IMPACTS OF PARTICIPATORY FOREST MANAGEMENT ON FOREST CONDITIONS AND LIVELIHOODS IN TANZANIA: A CASE STUDY OF MONDULI CATCHMENT FOREST RESERVE.

BY

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ABSTRACT

Wide acceptance of sustainable development as a concept and as the goal of forest management has shifted policies from a traditional to people oriented approach. Tanzania mainland is exercising Participatory Forest Management (PFM) since 1994 aiming at protecting the forests from unplanned exploitation, making the forest products and services available while preserving the ecosystem, hence contributing to sustainable development and alleviating poverty. Today about 9.5% of the country's forests and woodlands are under PFM programme. This study aimed to analyse the impact of PFM on vegetation attributes in Monduli forest reserve and livelihood of the adjacent communities. Forest assessment was done through 56 sample plots laid down randomly, while socio-economic survey was conducted in 74 households. Generally, the study showed that involvement of local people is the reliable management tool in reserved forest areas. However, long term support of the people is fundamental. Findings indicated that, forest condition is now better than when under non-PFM situation. Average number of trees has increased from 311±43 to 1156±111 in 1999 and 2006 respectively. Mean basal area has also increased from 27.1±2.5 m^2ha^{-1} in 1999 to 37±4.7 in 2006. On the other hand, PFM showed to have no significant contribution to the average volume as the 346±68.78 m^3h^{-1} observed in 2006 was low compared to 393±47 m^3h^{-1} recorded in 1999. As regard to livelihood, the study revealed that, PFM have less contributed to the livelihoods of the forest adjacent communities. However, PFM has contributed to stabilisation of the resource base for various livelihood activities such as, forest pasturage/fodder; availability of herbal medicine; and use of brush wood both as fuel and for household needs. The study recommends for local communities to have more sufficient incentives to properly participate in PFM initiatives.

DECLARATION

I, Deusdedit Kamalamo Bwoyo, do hereby declare to the Senate of the Sokoine University of Agriculture that, the content of this dissertation is my original research work which has never been submitted for the award of any other degree or diploma or other similar titles in any other University.

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Deusdedit Kamalamo Bwoyo Date

(MSc Candidate)

The above declaration is confirmed

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Prof. R.E. Malimbwi Date

(Supervisor)

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DEDICATION

This work is dedicated to my beloved parents, Euphrasia and Ferdinand who raised me to see the all nature as a celebration of life.

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ABBREVIATIONS AND ACRONYMS

CANARI	Caribbean Natural Resources Institute
CBNRM	Community Based Natural Resources Management
CBWM	Community based Wildlife Management
CBC	Community based conservation
CF	Catchments Forestry
DBH	Diameter at breast Height
DRC	Democratic Republic of Congo
FAO	Food and Agriculture Organization
FBD	Forestry and beekeeping Division
GEF	Global Environmental Facility
ICDP	Integrated Conservation and development Programmes
JFM	Joint Forest Management
MFR	Monduli Forest Reserve
MNRT	Ministry of National Resources and Tourism
NGO	Non governmental Organization
NTFP	Non timber forest products
NEMC	National Environmental Council
PFM	Participatory Forest Management
PAOP	Protected Area Outreach Programme
SNAL	Sokoine National Agriculture library
SPSS	Statistical package for social science
SPH	Stems per hectare
TZS	Tanzanian Shillings
UNDP	United Nations Development Programme
URT	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

Tanzania has a total area of about 945 000 km², of which the mainland covers about 881 000 km² and Zanzibar covers about 2000 km². The remaining 62 000 km² is covered by water (URT, 2006). The country is well – endowed from natural resource point of view with forests and woodland covering a total of about 38.8 million hectares (MNRT, 2002). This constitutes 41% of the total land area in the mainland (Fig. 1). Out of the total forest area, 57% are classified as forests in non-reserved land, 37% as forest reserves, while 6% are forests in National Parks. Further, based on forest types, the forests in Tanzania are categorized as woodlands that cover 96%, and montane forests and mangroves occupying 4% of the total forestland (Kijazi, 2006).

Tanzania followed the colonial approach of command and control in forest management until recent times. Important policy initiatives were undertaken to change this approach in 1998. Since then, “participatory” forestry has been gradually maturing. Although “participatory” forestry is a modern concept, “community” management has a long history. The local village communities in the pre-colonial era, used to control and manage forest resources fairly. The forests were by then communal properties with no private claim by individuals, and all the members of a community had access to forests for their needs.

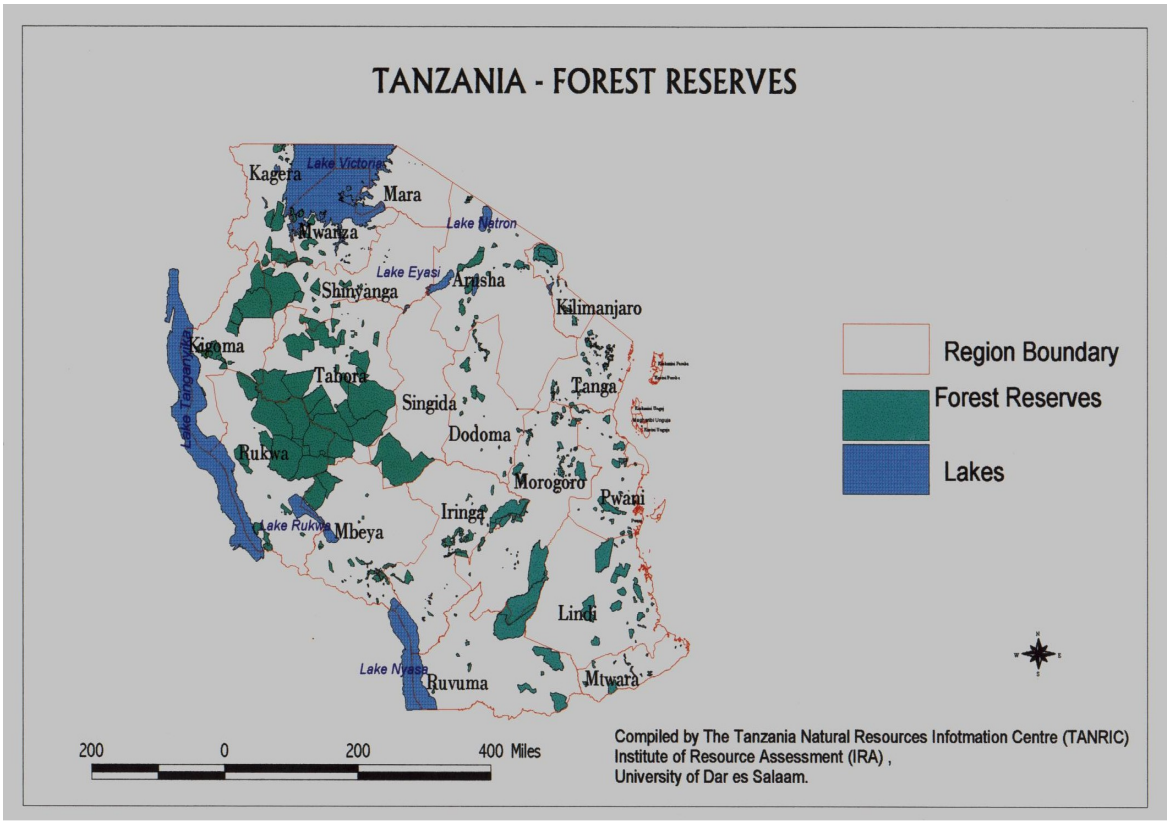

Figure 1: Map of Tanzania showing distribution of forest reserves.

Source: MNRT (2002).

Despite the fact that, during the pre-colonial period, there were few incentives for the tribal communities to conserve forests, as there existed vast tracts of healthy forests with low utilization pressure, conservative use of the resources was in practice. Restrictions on reckless and indiscriminate exploitation have always been the foundation of the social and cultural institutions developed by people in various forest areas. Before colonial era, social laws and norms in place ensured that even as human beings extracted their needs from the forests, the rate of extraction did not exceed the natural growth, which avoided resource depletion. Nevertheless, this situation changed during colonial and post-colonial period whereby the forest communities then became “intruders” and “aliens” over the state property (Kihiyo and Kajembe, 2000).

According to MNRT (2002), the forests offer habitat for wildlife, beekeeping, unique natural ecosystems and genetic resources as well as forming an important economic base for the country's development. The forests and woodland resources however, face both ecological and socio-economic threats which escalate the rate of resource base degradation. This has been caused by a number of factors including, poverty, agriculture expansion and lack of alternative income sources; firewood and charcoal production; wood based industries and related business; impact of refugees; and forest fires, natural/man-made disasters and climate change (MNRT, 2004). About 90% of the poorest of the poor live in rural areas (URT, 2000). Rural communities mostly rely on forest resources for their livelihoods and hence contributing to some negative impacts on the forests. Hamza and Makonda (1998) reported that, the forest cover in Tanzania was more than 50% before independence, about 45% in the late 1970s, and 41% in 2002. This implies that the country has lost 9% of forest land over a period of 40 years. Furthermore, Idd (2002) reported that, deforestation in forest estates in Tanzania currents takes place at a rate of 91 200 ha per annum. With an estimated value of USD 1500/ha/year, deforestation represents an annual loss of USD 136.5 million (Monela and Salmi, 2000). It is needless to say therefore that, the forests and woodland resources need proper management for the benefit of the present and future generations.

1.2 Problem statement and study justification

The Catchment forests provide a stream of benefits locally, nationally and globally. However, these benefits are being jeopardized by increased human pressure, commercialization of the resources and decreased government capacity for law enforcement. It is for this reason that the government of Tanzania has introduced Participatory Forest Management (PFM) as the best management approach. The introduction of PFM is aimed to protect the forests from unplanned exploitation, making

the forest products and services available while preserving the ecosystem, hence contributing to sustainable development and alleviating poverty. Tanzania has been exercising PFM strategy with varying degrees of success since 1994. Today, more than 3.67 million hectares out of 38.8 million hectare of forests and woodlands of Tanzania mainland are under PFM programme (MNRT, 2006). In Monduli district, the Monduli Catchment Forest Reserve (MFR) has been under PFM since 1998. Although PFM is now widely practiced in Tanzania (Kajembe and Kessy, 2000; Iddi, 2002; Kajembe *et al.*, 2004), little is known about its impact on ecology of forests as well as on communities' livelihoods.

The aim of this study, therefore, was to conduct a case study in Monduli Catchment Forest Reserve to assess the forest conditions and rural livelihoods as influenced by the PFM practice. The findings of this study are hoped to would contribute to efforts towards improvements of PFM with a view to bring about improved livelihoods and forest conditions. The information is also useful to various decision makers, research institutions, Non-Governmental Organizations and other stakeholders engaged in PFM.

1.3 Why choose Monduli forest reserve?

The reasons that have prompted the study to be carried out in Monduli were:

i. It is one of the first pilot catchment forest reserves in Arusha region as well as in the country wherein PFM regime was initiated.
ii. Selection of Monduli forest reserve as a study area was also based on an inventory carried out in the forest in 1999. The assessment aimed to provide some basic information about the forests available for the new approach of management (MNTR, 2002). Again, Mialla (2002) carried out a study on participatory forest resource assessment in Monduli Mlimani forest, which is the part of MFR. The study had the objective of assessing the status of forest resources for sustainable

management. The two studies established some baseline data which formed a basis for determining change.

1.4 Objectives

1.4.1 Overall objective

The overall objective of this study is to analyze the impacts of participatory forest management on the forest conditions and community livelihoods adjacent to Monduli catchment forest reserve.

1.4.2 Specific objectives

i. To analyze the impacts of Participatory Forest Management on stocking, basal area, standing wood volume, as well as tree species composition, diversity, and regeneration in Monduli forest reserve.
ii. To analyze the impacts of Participatory Forest Management on livelihoods of the communities adjacent to Monduli forest reserve.

1.5 Key research questions

i. Does PFM contribute to improved forest conditions compared to non-PFM situation?
ii. Does PFM contribute to improved community livelihoods compared to non-PFM situation?

1.6 Conceptual framework

Based on the study objectives, an impact pathway (Fig. 2) was prepared to assess the ecological and livelihood impacts of PFM in Monduli. The framework describes the

cause-and-effect relationship as a result of PFM implementation and the impact it may have on forest conditions and rural livelihoods.

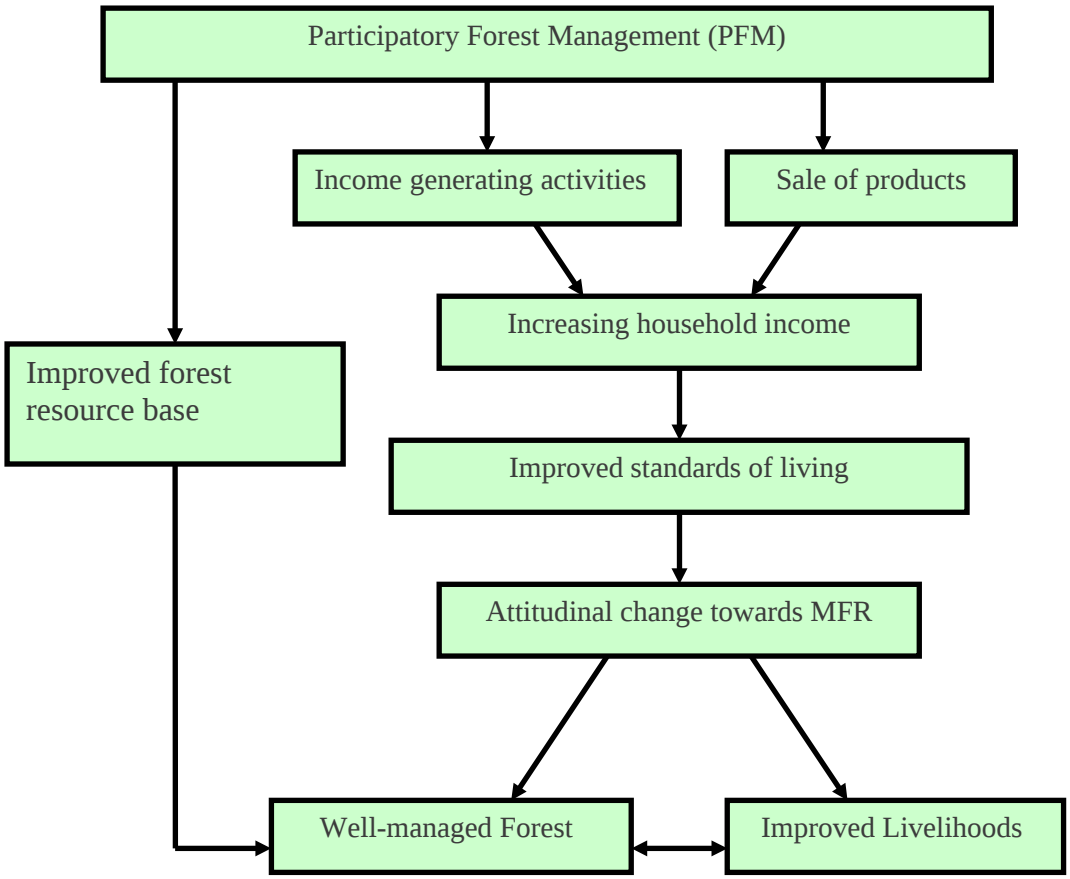

Figure 2: Conceptual framework of the study.

Adapted from Panday (2005).

1.7 Hypothesis

Based on the specific objectives, two hypotheses were tested;

H_1: PFM has significant positive impact on the conditions of Monduli Forest Reserve

H_2: PFM has significant positive impact on community livelihoods.

1.8 Study limitations

The major limitation during data collection was the difficulty to reach some of sample plots due to the topographical nature of the study area. The study was conducted during the rainy season which impaired performance both in resource assessment and village survey. For example in villages the respondents were busy in their farms of which numerous visits were needed to get them.

On the other hand, most women members apparently lacked leadership initiatives and felt shy in giving answers. Few women were co-operative and willing to share everything they knew while many hesitated even in giving a single word.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Catchment forests in Tanzania

Protective forests that are gazetted as catchment forest reserves in Tanzania cover about 2.8 million hectares (MNRT, 2002) and mostly located in areas with mean annual rainfall of above 1000 mm. Fig. 3: Currently, these forest reserves are managed and administered by two different authorities – the Central Government (1.6 million ha), and the Local Governments (1.2 million ha) (Mugasha *et al.*, 2002; Kijazi, 2006).

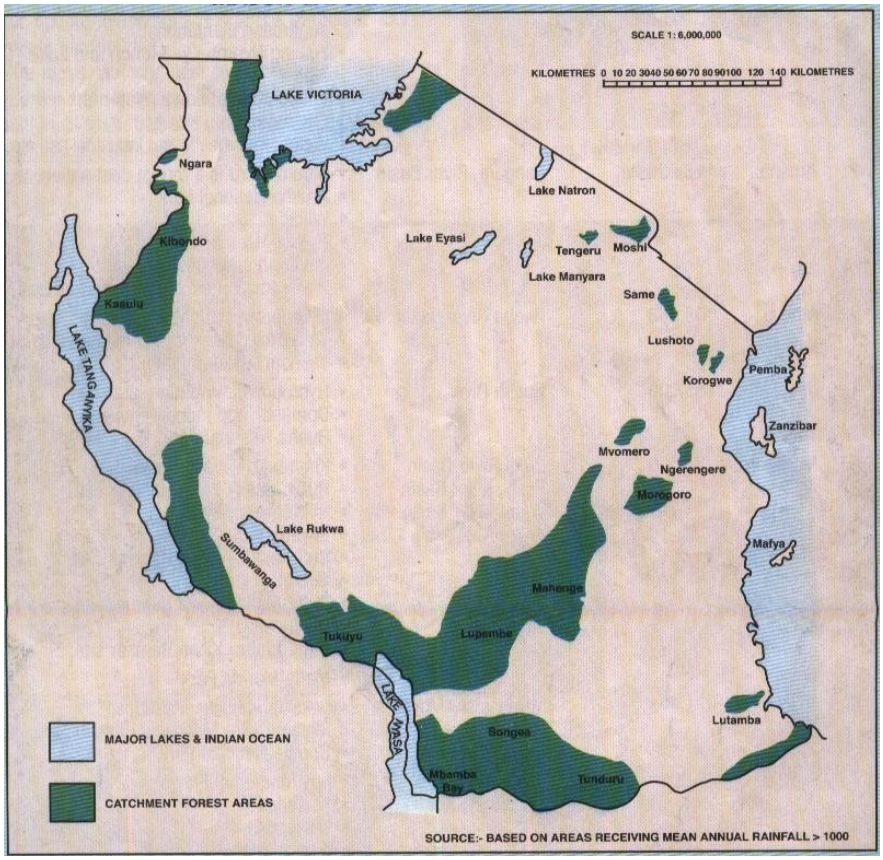

Figure 3: Major catchment areas in Tanzania.

Source: Zahabu *et al.* (2006).

According to the National Forest Policy (MNRT, 1998), catchment forest reserves are managed for three main objectives specifically:

i. Water conservation so as to guarantee permanent and good water supply for domestic as well as agricultural, hydro electric generation and industrial use;
ii. Ensure protection of unique habitats for maintaining biodiversity, as catchment forests are exceptionally rich in plant and animal species including many endemic as well as rare species; and
iii. Soil conservation, as most catchment forests are located in the mountains and hilltops, thus forest cover is maintained in order to ensure perpetual physical, chemical, biological and economic properties of soils.

2.2 Contribution of catchment forests to livelihood

Catchment forest resources support local livelihood systems through the provision of fodder/pasture, fuel wood, construction materials, honey, traditional medicines, water spiritual and physiological satisfaction. According to Satterhwaite (2003), more than 1.6 billion people worldwide rely on forest resources for all or part of their livelihoods. In relation to this, numerous studies have found that, it is often the poorest households that are most dependent on these resources for food, timber, medicines, and ecosystem services such as clean water supply (Myres, 1985). But in the real sense urban populations also need the same services. Mariki *et al.* (2003) indicated that, in Tanzania wood-based energy in both rural and urban areas is estimated to account for about 92% of total energy demand. The energy is mostly used by 85% of rural dwellers and large majority of low and middle income urban people.

As far as water catchment is concerned, a good catchment forest has the ability to maximize water storage in the ground by exerting a sponge effect, soaking up moisture

before releasing it at regular rates (MNRT, 2003). Water supply of Arusha and Dar es Salaam cities, Moshi and Morogoro municipalities depends largely on catchment forests. Similarly, some hydroelectric plants like Mtera, Kidatu and Nyumba ya Mungu also receive a big portion of water from the catchment forests (Nsolomo and Chamshama, 1988; Mariki *et al.,* 2003). The forests regulate water flows such that water is released over a long period of time, control floods, control soil erosion and sedimentation. The importance of natural forests were also realised by Jahan (2003), when he reported that, millions of urban dwellers derive part of their income from industries or services that depend on forests. In the catchment forests there are many fruit species and wild animals for human consumption. Natural forests especially tropical forests represent nature's main storehouse of raw material for modern medicine. Among the most important materials with which pharmacologists manufacture drugs are alkaloids, which are complex bio compounds produced by many categories of plants. In addition, the forests are sources of traditional medicines (Myres, 1985).

As regard to Monduli, the mountain forests in the district acts as catchment areas for all the water for wildlife, livestock and human use. Grant (2002) reported that nearly 100% of the forest adjacent dwellers depend on water from MFR while another 70% depend on fuel wood collected from the reserve. It is estimated that the average value of the forest to a typical household living in Olarash and Mlimani villages is about TZS 2.9 million and TZS 2.0 million per year, respectively. On the other hand, the value of the forest to Mlimani village is estimated at TZS 350 million. This value reflects only the direct benefits from the forest (Table 1).

Table 1: Economic value of MFR to a typical local household at Olarash village.

Forest good	Forest value/ yr (TZS)
Fuel wood	62 400
Water	876 000
Poles	25 000
Herbal medicine	12 000
Fodder/pasture	225 500
Honey	165 000
Total	2 855 925

Source*:* Grant (2002).

2.3 A shift in conservation thinking in Tanzania

From the 1890's until the 1970's, conservation was promoted throughout the world using exclusionary means to preserve landscapes from human use. This included national park or wilderness models from State-led, bureaucratic, technocratic or expert driven approaches (Brechin *et al.,* 2002; Sheffy, 2005). The models remain common, but have lost popularity, particularly among non-biologists as they are not effective. They excluded local residents (often lower class and ethnic minorities) in protecting resources within their boundaries. As a result, the situation inflicted negative social impacts on local populations' dependent on those resources (Brandon and Wells, 1992; Sheffy, 2005). This has lead to a greater transition toward what theorists call 'new conservation' which considers the role of local people in conservation as well as interdisciplinary approaches to conservation that incorporate multiple scales of ecological, social, political, and economic concerns (Scotty, 1998; Hulme and Murphree, 1999; Berkes, 2004).

Deforestation has been variable in time and space, and over the last 50 years it has increased (FAO, 2000). Globally, forest management has been responding in recent years to demands for greater equity in the distribution of forest resources and to the failure of traditional forestry approaches to achieve sustainable development objectives.

Increasingly, stakeholder participation, or participatory forest management, has become an important element of forest management strategies. In Tanzania, over the years the government assumed the role of the manager and the owner of the natural forests in belief that it will be able to control and direct the use of resources so that social benefits would be maximised while conserving the resource base. This government role on behalf of the public at large has been practised over the years and found ineffective. One of the main reasons advanced for the ineffective management of the natural forest resources is that the government alienated resident people to participate in the overall management of the resources. People living around the forest areas, particularly women rely on utilization of forest products as one of their livelihood strategies.

However, inadequate forest use and benefit sharing regulations resulted in a situation that people were forced to utilize forest resource illegally and that they do not feel responsible for the forest condition. On the other hand, state forest authorities had neither the resources and know-how, nor the support of the local people to enter into sustainable management of existing forests. Poor communication and incompatible objectives between communities and forest administration were causing an ever-widening gap between forest dependent communities and forest administration. This resulted in emergence and escalation of conflicts in use and management of these resources contributing to uncontrolled over-utilization and degradation of forest resources. In Tabora region for example, two forest reserves got completely cleared and though they were reported in the papers as forest reserves whereas the truth on the ground showed that they had been completely turned into agricultural land (Masanyika and Mgoo, 2001).

Consequently, the failure of state agencies to effectively manage protected areas; the potential for cost effectiveness in managing the forests; the relevance of local knowledge

of ecological dynamics to proper management; the increased motivation for local community to conserve forests following recognition of their critical role in the management of local forests; the eventual increase in tangible benefits from the forest (economic incentives); and the sense of ownership regained over their forest resources (empowerment) as outlined by Kajembe and Kessy (2000), have engineered the shift. Chapter 26 of Agenda 21 of Rio de Janeiro's Earth summit in 1992 greatly influenced initiation of participatory natural resources management programmes (Mialla, 2002).

2.4 What is Participatory Forest Management?

Participatory forest management initiatives are a subset of the types of environments, resources, and conservation programs involving local peoples that can be more generally termed 'participatory conservation'. Participatory conservation is a way of approaching conservation issues through building relationships between local peoples and conservation initiatives, which has emerged along with participatory approaches to development since the 1970's (Sheffy, 2005). The strategies and activities at work in participatory conservation initiatives are diverse and applied in many conservation approaches, including Protected Area Outreach Programs (PAOP), co-management; joint forest management (JFM); community-based conservation (CBC), natural resource management (CBNRM), and wildlife management (CBWM); integrated conservation and development projects (ICDP); biospheres; resource reserves; sacred groves; working landscapes; and various other nuanced titles (Borrini-Feyerabend *et al*., 2004).

Infield and Namara (2001), Brechin *et al*. (2002), and Michaelidou *et al*. (2002) characterised participation strategy as 'shallow' and 'deep'. There can be both shallow (e.g. involvement in a limited set of activities such as revenue sharing) and deep (e.g. involvement in initiative definition, goals setting, and critical program evaluation

throughout all stages) participation strategies at work in both cases. Therefore, participatory conservation cannot be understood in terms of a particular strategy, policy, or management activity that can be chosen and implemented. Rather, it is a process of decision making and negotiation required to involve the governance structures and livelihoods of local residents, which are made up of complicated political, social, and economic issues. Whether a participation strategy is characterized as shallow or deep depends on the qualities of decision making and negotiation, particularly in their inclusiveness of multiple parties and interests. Participatory Forest Management therefore, can be defined as structured collaboration between governments, commercial and non-commercial forest resource users, interested organizations, community groups, and other stakeholders, to achieve shared objectives related to the sustainable use of forest resources. Under PFM stakeholders are entrusted with the protection and management of nearby forests.

2.5 Overview of Participatory Forest Management

The need for sharing forest management responsibilities with various stakeholders is now generally accepted worldwide. It is increasingly becoming clear that the management of natural forests by the states alone has been ineffective. Participatory forestry approaches have been adapted in response to the widespread view that other forestry management approaches have failed to halt forest degradation in many parts of the world.

2.5.1 Participatory Forest Management in India

PFM in India has emerged as a response to the severe degradation of forest resources and the persistent conflicts and movements against the state (Ballabh *et al.*, 2002**).** In many parts of India, small village groups are protecting natural forests either on their own initiative or with the encouragement of Forest Department. Communities are organized into formal and informal groups for forest protection and management (Sarin, 1995). The

PFM programme seeks to develop partnerships between local community institutions and state forest departments for sustainable management and joint benefit sharing of public forest lands. The primary objective of PFM is to ensure sustainable use of forests to meet local needs equitably while ensuring environmental sustainability. The central premise is that local women and men who are dependent on forests have the greatest stake in sustainable forest management (Salam *et al.*, 2005).

The National Forest Policy of 1988 and the PFM resolution of 1990 combined with state level resolutions acknowledged the need to give greater rights and authority to community groups. The policy envisages a process of joint management of forests by the state government and the local people, who would share the responsibility or managing the resource and the benefits accruing from this. Under PFM, village communities are entrusted with the protection and management of nearby forests. These communities are required to organise forest protection committees, village forest committees, village forest conservation and development societies. The guidelines provide for rights to usufruct and non-wood forest products and percentage share of final harvest to organized communities willing to help regenerate depleted forest and waste lands. Around 19 states have issued enabling orders for implementation of PFM. At present, over 14 million ha covering nearly 50% of open forests in India are under Joint Forest Management, the most common PFM in India (Murali *et al.*, 2002; Ravindranth and Sundha, 2004).

2.5.2 Participatory Forest Management in the Caribbean

Forest management partnerships in the Caribbean involve forest management agencies, NGOs, community groups, businesses, local resource users, and technical assistance organizations. The different stakeholders often play multiple roles, including mobilizers, partners, facilitators, regulators, and technical advisors. NGOs have been crucial in

supporting the participation of weaker community and resource user groups. The motivations of different stakeholders vary. Forestry administrations and other governmental stakeholders are usually interested in increasing their management capacity by securing the help of other partners. Local resource users tend to be interested in improving livelihoods, income, and quality of life, while other civil society stakeholders are motivated by concerns about equity and social justice. In entering into partnerships, negotiation on objectives is often needed, resulting in projects that have both environmental and socio-economic dimensions and that require input from a range of non-traditional actors, such as water resource management agencies, development NGOs, ministries of community development, and tourism enterprises. In the Caribbean, participatory forest management embraces many types of partnerships and arrangements as outlined in Table 2.

Table 2: Common types of PFM in the Caribbean.

Type of arrangement	Characteristics
Contractor/contractee relationship	•Objectives and outputs defined by the contracting party •The arrangement only defines the rights and responsibilities of parties to contract, not others who may affect or be affected by management
Loose collaboration	•Objectives generally defined by initiating party; entry open to others based on interest •Parties not bound by a formal agreement
Formal collaboration	•Objectives defined jointly by parties to agreement •Roles, responsibilities, rights and benefits clearly spelled out and to some extent binding •Important stakeholders may be left out, affecting the potential for achieving management objectives
Multi-stakeholder management or advisory bodies	•Objectives defined by multiple stakeholders •May not result in actual reallocation of responsibility but function only at an advisory level •May influence or define policy •Benefits to participants least direct; maintaining interest can be a challenge

Source: CANARI (2002).

2.5.3 Participatory Forest Management in Africa

Natural forests of moist, coastal and especially dry types represent a massive resource of more than 500 million ha, found in all 56 states of Africa, ranging from 135 million ha in Democratic Republic of Congo (DRC) to 2000 ha in St. Helena (FAO, 2001). Though at different stages, PFM is sufficiently widespread and effective in Africa today (FAO, 2002a). It is recognized as a significant route towards securing and sustaining forest resources. Wily (2002) reported that, PFM is practiced in more than 30 African countries, involving around 5000 communities, affects more than 100 national forests and introduces more than 1000 new community forests.

Tanzania has been promoting participatory forest management since the early 1990s and currently extending over 9.5% of the total forested area (Table 3). The approach has been

reinforced by national and international NGOs promoting forest conservation (MNRT 2006). PFM was introduced into law with the passing of the Forest Act 2002. The law recognises Community Based Natural Resource Management (CBFM) and Joint Forest Management (JFM) as the types of PFM. The Act provides a clear legal basis for communities, groups or individuals across mainland Tanzania to own manage or co-manage forests under a wide range of conditions. However, involvement of local people in protected areas is not only undertaken in forestry. Yanda and Madulu (2003) reported that, local communities have also been involved in the management of special portions of protected areas in Serengeti through the Serengeti Regional Conservation Programme (SRCP), and around Selous game reserve through the Selous Conservation Programme whereby local communities adjacent to the reserve are involved in the management of special protected areas.

Table 3: Overview of Participatory Forest Management in mainland Tanzania.

Total forested area in Tanzania mainland (ha)	38 811 322
Total area of forest covered by PFM arrangements (ha)	3 672 854
Percentage of total forest area under PFM (%)	9.5
Number of villages involved in PFM	1 821
Percentage of total villages involved in PFM (%)	17.5

Source: Adapted from MNRT (2006).

2.6 Impacts of Participatory Forest Management on forest conditions

In India, although there are few studies done as regard to 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 are showing an 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 lead 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, on the other hand, community based Forest Management (CBFM) initiative has resulted into visible impacts mainly in two areas: first, is 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 the regeneration of about 50% before the initiative. Kajembe *et al.* (2004), observed a

negative PFM impact at Kwizu forest reserve in Kilimanjaro region Tanzania, 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.

2.7 Impacts of Participatory Forest Management on livelihood

Natural resources, particularly forest resources, play a key role in livelihood systems. Examples of PFM cited in the previous section suggest that important progress in local people's empowerment has been made in many countries. Where 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 secure 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). Experiences from Andra

Pradesh – the best PFM programme in India, indicated an increase benefit share from 25% to 100%, albeit restricted to incremental volumes in timber and bamboo. The participating communities are also given 50 and 25 percent share in net revenue in *beedi* leaf (used to make local cigarettes) and from forest offences respectively. 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 costal 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. The loss of forested areas upsets soil-water relations, creates erosions, and lower water quality that, in turn has an associated effect on human health. 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, few studies done, so far show little positive impact on livelihoods. 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 to reduce poverty 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).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study area

3.1.1 Monduli district

Monduli district is in Arusha Region in the northern part of Tanzania (Fig. 4). It occupies an area of about 15 775 square kilometres and the main ethnic group is Maasai. The district capital, Monduli lies 46 km west of Arusha municipality. In 2002, the population of Monduli district was 185 190 people, (URT 2002) with an average annual growth rate of 4.3% (Table 4).

Table 4: Population status of Monduli district.

Total households	Males	Females	Total
41 046	89 739	95 451	185 190

Source: URT (2002).

Administratively the district is divided into six divisions, 20 wards and 73 registered villages (Monduli district council (2000) in Kaale and Mshana, 2004). The main economic activities in the district are livestock keeping, crop production and wildlife. More than 90 percent of the population is engaged in livestock keeping and crop production (Kilahama and Massao, 1999; Kaale and Mshana, 2004).

The land surface of Monduli district is characterized by isolated mountains of Gelai, Kitumbeine, Lepruko, Longindo, Losimingori, Monduli, and Oldonyolengai. Altitude ranges from 6000 to around 2900 m.a.s.l.

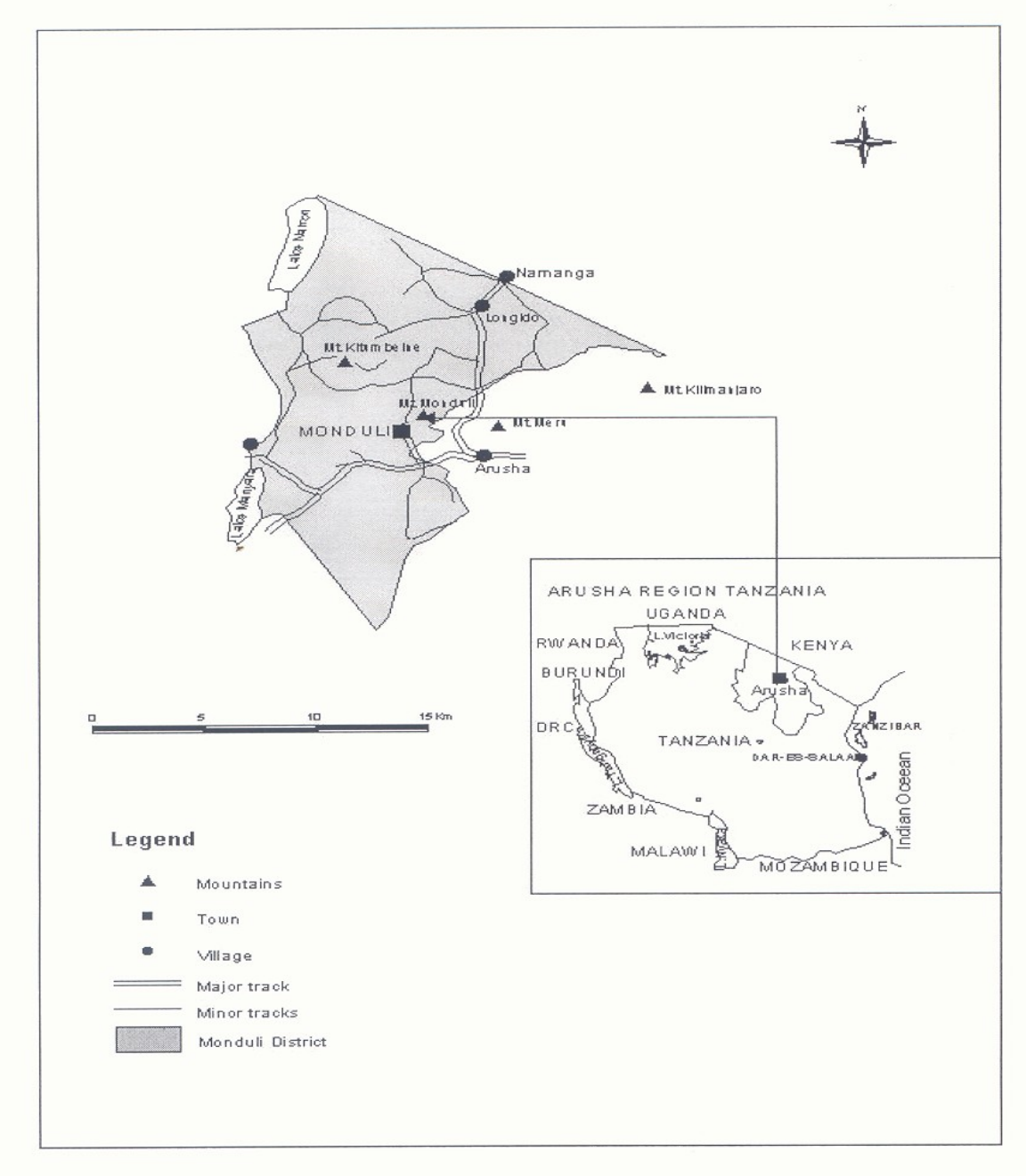

Figure 4: Location of Monduli District.

Source: Meinderstesma and Kessler (1997).

The district has two major ecological zones, the highlands and the lowland. The highland zone, which occurs on altitudes above 1200 m.a.s.l., has deep freely-draine.d loamy soils with natural fertility status. The main activities in this zone are farming and livestock keeping. The lowland zone is characterized by flat, rolling plains with altitudes ranging from 600 to 1200 m.a.s.l. Dominant soils in this zone are deep, freely-drained clays with moderate natural fertility status (Kaale and Mshana, 2004). About 50% of the district land is covered by natural vegetation consisting of shrubs trees and grass. The district has 10

forest reserves covering a total of 31 276 hectares. Out of these, seven reserves (28 172 ha) have legal status and the rest (3105 ha) are proposed village forest reserves. Water supply and management is an important activity in Monduli District. Water resources are seasonal in the sense that a large part of the district is semi-arid in nature.

3.1.2 Monduli Catchment Forest Reserve

The study was carried out in Monduli forest reserve. The reserve with gazetted area of 6058 ha and boundary length of 39 km covers the top and slopes of mount Monduli from an altitude of 1615 to 2660 m.a.s.l. The forest is surrounded by ten villages namely Mlimani, Ngarash ya Juu, Enguik, Emairete, Mfereji, Engalaon, Imbibia, Likamba, Oljoropus, and Olarash. The climate of the reserve varies with respect to aspect and elevation. The mountain gets relatively more rain at higher altitudes. While the estimated annual rainfall ranges from 750 mm to 1500 mm. Dry season is June to September, mean annual temperatures stand at 11 - 15^0 C (Lovett and Pocs, 1993).

The soils of Monduli catchment forest reserve are dark brown humus rich over volcanic rocks. The vegetation of the forest is of dry montane type. At higher altitude the forest has a closed canopy containing species like *Xymolos monospora, Rhamnus prinoides, Prunus africana, Dombeya torrida, Nuxia congesta*, and *Maesa lanceolata* being among the species found in this area. The dry montane is dominated by *Olea europea sub sp. africana, Albizia gummifera, Bersama abyssinica, Fagaropsis angolensis, Cassipoerea malossana, Juniperus procera, Teclea simplicifolia* and *Turrea spp.* (Mialla, 2002). On lower altitudeS there are thick shrubs of 2 – 3 m tall with trees to 5 m. Thick secondary scrub is dominated by *Vernonia* spp which occurs in the area formerly disturbed by fires or excessive grazing (Lovett and Pocs, 1993).

Grant (2002) reported that nearly 100% of the forest adjacent dwellers depend on water from MFR, however, the area does not contain any river flowing downstream as almost all rivers are seasonal. According to Mialla (2002), the forest contributes to underground water in lowland plains. Maindertsma and Kessler (1997) reported that, the highest rate of water flow from streams is experienced between May and June while the minimum discharge is during the end of dry season (between September and October). The forest ecosystem plays an indirect role wildlife conservation, agricultural development and tourism and livestock development. MFR harbours open glades having good grasses that supporting grazing animals like buffaloes. Part of MFR is designated as game controlled area. There are various types of wild animals and birds from smaller to large animals like elephants and buffaloes. Similarly, different birds are found in the reserve. And according to avifauna survey report (Baker, 2001 in Matungwa, 2003), a total of 45 bird species were recorded during a five-day survey. Of these, 25 species (56%) were forest dependent.

3.2 Methodology

3.2.1 Primary data collection

3.2.1.1 Socio - economic data

Socio-economic data was collected through direct interview with the forest users, specifically heads of households and village leaders, in the selected village using structured questionnaires (Appendix 1). The survey was conducted in only four villages (one in eastern, western, southern and northern part of the reserve. Population sample was determined according to Boyd *et al.* (1981, in Njana 1998), that at least 5% of households in each of the selected study villages. A total of 105 households were randomly selected based on the four village registers. However, because of the rural setting (communication difficulties), limited time and financial constraint, it was not possible to interview all the households selected. Only 77 household heads were interviewed (Table 5).

Table 5: List of respondents and location.

Name of village	Total No. of households	No. of households selected	Achievement (households visited)	Sex of respondents	
				Female	Male
Mlimani	378	19	18	4	14
Emairete	413	21	19	5	14
Mfereji	864	43	23	0	23
Imbibia	450	22	17	5	12
Total	2105	105	77	14	63

Direct observation and semi-structured interviews were used to triangulate information given through questionnaire, and to obtain detailed information that may not be covered by the questionnaire. Checklists (Appendix 1) were used to guide the discussions with key informants who comprised of Regional and District Forest Officers, Village Councils and Village Natural Resource Committees (VNRC).

3.2.1.2 Forest inventory data

Vegetation in MFR is not homogeneous in such a way that its characteristics differ from one side of the forest to another. In order to ensure that all vegetation types are visited, the forest was stratified into five strata namely, forest 15 - 25 metres high with high density; forest 15 - 25 metres high with medium density; forest 15 - 25 metres high with low density; forest < 15 metres high; and lastly scrub and grass glades. Vegetation map of Monduli was used to determine vegetation classification. The area of each stratum was calculated. The sampling intensity planned in this study was 0.1% as suggested by Malimbwi and Mugasha (2001a) which is equivalent to 86 sample plots, each having an area of 0.07 ha. However, due to limited time and resources only 56 sample plots were measured. This is equivalent to a sampling intensity of 0.06%. Number of sample plots per stratum was calculated using the principles of proportional allocation according to area of each stratum (Table 6). The plots were randomly distributed as shown in Fig. 5.

Table 6: Distribution of sample plots per stratum in MFR.

Stratum	Area (ha)	Weighted %	Expected No. of sample plots	Measured No. of sample plots
A	124	1.8	2	2
B	2 178	39.0	31	20
C	1 556	27.9	22	18
D	1 222	21.9	17	11
E	978	9.4	14	5
Total	6 058	100.0	86	56

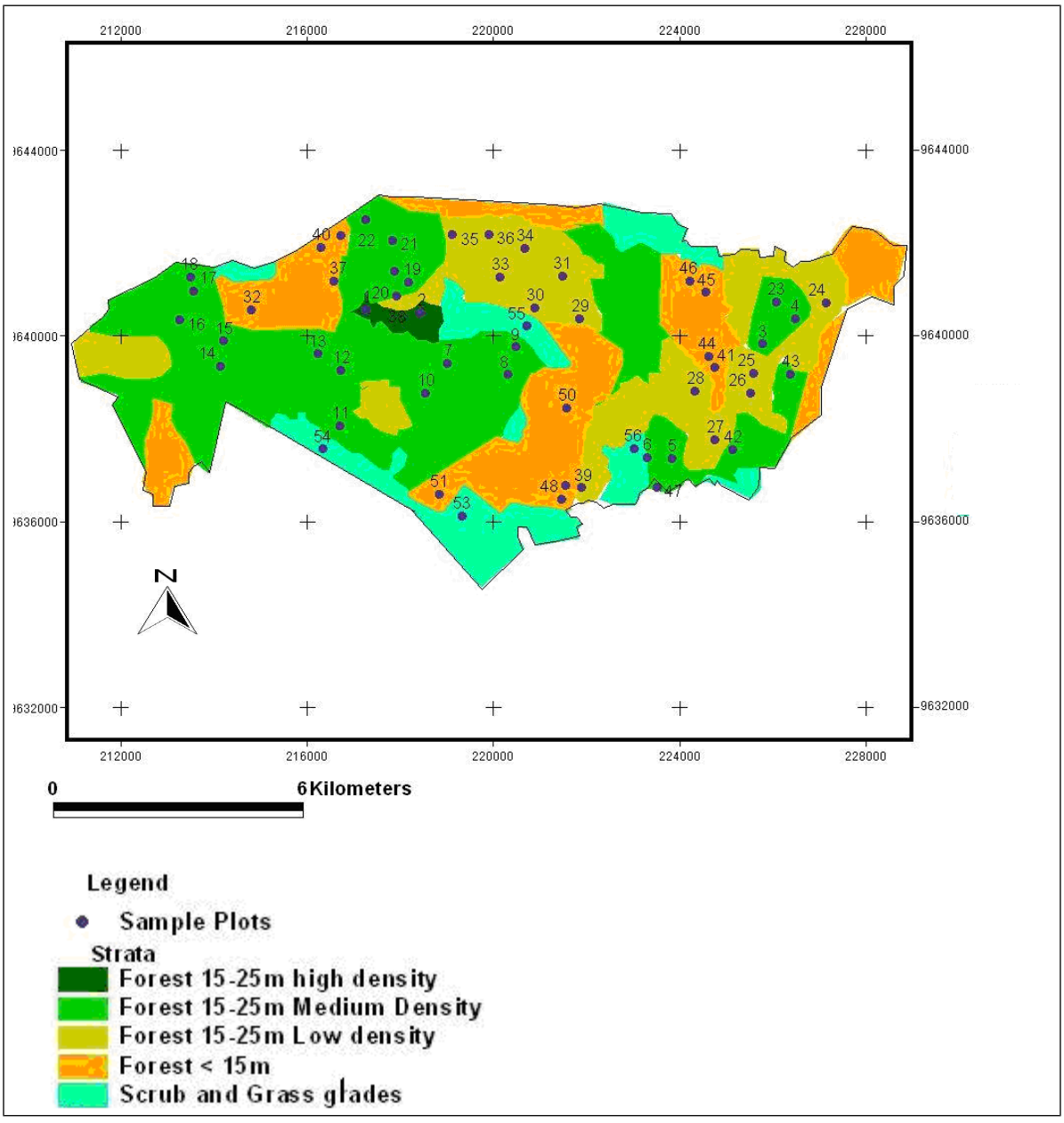

Figure 5: Random layout of sample plots in Monduli Forest Reserve.

The plots were circular in shape with concentric rings of radii 2, 5, 10, and 15 m. Measurements in the plots were taken as shown in Table 7.

Table 7: Sample plot design framework.

Plot radius (m)	Measurements
2	Identification and counting all trees with 1≤dbh<5 cm
5	Dbh measurement of trees with ≥5 dbh ≤ 10 cm
10	Dbh measurement of trees with >10 dbh ≤ 20 cm
15	Dbh measurement of trees with dbh >20 cm

Source: Malimbwi and Mugasha (2001a).

In addition to the above measurements, the GPS location of each plot was determined. Also the species vernacular name, total tree heights of three trees nearest to the plot centre and general condition of the plot were recorded (Appendix 3). Suunto hypsometer was used to estimating tree heights. Although circular plots are not easy to demarcate in closed forests like Monduli, they were adopted because only a single dimension, radius, is needed to determine the outer limits. They have also the advantage of reducing edge effect that may lead to possible counting errors (Mialla, 2002; Mafupa, 2005). Also, through concentric plots, it is possible to reduce the plot area for small-sized trees and increase the same for large-sized trees with the objective of taking approximately equal number of trees in several size classes (Husch *et al.*, 1992*).*

3.2.2 Secondary data collection

The secondary data was collected from different relevant publications and reports in Websites, Arusha Catchment Office, and Monduli District and National Environmental Management Council (NEMC) Arusha office. Forest Division Headquarters library was visited for secondary data from relevant government documentary in addition to the Sokoine National Agricultural Library (SNAL) which was the major source of literature.

3.3 Data analysis

3.3.1 Socio – economic data

These included qualitative and quantitative data. The quantitative data was processed to obtain descriptive statistics (i.e. frequency, means and standard deviations) by using the Statistical Package for Social Sciences (SPSS) 11.5 edition. The data was first coded in a form suitable for addressing research questions and the method of analysis to be employed. Frequencies and histograms were used to summarise the data. In order to assess the impact of PFM on livelihoods of local communities surrounding MFR, chi square test at 5% level of significance, was used to test if there was a significant change on livelihoods of the communities as impacted by PFM between year 1998 and 2006.

The qualitative data was analyzed using the content-structural analysis. The content-structural analysis was used to analyze in detail the components of verbal discussions held with key informants. This helped the researcher in ascertaining values and attitudes of the respondents (Kajembe, 1994). The results were summarised in table formats suitable for discussion.

3.3.2 Forest inventory data

The forest inventory data were analyzed by using the MS excel spread sheet. Before computation of various stand parameters, a tree species list was prepared. Local names were matched with botanical names to form a tree list of the entire forest. The list was arranged alphabetically and each tree given a code number to work within the subsequent calculations (Appendix 4). Regeneration status was then assessed by expressing the number of seedlings and saplings recorded on a hectare basis. Heights measured from 80 sample trees were utilised to develop prediction equations through regression techniques. Heights were treated as dependent variables while dbh formed an independent variable in

the regression. Four standard models of height prediction equations were used (Table 8) (FORSPA-FAO, 2000). Four height-diameter equations for the forest were developed. The best fitting equation was selected based on highest coefficient of determination (R^2), lower standard error (S.E) and homogeneous distribution of residuals, which implies lower experimental error (Table 8).

Table 8: Height-diameter equations for Monduli Forest Reserve.

Model	Equation	R^2	S.E	Remarks
Ht = a + bD	Ht = 8.44 + 0.15D	0.47	6.7	Not selected
Ht = a + blnD	Ht = -8.68 + 7.25lnD	0.66	5.34	Not selected
lnHt = a + bD	lnHt = 1.99 + 0.01D	0.45	0.52	Not selected
lnHt = a + blnD	lnHt = 0.52 + 0.6lnD	0.79	0.32	Selected

Where:

Ht = total tree height in metres,
D = diameter at breast height
a = y - intercept
b = constant
ln = natural logarithms
R^2 = coefficient of determination
S.E = the standard error of estimates

The selected equation was used to estimate heights of trees that were measured for dbh only. However, height growth culminates at a certain point of the growth curve so the model tends to overestimate height of larger trees. To avoid this, the maximum height for all trees with dbh >200 cm was set at 35 m as suggested by Mialla (2002). Calculations of the basic stand parameters, that is, number of stems per ha (N), basal area (G) and volume (V) was done by using the Microsoft excel spread sheet software. In wood volume computations, a form factor of 0.5 for montane tropical forests was used as recommended by Malimbwi and Mwansasu in Njana (1998). The same method was used in 1999.

Apart from stand parameters, the individual species contribution to the diversity of the forest was assessed using the species Importance Value Index (IVI). The IVI of the

$$\frac{\text{Number of occurrences of a species}}{\text{Number of occurrences of all species}}$$

species is the sum of the relative frequency, density and dominance of that species. According to Kent and Cooker cited in MNTR (2002), these constituent parameters are calculated as follows;

Relative frequency = × 100

$$\text{Relative density} = \frac{\text{Number of individuals of a species}}{\text{Number of individuals of all species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \times 100$$

3.3.3 Statistical test for significance

The processed data were expressed in tables, histograms as well as pie charts. Mean values of stems per hectare (N), basal area (G) and volume (V) were compared with those of 1999. A two-sample t-test at 5% level of significance (two-tailed) - the same method used in 1999, was used to test if there was significance change on forest density, basal area and volume between year 1999 and 2006. The equation below was used to compare the means of samples drawn from the population in 1999 and 2006.

$$t_{0.05} = (\overline{x_1} - \overline{x_2}) / \sqrt{s_1^2/n_1 + s_2^2/n_2}$$

Where:

$\overline{x_1}$ = Mean values for year 1999 for N, G, V
$\overline{x_2}$ = Mean values for year 2006 for N, G, V
s_1^2 = Variance for year 1999
s_2^2 = Variance for year 2006
n_1 = No. of plots in 1999 and
n_2 = No. of plots in 2006

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents and discusses findings of the impact of PFM on forest conditions and livelihood for the villages bordering MFR.

4.1 Forest stand parameters

Although data collection was stratified, the discussion of stand parameters is focusing on the overall mean values as the 1999 baseline data were presented based on diameter classes. Stratification in this study was therefore done only to ensure that all vegetation types in the reserve are visited. Table 9 shows the stand parameters of MFR in terms of stocking, basal area and volume per hectare. The presented results are based on trees above 5 cm DBH in the 56 measured sample plots. Details of distribution of stand parameters and DBH classes are shown in Appendix 7. Table 10 compares the summarised stand parameters for year 1999 and 2006 at 5% probability level.

Table 9: Stand parameters for the Monduli Forest Reserve.

Dbh class	Dbh range (cm)	Stocking (stems per ha)	Basal area(m^2/ha)	Standing volume (m^3/ha)
1	<5.0≤10.0	701	3.19	9.37
2	>10.0≤20.0	320	6.02	27.06
3	>20.0≤30.0	73	4.19	24.48
4	>30.0≤40.0	27	3.70	26.72
5	>40.0≤50.0	13	2.86	23.66
6	>50.0≤60.0	7	2.29	21.90
7	>60.0≤70.0	5	2.44	29.95
8	>70.0	10	12.55	183.07
	Total	1 156	37.24	346.22

Table 10: Comparison of stand parameters in year 1999 and 2006 in MFR.

	Stems per hectare		Basal area (m^2/ha)		Volume (m^3/ha)	
	1999	2006	1999	2006	1999	2006
Mean	311	1156	27.10	37.24	393	346.22
Observations	70	56	70	56	70	56
Standard error	43	111	2.50	4.70	47	68.80
t Stat		3.180		0.189		0.595
P value		0.001		0.171		0.413
Significance		**		NS		NS

** Significant at 0.05 level; NS - no significance.

4.1.1 Stem density

As presented in table 10 above, the average number of stems per hectare in MFR is about 1156. Diameter classes 1 and 2 contribute significantly to the overall total number of stems per hectare as compared to the subsequent classes (Table 9). This shows that stocking decreases with increasing diameter class (Fig. 6). The trend concurs with findings by Phillip (1983) and Mialla (2002), that stocking of any natural forests where there is a mixture of age classes with an active regeneration follows an “inverted J”. That is, for a forest to survive in years to come, it is essential that there be adequate representation in all the DBH classes, particularly in the lower DBH classes. If there are more trees in the higher DBH classes and very few in the lower DBH classes, it indicates that succession of younger ones is severely affected. The future of the forest is not stable for there are no young seedlings to take over on death of the older individuals. Likewise in MFR, there is adequate representation in all the DBH classes, indicating a healthy forest.

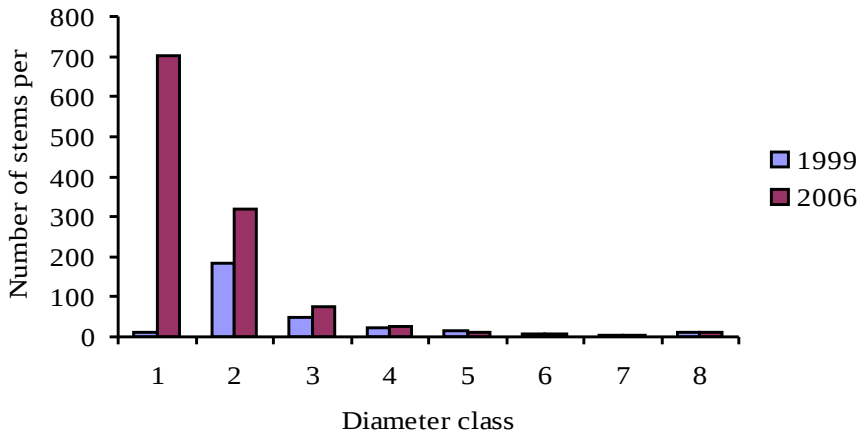

Figure 6: Comparison of stocking distribution in 1999 and 2006 in the MFR.

Ten tree species, *Teclea simplicifolia* ranking first, were observed to have highest number of stems per hectare (Fig. 7). One of the reasons may be favourable environment for the species. Also the species are not well known hence not widely used.

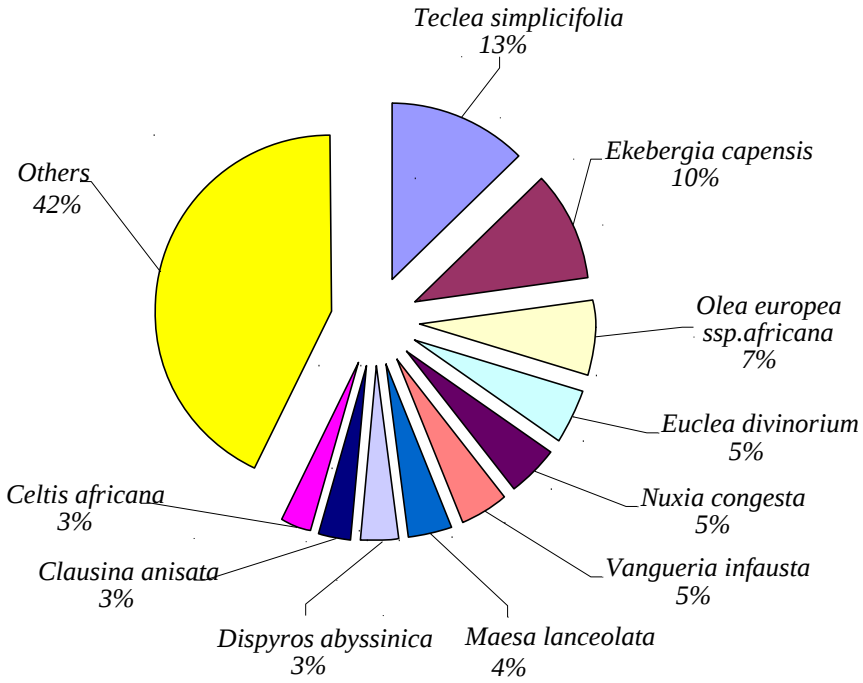

Figure 7: Percentage distribution of stocking by species in MFR.

In an inventory done in MFR December 1999 to January 2000, a year after inception of PFM, Malende and Shemwetta (2002a) reported the mean stocking of 311 SPH. Surprisingly, species like *Casearia battiscombei*, *Diospyros abyssinica* and *Rapanea melanophloeos* were reported in 1999 as being the least stocked in the forest with less than one stem per hectare. The 2006 results show them having 23, 39, and 21 stems per hectare, respectively, mostly concentrated in diameter class one. The significant increase in the mean stocking, from 311 SPH in 1999 to 1156 SPH in 2006, could have been attributed to reduced fire occurrences, controlled grazing and tree cutting as a result of effective protection under PFM strategy. It implies therefore that PFM has positive impact on stocking distribution in Monduli forest reserve hence partly proving hypothesis no.1 of this study to be true. The same observation was also noted by Mohamed (2006) in Handeni Hill Forest Reserve, whereby stocking increased from 242±103 to 1083±184 within a three-year period (2001 - 2004).

Additionally, considerable increase was observed in diameter class one (5 – 10 cm dbh) (Fig. 6), whereby 701 SPH were recorded during this study while in an assessment done in the same forest in 1999 only 12 SPH were recorded. As regard to the stocking of known timber species like *Juniperus procera* and *Olea capensis*, the study revealed an increased stocking as compared to the one reported in 1999. The species had 2 and 2.6 SPH, respectively in 1999, but this study observed 16 and 25 SPH respectively; again with high stocking in diameter class one. The increased stocking of the known timber species could be attributed by reduced illegal incidences in the forest as only old tree cuts and several regenerants of the species were observed (Plate 1).

Plate 1: Saplings of *Juniperus procera* in Monduli Forest Reserve.

4.1.2 Basal area

In this study, it was found that the mean basal area for MFR is 37± 4.7 m^2 ha^{-1}, as compared to 27.1±2.5 m^2 ha^{-1} recorded in 1999 (Table 10). Fig. 8 below, compares the basal area in 1999 and 2006 in the forest. Although the recorded basal area in this study is slightly greater than the one observed in 1999, statistically the difference is not significant ($P<0.05$) (Table 8). This reveals that, PFM had no significant impact on basal area. The most likely reason falls within the time frame, of which the period of six years is short to show a significant increase especially in natural forests. However, the observed basal area is quite good as it is within the range of 24 – 60 m^2 ha^{-1} which is accepted for montane rain forests (Malende and Shemwetta, 2002b). Although the difference is not significant, the general trend shows a positive indication of good management because illegal activities like logging tend to have negative impact on basal area distribution.

On the other hand, the basal area in Monduli forest reserve seems to be average when compared to forests of similar nature (montane) such as, 44 m^2 ha^{-1} for Chome forest reserve (Malimbwi and Mugasha, 2001a), 17 – 45 m^2 ha^{-1} for Kilimanjaro forest reserve

(Malimbwi *et al.*, 2001), 51.49 $m^2 ha^{-1}$ for Mazumbai forest reserve (Temu and Malimbwi, 1991), and 30 $m^2 ha^{-1}$ for Meru forest reserve (Malende and Shemwetta, 2002b).

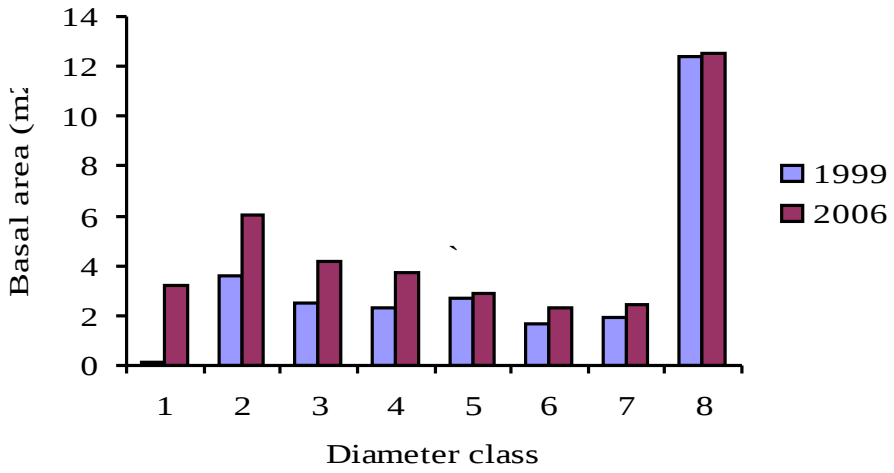

Figure 8: Comparison of basal area distribution between 1999 and 2006 in MFR.

4.1.3 Wood volume

The average standing wood volume for all diameter classes is 346 ± 68.78 $m^3 h^{-1}$. Nine species were found to have a significant contribution to the overall standing volume in MFR, with *Nuxia congesta*, *Ekebergia capensis* and *Ficus thoningii* ranking highest. In Fig. 9, the percentage distribution by species in MFR shows that 72% of the average total standing wood volume is distributed among the nine species, while only 28% is shared among the remaining 41 tree species. It was noted with interest that, almost all the nine species are not well known, the only exception being *Albizia gummifera.* MFR is very close to Moduli town, the headquaters of Monduli district. This closeness, together with change in technology and population increase, could have contributed to over exploitation of some known timber species like *Olea capensis* and *Fagaropsis angolensis.* In the past, the two tree species were common in the forest but their distribution is now poor.

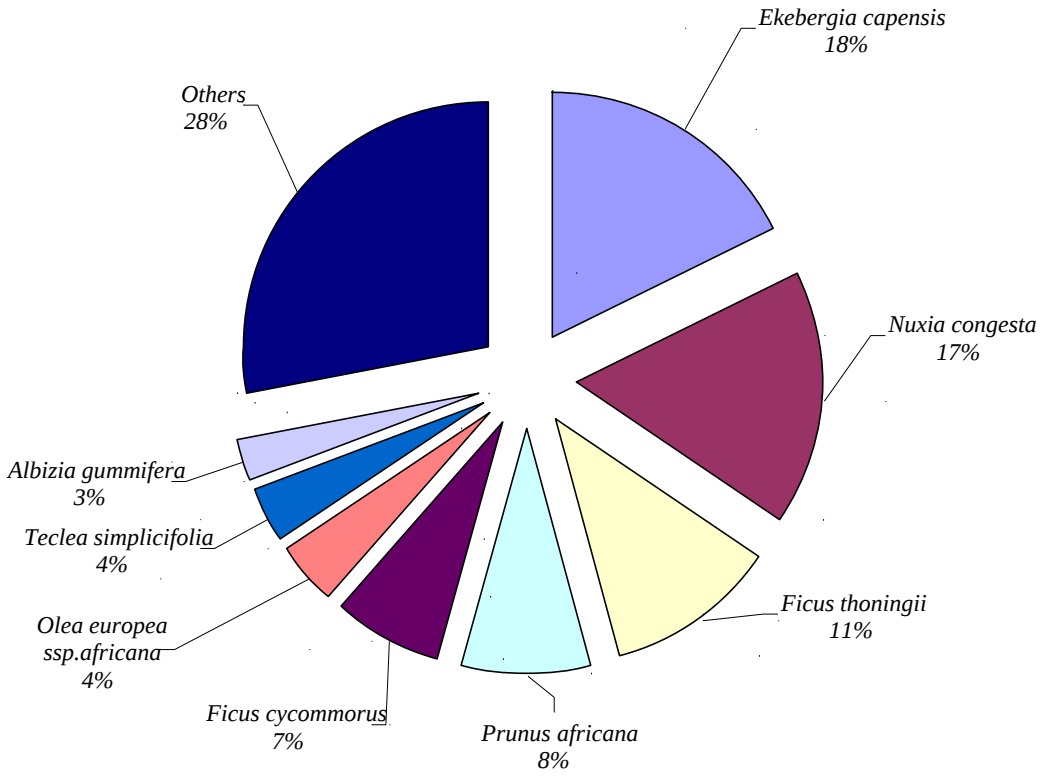

Figure 9: Percentage distribution of volume by species in MFR.

Nevertheless, the volume recorded in this study is 6.4% lower than that recorded six years back. Fig. 10 shows the trend based on diameter classes for the year 1999 and 2006 volumes. For diameter classes one, two, three and four, wood volumes were larger in 2006 than in 1999; while for diameter classes five, six and eight, volumes were lower in 2006. These results indicate that, larger trees may have been extracted from the forest although indication of tree cuts was hardly observed, implying that, PFM had no significant contribution to the average standing wood volume. This was further proved statistically not significance ($P<0.05$) hence proving hypothesis one negative. However, natural fall of large mature trees which was common especially on the southern side of the reserve was thought to be a major contributing factor (Plate 2).

Plate 2: Natural fall of trees in Monduli Forest Reserve.

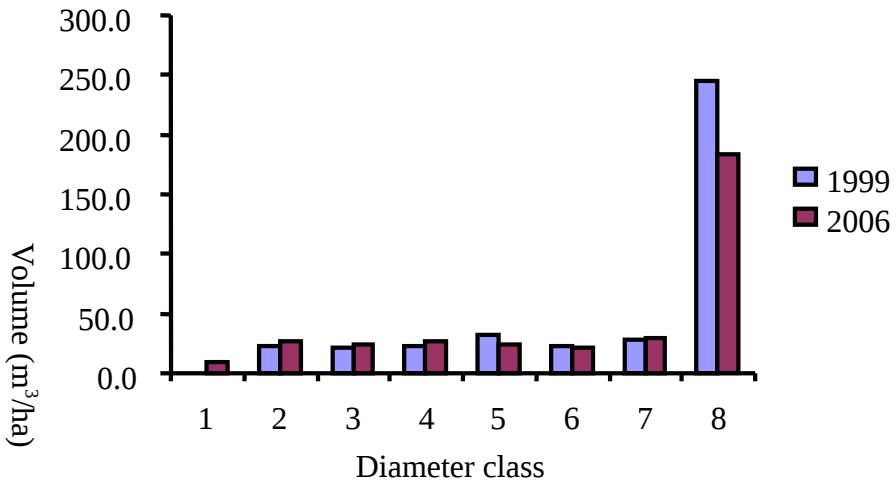

Figure 10: Comparison of wood volumes by diameter classes between 1999 and 2006 in MFR.

4.1.4 Tree species composition and diversity

Importance Value Index (IVI) was calculated in order to determine tree species dominance in MFR. The results showed that out of the 50 identified species, the forest is dominated by *Ekebergia capensis, Teclea simplicifolia, Nuxia congesta, Olea europaea* ssp *Africana, Prunus Africana* and *Dispyrous abyssinica.* (Fig. 11; Appendix 6). On the other hand, *Fagaropsis angolensis, Turrea holstii, Randia* sp, Enongujuka and Aladarda were the least

dominant species in the forest. Compared to the 1999 findings, *Prunus africana* and *Dispyrous abyssinica* were not among the six dominant tree species as the forest was dominated by *Teclea simplicifolia, Ekebergia capensis, Nuxia congesta, Olea europaea* ssp *Africana,Deinbollia bobonica* and *Cassipourea malosana.* This indicates that, there is no significant different in respect to dominant tree species. Furthermore, the findings reported *Trimeria grandifolia, Apodytes dimidiata, Rapanea melanophloeos* and *Caesaria battiscombei* as the least dominant tree species. According to the current study, *Trimeria grandifolia* species is approaching extinction, as neither mature trees nor regenerants were evident in the field. This situation has not to do with PFM because the species is not among the preferred tree species in Monduli. The reason might be the ecology of the forest does not favour the growth of these trees.

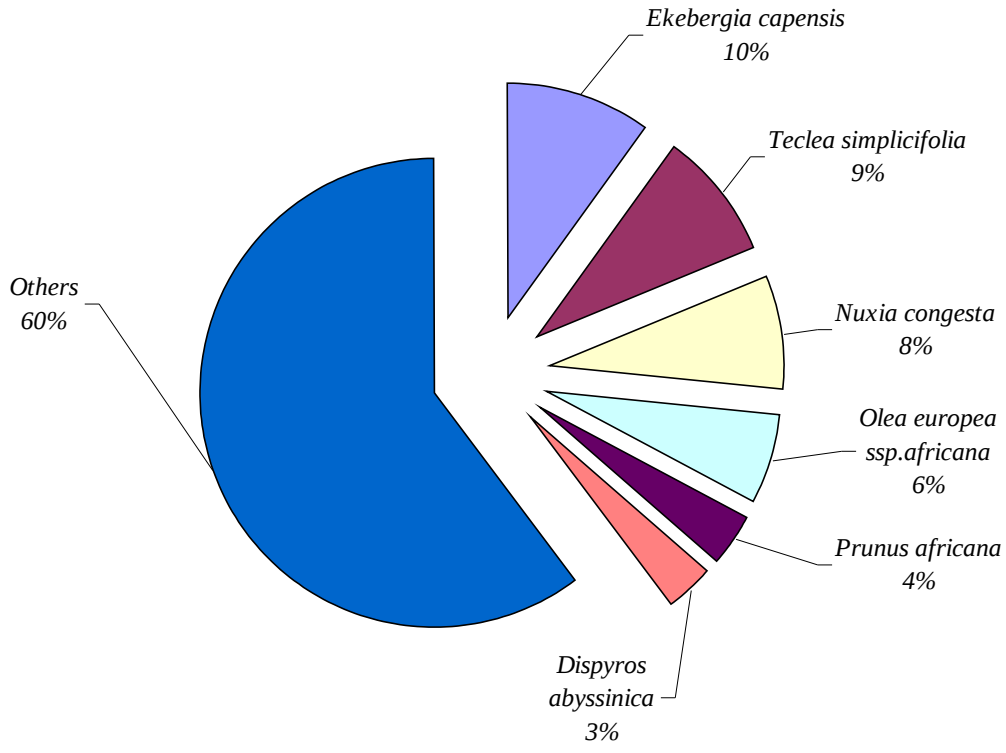

Figure 11: Percentage distribution of six dominant species with respect to IVI.

4.1.5 Vegetation regeneration

Regeneration is an indicator of the success of protection and it is also an indicator of the sustainability of the current practice with respect to each species. Appendix 5 shows the list of regenerating tree species having diameter at breast height less than 5 cm. An average of 6483 stems per hectare of the regenerants from a total of 32 different tree species was noted. Five tree species, *Clausina anisata*, *Caspourea alastroides*, *Teclea simplicifolia*, *Albizia gummifera* and *Olea europea* ssp. *Africana* noted to have higher regeneration potential (57%) as compared to 43% of remaining 27 species altogether (Fig. 12).

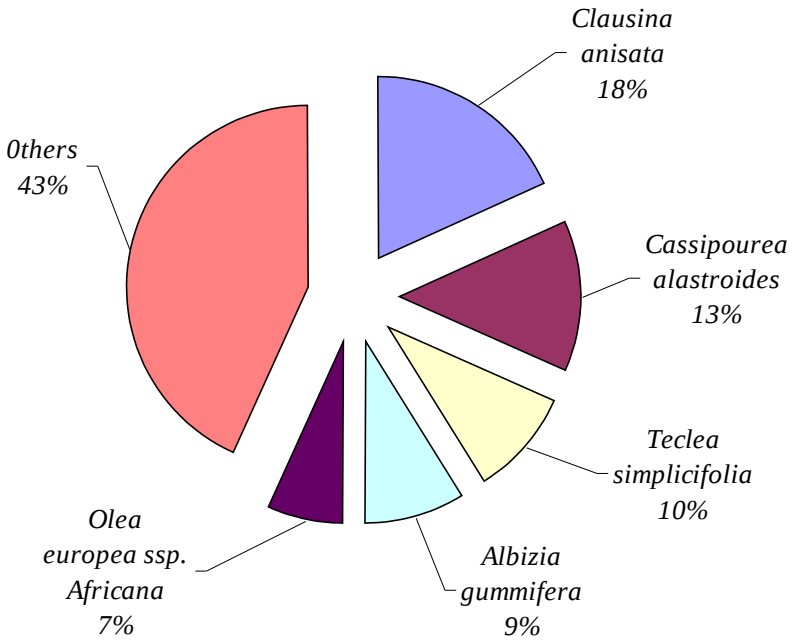

Figure 12: Percentage distribution regeneration by species in MFR.

It was observed that stratum 'A', which is characterised with trees more than 25 m with closed canopy, has very low number of regenerants per hectare as compared to stratum 'B'. This is due to the fact that stratum 'A' with its closed canopy, allows limited light which is important for regeneration, thereby suppressing the ground vegetation

regeneration; while stratum ‘B’, has crowns which allows light to penetrate. Less regeneration with poor survival was also recorded at the glades and at the border. This could be due to the fact that, areas close to the boundary is dominated by scrubs and grasses which suppress regenerants. Another reason could be, repeated disturbances caused by human activities such as grazing. It is also apparent that, if the current rate of seedling mortality continues for few more years, the forest regeneration at the periphery, would be severely affected leading to degradation or replacement by pioneers. However, it was not be possible to make a comparison of regeneration status as the parameter was not assessed in 1999. A higher percentage of regenerating trees may indicate successful protection (controlled grazing and removal). On the other hand, it was observed that the regeneration of well known tree species like *Juniperus procera*, *Olea capensis* and *Fagaropsis angolensis* were found to be 28, 71 and 14, respectively (Appendix 5). This may indicate a positive impact of PFM since the assessment done in 1999 reported little evidence of natural regeneration of these species in the field.

4.1.6 Communities’ perception on general benefits of PFM on forest conditions

During social data collection, the respondents were interviewed on their views on the general benefits of PFM. While 79.2% claimed that protection of the forest has improved considerably, 11.7% responded that PFM has reduced forest fires as a result the forest have benefited from this, 5.2% said rainfall has increased as a result of PFM, while 3% noted that utilisation of forest products is now done on a sustainable basis (Table 11). This implies that the health of MFR was being improved over time. A threat reduction assessment done in the forest in 2002 (Matungwa 2003) showed that, fire outbreak had reduced by 90%, illegal grazing had reduced by 60%, illegal lumbering reduced by 85%, and illegal cutting of live trees for poles and firewood had reduced by 50%.

Table 11: Perception of respondents on the general benefits of PFM.

Type of benefit	Village								Total (N=77) Chi-square 0.002	
	Mlimani (N=18)		Emairete (N=19)		Mfereji (N=23)		Imbibia (N=17)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Forest products utilised sustainably	0	0.0	0	0.0	0	0.0	3	17.6	3	3.9
Rainfall Increased	0	0.0	0	0.0	4	17.4	0	0.0	4	5.2
Fire incidences and illegality reduced	5	27.8	2	10.5	2	8.7	0	0.0	9	11.7
Forest conditions improved	13	72.2	17	89.5	17	73.9	14	82.4	61	79.2
Total	18	100.0	19	100.0	23	100.0	17	100.0	77	100.0

Before PFM, illegal cutting of trees was common in the forest. Nearly all the good timber like *Fagaropsis angolensis* had gone. Fires damaged the forest almost every dry season. During data collection, large groups of game such as buffaloes and elephants were common. This observation supports the report from Massawe (1999) which reported that, "Mgori Forest in Singida Region was on the way to extinction through improper management when under Government control. Many areas were being cleared by shifting cultivation. Illegal tree cutting claimed many good timber species. But the situation was arrested through community management". Similar observations were also made by Iddi (1999) in Gologolo forest Tanzania. 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 lead to improved biodiversity and ecological conservation (Branney and Yandav, 1998). However, contrary to these observations, PFM was found to have no impact on resource

base in Kwizu forest reserve (Kajembe *et al.,* 2004) implying that forest utilisation pressure is still high despite the presence of PFM.

Though generally, PFM seems to contribute significantly to the condition of the forest, this study observed some more factors that contributed to the situation. These are: ongoing awareness campaigns on environmental issues which are almost done countrywide and secondly, increased demand of wild meat which has lead to illegal pit sawyers to turn to poaching. Unlike 2002, where the threat reduction analysis done in the study forest recorded 85% reduction of illegal hunting, the situation was found opposite in 2006. Poaching is a serious and increasing problem especially in villages close to Monduli town. During the field survey some animal snares were seen in the forest. The continuing increase of cattle meat prices makes poaching of cheaper meat from wild animals more attractive. Again, poaching is easier and less time consuming than pit sawing.

4.2 Community livelihoods

"PFM being part of sustainable forest management has three equally important pillars. This includes the social; the environmental/ecological and the economical sustainability. Hence in order to secure the overall sustainability of PFM, focus should not only be on conservation, but also on economic incentives for communities to become and remain forest managers" (MNRT, 2003).

4.2.1 Awareness and involvement of local people in PFM

Fig. 13 below shows people's perception on PFM among the community in villages bordering the Monduli forest reserve. Overall,41% of the respondents believed that the awareness of local people is high, 40% moderate, while 19% thought that the awareness and involvement of the people in forest management is low.

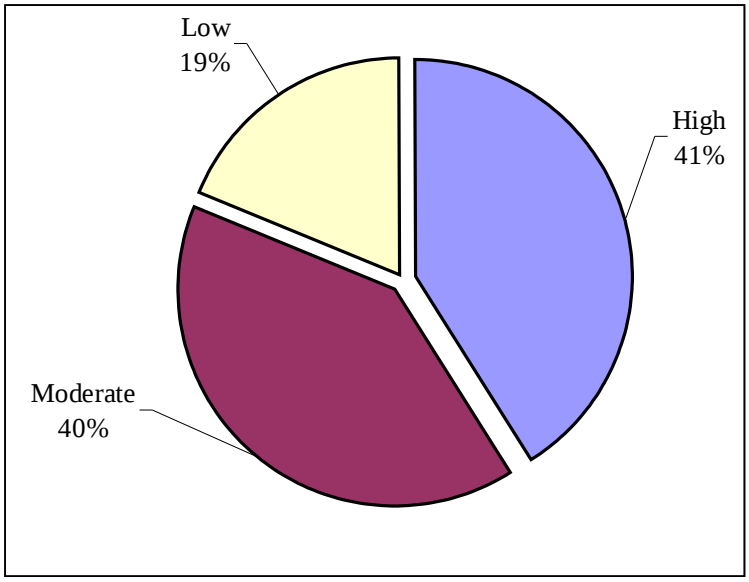

Figure 13: Stakeholders' awareness on PFM in villages bordering MFR.

This implies that about 81% of the people living adjacent to the forest are aware of their engagement on PFM and the remaining 19% are not. Similar results were reported by Kigula (2006) in East Usambara Forests where by about 71% of the respondents were aware of their village involvement in PFM. Also other studies, (Pokharel, 2000 cited in Kigula 2006; Polansky, 2003; Ghate and Mehra, 2006), indicated that participatory efforts in forests are significantly becoming acceptable at various levels of governance in Nepal, India and elsewhere in the world.

4.2.2 Food security

Food security is defined as "access by all people at all times to enough food for an active, healthy life" (FAO, 2002b). Generally, over the years food production in Tanzania has failed to meet demand and the country has been importing food and receiving food aid to meet its production shortfall (URT, 2006).

During the study, respondents were asked to state the main staple food of the household and if the food produced is enough or not. The study observed that communities adjacent

to MFR mainly depend on maize and beans for food and cash. In the study, the community was classified into two main groups viz those dependent on agriculture (agriculture and livestock keeping - 51.9%; agriculture only - 2.6%; agriculture and business - 2.6 %,), and secondly those dependent on livestock (entirely engaged on livestock keeping - 41.6%). The third group comprised of few members of the community who are employed especially primary school teachers, these mostly depend on their salary to buy food (Table 12). This observation fully concurs with Kilahama and Massao (1999), Mialla (2002), and Kaale and Mshana (2004) who reported that the main economic activities of the Monduli people are livestock keeping and agriculture.

Table 12: Distribution of respondents engaged in food production and economic activities.

Livestock only		Agriculture only		Livestock + Agriculture		Livestock + Employment		Agriculture + business		Total	
Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
32	41.6	2	2.6	40	51.9	1	1.3	2	2.6	77	100.0

Key: Freq = Frequency

Analysis done on the first group showed that 82% of the group is characterised with low food production. This is because the amount harvested could not sustain them for the whole year. The condition necessitates them to supplement food while the rest 18% do not. Generally, the results imply that PFM strategy had no impact on food production. The respondents were asked to mention the contributing factors which hindered them to produce adequate amount of food, of which drought and land scarcity ranked high as the major reasons for low food security (Table 13).

Table 13: Reasons for food insufficiency.

Reason	Frequency	%
Drought	31	40.2
Poor soil fertility	5	6.5
Land scarcity (small farms)	28	36.3
Poor farming systems	13	17.0
Total	77	100.0

Similar situation was observed by Mohamed (2006) in Handeni Hill Forest Reserve when he was assessing the impact of Joint Forest Management (JFM) on the reserve and adjacent communities. Mohamed reported that 91.1% of the villagers purchase food every year to supplement the deficit while only 8.9% maintained food security. Again drought was mentioned as the major reasons for the situation. Overall, the study observed that the problem of low food production is a major hindrance to achievement of communities' livelihoods. On the other hand, focus group discussion with district officials revealed that the district is a net importer of food, hence being one of the districts in the country characterised by low food production. During periods of drought, Monduli receives large quantities of food aid. Generally, villages situated in highlands zones of the district (studied villages being among them) are relatively characterized with high food security as compared to sister villages located at lowland zones. This is because of the favourable environment highly contributed by the forests.

4.2.3 Forest products and services obtainable by local people from MFR

When asked as to whether they have been enjoying some forest products and services from MFR, almost all respondents responded in affirmative. Further analysis on the benefits that have been obtained throughout (before and during PFM) by the communities, water ranked highest (97.4%), followed closely with firewood (96.1%) and fodder (88.3%). Other benefits given significant weight were herbal medicines and building poles

(Table 14). This implies that many people in the surveyed villages have limited alternatives hence tend to rely on easily accessible forest resources to earn a living. However, the situation on the ground reveals that collection of such products is not under proper control of Village Natural Resources Committees (VNRC) as it was stipulated in village forest management plans. Lack of incentives has led to laxity among the VNRCs members.

Table 14: Access of communities to forest products and services.

Type of products	Participants								Total	
	Before PFM		During PFM		Both before and during PFM		Neither before nor during PFM			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Vegetable (N=77)	2	2.6	5	6.5	11	14.3	59	76.6	77	100.0
Firewood (N=77)	1	1.3	1	1.3	74	96.1	1	1.3	77	100.0
Wild fruits (N=77)	1	1.3	0	0.0	35	45.5	41	53.2	77	100.0
Medicine (N=77)	1	1.3	2	2.6	59	76.6	15	19.5	77	100.0
Building poles (N=77)	7	9.1	1	1.3	57	74.0	12	15.6	77	100.0
Wild meat (N=77)	1	1.3	0	0.0	20	26.0	56	72.7	77	100.0
Timber (N=77)	22	28.6	2	2.6	7	9.1	46	59.7	77	100.0
Fodder (N=77)	3	3.9	0	0.0	68	88.3	6	7.8	77	100.0
Honey (N=77)	0	0	13	16.9	8	10.4	56	72.7	77	100.0
Water (N=77)	0	0.0	2	2.6	75	97.4	0	0.0	77	100.0

4.2.4 Income generating activities

Kahyarara *et al.* (2002) highlighted that there is a profound and vicious cycle between poverty and deforestation around the gazetted forests. This implies that economic status of any community adjacent to any forest resource has a direct impact on the resource. Results showed that little has been done in initiation of income generating activities for the communities adjacent to MFR. The reason was insufficient funds allocated for the activities.

Table 15: Distribution of respondents engaged in income generating activities.

Activity	Status	Before PFM		During PFM		Chi-square	Remark
		Freq	%	Freq	%		
Selling of tree products and seedlings	Not engaged	73	94.8	68	88.3	0.000	
	Engaged	4	5.2	9	11.7		
	Total	77	100.0	77	100.0		
Beekeeping	Not engaged	68	88.3	57	74.0	0.000	
	Engaged	9	11.7	20	26.0		
	Total	77	100.0	77	100.0		
Boundary management	Not engaged	77	100.0	60	78.0	0.000	Only introduced in one village - Imbibia
	Engaged	0	0.0	17	22.0		
	Total	77	100.0	77	100.0		
Ecotourism	Not engaged	77	100.0	73	94.8	0.000	
	Engaged	0	0.0	4	5.2		
	Total	77	100.0	77	100.0		

Table 15 shows only two activities, boundary management and ecotourism, have been introduced as a result of PFM. The other two activities, seedlings production and beekeeping, have just been emphasised with low adoption rate. Statistical test shows that there is a significant difference between those who are engaged in income earning activities and those who are not. Before PFM, 5.2% were engaged in selling of tree products and seedlings, but during PFM, 11.7% are involved in the activity, an increase of 6.5% within a period of six

years. Regarding beekeeping, the difference was also not significant as only 11.7% were engaged in beekeeping at the inception of PFM (1998), and 26% in 2006. It was observed that most beehives placed in the forest are traditional, and only few comply with modern techniques (plate 3a).

(a)

(b)

(c)

(d)

Plate 3: Income generating activities in Monduli. (a) & (b) beekeeping; (c) commercial tree nursery of HIMAWAMO women group; (d) boundary management

Boundary management initiatives, started recently as a trial in Imbibia village (Plate 3d). The aim was to create a production zone along the boundary. The activity involved clearing of part of the forest having no trees about 150 metres wide. The area was subdivided into smaller

plots of about 50 × 50 m each, which were then distributed to households within the village with priority given to those bordering the forest. Trees were planted and at the same time villagers were allowed to raise cash crops like carrots, tobacco and vegetables. The observed short falls of this initiative is that, plots were few hence only few village members benefited. Secondly, not all areas at the periphery of the MFR are suitable for production; some have steep slopes hence did not qualify for the activity. And thirdly was the tendency for farmers to expand their plots by extending beyond the 150 m limit.

The observed low adoption of alternative income earning strategies could be in due to two reasons; First, meagre funds allocated for income generating activities; and second, the nature of the community who mostly depend on livestock as their major economic activity. Kigula (2006) reported that, in interviews conducted in 210 households adjacent to West Usambara forests, 35% of the respondents agreed that there has been an increase of income generating activities as a result of PFM; 7% claimed such opportunities to have decreased; while 24% said activities have remained the same. On the other hand, 34% knew nothing about the situation of income generating as a result of PFM.

Contrary to Monduli results, the Handeni Hill results showed that JFM had a positive impact on income generating activities, but overall JFM did not seem to contribute substantially to the level of sustaining normal daily life. Such activities are commercial tree nurseries, beekeeping, and small scale business and making of burnt bricks (Mohammed, 2006).

4.2.5 General perception of respondents as regard to impacts of PFM on communities livelihood

When the respondents asked their views whether PFM has contributed anything to their livelihood, 15% agree that PFM has improved the forest conditions as well as communities livelihoods, 57% claimed that PFM has only improved general conditions of the MFR, a small portion (5%) of respondents did not see any impact of PFM neither on forest conditions nor livelihood. On the other hand, no one agrees that PFM has impact on people's livelihood only (Table 16). As such, it is appropriate to note here that the majority of people (especially low income) bordering the forest are not happy with PFM. This was due to the fact that formal mechanisms for cost and benefit sharing are not in place. They thought PFM strategy would have been of benefit to both the forest and the community. Furthermore, it was observed that economic incentives have been decreasing as before PFM the forest was more or less an open access hence more benefits.

Table 16: Perception of respondents on impacts of PFM on livelihoods.

Item	Village name								Total (N=77) Chi-square 0.000	
	Mlimani (N=18)		Emairete (N=19)		Mfereji (N=23)		Imbibia (N=17)			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
PFM has improved MFR conditions and livelihood	2	11.1	0	0	1	4.3	12	70.6	15	19.5
PFM has only improved MFR conditions	16	88.9	18	94.7	18	78.3	5	29.4	57	74.0
PFM has only improved livelihood	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
PFM has no impact on MFR and livelihood	0	0.0	1	5.3	4	17.4	0	0.0	5	6.5
Total	18	100.0	19	100.0	23	100.0	17	100.0	77	100.0

In his study, Mohammed (2006), got similar observations in Handeni Hill Forest when he made a general conclusion that JFM did not have positive significance impact on household livelihood. Kigula (2006) pointed out that, stakeholders adjacent to East Usambara forest are not fully empowered in managing the forest resulting into poor access, control and use of the resource and reduce the chances to explore potentials for PFM to reduce poverty and enhance their livelihoods. Similar observations were also made in Kwizu Forest Reserve (Kajembe *et al.,* 2004). Unlike to these negative observations, he observed positive contribution of PFM to community livelihood of Duru Haitemba whereby villagers are satisfied with the products they collect from the forest.

In India, stakeholders are happy with the approach. Small-scale forest based enterprises, many of which rely on NTFPs, have been established. The enterprises provide up to 50 percent of the income for about 25 percent of India's rural labour force (Prasad and Bhatnagar, 1991; Tewari and Campbell, 1995). Additionally, in the Caribbean, CANARI (2002) reported that livelihoods of persons who depend on forest resources have become more secure as a result of better managed forests (whose products can be sold at a higher price), increased skills, and the exclusion of competitors; and participatory arrangements have generated local employment. But conversely, livelihoods of those excluded from access to forest resources have become less secure, with fewer economic opportunities.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

PFM is one of the largest efforts in the world to involve village communities for the twofold objectives of, the sustainable management of forests; and providing for the sustainable livelihoods of participating village communities. This survey set out to review ecological and livelihood impact of PFM strategy in Monduli Forest Reserve and the surrounding community. The study concludes that PFM has positive impacts on the conditions of the forest; however, local communities have insufficient incentives to properly participate in these initiatives since livelihood issues have not been successfully addressed.

Before PFM illegal cutting of trees was common in the forest. Nearly all the good timber had gone and as well fires damaged the forest almost every dry season. But presently the forest is in a better condition. Regeneration especially in areas where the canopy is not closed is good. Average number of trees per hectare in smaller diameter class (5 – 10 cm) has increased tremendously from 12 stems per hectare in 1999 to 701 stems per hectare in 2006. Game has returned in substantial numbers in a way that instead of timber harvesting as it was used to be, illegal hunting for wild meat and animal damages to fields are now new problems.

As regard to livelihood, the study concluded further that, PFM has been contributing to stabilization of the resource base for various livelihood activities such as year-round forest pasturage; water; herbal medicine; and use of brush wood as fuel for household needs. However the strategy has done little to stimulate the development of new income sources

in the study villages. Only a few income generating activities have been initiated as a result of PFM.

Observations on the declining villagers' interest in PFM suggest that the main challenges in adopting the PFM policy at the ground level - where people's participation is needed - are economic. This is because the needs and aspirations of the people living around the MFR are mainly economic and developmental. The study further observed that, while foresters regard forest improvement as an aim and the villagers' involvement as a means, villagers on the other hand, see village and personal improvement as the aim and PFM as a means.

5.2 Recommendations

In order to make PFM on a scale sufficient to make a real difference in the future of Tanzanian's CFRs, (Monduli forest inclusive), this study makes recommendations in five thematic issues.

i. Intensifying funding for forest conservation

   There is a need to intensify political will and priority for ensuring sufficient funding of forest conservation programmes at local level particularly related to the community livelihood improvements and poverty reduction components.

ii. Promotion of alternative income earning strategies other than Non Wood Forest Products.

   Concerted efforts are required to promote alternative income earning to local communities currently relying on unsustainable utilisation of forest resources. Suggested strategies include, tree planting as cash crops, promotion of efficient firewood stoves, intensification of agricultural and livestock production as well as marketing.

iii. Promotion of the use of Non Wood Forest Products.

Due attention should be paid to the potential for sustainable production of NWFPs in forest management efforts, including PFM arrangements. NWFPs are integral to the lifestyle of forest-dependent communities. They have an added advantage over timber in terms of the time needed to achieve significant volumes of commercially valuable production. Further, in some areas timber harvesting may not be ecologically desirable.

iv. Putting mechanisms for cost and benefit sharing in place.

The study also recommends formal mechanisms for equitable benefits including revenue, and cost sharing to be worked out immediately. This will constitute an important element of motivation for stakeholders to embark on PFM process.

v. Introducing Payment for Environmental Services (PES).

Finally, local communities have insufficient incentives to properly participate in PFM initiatives. The study recommends introduction of PES system, which requires local communities engaged in PFM be compensated for their management efforts and, in turn safeguard their livelihoods. The incentives are expected to motivate the communities to participate in forest management at a much larger scale.

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APPENDICES

Appendix 1: Questionnaire for PFM impact evaluation

Basic information

1. Date ……..

2. Household ID/No. …….

3. Name of the household head/Respondent …… …….. Sex: F/M

4. Age …… 5. Ethnic/Tribe …… ….. 6. Wealthy rank ……

7. Village name …… 8. Ward …….. 9. Division ……

Section A: Food, nutritional and healthy security

1.1 What is the staple food of your family?

1- Maize

2- Banana

3- Beans

4- Others (specify) …….

1.2 Do you supplement staple food by buying every year? – Yes/No.

What about year 2005/2006 ……If you bought, how much?

1- Most

2- Half

3- Little

1.3 What are the reasons for not satisfying staple food for your household use?

1- Drought

2- Poor fertility

3- Small farms

1.4 Access to forest resources/products for a living in a household

i. Is your household having access to forest products:

- Yes
- No

ii. If Yes which among the following

Type of forest products	Before PFM	During PFM
Vegetables		
Firewood		
Wild fruits		
Herbal medicine		
Building poles		
Wild meat		
Timber		
Fodder/pasture		
Water		
Others (Specify)		

iii. Is there any effort of making alternatives of the products obtained in the forest reserve outside the forest reserve?

- Before PFM: Yes/No
- After PFM: Yes/No

iv. If yes mention them

Alternative efforts	Before PFM	During PFM

NB: Alternative efforts can be tree planting for building poles, firewood production, brick making, fuel saving stoves construction and using, vegetable gardens and others

v. How do you say on the rate of forest utilisation and accessibility to the resource before and during PFM?

- Accessibility: Before PFM: 1 - High 2 - Medium 3- Low
  During PFM: 1 - High 2 - Medium 3- Low
- Utilisation: Before PFM: 1 - High 2 - Medium 3- Low
  During PFM: 1 - High 2 - Medium 3- Low

Section B: Economic security (household assets and income streams)

2.1 Is there any difference between your construction materials for your house before?

PFM and after PFM:

- Yes
- No

2.2 Dou you posses land: Yes/No what size is your farm ……..

2.3 How did the land acquired?

- Inheritance
- Borrowed
- Purchased
- Village offer

2.4 Household income streams/sources

Income sources	Earnings per year	Before PFM	During PFM
Cultivation of Cash crops			
Selling tree products			
Selling nursery seedling			
Livestock keeping			
Beekeeping			
Poultry keeping			
Employed			
Any other sources			

2.5 Do your household or village get any revenue accrued from ecotourism?

1. Before PFM: Yes/No
2. During PFM: Yes/No

2.6 Do you plant trees for your household use?

1. Before PFM
2. During PFM
3. Both

2.7 List the name of the trees planted and expected end use

No.	Name of species	Uses

2.8 Human resource capital (Access to training opportunities)

1. Is your household members participated in any of the farmers' training opportunities below

Training opportunity	Before PFM	During PFM
Seminars		
Study tours		
Meetings		
Workshop		
Cinema/Video shows		
Seedling raising		
Energy saving stoves construction		
Contour construction		
Others (Specify)		

2. What can you comments on capacity/awareness of you household and villagers in general on management of forest resources in general if you compare the situation before PFM and after PFM?
    - High
    - Moderate
    - Low
3. What is your recommendation on capacity building for the future of your household and the village in general?

Section C: Forest management issues

3.1. In your opinion, what is the rate of forest depletion in the area?

1. Very high
2. Moderate
3. High
4. Low

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

1. Creation of new farms
2. Creation of new settlements
3. Fires
4. Tree cutting for poles, timber, and fuel wood
5. Others (specify)…….

3.3. How are people involved in the protection of MFR? …….

3.4. Do you feel there has been a change in (rainfall, water availability, regeneration) over the past?

1. Yes
2. No

3.5 If yes, please give at least one reason…….

3.6. Do you know the forest reserve boundaries?

1. Yes
2. No

3.7 If yes, are they respected?

1. Yes
2. No

3.8 Are there any ritual sites in the forest reserve?

1. Yes
2. No

3.9 If yes, how do you get access to that?

1. Permission
2. Free
3. Illegally

3.10 Is there illegal pit sawing

1. Yes
2. No

3.11 If yes, what is their extent?

1. Large
2. Medium
3. Small

3.12 Do you know any case of encroachment in the forest reserve

1. Yes
2. No

3.13 If yes, mention reasons for encroachment

1. Boundary not known
2. Poor soil fertility outside the reserve
3. Land scarcity
4. Migration
5. Livestock keeping
6. Others

4. What are the general benefits of PFM?

1. Income generating activities has been introduced
2. Forest products has been utilised sustainably
3. Rainfall has increased
4. Forest fire incidences and illegalities has reduced
5. Forest conditions has improved
6. No remarkable benefits

5. What are the benefits of PFM on communities' livelihood?

1. PFM has improved both the forest conditions and local communities livelihood
2. PFM has only improved forest conditions
3. PFM has only improved livelihoods
4. PFM has no impact on the forest conditions and communities livelihoods

Appendix 2: Checklist for key informant survey

A: Regional and district catchment forest officers

1. Past and current management strategies and their differences
2. Existing forest management problems and success
3. Weakness and strength of PFM and its impact to sustainability of forests
4. Cost and benefit sharing mechanism between government and communities
5. Sustainability of income generating sources and alternative use of forest resources
6. Improvement in forest and society as a result of PFM.
7. Comments and future prospects of PFM

B: District forest and natural resources officers (DFO and DNRO)

1. Collaboration between District Catchment Forest Office (DCFO) and DFO/DNRO
2. Programs related to PFM (CBFM and JFM) in local and central government forests and their impacts.
3. Comments on PFM and three parallel structures on natural resources management

C: Village Governments And Village Natural Resources Committees (VNRCs) and other community based organisations dealing with environment conservation and/or poverty alleviation.

1. Situation in forest and society before and after PFM
2. Initiatives and activities on PFM
3. Do community participate in the management activities of the reserve? What are the activities
4. Cost and benefit on PFM
5. Strength weaknesses of VNRC in protection and conservation of MCFR
6. Strength and weakness of village bylaws

7. Strength and weakness forest management agreements between government and villages
8. What about income generating activities as one of the component of PFM
9. Land availability
1. Fire occurrences, illegal acts, encroachment in forest reserve
2. Capacity building on forest management and how women are involved. Situation compared Before and after PFM
3. General comments on PFM

Appendix 3: Field form

Date …… Recorder …… …… Form No. …….

Village……. Ward …… Division ……...

Strata …… …… Plot No. ……... Slope …….

Altitude ……. (masl) Location- Easting…… Northing ……...

Tree No.		DBH (cm)	Tree No.		DBH (cm)	Remarks

Sample trees for height estimation

Tree No.	Local name	DBH (cm)	Est. tree ht (m)
1			
2			
3			

Appendix 4: List of tree species found in Monduli Forest Reserve

Spp code	Scientific name	Local name
1	*Acacia lahai*	*Olorimbai/olabai*
2	*Albizia gummifera*	*Osangupes*
3	*Apodytes dimidiata*	*Enjani-naiboro*
4	*Bersama abyssinica*	*Eng'arangupe*
5	*Buddeia salvifolia*	*Olopironi-naiboro*
6	*Caearia battiscombei*	*Olmorijoi*
7	*Calodendron capense*	*Alalashii*
8	*Cassipourea alastroides*	*Osojo*
9	*Cassipourea malosana*	*Olaiselegi/olmubara*
10	*Catha edulis*	*Olemiraa*
11	*Celtis africana*	*Ositeti-lendin*
12	*Clausina anisata*	*Emartasian, olmatasian*
13	*Fagaropsis angolensis*	*Olmorijoi*
14	*Croton macrostachyus*	*Oloiyapiyapi*
15	*Cussonia arborea*	*Oltimaron*
16	*Denbollia borbonica*	*Oloibor-kulalet*
17	*Dispyros abyssinica*	*Olchatian/ ndatuian*
18	*Dombeya rotundifolia*	*Osupukei*
19	*Ehretia cymosa*	*Emwiimbi/Enjaniekahe*
20	*Ekebergia capensis*	*Olmukuna*
21	*Elaeodendron buchananii*	*Orbharasendu*
22	*Euclea divinorium*	*Olkinyei/mdaa*
23	*Ficus cycommorus*	*Olngaboli*
24	*Ficus thoningii*	*Oleteti*
25	*Flacourtia indica*	*Emadwa*
26	*Juniperus procera*	*Oltarakwai*
27	*Lepidotrichilia volkensii*	*Engilelekuru*
28	*Maesa lanceolata*	*Orong'orwa*
29	*Maytenus mossambicensis*	*Olemunyi/ olaimurunyai*
30	*Nuxia congesta*	*Olopironi*
31	*Ochna holstii*	*Enjaniondari*
32	*Olea capensis*	*Ololiondo*
33	*Olea europea ssp. Africana*	*Oloiyen/ olorien*
34	*Prunus africana*	*Olkujuki*
35	*Rapanea melanophloeas*	*Lodwa/Engodwai/ngesi*
36	*Rhandia*	*Osieki/mviru*
37	*Rhoicissuss revoilii*	*Engaimoronyai*
38	*Ritchiea albersii*	*Enjanengai/mlandege*
39	*Schrebera alata*	*Olbobok/ olkobobi/Oloiborbenek*
40	*Teclea simplicifolia*	*Engilai/Olgilai*
Spp code	**Scientific name**	**Local name**
41	*Turrea holstii*	*Enjader-der/ enjaninado*

42	*Vangueria infausta*	*Engodo/ Engumi?*
43	*Zanthozylum chalybium*	*Oloisuki*
44	*Unknown 1*	*Olpopong'i*
45	*Unknown 2*	*Ethumutent*
46	*Unknown 3*	*Engoipiri*
47	*Unknown 4*	*Enogujuka*
48	*Unknown 5*	*Aladarda*
49	*Unknown 6*	*Olodoh*
50	*Unknown 7*	*Engikaret*

Appendix 5: Regeneration for tree species less than 5 cm in Monduli Forest Reserve

Scientific name	Local name	Reg.per ha.	Mean reg/ha
Clausina anisata	*Emartasian*	66864	1194
Cassipourea alastroides	*Osojo*	47771	853
Teclea simplicifolia	*Olgilai*	35024	625
Albizia gummifera	*Osanguves*	31847	569
Olea europea ssp. Africana	*Oloiyeni*	23885	427
Cassipourea malosana	*Laiseleki*	15127	270
Ekebergia capensis	*Olmkuna*	13535	242
Rapanea melanophloeas	*Lodwa*	11943	213
Rhoicissuss revoilii	*Engaimurunyai*	11943	213
Zanthozylum chalybium	*Oloisuki*	11146	199
Catha edulis	*Olemoraa*	10350	185
Dispyros abyssinica	*Ndartuian*	9554	171
Bersama abyssinica	*Emarangguve*	8758	156
Vangueria infausta	*Engodo*	8758	156
Maytenus mossambicensis	*Olemunyi*	7962	142
Nuxia congesta	*Olopironi*	6369	114
Schrebera alata	*Oloibobok*	6369	114
Ehretia cymosa	*Emwiimbi*	5573	100
Caearia battiscombei	*Olmorijoi*	4777	85
Olea capensis	*Oloriondo*	3981	71
Prunus africana	*Olkujuki*	3981	71
Celtis africana	*Ositet lendin*	3185	57
Denbollia borbonica	*Oloibokularet*	2389	43
Euclea divinorium	*Enginyei*	2389	43
Buddeia salvifolia	*Engophiron*	1592	28
Calodendron capense	*Alalashi*	1592	28
Croton macrostachyus	*Oloipiyapiya*	1592	28
Juniperus procera	*Oltarakwai*	1592	28
Acacia lahai	*Olimbai*	796	14
Ochna holstii	*Enjaniondar*	796	14
Turrea holstii	*Enjaninado*	796	14
Fagaropsis angolensis	*Olmorijoi*	796	14

Appendix 6: Species distribution in order of IVI in Monduli Forest Reserve

Code	Botanical name	N	G	V	Freq	Rel. Freq	Rel. Dom.	Rel. Dens.	IVI
20	*Ekebergia capensis*	114	5.11	61.95	24	6.35	13.71	9.86	29.92
40	*Teclea simplicifolia*	148	2.29	12.35	29	7.67	6.16	12.83	26.66
30	*Nuxia congesta*	55	5.62	57.77	14	3.70	15.09	4.77	23.56
33	*Olea europea ssp.africana*	82	1.79	14.51	23	6.08	4.82	7.07	17.97
34	*Prunus africana*	20	2.75	28.38	7	1.85	7.39	1.72	10.97
17	*Dispyros abyssinica*	39	0.92	5.93	17	4.50	2.47	3.37	10.33
28	*Maesa lanceolata*	45	1.35	7.85	7	1.85	3.63	3.90	9.38
42	*Vangueria infausta*	53	0.51	2.29	10	2.65	1.38	4.60	8.62
11	*Celtis africana*	33	0.89	5.65	12	3.17	2.39	2.89	8.45
24	*Ficus thoningii*	6	2.25	39.42	7	1.85	6.03	0.55	8.43
22	*Euclea divinorium*	56	0.85	3.84	4	1.06	2.29	4.86	8.21
16	*Denbollia borbonica*	28	0.83	8.86	13	3.44	2.23	2.43	8.10
15	*Cussonia arborea*	25	0.66	4.86	12	3.17	1.76	2.19	7.13
2	*Albizia gummifera*	14	1.15	10.21	8	2.12	3.09	1.17	6.37
26	*Juniperus procera*	16	1.02	9.84	7	1.85	2.73	1.42	5.99
9	*Cassipourea malosana*	24	0.46	2.47	10	2.65	1.23	2.06	5.93
19	*Ehretia cymosa*	13	0.69	3.97	10	2.65	1.86	1.16	5.67
12	*Clausina anisata*	36	0.16	0.51	8	2.12	0.44	3.10	5.65
6	*Caearia battiscombei*	23	0.26	1.21	10	2.65	0.70	1.95	5.30
37	*Rhoicissuss revoilii*	19	0.16	0.72	12	3.17	0.43	1.67	5.28
32	*Olea capensis*	25	0.33	1.87	8	2.12	0.88	2.15	5.14
23	*Ficus cycommorus*	2	1.50	24.59	3	0.79	4.02	0.13	4.94
18	*Dombeya rotundifolia*	15	0.61	5.63	7	1.85	1.63	1.28	4.76
21	*Elaeodendron buchananii*	11	0.55	3.51	8	2.12	1.48	0.95	4.54
4	*Bersama abyssinica*	18	0.17	0.75	9	2.38	0.46	1.57	4.41
14	*Croton macrostachyus*	14	0.31	2.14	9	2.38	0.82	1.18	4.38
39	*Schrebera alata*	18	0.25	1.26	8	2.12	0.66	1.51	4.29
35	*Rapanea melanophloeas*	21	0.22	1.01	6	1.59	0.60	1.78	3.97
1	*Acacia lahai*	15.7	0.29	1.52	6	1.59	0.79	1.36	3.74
46	*Unknown 3 (Engoipiri)*	20	0.23	1.22	5	1.32	0.61	1.71	3.64
49	*Unknown 6 (Olodoh)*	12	0.28	1.73	7	1.85	0.75	0.99	3.60
31	*Ochna holstii*	16	0.18	1.00	6	1.59	0.49	1.39	3.47
8	*Cassipourea alastroides*	13	0.22	1.07	6	1.59	0.59	1.15	3.32
5	*Buddeia salvifolia*	13	0.30	1.70	5	1.32	0.80	1.14	3.26
10	*Catha edulis*	15	0.12	0.41	5	1.32	0.32	1.33	2.97
27	*Lepidotrichilia volkensii*	4	0.47	4.06	4	1.06	1.27	0.36	2.68
7	*Calodendron capense*	6	0.16	0.89	6	1.59	0.42	0.56	2.57
50	*Unknown 7 (Engikaret)*	19	0.10	0.33	2	0.53	0.27	1.62	2.42
43	*Zanthozylum chalybium*	6	0.25	1.83	3	0.79	0.68	0.49	1.96
38	*Ritchiea albersii*	7	0.05	0.16	4	1.06	0.14	0.64	1.83
3	*Apodytes dimidiata*	5	0.23	2.38	2	0.53	0.63	0.42	1.57
25	*Flacourtia indica*	9	0.15	0.66	1	0.26	0.39	0.78	1.44
29	*Maytenus mossambicensis*	5	0.05	0.18	3	0.79	0.13	0.39	1.32
44	*Unknown 1 (Olpopong'i)*	1	0.24	2.48	2	0.53	0.64	0.04	1.21
45	*Unknown 2 (Ethumutent)*	6	0.04	0.16	2	0.53	0.12	0.54	1.19
13	*Fagaropsis angolensis*	4	0.10	0.59	2	0.53	0.27	0.36	1.16
41	*Turrea holstii*	3	0.02	0.07	2	0.53	0.05	0.25	0.83
48	*Unknown 5 (Aladarda)*	2	0.05	0.26	1	0.26	0.15	0.20	0.61
36	*Rhandia spp*	1	0.02	0.11	1	0.26	0.07	0.10	0.43
47	*Unknown 4 (Enogujuka)*	1	0.02	0.09	1	0.26	0.06	0.10	0.42
TOTAL		**115 6**	**37.2 4**	**346.2 2**	**378**	**100.00**	**100.00**	**100.00**	**300.00**

Appendix 7: Distribution stands parameters based in and diameter classes in Monduli Forest Reserve

Code	Botanical name	DBH CLASSESS																								TOTAL		
		I (5 – 10 cm)			II (10.1 – 20 cm)			III (20.1 – 30 cm)			IV (30.1 – 40 cm)			V (40.1 – 50 cm)			VI (50.1 - 60 cm)			VII (60.1 – 70 cm)			VIII (> 70.1 cm)					
		N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V
1	*Acacia lahai*	6.8	0.03	0.08	7.4	0.15	0.71	0.8	0.04	0.23	0.8	0.07	0.51	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**15.7**	**0.29**	**1.52**
2	*Albizia gummifera*	6.8	0.03	0.09	3.4	0.07	0.29	1.3	0.06	0.34	0.3	0.20	1.30	0.3	0.03	0.25	1.0	0.23	2.18	0.3	0.08	0.78	0.3	0.45	4.98	**13.5**	**1.15**	**10.21**
3	*Apodytes dimidiata*	4.5	0.03	0.12	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.3	0.20	2.26	**4.8**	**0.23**	**2.38**
4	*Bersama abyssinica*	13.6	0.07	0.20	4.0	0.06	0.26	0.3	0.01	0.09	0.3	0.03	0.21	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**18.1**	**0.17**	**0.75**
5	*Buddeia salvifolia*	6.8	0.04	0.14	4.5	0.10	0.47	0.8	0.04	0.21	0.8	0.07	0.51	0.3	0.04	0.37	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**13.1**	**0.30**	**1.70**
6	*Caearia battiscombei*	15.9	0.09	0.27	5.1	0.08	0.32	1.3	0.08	0.48	0.3	0.02	0.15	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**22.6**	**0.26**	**1.21**
7	*Calodendron capense*	2.3	0.01	0.04	3.4	0.07	0.34	0.3	0.01	0.09	0.3	0.02	0.15	0.3	0.03	0.27	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**6.4**	**0.16**	**0.89**
8	*Cassipourea alastroides*	4.5	0.02	0.04	8.0	0.15	0.69	0.5	0.02	0.13	0.3	0.03	0.20	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**13.3**	**0.22**	**1.07**
9	*Cassipourea malosana*	11.4	0.06	0.17	9.1	0.18	0.80	2.3	0.10	0.58	0.8	0.08	0.59	0.3	0.04	0.33	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**23.8**	**0.46**	**2.47**
10	*Catha edulis*	13.6	0.09	0.31	1.7	0.03	0.11	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**15.4**	**0.12**	**0.41**
11	*Celtis africana*	25.0	0.12	0.34	5.1	0.11	0.50	2.5	0.11	0.65	0.5	0.50	3.70	0.0	0.00	0.00	0.3	0.05	0.46	0.0	0.00	0.00	0.0	0.00	0.00	**33.4**	**0.89**	**5.65**
12	*Clausina anisata*	31.8	0.11	0.29	4.0	0.05	0.22	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**35.8**	**0.16**	**0.51**
13	*Fagaropsis angolensis*	2.3	0.01	0.05	0.6	0.01	0.05	1.0	0.05	0.26	0.3	0.03	0.24	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**4.1**	**0.10**	**0.59**
14	*Croton macrostachyus*	9.1	0.03	0.08	1.7	0.03	0.13	2.3	0.12	0.73	0.0	0.00	0.00	0.0	0.00	0.00	0.5	0.13	1.20	0.0	0.00	0.00	0.0	0.00	0.00	**13.6**	**0.31**	**2.14**
15	*Cussonia arborea*	13.6	0.05	0.14	7.4	0.12	0.49	2.3	0.11	0.67	1.3	0.12	0.81	0.0	0.00	0.00	0.3	0.05	0.45	0.0	0.00	0.00	0.5	0.21	2.29	**25.3**	**0.66**	**4.86**
16	*Denbollia borbonica*	22.7	0.10	0.28	4.5	0.07	0.28	0.0	0.00	0.00	0.0	0.00	0.00	0.3	0.05	0.44	0.0	0.00	0.00	0.0	0.00	0.00	0.5	0.62	7.86	**28.1**	**0.83**	**8.86**
17	*Dispyros abyssinica*	22.7	0.09	0.25	9.1	0.17	0.76	3.5	0.18	1.06	2.3	0.24	1.74	0.8	0.13	1.07	0.5	0.11	1.04	0.0	0.00	0.00	0.0	0.00	0.00	**38.9**	**0.92**	**5.93**
18	*Dombeya rotundifolia*	6.8	0.03	0.08	5.7	0.10	0.45	1.3	0.07	0.46	0.5	0.04	0.31	0.0	0.00	0.00	0.3	0.06	0.53	0.0	0.00	0.00	0.3	0.30	3.80	**14.8**	**0.61**	**5.63**
19	*Ehretia cymosa*	6.8	0.03	0.08	4.5	0.09	0.38	0.8	0.40	2.00	0.8	0.08	0.55	0.3	0.04	0.38	0.3	0.06	0.57	0.0	0.00	0.00	0.0	0.00	0.00	**13.4**	**0.69**	**3.97**
20	*Ekebergia capensis*	81.9	0.37	1.09	20.5	0.36	1.56	4.8	0.23	1.34	2.3	0.20	1.40	0.8	0.12	0.99	0.3	0.07	0.70	0.8	0.25	2.62	2.8	3.50	52.25	**114.0**	**5.11**	**61.95**
21	*Elaeodendron buchananii*	4.5	0.02	0.05	5.1	0.08	0.32	1.0	0.06	0.34	0.0	0.00	0.00	0.3	0.40	2.80	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**10.9**	**0.55**	**3.51**
22	*Euclea divinorium*	22.7	0.11	0.32	30.7	0.62	2.79	2.8	0.13	0.73	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**56.2**	**0.85**	**3.84**
23	*Ficus cycommorus*	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.5	0.08	0.70	0.3	0.06	0.61	0.0	0.00	0.00	0.8	1.35	23.27	**1.5**	**1.50**	**24.59**
24	*Ficus thoningii*	4.5	0.02	0.04	0.0	0.00	0.00	0.5	0.03	0.21	0.8	0.08	0.59	0.0	0.00	0.00	0.3	0.07	0.62	0.0	0.00	0.00	0.3	2.05	37.96	**6.3**	**2.25**	**39.42**
25	*Flacourtia indica*	4.5	0.03	0.11	4.0	0.08	0.39	0.5	0.03	0.17	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**9.0**	**0.15**	**0.66**
26	*Juniperus procera*	11.4	0.06	0.17	4.0	0.09	0.40	0.3	0.01	0.09	0.3	0.02	0.12	0.3	0.04	0.34	0.0	0.00	0.00	0.0	0.00	0.00	0.3	0.80	8.72	**16.4**	**1.02**	**9.84**
27	*Lepidotrichilia volkensii*	2.3	0.02	0.06	0.6	0.01	0.02	1.0	0.05	0.28	0.0	0.00	0.00	0.3	0.40	3.70	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**4.1**	**0.47**	**4.06**
28	*Maesa lanceolata*	11.4	0.05	0.16	21.6	0.47	2.17	7.1	0.34	1.96	4.0	0.35	2.38	1.0	0.15	1.18	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**45.1**	**1.35**	**7.85**
29	*Maytenus mossambicensis*	2.3	0.02	0.06	2.3	0.03	0.12	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**4.5**	**0.05**	**0.18**
30	*Nuxia congesta*	15.9	0.06	0.17	13.6	0.29	1.33	9.6	0.48	2.81	3.8	0.40	2.89	4.5	0.76	6.38	2.3	0.57	5.37	2.3	0.74	7.56	3.0	2.33	31.26	**55.1**	**5.62**	**57.77**
31	*Ochna holstii*	13.6	0.05	0.13	1.7	0.05	0.23	0.0	0.00	0.00	0.8	0.09	0.64	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**16.1**	**0.18**	**1.00**
32	*Olea capensis*	18.2	0.07	0.20	5.1	0.10	0.43	0.8	0.04	0.23	0.3	0.02	0.17	0.5	0.10	0.85	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**24.8**	**0.33**	**1.87**
33	*Olea europea ssp.africana*	40.9	0.15	0.40	27.9	0.44	2.02	9.8	0.15	0.90	1.0	0.09	0.59	0.0	0.00	0.00	0.8	0.17	1.58	0.8	0.28	2.98	0.5	0.52	6.04	**81.7**	**1.79**	**14.51**

Code	Botanical name	DBH CLASSESS																						TOTAL		
		I (5 – 10 cm)			II (10.1 – 20 cm)			III (20.1 – 30 cm)			IV (30.1 – 40 cm)			V (40.1 – 50 cm)			VI (50.1 - 60 cm)			VII (60.1 – 70 cm)			VIII (> 70.1 cm)					
		N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V
34	*Prunus africana*	9.1	0.05	0.14	8.5	0.16	0.71	1.3	0.60	3.70	0.3	0.30	2.30	0.3	0.05	0.44	0.3	0.60	6.10	0.3	1.00	15.00	0.0	0.00	0.00	**19.9**	**2.75**	**28.38**
35	*Rapanea melanophloeas*	13.6	0.05	0.15	5.7	0.11	0.51	1.0	0.04	0.22	0.3	0.02	0.13	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**20.6**	**0.22**	**1.01**
36	*Rhandia spp*	0.0	0.00	0.00	1.1	0.02	0.11	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**1.1**	**0.02**	**0.11**
37	*Rhoicissuss revoilii*	13.6	0.04	0.11	5.1	0.07	0.31	0.0	0.00	0.00	0.5	0.04	0.30	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**19.3**	**0.16**	**0.72**
38	*Ritchiea albersii*	6.8	0.05	0.14	0.6	0.01	0.02	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**7.4**	**0.05**	**0.16**
39	*Schrebera alata*	13.6	0.10	0.32	2.8	0.05	0.24	0.5	0.03	0.18	0.3	0.02	0.14	0.3	0.04	0.37	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**17.5**	**0.25**	**1.26**
40	*Teclea simplicifolia*	91.0	0.43	1.30	44.9	0.87	3.90	7.6	0.38	2.21	3.0	0.31	2.21	1.5	0.22	1.73	0.0	0.00	0.00	0.3	0.09	1.01	0.0	0.00	0.00	**148.3**	**2.29**	**12.35**
41	*Turrea holstii*	2.3	0.01	0.04	0.6	0.01	0.03	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**2.8**	**0.02**	**0.07**
42	*Vangueria infausta*	40.9	0.19	0.56	9.7	0.17	0.77	2.3	0.11	0.67	0.0	0.00	0.00	0.3	0.04	0.29	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**53.1**	**0.51**	**2.29**
43	*Zanthozylum chalybium*	4.5	0.03	0.09	0.6	0.01	0.04	0.3	0.02	0.09	0.3	0.20	1.60	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**5.6**	**0.25**	**1.83**
44	Unknown 1	0.0	0.00	0.00	0.0	0.00	0.00	0.3	0.02	0.11	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.3	0.22	2.37	**0.5**	**0.24**	**2.48**
45	Unknown 2	4.5	0.02	0.05	1.7	0.03	0.11	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**6.3**	**0.04**	**0.16**
46	Unknown 3	15.9	0.07	0.19	2.8	0.06	0.30	0.5	0.02	0.12	0.3	0.02	0.12	0.0	0.00	0.00	0.3	0.05	0.48	0.0	0.00	0.00	0.0	0.00	0.00	**19.8**	**0.23**	**1.22**
47	Unknown 4	0.0	0.00	0.00	1.1	0.02	0.09	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**1.1**	**0.02**	**0.09**
48	Unknown 5	0.0	0.00	0.00	2.3	0.05	0.26	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**2.3**	**0.05**	**0.26**
49	Unknown 6	4.5	0.02	0.04	5.7	0.12	0.57	0.5	0.03	0.15	0.3	0.02	0.18	0.5	0.09	0.79	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**11.5**	**0.28**	**1.73**
50	Unknown 7	18.2	0.08	0.25	0.6	0.02	0.08	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	**18.8**	**0.10**	**0.33**
TOTAL		**700.6**	**3.19**	**9.37**	**320.2**	**6.02**	**27.06**	**73.3**	**4.19**	**24.48**	**27.3**	**3.70**	**26.72**	**13.1**	**2.86**	**23.66**	**7.3**	**2.29**	**21.90**	**4.5**	**2.44**	**29.95**	**9.6**	**12.55**	**183.07**	**1156.0**	**37.24**	**346.22**