.4 million tonnes (Mutimba and Baraza, 2005), with 10 % of the charcoal heading to the capital city, Nairobi (Njenga *et al*., 2013). In Malawi, the four largest urban centres account for roughly 90% of the charcoal used in the country (Kambewa *et al*., 2007).Various energy studies have concluded that biomass fuels for the foreseeable future will remain the main energy source for the household sector (Camco, 2014).

2.4 Charcoal Production in Songwe District and Its Importance and Challenges

In Songwe district charcoal production is mainly done using Earth pit kilns. Earth pit kilns are the traditional way of making charcoal and may represent the simplest technology for charcoal production. In brief, the process of using an earth pit kiln begins by stacking wood in a pit, sealing it with a layer of grass and soil and starting carbonization by igniting the wood at one end. Earth pit kilns are typically large and large pieces of wood can be used (Zulu and Richardson, 2012).

Charcoal business in Songwe District is controlled by wholesale businessman from Mbeya City**.** The wholesale-retail marketing channel is more complex; where intermediaries buy charcoal from producers and sell it to secondary intermediaries who transport and package the charcoal for sale to consumers in retail markets. This channel is more common in larger urban areas. Charcoal production in Songwe District enhances social and economic security in rural areas, and is an important source of non-farm income for some households which burn and sell charcoal for cash to buy grains and other household commodities when food supplies run low in the off-season.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Location of study area

Mbangala village is located in the South - Western part of Songwe District. It lies between 7° and 9° Latitudes South and between 32° and 34° Longitudes East. The village has a total area of 45 522.2ha (Fig. 2). The village is bordered by Kapalala village to the North; Luika river to the East; Shanta Gold mine and Saza village to the South; Mamba village to the West.

Mbangala Village Land Forest Reserve is called Kalambo Forest Reserve. Is located south-western part of the village. The forest has a total area of 9 306 ha. To the North is bordered by Kapalala village, Patamela Forest Reserve to the South, Luika river and Kinyampuma hill to the East; Kininga Forest and Nkunungu Forest to the West.

3.1.2 Climate

The average temperature ranges between 21° C and 23° C annually and this is very much influenced by physiography and altitude. Average annual rainfall ranges from 600 mm to 1 000 mm. Normally the rainy season is during the months of December to April and dry season from May to November almost every year (URT, 1997).

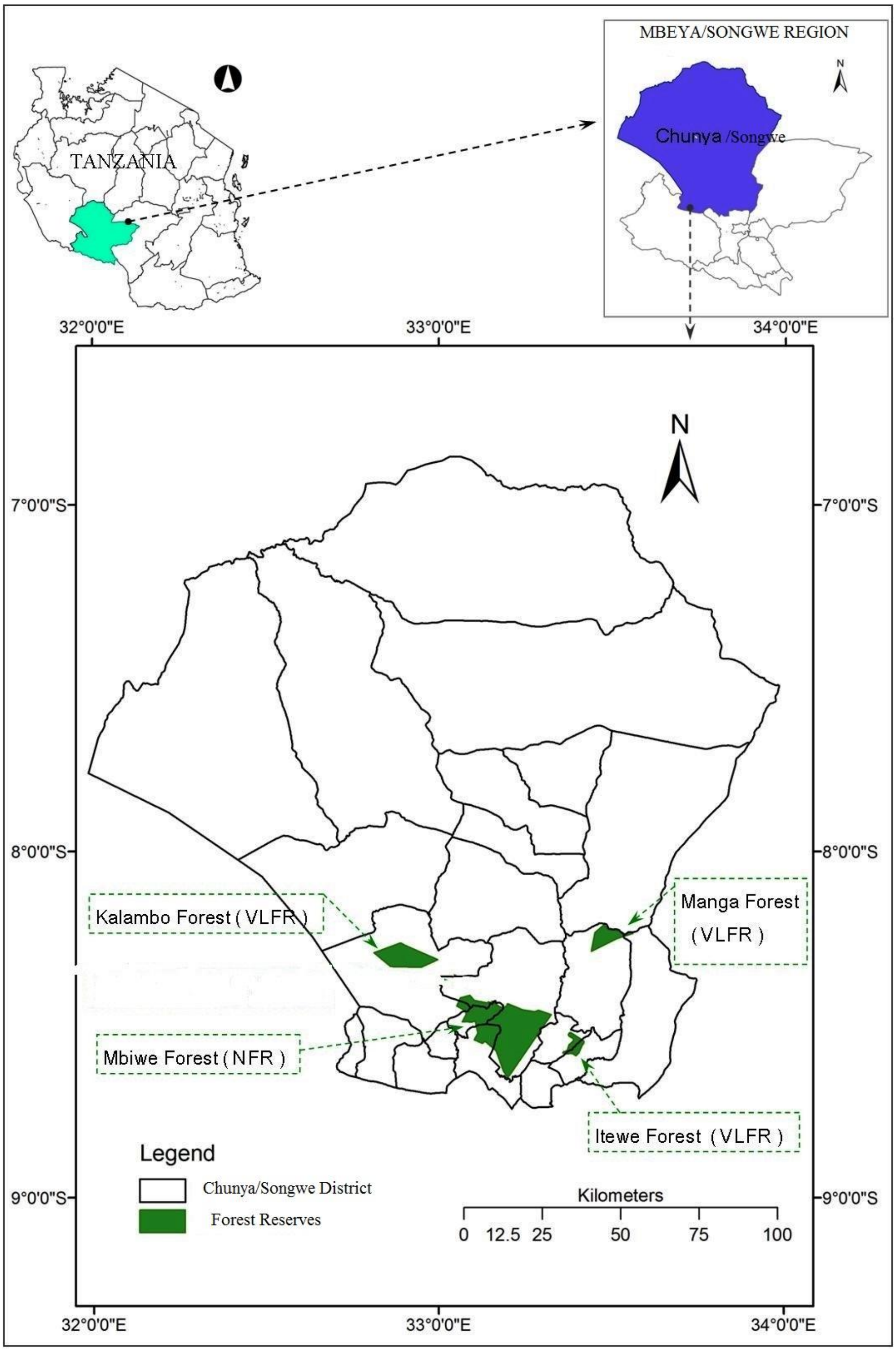

Figure 2: Location of the study area (Kalambo VLFR) and other Forest Reserves in Chunya/Songwe District, Tanzania.

Source: Mpya (2012)

3.1.3 Topography and vegetation

The village is characterized by a hilly landscape with thick forests, Miombo woodlands, scattered trees, bush and thickets. Also the village has flat low lands along Lake Rukwa basin and plateau. The main permanent drainage system include Luika river, on the other hand, non permanent rivers (seasonal) exist and mostly flow during the rainy seasons (URT, 1997).

The most predominant natural vegetation is Miombo woodlands, with vast areas in. Common plant species include those of *Brachystegia spp, Dalbergia spp, and Pterocarpus spp*. Overgrazing, gold mining, settlement and agriculture have seriously reduced the natural vegetation of the village. Settled areas are widely planted with *Senna siamea* (*mijohoro*) trees (URT, 1997).

3.1.4 Population size, growth and socio-economic activities

According to the 2012 National Population Census reports, Mbangala village has a population of 2 617 people with 419 household with average of 5.4 people per household. Songwe is the least populated district in Songwe region with the population density of six (6) persons per km^2.

Mining activity in Songwe district has led to gradual changes in population densities. It is now a common phenomenon that new settlements are being established in Songwe by the incoming herdsmen and cotton (*Gossypium hirsutum*) /tobacco (*Nicotiana tabacum*) growers from Tabora, Shinyanga, Singida, Manyara and Arusha Regions. Movements from the southern regions are normally seasonal. Farmers open up new land for cotton (*Gossypium hirsutum*) and tobacco (*Nicotiana tabacum*) growing whereas herdsmen move into wooded grassland areas, both changing the natural environment of the district (URT, 1997).

3.2 Methods

3.2.1 Data collection

Data were collected from both primary and secondary sources. Two types of data were collected, namely forest inventory and socio-economic. This activity involved collection of the vegetation (Biophysical) information, and socio-economic data of Charcoal makers in Mbangala village.

3.2.1.1 Forest inventory data

(i) Reconnaissance survey

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

(ii) Plot shape, size and sampling intensity

Concentric circular sample plots of the standard size of 0.071 ha with sub plots of 1, 5, 10 and 15 meter radii were adopted for inventory data collection. Circular plot were adopted with the aim of increasing the accuracy of measurement and sampling intensity of large trees, saving time and it reduce the edge effect. Circular plots are less vulnerable to errors in the plot area than square plots since the perimeter (boundary of the plot) is smaller in relation to the area and thus the number of trees on the edge is less (Lackmann, 2011). Square plots were not used since they are very vulnerable to errors in the plot area due to the large perimeter and are difficult in establishment and wrong angle of the plot corners which significantly changes the area of the plot and thus bias the estimates (Lackmann, 2011).

For a forest reserve with 9 306 ha using a sampling intensity of 0.5%, a total number of 665 sample plots with the size of 0.071 ha would have been measured. However, due to limited financial and time resources, only 9% of the total number of plots was taken for measurement. Taking small samples have no effect on results since systematic sampling procedure was employed and hence the whole forest was covered. In order to cover the whole area, a systematic sampling design was adopted. The forest was divided into 6 transects located at an interval of 2.5km apart with the first transect starting at a distance of 1.25km from the starting point to avoid edge effects (Fig. 3). Plots were in interval of 0.5 km from one plot to another. Therefore, a total of 60 sample plots were established along transects. Equipment used in setting transects included Geographical Positioning System (GPS), Compass and Tape measure.

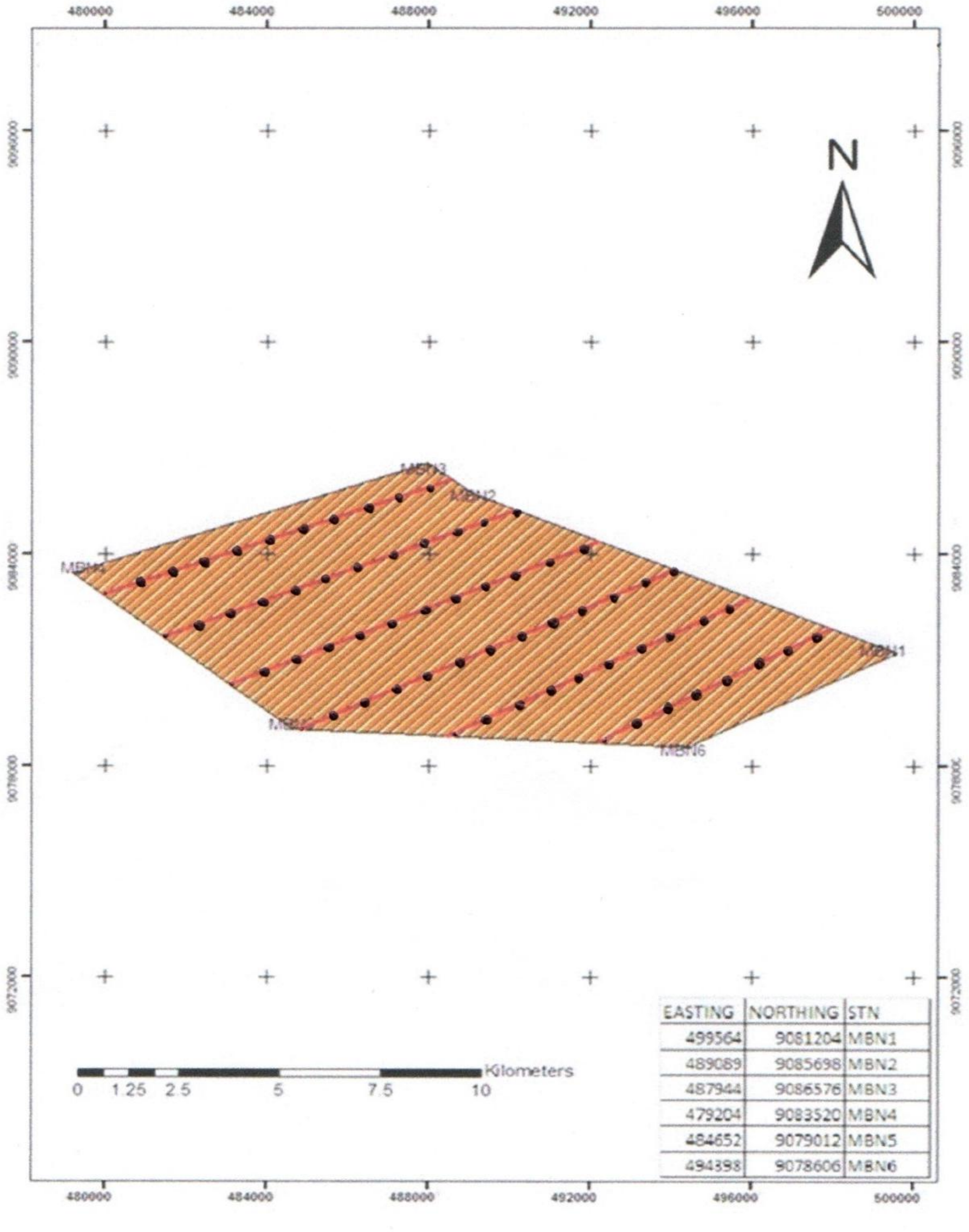

Figure 3: **Layout of transects and plots in Mbangala VLFR, Songwe, Tanzania**

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

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

(ii) Within a 5m radius, all woody plants with dbh ≥ 1cm but ≤ 10cm were measured for dbh and identified to species level

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

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

These classes were designed with reference to the structural composition of the woodlands (NAFORMA, 2015).

Description of the plot: slope, vegetation type, altitude and location according to Geographic Positioning System (GPS) coordinate reading and species names of all recorded trees

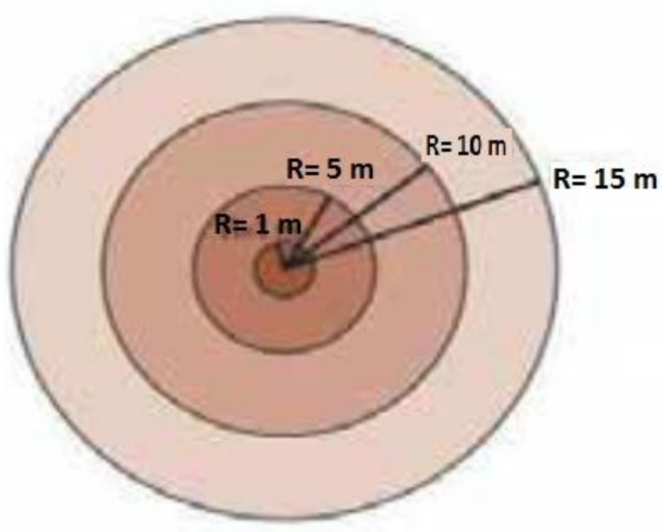

Figure 4: **Concentric circular shapes of nested sample plots used in Mbangala VLFR, Songwe, Tanzania**

3.2.1.2 Socio-economic data

Data from primary sources were collected through interviews with charcoal makers, Village leaders, Village Natural Resource Committee members and District officers using structured questionnaire with both open and closed-ended questions, informal discussion with village elders, direct, observation and a checklist was used to guide discussion with key informants (Appendix 5 and 6). According to Mettrick (1993) a key informant is an individual who is knowledgeable, accessible and willing to talk about issues under study. Focus group discussions were conducted with members of Village Natural Resource Committee and Village leaders to provide essential information about village and forest at large. It was also used to supplement the structured questionnaire and other instruments to fill the perceived gaps. A list of questions to guide focus group discussion is given in Appendix 6.

3.2.1.3 Sampling

Charcoal makers were very difficult to meet. They live within the forest, no any document in the village office about their name and location, hence I had to find them within the forest and snowball sampling was used, where 56 charcoal makers were interviewed. Snowball sampling (or chain sampling, chain-referral sampling, referral sampling) is a non-probability sampling technique where existing study subjects recruit future subjects from among their acquaintances. Thus the sample group is said to grow like a rolling snowball. As the sample builds up, enough data are gathered to be useful for research. This sampling technique is often used in hidden populations which are difficult for researchers to access (https:// en. wikipedia. org/ wiki/ snowball sampling). An individual or a group receives information from different places through a mutual intermediary. This is referred to metaphorically as snowball sampling because as more relationships are built through mutual association, more connections can be made through those new relationships and a plethora of information can be shared and collected, much like a snowball that rolls and increases in size as it collects more snow.

Snowball sampling is a useful tool for building networks and increasing the number of participants. However, the success of this technique depends greatly on the initial contacts and connections made. Thus it is important to correlate with those that are popular and honourable to create more opportunities to grow, but also to create a credible and dependable reputation (https: //en .wikipedia. org/ wiki/ snowball _sampling).

3.2.1.4 Secondary data collection

The researcher spent some time in searching for relevant information in libraries, the internet and government offices. Among the government offices visited include Songwe District Council, Chunya District Council, Mbeya Regional Secretariat and Sokoine National Agriculture Library (SNAL).

3.2.2 Data analysis

3.2.2.1 Forest inventory data

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

(i) Number of stems (N) per hectare

Number of stems per hectare was calculated using total counts pooled from all 60 plots in the forest reserve. The formula used was:

$$N = \frac{(1/ai)}{n} \quad \ldots\ldots \text{Eq (1)}$$

Where,

N = number of stems per ha.

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

n = number of sample plots

(ii) Basal area (G) per hectare

Basal area (m^2ha^{-1}) was calculated from measurements of stem diameters at breast height (1.3m) for all woody individuals and was pooled from the 60 plots in the forest reserve. The basal area in m^2 per hectare was determined using the following formula:

$$G = \sum(\frac{Gi}{n}) \quad \text{…… Eq (2)}$$

Where,

G = average basal area per hectare of the stand (m^2ha^{-1}).

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

n = number of sample plots.

(iii) Volume (V) per hectare

Volume equation model developed by Mauya *et al.* (2014) for miombo woodlands in Tanzania was used to determine single tree volumes. This equation was as follows:

$$V = 0.00016dbh^{2.46300} \quad \text{…… Eq (3)}$$

Where,

V = total tree volume (m^3)

dbh = tree diameter at breast height (cm)

(iv) Species Important Value Index (IVI)

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

$$IVI = \frac{\sum(RF + RN + RD)}{3} \quad \text{…… Eq (4)}$$

Where,

IVI = Important value index

Σ = Summation symbol

The constituent's parameters were calculated as follows:

$$RF = \text{Relative frequency} = \frac{\text{Frequency of occurrence of a species}}{\text{Frequency of occurrence of all species}} \quad \text{.................Eq (5)}$$

$$RN = \text{Relative density} = \frac{\text{Number of individuals of species}}{\text{Number of individuals of all species}} \quad \text{.....................Eq (6)}$$

$$RD = \text{Relative basal area} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \quad \text{..........................Eq (7)}$$

(v) Diversity indices

Shannon Wiener index of diversity (H')

Shannon – Wiener index of diversity (H`) will be used to determine tree species diversity. This is the most widely used index of diversity, which combines richness and evenness and also not affected by sample size.

$$H` = -\sum_{i=1}^{s} (P_i \log_a p_i) \quad \text{..Eq (8)}$$

Where;

H` = the Shannon- Wiener index of diversity,

s = the number of species,

Pi = the proportion of individuals or the abundance of species in the sample,

$\log_a$ = the logarithm to base a (any base of logarithm may be taken), and

\- the negative sign multiplied with the rest of variables in order to make H` positive.

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

Index of dominance (Simpson Index)

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

$$ID = \sum (ni/n)^2 \quad \text{..........Eq (9)}$$

Where;

ID = Index of dominance

ni = Number of individuals of species i in the sample

N = Total number of individuals of all species in the sample.

Σ = Summation symbol.

3.2.2.2 Socio-economic data

(i) Quantitative data

The Statistical Package for Social Sciences (SPSS) was the main tool used for data analysis. Both descriptive and inferential statistical analyses were carried out to analyze the quantitative data. Descriptive statistical analysis using frequency counts and percentages was used to describe the socio-economic characteristics of the charcoal makers.

(ii) Qualitative data

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

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Status of the Forest Resources Base

Table 4 summarizes stand parameters, which give the status of Mbangala VLFR.

Table 4: Stand Parameters in Mbangala VLFR, Songwe, Tanzania

Stand Parameter	**Value**
Density (stems ha $^{-1}$)	297
Basal area (m^2 ha^{-1})	5.2
Wood Volume (m^3 ha^{-1})	51.15
Regeneration (stems ha^{-1})	12 201
Species Richness	78
Species Diversity:	
• Dominance Index (C)	0.064
• Shannon Index (H')	3.29

4.1.1 Species richness

A total of 78 species (30 plant families) of standing trees and regenerants were identified in Mbangala VLFR. In general, tree species from the Caesalpiniaceae contributed the most (14%) to the total number of species, followed by those from Mimosaceae (12%), Combretaceae (12%), Rubiaceae (6%), Fabaceae (6%), Papilionaceae (5%) and Anacardiaceae (5%).

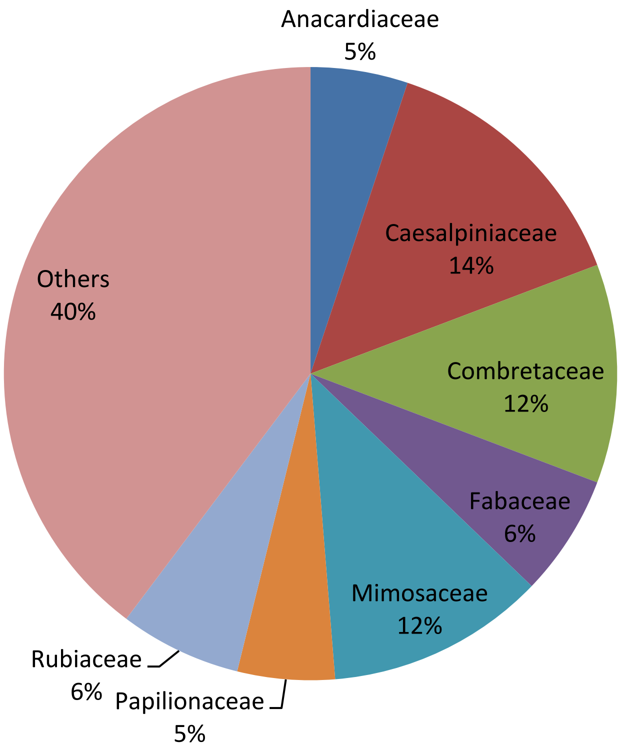

Figure 5: **Tree family compositions in the Mbangala VLFR, Songwe, Tanzania**

The results reported in this study show that the composition of the vegetation types found in the Mbangala VLFR, especially the dominance of species from the family Caesalpiniaceae, agreed well with previous descriptions and classifications of plant communities commonly found in miombo woodlands. The dominance level of species observed were *Brachystegia spiciformis* (14.1%), *Brachystegia boehmii* (12.9%), *Combretum molle* (8.2%) *and Isoberlinia globiflora* (8.2%). This observation contradicts to observations in other miombo woodland elsewhere. For example, Mwakalukwa *et al.* (2014), in Gangalamtumba Village Land Forest Reserve, observed that the dominant genera were *Dalbergia*, *Commiphora*, and *Combretum*. The results suggest that on a larger spatial scale the species diversity of miombo woodlands is very high and that the three common genera *Brachystegia*, *Julbernadia*, and *Isoberlinia* are not always dominant at the local scale. Jew *et al*. (2016), reported species richness of 122 species from 46 families in Kipembawe division forest reserves at Chunya district. This is higher compared to species reachness observed in Mbangala VLFR. This result suggest decrease of species richness due to charcoal production and other human disturbances.

4.1.2 Species diversity

A Shannon-Wiener diversity index (H`) was found to be 3.29 and the Simpson index (C) was 0.06. The following species were observed to have the greatest contributions to the Shannon-Wiener diversity index: *Brachystegia spiciformis* (contributing 0.27), *Brachystegia boehmii* (0.26), *Combretum molle* (0.20) and *Isoberlinia globiflora* (0.20). Mwakalukwa *et al*. (2014), reported H` value of 3.44 and C value of 0.06, also Mcharo (2007) report C value of 0.07 and H`value of 2.72. The values of the Shannon-Wiener (*H`* = 3.29) and Simpson indices (C = 0.06) reported in this study are within the range observed for most communities of particular life forms. For example, *H`* usually does not exceed 5, although this maximum value varies depending on the type of the biological community sampled and the sampling approach applied (e.g. minimum diameter and size of sample units).

The Importance Value Index (IVI) shows that, *Brachystegia spiciformis* (10.01), *Brachystegia boehmii* (9.99), *Isoberlinia globiflora* (6.28) *and Diplorhynchus condylocarpon* (5.57) were the most important species among standing individuals.

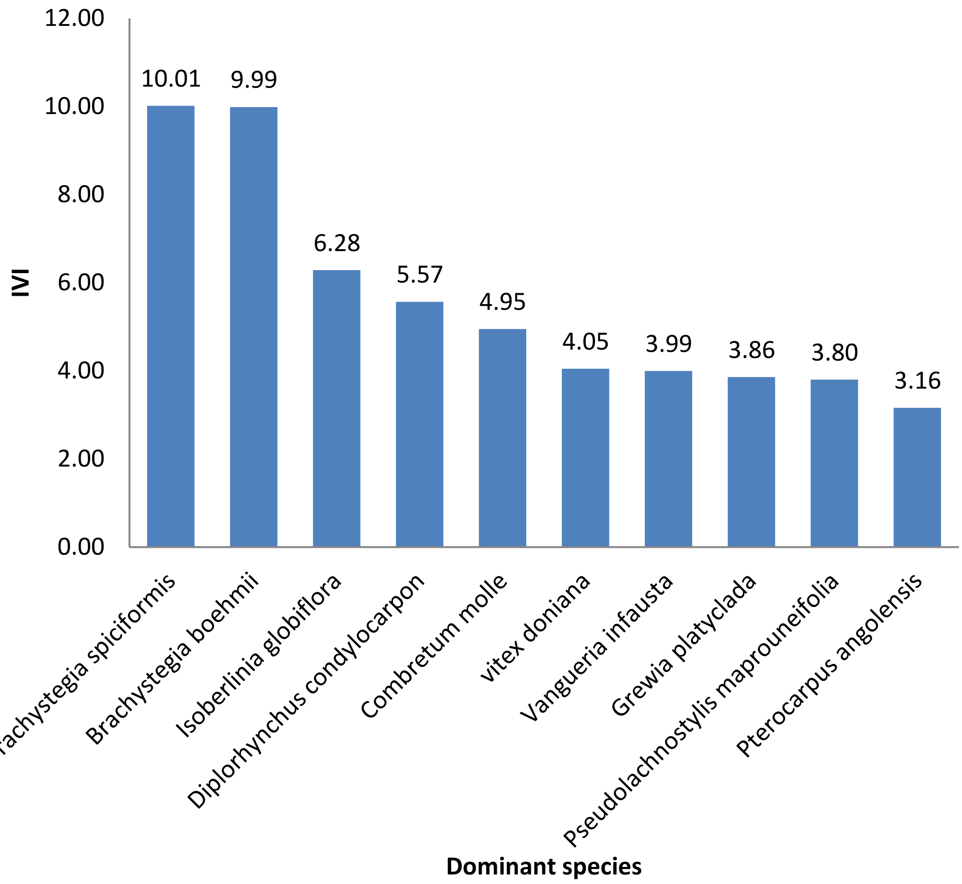

Figure 6: Dominant tree species in terms of Important Value Index (IVI) in Mbangala VLFR, Songwe, Tanzania

4.1.3 Stem density

The mean stock density was 297 stems ha^{-1}. The most abundant species in percentage were *Vangueria infausta* (11.36), *Vitex doniana* (11.36), *Grewia platyclada* (8.98) and *Dalbergia melanoxylon* (6.59). This stocking is slightly lower than that of 454 stems ha^{-1} obtained by Malimbwi *et al.* (1998) in old growth miombo at Kitulang'alo Forest Reserve, Morogoro, Tanzania. In another study carried out in the same reserve, Malimbwi and Mugasha (2001) reported a total of 352 and 561 stems ha^{-1} in miombo and Semi-evergreen forests respectively. The stems per hectare obtained from this study are relatively lower than miombo stocking reported by Nduwamungu (1996) of 691 stems ha^{-1} at Kitulang'alo SUA Training Forest. NAFORMA (2015) reported 954 stems ha^{-1}in open woodland of Chunya/Songwe district.

From the observations above it can be deduced that stocking in Mbangala VLFR is lower than other findings reported in miombo woodlands due to uncontrolled exploitation of charcoal, settlement and cultivation within forest reserve. The distribution of stem numbers per hectare follows the usual reversed J-shape (Fig. 7), common in natural forests that its frequencies decrease with increasing dbh. This is an indication of good forest recruitment and regeneration trend (Malimbwi and Mgeni, 1991; Nduwamungu, 1996).

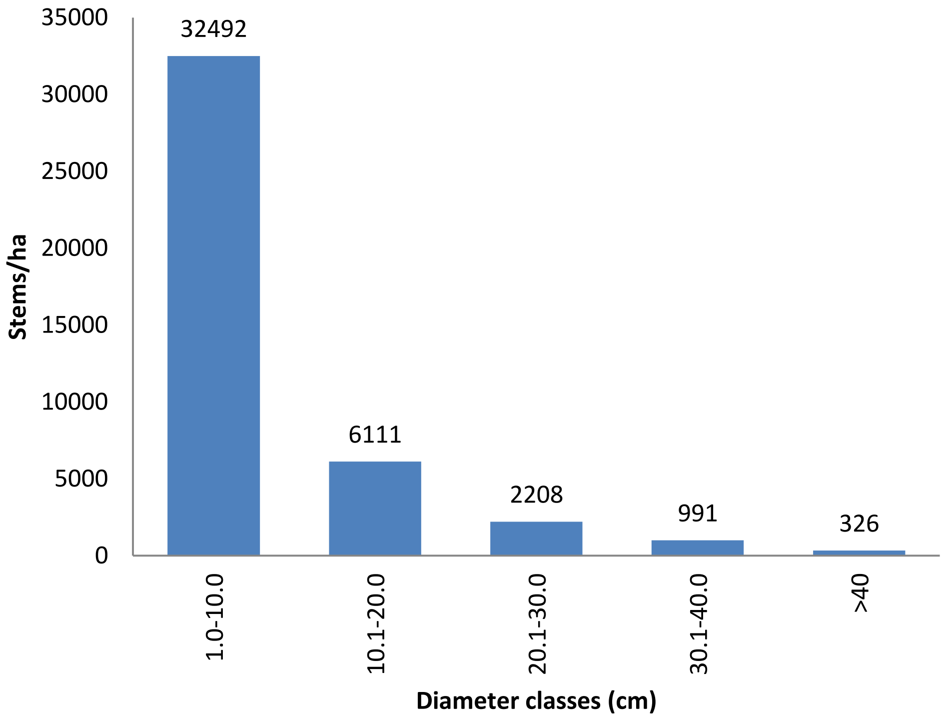

Figure 7: Density of standing trees ≥1 cm Dbh by diameter class in Mbangala VLFR

4.1.4 Basal area

The mean basal area in Mbangala VLFR was found to be 5.2m^2 ha^{-1} distributed in five diameter classes as 0.6m^2 ha^{-1} in class 1 (1.0 – 10.0cm), 0.5m^2 ha^{-1} in class 2 (10.1 – 20.0cm), 0.7m^2 ha^{-1} in class 3 (20.1-30.0cm), 1.3m^2 ha^{-1} in class 4 (30.1- 40cm) and 2.1m^2 ha^{-1} in class 5 (above 40 cm) (Fig. 8).

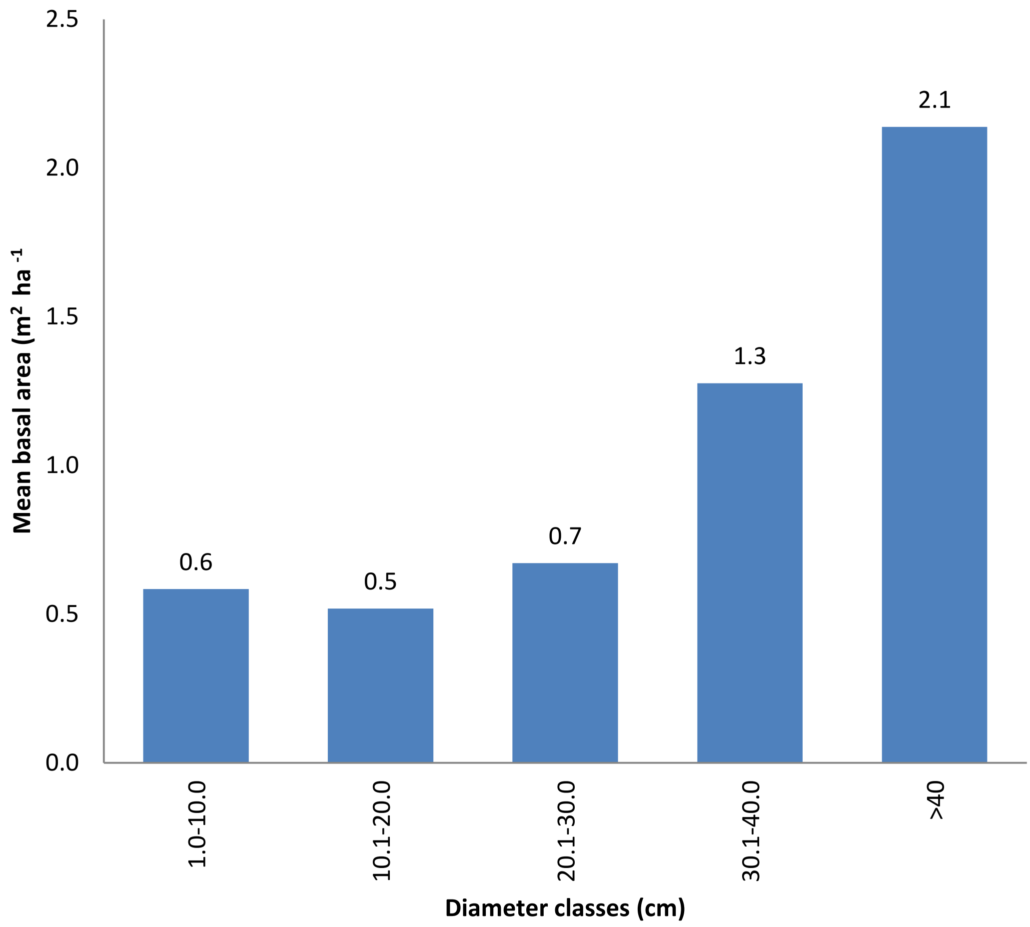

Figure 8: Distribution of basal area per hectare for standing trees ≥1 cm Dbh by diameter classes in the Mbangala VLFR

The recorded basal area of trees in old growth, mixed-age stands ranges from as little as 7m^{2}ha^{-1} in southern Malawi at about 650 mm mean annual precipitation (Lowore *et al.*, 1994) to 22m^2 ha^{-1} in wet miombo woodland on deep soils in the Democratic Republic of Congo at 1270 mm rainfall (Freson *et al.*, 1974). In another study conducted in Kilosa district, eastern-central Tanzania by Backeus *et al.* (2006), the basal area varied between 3.9 and 16.7m^2 ha^{-1}. NAFORMA (2015) reported basal area of 8.9m^2 ha^{-1} in open woodland in Chunya/Songwe district.

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

4.1.5 Volume

The mean volume was 51.15m^3 ha^{-1}. This volume is distributed in the five diameters classes as follows: 2.91 m^3 ha^{-1}, 3.72m^3 ha^{-1}, 6.06m^3 ha^{-1}, 13.32m^3 ha^{-1} and 25.14m^3 ha^{-1} in class 1 (at dbh 1.0 – 10.0cm), 2 (at dbh 10.1- 20.0cm),3 (at dbh 20.1- 30.0cm), 4 (at dbh 30.1- 40cm) and 5 (above 40 cm) respectively (Fig. 9). The species contributing most to the volume of large individuals were *Sterculia mhosya* (6.68%), *Pterocarpus tinctorius* (3.98%), *Diospyros mespiliformis* (3.48) and *Julbenardia globiflora* (3.29%).

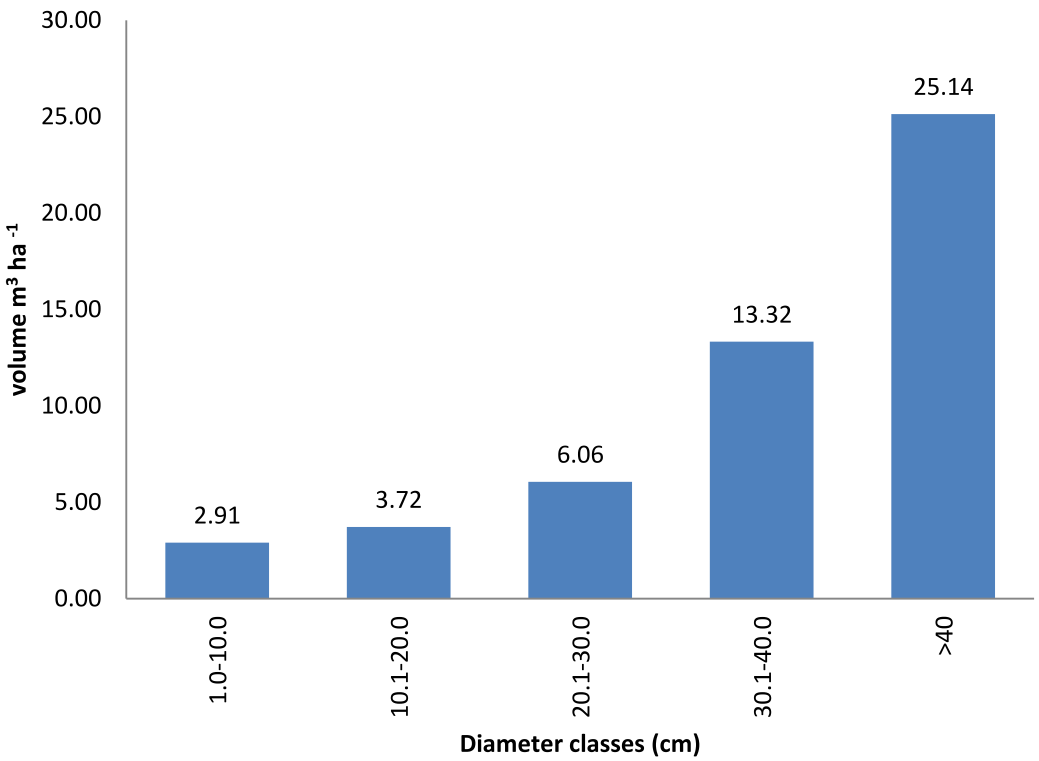

Figure 9: Volume distribution in different diameter classes at Mbangala VLFR

NAFORMA (2015) reported mean volume of 75.4m^3 ha^{-1} from Chunya/Songwe district. Volume reported in study area is small compared with the one reported by NAFORMA probably charcoal production in the forest could be the main cause of the low volume. The distribution of volume in Mbangala VLFR shows a J-shaped trend as expected in a natural forest with good recruitment.

4.1.6 Regeneration

Table 5 shows the list of regenerating woody species with dbh< 1cm in the Mbangala VLFR. The regeneration density was 12 201 stems ha^{-1} from a total of 25 different woody species. *Brachystegia spiciformis, Pseudolachnostylis maprouneifolia, Isoberlinia globiflora* and *Combretum molle* appear to contribute to the level of regeneration in the reserve. This regeneration is higher than that reported by Malimbwi and Mugasha (2001) of 4 637stems ha-1 at Kitulang'alo Forest Reserve which indicates greater disturbance in Mbangala VLFR. In another study in the Miombo woodlands stands in Kilombero Valley, Dirninger (2004) reported an average regeneration of 13 430 stems ha^{-1}. Mwakalukwa *et al.* (2014), in Gangalamtumba Village Land Forest Reserve reported an average regeneration of 14 318 stems ha $^{-1}$ which indicate greater disturbance in forest reserve. Higher regenerations indicate high level of forest disturbances. Therefore Mbangala VLFR has high regeneration as a result of greater disturbance in forest due to charcoal production and other human intervention.

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

Table 5: **List of regenerating tree species with dbh < 1cm in the Mbangala VLFR**

Botanical name	Stems/ha	Percentage
Acacia drepanolobium	255	2.1
Allophyllus africanus	85	0.7
Bauhinia petersiana (mnoga)	85	0.7
Brachystegia boehmii	1 005	8.2
Brachystegia spiciformis	2 435	20.0
Burkea africana	184	1.5
Combretum molle	1 146	9.4
Dichrostachys glomerata	28	0.2
diospyros kirkii	42	0.3
Diospyros mespiliformis	85	0.7
Diplorhynchus condylocarpon	934	7.7
Diplorhynchus mossambicensis	297	2.4
ficus sp	57	0.5
Isoberlinia globiflora	1 798	14.7
Julbernardia globiflora	439	3.6
Loranthus hildebrandtii	99	0.8
Markhamia acuminata (makamia)	28	0.2
Ochna holstii	85	0.7
Pseudolachnostylis maprouneifolia	2 180	17.9
psychotria sp	57	0.5
Pterocarpus angolensis	42	0.3
strychnos innocua (mkulwa)	283	2.3
Terminalia aemula	85	0.7
Terminalia sericea	382	3.1
vitex keniensis	85	0.7
Total	**12 201**	

4.2 Socio-economic Aspects

4.2.1 Charcoal makers

The economic, mainstay of the people in the studied village is agriculture. 100% of the interviewed respondents were doing all of the two activities essentially in their effort to subsidize income from agriculture. Charcoal production in Tanzania is known to contribute substantially to the economy of rural people in Eastern Tanzania (Monela *et al.,* 1993). It was also deduced that 98% of the interviewed people in this village were young men below 50 years and earn life through charcoal making and little farming. Charcoal making is a laborious undertaking, hence requiring physically strong and active people and may require putting them away from home over extended period of time. All people involved in charcoal making were males and belong to the ethnic tribes of Wamalila, Wabungu, Wasafwa and Wanyiha. These findings are almost similar to that of Kazimoto (2015) who reported that charcoal production in the Uyui district, Tanzania is dominated by males (100%) due to the physical nature of the activity. However 78.6% interviewed people were not born in their respective village, which implies that most of them have their origin outside the area. The marital status of these people is shown in Table 6.

In terms of education level, 17.9% of the interviewed people reported no formal education while the rest have standard seven years of primary education. Generally most of the people making charcoal in this area have low education level. The larger number of people 82.1% with just attained primary education and others having no formal education suggests that charcoal production has been considered as self-employment by the majorities who have not been employed and have failed to advance themselves in education. The study findings on education concur with Shively *et al*. (2010) who argued that charcoal producers in Uganda have the lowest level of education.

Table 6: **Marital status of charcoal makers in Mbangala village**

Marital status	**Frequency**	**Percent (%)**
married	51	91.1
single	3	5.4
separated	2	3.6
Total	**56**	**100.0**

4.2.2 The charcoal making process

Charcoal in this area is made by covering a pile of logs (rectangular pile) with earth blocks (Plate 1).

Plate 1: Typical charcoal kiln in Mbangala VLFR

Charcoal making process involves wood cutting, kiln preparation, carbonization, unloading charcoal from the kiln and finally packing in bags. The average number of days spent for each activity is shown in Table 7. The average working days per month are 20 days with 8 average working hours per day. Special months for charcoal making is between February to November where in given area there are few rains and long term of drought.

Table 7: Number of man-days spent for different steps in charcoal making process

Activity	No of days
Wood cutting	60
Kiln preparation	45
Carbonization	30
Unloading charcoal	20
Packing in bags	5
Total	**160**

Most of the charcoal makers interviewed produce more than 200 bags of charcoal of 75kg each. From Table 7 on average working days some activities are done by cooperation with other charcoal makers, these activities are kiln preparation and packing in bags.

4.2.3 Charcoal pricing

The average prices for charcoal at different market price are given in Table 8.

Table 8: **Average charcoal prices at different market place**

Market place	TZS/bag of 75kg
Kiln site	6000
At village	15 000
Mbeya city	35 000

Interview of the forest officials in Songwe district showed that no licenses are usually offered for charcoal producers and instead wholesalers are the one given license to harvest at particular forest. Charcoal makers do neither be registered no pay any levy for charcoal they make. It is the wholesalers who register themselves from the forest office to enable bulky transportation of charcoal using lorries to consumers in Mbeya city and nearby town. All of these wholesalers are from outside the area.

4.2.4 Licensing and other payable fees

The wholesalers charcoal buyers bother to be registered as charcoal dealers from which revenue goes to the government. In current Forest Act No 14 of 2002, there is no license for charcoal dealers. Only Registration form is issued, the registration fee is TZS 256 000/= paid to the government through District Forest Manager. Apart from the registration fees, other levies collected from charcoal dealers amounts to TZS 15 505/= collected by Village government and TZS 7000/= collected by District council per bag of 75kg in Songwe district. This system of levy collection is purely contradicting Forest policy of 1998 which state that “to enable sustainable management of forests on public lands, clear ownership for all forest and tree on those lands will be defined. The allocation of forests and their management responsibility to village, private individuals or the government will be promoted. Central, local and village may demarcate and establish new forest reserves” that means benefit obtained from forest owned by village should 100% owned by villagers. From this study average earning per person is between TZS 600 000 to TZS 3million. This income is considerable high, given the low education level of these charcoal makers, the income may be attractive enough even to other people to join the business, and hence more deforestation of the forest.

Plate 2: Charcoal packaged ready for sell in Mbangala VLFR

4.2.5 Local community services and development

Result from this study show that charcoal production and trading offer many opportunities and can help to alleviate poverty at multiple scales: enhanced government revenues from charcoal licensing and taxation and significant contribution to GDP nationally, meeting productive energy needs in urban areas inexpensively and potentially sustainably, and increasing household incomes for charcoal makers. In Mbangala village about TZS 70million are collected annually and the money were allocated to finance different activities in village. Revenue from CBFM were used to build Village office, Village Executive office resident, 2 teachers house in village primary school, one classroom as well as teachers office. Also village bought one motorcycle for making patrols in forest.

In Mbangala village charcoal proceeds are often used to buy agricultural inputs and can enhance agricultural productivity and food security. Charcoal incomes often provide "seed" money (capital) for alternative income generating activities, and have other positive downstream economic effects in producing areas. For example charcoal makers in Mbangala village use their money to buy iron sheets, motorcycle, cattle, milling machine, establish petty business (small shops) and tree farm in their native villages to supplement household income.

Table 9: Income sources of charcoal producers

Income source	N	Minimum	Maximum	Mean	Std. Deviation
Charcoal production	56	630 000	2 934 000	1 678 071	547 452
Selling of maize	24	100 000	400 000	212 083	87 971
Petty business	9	150 000	850 000	375 556	232 546
Cash crops	9	150 000	800 000	391 250	232 546
Others	33	150 000	850000	487 059	671 996

In Mbangala village main economic activities are agriculture, fishing, mining and small business. Cash crops produces in area are simsim and tobacco. Therefore charcoal produce considerable income for charcoal makers compared to other economic activities.

Chunya District before divided to Chunya and Songwe, collect cess from charcoal royalty of about TZS 500 million annually to be used in different development programme within district. Income from charcoal cess is among district highest collection apart from agriculture produce and mining.

Table 10: Chunya/Songwe district income trend

Year	2011/12	2012/13	2013/14	2014/15	2015/16
Charcoal	180 350 000	213 850 900	296 700 000	430 345 000	500 860 800
Mining	230 471 320	280 675 000	308 282 875	471 933 239	521 378 435
Agriculture	310 472 675	420 942 433	600 345 455	510 486 000	512 745 493

4.3 Compliance to Existing Laws and Regulations

4.3.1 Compliance of community to harvesting plan

From the list in the village only 8 wholesalers were allowed to harvest charcoal in area, but this study shows that 23 wholesalers were mentioned by charcoal makers. This implies that if harvest plan was for 8 wholesalers with 4 people per each wholesaler, excessive exploitation of the forest is going on and that means high depletion of forest resources. Survey data show that harvesting is taking place irrespective of harvesting plan. Village natural resource committee members do not supervise at all during tree cutting and most of the areas were clear felled.

Some of these clear felled areas have been invaded by Sukuma people which carry out grazing and agriculture activities within the forest. Regeneration in this Miombo woodland forest is endangered by agriculture activity in the forest which might result to depletion of all vegetation.

Plate 3: Part of clear-felled area in Mbangala VLFR, Songwe, Tanzania

From the existing harvesting plan, tree with greater than 20 cm dbh are the one to be harvested. Researcher saw many trees with less than 20 cm dbh felled down, no marking of trees by VNRC members are being done. At a time harvesting plan are prepared wood volume was 77.14 m^3 ha^{-1} equal to 717 882.94 m^3 for the whole forest, this study result revealed that wood volume is 51.15 m^3 ha^{-1} equal to 476 001.9 m^3. Annual harvesting volume from harvesting plan should be 2884.54 m^3, therefore in five years period harvested volume was supposed to be 14 422.27m^3.

The results above shows that harvested wood volume was 241 884.04 m^3 equal to 48 376 m^3per year. This mean harvestable volume in each year is 17 times more than it required, which result to high depletion of forest resource and endanger benefit obtained from forest reserve.

4.3.2 Compliance of community to existing laws and regulations

The Village Natural Resource Committee has total of 20 members, 10 members from village assembly and other 10 members from village government. Currently this committee has 15 members whom are selected after every three years. 2011 formulation of village by laws to protect the forest reserve were established. Number of forest patrols is two per week in every Monday and Thursday, whereby two members of the committee patrols the forest by using motorcycle brought from revenue collected. Among the success of patrols were to confiscate 180 bags of charcoal which were transported without permit and 30 pieces of timber. In general very few forest produce were confiscated.

Within the forest there are settlement made mostly by Sukuma people who carried on grazing and agriculture practice in the forest. Large part of the forest is already turned to farmland and big number of cattle herd was observed.

Forest act No 14 of 2002 prohibit grazing, cultivation and settlement within forests boundaries, evidence from this study shows that all these prohibited activities are being done in Mbangala VLFR at accelerating rate which might jeopardize the whole meaning of CBFM.

Plate 4: Livestock graze near cultivated area in Mbangala VLFR,

During focus group discussion Village Executive Officer reported that, there is contradiction on evicting those people, because of shortage of resource that is security and money, as well as political interference in given chaos. District Executive Director issue receipt book to VEO inorder to collect revenue from cattle auction which has been established within village forest boundaries.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 Forest resource base

Basing on the forest resource base results it can be concluded that, the Mbangala VLFR is over exploited for charcoal making and other severe human disturbance. This is evidenced by low tree stocking, less basal area and volume as compared to other reported Miombo woodlands, existing Forest Management Plan and NAFORMA report. This implies that if the current trend of exploitation is not controlled, there is a danger of destruction or decimation of the forest reserve.

5.1.2 Socio-economic aspects

Charcoal extraction provides substantial income to charcoal makers of Mbangala village. As regards to community development, the result shows that, CBFM has been contributing much to development projects in health, education and good governance. Revenue collected by village government has significant effect on development of the village, though it does seem there no transparent on collection of revenue.

5.1.3 Compliance to existing laws and regulations

This study demonstrated that charcoal production in the village does not follow existing laws and regulation. Having 23 wholesalers names instead of 8 found in village register shows there were poor record keeping and control of charcoal business in the village. The policy implication is that the increased demand for charcoal from the growing urban population with no reliable and affordable alternative sources of energy is likely to cause high loss of forest resources.

5.2 Recommendations

5.2.1 Forest resource base

In the face of increasing population and the demand for agricultural land, the forest may not be given enough room to regenerate. This calls for appropriate management strategies to ensure regeneration so that the remaining woodlands continue to supply charcoal to Mbeya City and other urban areas. Furthermore all people who invaded the forest and conducting agriculture and animals husbandry should be evicted.

5.2.2 Socio-economic aspects

There is a need to intensify political will and priority for ensuring forest conservation programmes at local level particularly related to the community livelihood improvements and poverty reduction components are well supervised and improved. There should be transparency and auditing of all revenue from forests.

5.2.3 Compliance to existing laws and regulations

To reduce over harvesting by charcoal makers, harvesting plans should be revised in comply with available forest resources and existing laws. VNRCs with the help of village governments should make concerted efforts to stop the prevailing forest disturbances by increasing the number of forest patrols and evicting all invaders.

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APPENDICES

Appendix 1: Tree species checklist for Mbangala VLFR Local name in Bungu, Malila, Nyiha, Safwa and Nyakyusa languages spoken in Mbangala village

Botanical name	Local name	Genus	Family
Acacia abyssinica	mgunga	Acacia	Mimosaceae
acacia drepanolobium	mluzi	Acacia	Mimosaceae
Acacia nigrescens	msengele	Acacia	Mimosaceae
Acacia polyacantha	obwi	Acacia	Mimosaceae
Acacia sp	livindwe	Acacia	Mimosaceae
Afzelia quanzensis	mkola	Afzelia	Caesalpiniaceae
Albizia amara	mporogoro	Albizia	Mimosaceae
Albizia petersiana	mkalale	Albizia	Mimosaceae
allophyllus africanus		Allophyllus	Sapindaceae
Bauhinia petersiana	mnoga	Bauhunia	Caesalpiniaceae
Bauhunia sp	nangue	Bauhunia	Caesalpiniaceae
Boscia salicifolia	mvuuti	Boscia	Capparanceae
Brachystegia boehmii	miombo	Brachystegia	Caesalpiniaceae
Brachystegia longifolia	myombwe	Brachystegia	Caesalpiniaceae
Brachystegia spiciformis	miombo	Brachystegia	Caesalpiniaceae
Burkea africana	mgando	Burkea	Caesalpiniaceae
Cassia abbreveata	mzoka	Cassia	Caesalpiniaceae
Cassipourea mollis	mulugati	Cassipourea	Rhizophoraceae
catunaregam spinosa	mchong'oko	catunaregam	Rubiaceae
Combretum molle	mlama	Combretum	Combretaceae
Combretum quainzii	mlama	Combretum	Combretaceae
Combretum tenuiapicatum	singila	Combretum	Combretaceae
Combretum zeyheri	msanati	Combretum	Combretaceae
Commiphora africana	Ntonto	Commiphora	Burseraceae
Cordia sinensis	mdavi	Cordia	Boraginaceae
Crossopteryx febrifuga	msasambega	Crossopteryx	Rubiaceae
Dalbegia melanoxylon	mpingo	Dalbegia	Papilionaceae
Dalbergia nitidula	kalongwe	Dalbegia	Papilionaceae
Dichrostachys cinerea	mtundulu	Dichrostachys	Mimosaceae
Dichrostachys glomerata	mtundulu	Dichrostachys	Mimosaceae
Diospyros kirkii	mnumbulu	Diospyros	Ebenaceae
Diospyros mespiliformis	msimbe	Diospyros	Ebenaceae
Diplorhynchus condylocarpon	msongo	Diplorhynchus	Apocynaceae
Diplorhynchus mossambicensis	mtogo	Diplorhynchus	Apocynaceae
Euclea natalensis	muheche	Euclea	Ebenaceae
Fadogia ancylantha	mandunguli	Fadogia	Rubiaceae
Ficus sp	mnembwe	Ficus	Moraceae

Diplorhynchus condylocarpon	msongo	Diplorhynchus	Apocynaceae
Diplorhynchus mossambicensis	mtogo	Diplorhynchus	Apocynaceae
Euclea natalensis	muheche	Euclea	Ebenaceae
Fadogia ancylantha	mandunguli	Fadogia	Rubiaceae
Ficus sp	mnembwe	Ficus	Moraceae
Grewia platyclada	mpelemense	Grewia	Tiliaceae
Isoberlinia angolensis	muwapa	Isoberlinia	Caesalpiniaceae
Isoberlinia globiflora	miombo	Isoberlinia	Caesalpiniaceae
Julbernardia globiflora	mkorongo	Julbernardia	Caesalpiniaceae
Kigelia africana	mvungwa	Kigelia	Bignoniaceae
Lannea schimperi	muumbu	Lannea	Anacardiaceae
Lannea sp	mulumbu	Lannea	Anacardiaceae
Lannea stuhlmannii	mnyumbuti	Lannea	Anacardiaceae
Lonchocarpus eriocalyx	muale	Lonchocarpus	Fabaceae
Loranthus hildebrandtii	mkole	Loranthus	Loranthaceae
Makhamia obtusifolia	mbapa	Makhamia	Bignoniaceae
Makhamia acuminata	makamia	Makhamia	Bignoniaceae
Ochna holstii	mkwati	Ochna	Ochnaceae
Ormocarpum kirkii	mhomba	Ormocarpum	Papilionaceae
Ozoroa mucronata		Ozoroa	Anacardiaceae
Pericopsis angolensis	muanga	Pericopsis	Fabaceae
Piliostigma thonningii	mtukutu	Piliostigma	Papilionaceae
Polyscias fulva	mfumbata	Polyscias	Araliaceae
Pseudolachnostylis maprouneifolia	msolo	Pseudolachnostylis	Euphorbiaceae
psychotria sp		psychotria	Rubiaceae
Pterocarpus angolensis	mninga	Pterocarpus	Fabaceae
Pterocarpus chrysothrix	mkula	Pterocarpus	Fabaceae
Pterocarpus tinctorius	mninga maji	Pterocarpus	Fabaceae
Schrebera trichoclada	mputika	Schrebera	Oleaceae
Steganotaenia sp	mnyongapembe	Steganotaenia	Steganotaenia
Sterculia mhosya	mfyosya	Sterculia	Sterculiaceae
strychnos innocua	mkulwa	strychnos	Loganiaceae
Strychnos sp	mdengeko	strychnos	Loganiaceae
Syzygium guineense	mzambarau pori	Syzygium	Myrtaceae
Tabernaemontana holstii	mlongelonge	Tabernaemontana	Apocynaceae
Terminalia aemula	mkulungu	Terminalia	Combretaceae
Terminalia brownii	mndwedwe	Terminalia	Combretaceae
Terminalia mollis	msanza	Terminalia	Combretaceae
Terminalia sericea	mshisha	Terminalia	Combretaceae
Terminalia sp	mkulungu	Terminalia	Combretaceae
Vangueria infausta	msada	Vangueria	Rubiaceae
vitex doniana	mfulu	vitex	Verbanaceae
vitex keniensis	mfutu	vitex	Verbanaceae
Xanthoxylum chalybeum		xanthoxylum	Rutaceae
Ximenia americana	mhundwa	ximenia	Olacaceae
Ziziphus mauritiana	mkunazi	ziziphus	Rhamnaceae

Appendix 2: Checklist of tree species recorded in Mbangala VLFR showing frequency, density (mean •} SE), basal area (mean •} SE), and Importance Value Index (IVI), for the current population (plot size = 15m radius; minimum Dbh = 1 cm)

Botanical name	Frequency	Density (stem/ha)	Basal area (m^2/ha)	Volume (m^3/ha)	IVI
Acacia abyssinica	2	80 ± 68	0.50 ± 0.20	2.87 ± 0.78	0.57
Acacia drepanolobium	12	96 ± 47	0.53 ± 0.25	3.01 ± 1.53	1.63
Acacia nigrescens	5	47 ± 45	0.55 ± 0.22	3.92 ± 2.11	0.72
Acacia polyacantha	6	20 ± 9	0.59 ± 0.22	4.98 ± 2.61	0.71
Acacia sp	8	115 ± 34	0.56 ± 0.18	3.10 ± 1.27	1.35
Afzelia quanzensis	1	14	0.69	6.28	0.18
Albizia amara	3	318 ± 415	0.63 ± 0.24	3.16 ± 1.23	1.83
Albizia petersiana	4	413 ± 440	0.65 ± 0.50	2.93 ± 1.90	2.40
Bauhunia sp	3	96 ± 55	0.33 ± 0.07	1.72 ± 0.67	0.70
Boscia salicifolia	1	32	0.72	5.47	0.26
Brachystegia boehmii	76	23 ± 23	0.94 ± 0.53	9.19 ± 6.82	9.99
Brachystegia longifolia	1	32	0.63	4.64	0.26
Brachystegia spiciformis	83	38 ± 90	0.79 ± 0.38	7.21 ± 4.80	10.01
Burkea africana	23	17 ± 7	0.78 ± 0.30	7.26 ± 3.61	2.78
Cassia abbreveata	1	32	0.47	3.21	0.25
Cassipourea mollis	3	64 ± 55	0.42 ± 0.22	2.40 ± 1.11	0.57
catunaregam spinosa	2	80 ± 68	0.26 ± 0.01	1.35 ± 0.39	0.53
Combretum molle	48	70 ± 115	0.51 ± 0.21	3.35 ± 1.74	4.95
Combretum quainzii	1	32	0.65	4.78	0.26
Combretum tenuiapicatum	1	32	0.31	1.91	0.23
Combretum zeyheri	9	229 ± 324	0.60 ± 0.30	4.24 ± 4.03	2.02
Commiphora africana	4	71 ± 65	0.70 ± 0.29	5.33 ± 3.66	0.78
Cordia sinensis	1	14	0.59	5.12	0.17
Crossopteryx febrifuga	3	14	0.62 ± 0.17	5.50 ± 1.89	0.38
Dalbegia melanoxylon	2	461 ± 471	0.73 ± 0.68	2.98 ± 2.69	2.42
Dalbergia nitidula	2	23 ± 13	0.69 ± 0.33	5.52 ± 2.62	0.33
Dichrostachys cinerea	4	80 ± 55	0.39 ± 0.17	2.09 ± 0.80	0.73
Diospyros kirkii	5	25 ± 10	0.69 ± 0.38	6.11 ± 4.60	0.67
Diospyros mespiliformis	5	14	1.16 ± 0.25	11.87 ± 3.14	0.80
Diplorhynchus condylocarpon	44	147 ± 212	0.69 ± 0.53	4.92 ± 6.39	5.57
Diplorhynchus mossambicensis	3	32	0.45 ± 0.06	3.06 ± 0.53	0.43
Euclea natalensis	3	64 ± 55	0.54 ± 0.27	3.31 ± 1.49	0.60
Fadogia ancylantha	1	32	0.25	1.48	0.23
Grewia platyclada	8	627 ± 308	0.66 ± 0.34	2.51 ± 1.36	3.86
Isoberlinia angolensis	3	20 ± 10	0.75 ± 0.42	7.00 ± 4.91	0.44
Isoberlinia globiflora	48	17 ± 6	0.93 ± 0.58	9.31 ± 7.61	6.28
Julbernardia globiflora	4	23 ± 10	1.08 ± 0.81	11.22 ± 10.15	0.67

Kigelia africana	1	32	0.87	6.82	0.28
Lannea schimperi	8	35 ± 38	0.67 ± 0.28	5.67 ± 3.55	1.04
Lannea sp	3	64 ± 55	0.58 ± 0.26	3.72 ± 1.60	0.61
Lannea stuhlmannii	8	25 ± 9	0.92 ± 0.71	9.21 ± 8.94	1.15
Lonchocarpus eriocalyx	4	23 ± 10	0.61 ± 0.16	4.87 ± 1.30	0.53
Loranthus hildebrandtii	1	32	0.27	1.63	0.23
Makhamia obtusifolia	4	127	0.49 ± 0.14	2.51 ± 0.89	0.99
Ochna holstii	2	14	0.50 ± 0.02	4.24 ± 0.21	0.26
Ormocarpum kirkii	2	32	0.28 ± 0.04	1.68 ± 0.28	0.31
Ozoroa mucronata	2	80 ± 68	0.56 ± 0.36	3.22 ± 1.91	0.58
Pericopsis angolensis	6	17 ± 7	0.88 ± 0.39	8.43 ± 4.99	0.83
Piliostigma thonningii	2	80 ± 68	0.71 ± 0.39	5.04 ± 4.12	0.60
Polyscias fulva	4	80 ± 55	0.56 ± 0.24	3.29 ± 1.33	0.78
Pseudolachnostylis maprouneifolia	34	45 ± 40	0.63 ± 0.22	4.82 ± 2.36	3.80
Pterocarpus angolensis	26	29 ± 30	0.77 ± 0.44	6.95 ± 5.53	3.16
Pterocarpus chrysothrix	2	127	0.75 ± 0.19	4.15 ± 1.32	0.84
Pterocarpus tinctorius	1	14	1.29	13.40	0.22
Schrebera trichoclada	1	14	0.58	5.01	0.17
Steganotaenia sp	2	80 ± 68	0.53 ± 0.16	3.07 ± 0.49	0.57
Sterculia mhosya	1	14	1.98	22.81	0.28
Strychnos sp	4	127	0.53 ± 0.24	2.75 ± 1.48	1.00
Syzygium guineense	2	14	0.81 ± 0.09	7.65 ± 1.03	0.31
Tabernaemontana holstii	2	127	0.81	4.57	0.85
Terminalia aemula	4	51 ± 51	0.53 ± 0.25	3.77 ± 2.60	0.64
Terminalia brownii	1	32	0.38	2.46	0.24
Terminalia mollis	1	127	0.46	2.2±	0.70
Terminalia sericea	10	38 ± 32	0.56 ± 0.23	4.25 ± 2.31	1.18
Terminalia sp	9	92 ± 54	0.77 ± 0.24	5.28 ± 3.04	1.48
Vangueria infausta	2	794	0.60 ± 0.05	2.06 ± 0.23	3.99
vitex doniana	2	794	0.94 ± 0.31	3.60 ± 1.43	4.05
Xanthoxylum chalybeum	2	127	0.74 ± 0.10	4.10 ± 0.66	0.84
Ximenia americana	1	127	0.29	1.30	0.69
Ziziphus mauritiana	1	32	0.36	2.32	0.24

Appendix 3: Shannon and Simpson diversity indices in Mbangala VLFR

SPECIES NAME	(ni)	(pi)	ln pi	pi(ln pi)	
Acacia abyssinica	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Acacia drepanolobium	12	0.020408163	-3.8918203	-0.0794249	0.00038244
Acacia nigrescens	5	0.008503401	-4.767289	-0.04053817	0.00005794
Acacia polyacantha	6	0.010204082	-4.5849675	-0.04678538	0.00008692
Acacia sp	8	0.013605442	-4.2972854	-0.05846647	0.00016225
Afzelia quanzensis	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Albizia amara	3	0.005102041	-5.2781147	-0.02692916	0.00001738
Albizia petersiana	4	0.006802721	-4.9904326	-0.03394852	0.00003477
Bauhunia sp	3	0.005102041	-5.2781147	-0.02692916	0.00001738
Boscia salicifolia	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Brachystegia boehmii	76	0.129251701	-2.0459936	-0.26444815	0.01651427
Brachystegia longifolia	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Brachystegia spiciformis	83	0.141156463	-1.9578863	-0.27636831	0.01971862
Burkea africana	23	0.039115646	-3.2412327	-0.12678291	0.00146600
Cassia abbreveata	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Cassipourea mollis	3	0.005102041	-5.2781147	-0.02692916	0.00001738
catunaregam spinosa	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Combretum molle	48	0.081632653	-2.5055259	-0.20453273	0.00653617
Combretum quainzii	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Combretum tenuiapicatum	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Combretum zeyheri	9	0.015306122	-4.1795024	-0.06397198	0.00020860
Commiphora africana	4	0.006802721	-4.9904326	-0.03394852	0.00003477
Cordia sinensis	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Crossopteryx febrifuga	3	0.005102041	-5.2781147	-0.02692916	0.00001738
Dalbegia melanoxylon	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Dalbergia nitidula	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Dichrostachys cinerea	4	0.006802721	-4.9904326	-0.03394852	0.00003477
Diospyros kirkii	5	0.008503401	-4.767289	-0.04053817	0.00005794
Diospyros mespiliformis	5	0.008503401	-4.767289	-0.04053817	0.00005794
Diplorhynchus condylocarpon	44	0.074829932	-2.5925373	-0.19399939	0.00548158
Diplorhynchus mossambicensis	3	0.005102041	-5.2781147	-0.02692916	0.00001738
Euclea natalensis	3	0.005102041	-5.2781147	-0.02692916	0.00001738
Fadogia ancylantha	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Grewia platyclada	8	0.013605442	-4.2972854	-0.05846647	0.00016225
Isoberlinia angolensis	3	0.005102041	-5.2781147	-0.02692916	0.00001738
Isoberlinia globiflora	48	0.081632653	-2.5055259	-0.20453273	0.00653617

Julbernardia globiflora	4	0.006802721	-4.9904326	-0.03394852	0.00003477
Kigelia africana	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Lannea schimperi	8	0.013605442	-4.2972854	-0.05846647	0.00016225
Lannea sp	3	0.005102041	-5.2781147	-0.02692916	0.00001738
Lannea stuhlmannii	8	0.013605442	-4.2972854	-0.05846647	0.00016225
Lonchocarpus eriocalyx	4	0.006802721	-4.9904326	-0.03394852	0.00003477
Loranthus hildebrandtii	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Makhamia obtusifolia	4	0.006802721	-4.9904326	-0.03394852	0.00003477
Ochna holstii	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Ormocarpum kirkii	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Ozoroa mucronata	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Pericopsis angolensis	6	0.010204082	-4.5849675	-0.04678538	0.00008692
Piliostigma thonningii	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Polyscias fulva	4	0.006802721	-4.9904326	-0.03394852	0.00003477
Pseudolachnostylis maprouneifolia	34	0.057823129	-2.8503664	-0.16481711	0.00325070
Pterocarpus angolensis	26	0.044217687	-3.1186304	-0.13789862	0.00188321
Pterocarpus chrysothrix	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Pterocarpus tinctorius	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Schrebera trichoclada	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Steganotaenia sp	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Sterculia mhosya	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Strychnos sp	4	0.006802721	-4.9904326	-0.03394852	0.00003477
Syzygium guineense	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Tabernaemontana holstii	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Terminalia aemula	4	0.006802721	-4.9904326	-0.03394852	0.00003477
Terminalia brownii	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Terminalia mollis	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Terminalia sericea	10	0.017006803	-4.0741419	-0.06928813	0.00026075
Terminalia sp	9	0.015306122	-4.1795024	-0.06397198	0.00020860
Vangueria infausta	2	0.003401361	-5.6835798	-0.0193319	0.00000579
vitex doniana	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Xanthoxylum chalybeum	2	0.003401361	-5.6835798	-0.0193319	0.00000579
Ximenia americana	1	0.00170068	-6.3767269	-0.01084477	0.00000000
Ziziphus mauritiana	1	0.00170068	-6.3767269	-0.01084477	0.00000000
				-3.29439774	**0.06398266**

Appendix 4: Sample plot field form

INVENTORY FORM

Forest name...........................

Plot no……..........of.....................

Eastings ....…

Northings……………….……

Plot size……………………

Altitude (m)………………….

Date………………………

Vegetation type…………………………

Area (Ha)………………

Tree no.	Species name	DBH (cm)	Total Height (m)	Remarks

General observations

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………

REGENERATION
Radius 1m

		Number of seedlings and saplings
No.	Species name (+ Dialect)	DBH< 1cm
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Remarks

Appendix 5: Questionnaires

Charcoal makers Questionnaire

Serial number……………………………………………………………………
Name of respondent……………………………………………………………..
Village…………………………………Ward………………………………..
Date………………………………………

Part one: Basic Information.

1. Sex of respondent
01 male 02 Female ………………………………………………
2. Age in years ………………………………………………….
3. Place of birth …………………………………………………
01 in the village 02 not in the village
4. Did you shift from another village to this village …………………
01 Yes 02 No
5. If yes, Years of residence in this village…………………………..
6. Education level …………………………………………………….
01 illiterate 02 primary education 03 Ordinary secondary school
04 Advanced secondary school 05 vocational training 06 College
07 University 08 others specify…………………………………………….
7. Marital status ……………………………………………………………….
01 married 02 single 03 divorced 04 widow 05 separated
8. Total number of household members ……………………………………….
9. Were you living in this village before CBFM was introduced?
01 YES, 02 NO ………………………………………………..
10. What changes you consider to have taken place significantly in your village?
……………………………………………………………………………………
……………………………………………………………………………………

Part Two: Charcoal making activity

11. What is present state of the forest?
1. Good 2.Bad
If bad, why?...
12. Is marking charcoal an important activity in the village?
(i) Yes
(ii) No
13. When did you start harvesting charcoal in this forest? In years……..
14. What made you engage in this business?
……………………………………………………………………………..
……………………………………………………………………………..
……………………………………………………………………………..
15. Are you working under contract production? Yes/No
If yes, who own the business?...
And where does she/he stays ………………………………………………...
16. Average working days in month…………………………………………

17. Average working hours in day…………………………………………..
18. Species preferred for charcoal production
 ………………………………………………………………
19. When you make charcoal do you select trees or clear the area completely? Yes/No
If yes, what tree species and average size are cut?

Species	**Average size cut**

20. Are there special months during which you cut tree and make charcoal? Yes/No
If yes, specify the months ………………………………………..
21. Is there any tree regeneration in charcoal making site? Yes/No
If yes, what types of tree do regenerate?
 (i) Those used for charcoal making
 (ii) Those not used for charcoal making
 (iii) Both types
22. Is the forest cover generally better since you started charcoal making? Yes/No
If yes, why? …………………………………………………………..
If no, why? ………………………………………………………………
23. What rules are used to regulate exploitation of trees for charcoal making?
 ……………………………………………………………………….

Part Three. Economic Security (Income and Assets)
24. Specify charcoal prices in market places

Name of market place	**Price (TZS/bag of ……kg)**
Charcoal making site	
Village	
Urban centre	

25. How many bags /kg do you produce per year? …………
26. Diversification of income sources

Income source	**Earning per year (TZS)**
Charcoal selling	
Selling of cash crops (list them)	
Selling of maize	
beekeeping	
Petty business	

27. How do you use money obtained from charcoal selling?
 …………………………………………………………………
 ………………………………………………………………….
 ………………………………………………………………….
28. Do you have any asset bought by money from charcoal selling? Yes/No
If yes, mention and its costs………………………….

29. What are your comments on charcoal business and CBFM programme in general?
…………………………………………………………………………………….
……………………………………………………………………………………..
…………………………………………………………………………………….

THANK YOU FOR YOUR TIME AND ATTENTION

Appendix 6: Checklist for key informant survey

A: Village government and Village Natural Resource Committee

1. Social services in the village
2. Main economic activities in the village
3. Average earning from each activity
4. Area of the forest and forest condition before and after CBFM
5. Formulation and strength of VNRC in protection and conservation of forest
6. Formulation and strength of village bylaws
7. Benefits villagers get from the forest
8. No of people who harvest charcoal legally in the forest
9. Revenue village charge per bag/kg of charcoal
10. Revenue collected in each year since starting harvesting under CBFM
11. Is there any forest management plan or harvesting plan used
12. No of forest patrols per month
13. Presence of receipt books and ledger
14. Revenue from fines and confiscated products from forest
15. How is distribution of revenue is done?
16. Is there any development activity in village funded by revenue from CBFM
17. Fire occurrence, illegal acts and encroachment in forest reserve
18. Comments on CBFM and charcoal trade

THANK YOU FOR YOUR TIME AND ATTENTION

B. District Forest Officer/District Forest Manager

1. When did CBFM start in your district?
2. Total area in hectare of forests under CBFM
3. No and area in hectare of CBFM forests declared and gazetted
4. How did you regulate charcoal extraction in CBFM forest
5. Revenue obtained per annum from charcoal royalty
6. Weakness and strength of CBFM and its impact to sustainability of forests
7. Sustainability of income generating sources and alternative use of forest resource
8. Collaboration between district officers and village government
9. Comments and future prospects

THANK YOU FOR YOUR TIME AND ATTENTION