FOREST CONDITION, THREATS AND MANAGEMENT EFFECTIVENESS OF RAU CATCHMENT FOREST RESERVE, MOSHI DISTRICT, TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FORESTRY OF SOKOINE UNIVERSITY OF AGRICULTURE.

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ABSTRACT

Forests and in particular catchment forests are important in providing economic and environmental resources supporting natural systems and catering for the welfare of the community. Poor management and unsustainable utilization to meet community needs for forest products and other forest based ecosystem services can however compromise forest conservation. This study was carried out to assess forest condition, threats and management effectiveness of Rau catchment forest reserve in Moshi District, Tanzania. The extent of disturbance was assessed through Threat Reduction Assessment Tool (TRA) and the management effectiveness was assessed using the World Commission Management Effectiveness Tracking Tool on Protected Areas. Socio-economic factors influencing forest utilization were assessed through a questionnaire survey administered to forest adjacent communities. The results showed that forest disturbance occurs in both forest edge and forest interior, though at different levels. The disturbance and use intensity through trees and poles cutting was significantly higher in the forest interior than the forest edge statistically ($p<0.05$). This signifies that there is higher human impact in the interior than the edge or periphery of the reserve. Plant species diversity using Shannon Winner index was $2.998 \approx 3$ indicating that the reserve is above average in terms of plant richness and diversity. The socio-economic factors influencing utilization in the reserve were education and age whereby increasing age increases the likelihood of forest conservation while education level on the other hand decreases the likelihood of conservation. The Threat Reduction Index was 19% implying that the reserve is highly threatened. The major threats were encroachment, illegal fire wood cutting, pole cutting, fodder and grazing. The management effectiveness score was 29% which indicates poor management with potential for deterioration of the ecosystem services provided by the forest. Among shortfalls in the management of the forest are lack of management plan, unclear and

unconsolidated boundaries for the forest, inadequate and unavailable funding, unavailability and poor condition of working gears, weak law enforcement and poor community involvement. Proper management plans, strengthening law enforcement, consolidation of forest boundaries and community involvement in management are important in ensuring sustainability of the forest reserve.

DECLARATION

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

Elimoo Nzinyangwa Mkiramweni Date

(MSc. Candidate)

The above declaration is confirmed

Prof. Munishi, P.K.T. ———Date

(Supervisor)

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DEDICATION

This dissertation is dedicated to my beloved parents; my father Nzinyangwa Senzighe Mkiramweni-, who taught me how to plough and my mother Nivoneia Langeni Mgonja, who taught me how to sow, my wife, the late Bupe, my beloved daughters Naomi and Sarah my son Nimrod, who missed my love during the period of study, “May God bless them! Amen.”

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ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of Variance
DBH	Diameter at Breast Height
EAMs	Eastern Arc Mountains
EPEH	Environment Pollution Effects on Humans
FORCONSUL	Forestry Consultancy Unit at Sokoine University of Agriculture
JFM	Joint Forest Management
MNRT	Ministry of Natural Resources Tourism
PFM	Participatory Forest Management
RCFR	Rau Catchment Forest Reserve
SE	Standard Error
SFR	Selela Forest Reserve
TFS	Tanzania Forest Services Agency
TRA	Threat Reduction Assessment
WCPA	World Commission on Protected Areas
WRI	World Resource Institute
WWF	World Wide Fund for Nature
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RCFR	Rau Catchment Forest Reserve
SE	Standard Error
SFR	Selela Forest Reserve
TFS	Tanzania Forest Services Agency
TRA	Threat Reduction Assessment
WCPA	World Commission on Protected Areas
WRI	World Resource Institute
WWF	World Wide Fund for Nature

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Forest degradation in the Tropics is a current concern to Conservationist. Reports show that the trend of degradation in Tanzania is increasing and currently is 400 000 ha/year (NAFORMA, 2013), despite efforts exercised by the Government and different Development Partners. Degradation and loss of biodiversity is still a problem, as well as timber harvesting (Lovett and Pocs, 1993).

The forest catchment conservation in Tanzania started back during colonial era in which more catchment values were there like the numerous water springs. It was reported that water is used to irrigate about 50 000 ha of rice farms and the forest harbours rare tree species, like the *Oxystigma msoo* and *Lovoa swinnertonii*, it is also a tourist attraction site (Lovett and Pocs, 1993). Forest in general land are 'open access', characterized by insecure land tenure, shifting cultivation, annual wild fires, harvesting of wood fuel, poles and timber and heavy pressure for other conversion to other competing land uses, such as agriculture, livestock grazing, settlements and industrial development. There is deforestation and degradation of reserved forests due to weak law enforcement (Zahabu*et al*., 2009).

These catchment forests are threatened by anthropogenic activities such as wild fires, agriculture shifting cultivation and animal grazing (Penzari and Marco, 2009). Most of our forests are under intense deforestation pressure with the remaining forests gazzetted as forest reserves managed as catchment forest for rain water capture. In contrast most lowland are either dry or have been deforested for some other activities including

agriculture (Munishi, 2001). Little is known about the effect of anthropogenic activities on biodiversity and water supply in the catchment forests that result in missing of scientific support tools for decision making.

Most gazzetted forest reserves are facing degradation on their biodiversity which need attention, Rau reserve's biodiversity and ecological systems is also affected (Lovett and Poc′s, 1993). According to Beazley (1995) lowland forest are more extensive but because they are easily accessible, they have suffered the most damage and clearance. The canopy can reach more than 45 metres in height and consists of many different tree species living close together, large and small size which is particularly significant ecologically.

Rau catchment forest reserve has high water table and ground water leading to the existence of semi-decidous and swamp forest (Akitanda, 1998). The fresh water springs of Rau are important source of water for river Pangani. There are three larger rivers (Mwananguruwe, Oraro and Rau) the former situated along western side, the middle is situated almost in the centre and is seasonal river, the latter in the lower eastern side of the reserve, some smaller once passing through the forest providing water for agriculture and other purposes. The reserve also has almost whitish water called "milk water" (due to white colour like milk) and hot water springs that have been used only for attraction to visitors. The fauna species found in the reserve are *Colubus abyssinicus, Cercopithecus mittis, Cercopithecus aethiops, Patamochorus porcus*and variety of birds. Due to floristic composition of the forest and existence of enough water for the wild species, there are found some bees and the surrounding community has some beehives (Akitanda, 1998).

According to Lovett and Poc′s (1993) timber values have been identified like the East African Mahogany (*Khaya anthotheca*) and *Milicia excelsa* are the major timber species

occurring in the reserve and are said to be more extracted. *Lovoa_swynnertonii*and *Oxystigma_msoo* these have been identified there and are said to be good for plywood. The forest have also been suggested to have different zones to protect springs and streams , in human impact reduction it was suggested that the reserve would be protected from pollution as a result of garbage dumping and cultivation should be stopped at the forest edges, all these suggested proposals have not been implemented. Therefore there is a need to determine the effect of anthropogenic activities to biodiversity and water supply in Rau catchment. Illegal activities done on reserved areas have also been reported in Kilombero Nature Reserve, these activities include setting fire in the reserves, encroachment, tree cutting, fuel wood collection, poaching grazing and tree harvesting for timber (URT, 2009a). Holmes (1995) reported that lowland forests, particularly those adjacent to urban centres have been affected by accelerating agricultural and other development undertakings, land use planning and its implementation is to be in place in order to rationalize this situation.

Threats for degradation in Eastern Arc mountains, according to Madoffe and Munishi (2005), includes fire, followed by tree and pole cutting then grazing, the least ranking being encroachment for settlement and farming, firewood collection. Stand structure is the distribution of species and tree sizes on a forest area (Husch, 1972). Mbwambo *et al*. (2008) pointed out that, stand structure encompasses stand species composition, diameter distribution and their spatial distribution. Basal area, volume and number of trees are stand parameters (Husch *et al*., 2002).

Anthropogenic disturbances which include clearing for subsistence agriculture, uncontrolled fires, illegal timber harvesting and charcoal making are considered to be the more serious threats to tropical forests than natural disturbances (Hall and Rodgers, 2009).

This is due to general consensus among scientists (Maliondo *et al*., 1997; Mehta *et al*., 2008; Taylor *et al*., 2008) that natural disturbances are among essential factors influencing biological diversity. Many studies (Attiwill, 1994; Sheil, 2000) show that the difference between anthropogenic and natural disturbances is very blurred and inextricably linked. Ecologist agree that mitigation of natural disturbances such as those due to insect attack, landslides and invasive species which are the result of anthropogenic disturbances is an important endeavor in management of natural ecosystem (Rakith *et al*., 2005; Wayne *et al*., 2009) In addressing such problems, emphasis is attached to precise temporal and spatial prediction of occurrences and magnitudes of these disturbances.

1.2 Problem Statement and Study Justification

1.2.1 Problem statement

Rau is a lowland forest and one of the important sites having multiple beneficial functions. The reserve is the source of water for irrigation to the rice farms not only that but is also a tourist attraction site. There are various biodiversity ranging from plants to animals all these alleviate its importance. The rich and distinct biodiversity of Rau forest is under multiple threats including agriculture (encroachment), grazing, illegal pole and tree cutting, spread of invasive species (*Lantana camara*) after fire incidences and pollution, also the reserve is a site for brewing illegal local brew (Lovett and Poc′s, 1993). There is an increasing demand for resources from Rau reserve which emanates from increased population of the surrounding communities hence causing unsustainable resource management (WRI *et al*., 1992).

Population growth among the local communities surrounding the reserve results to high demand and competition for the available resources such as land encroachment and grabbing woody resources. This situation has increased pressure and negatively affects the

reserve. Generally there is a loss of biodiversity, sedimentation which in turn affects the quality and quantity of water and the ecosystem within the reserve. Unplanned human related activities, lack of basic information and public awareness of their values, functions and products as well as management aspects may have caused these problems. The high valuable role of the reserve in serving the ecosystem of the area calls for a need to devise improved conserve strategies for curbing the prevailing degradation of the reserve. There is a rationale of finding out latest information about the prevailing threats, forest condition and the management effectiveness of the forest reserve. It is known that the rational decisions in management of natural forest depend on information available on the condition, threats and how forest is currently managed among many other things. Also it is known that the acquisition of the lacking information is the prerequisite to sustainable management and conservation of forest resources (Mgeni and Malimbwi, 1990).

However, there are few other studies on Community based conservation status of *Oxystigma msoo* a tree species in Rau, Mshumbusi (2010) and the other study by Lovett and Poc's (1993), so far there is no other study conducted to reveal the current status of Rau Catchment Forest Reserve, management effectiveness also identification of threats and then give the recommendations on the way forward. Forest threats cause impacts such as biodiversity and water loss and therefore forest threats need to be addressed because they have impact on attainment of the management objectives (Maddofe and Munishi, 2005).

This provides basis and rationale of assessing forest reserve current status, threats and management effectiveness towards revealing potentials of conservation of the Rau forest. This will significantly provide the basis to ensure sustainable ecosystems stability through conservation of forest biodiversity in Rau forest reserve.

1.2.2 Study justification

The study findings will be useful in developing, monitoring, guiding and formulating policies towards sustainable management of related catchment forests. The need for undertaking this study is to establish latest information on the status of the forest, major threats and their management effectiveness, deriving useful results to be used in safeguarding forest ecosystems and maintain its catchment value over time.

This information will be beneficial to those who are interested including forestry agencies and institutions. This study will assist in attaining better management approaches which aim at improving the conservation and sustainable use of the resources. Such information will be beneficial and form the basis for having proper policy intervention for management of the forest reserve's ecosystems and meanwhile meeting the livelihood requirements, conserving biological diversity and ensuring adequate water supply within Rau forest reserve.

1.3 Objectives of the Study

1.3.1 Overall objective

The overall objective of the study is to assess the utilization threats, forest condition and management effectiveness of Rau Forest Reserve.

1.3.2 Specific objectives

i. To examine forest condition (current status) in Rau catchment forest reserve.
ii. To identify and assess utilization threats in Rau Catchment Forest Reserve.
iii. To assess management effectiveness and conservation initiatives of Rau forest reserve.

1.4 Research Questions

i. What are the utilization threats in Rau Catchment Forest Reserve?

ii. What is the forest condition (current status) in Rau catchment forest reserve?

iii. How effective is the management and conservation initiatives in Rau forest reserve?

1.5 Conceptual Framework of the Study

The study assumes imposing effective management will result in good forest condition and biodiversity conserved. This is summarized in Fig. 1.

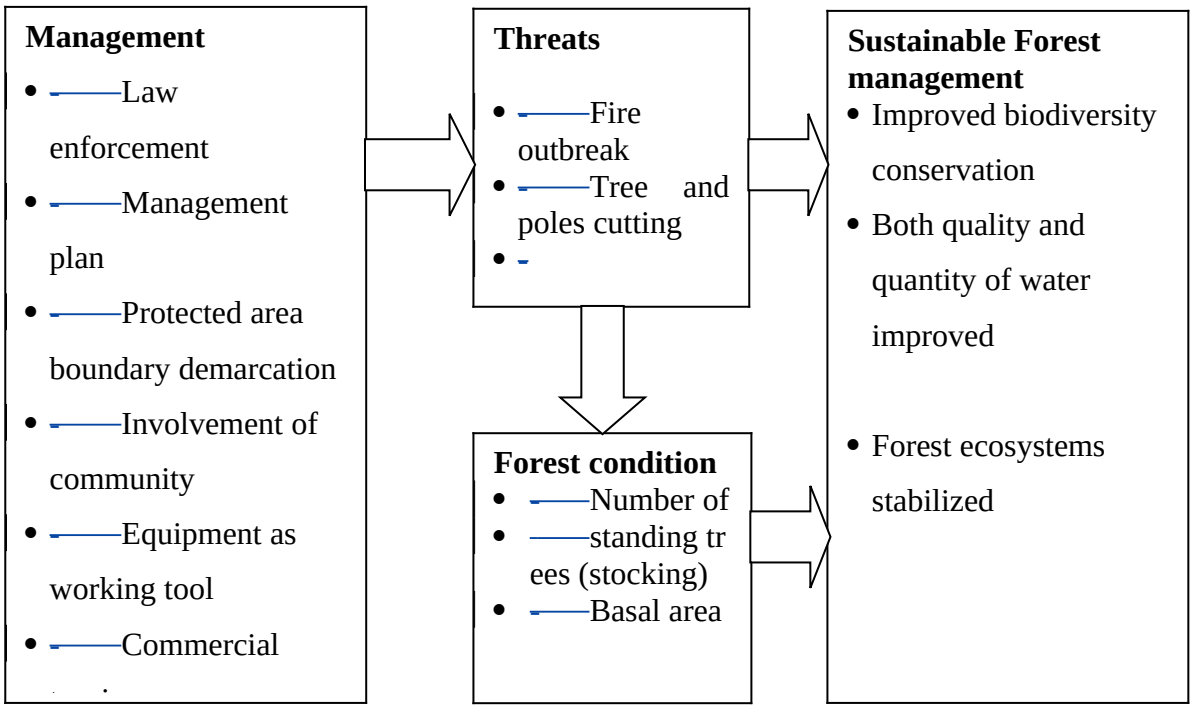


Figure 1: Conceptual framework

Management effectiveness in the forest reserve covers all administrational and institutional frameworks ensuring management of forest resources. Management refers to the mechanisms which is responsible to take care of all the activities that safeguard the catchment forest resources. Effective management entails the mechanism which curbs

illegal actions timely and effectively and results to the reduced or completely controlled destructive activities in the forest.

The existence of the prevailing threats in forests reserve such as fire outbreak, tree and poles cutting, encroachment, grazing and all of the prevailing destructive activities has a direct linkage to the role of the management effectiveness. Equally to the improved forest condition which depends on the strength of the management effectiveness to be able to persevere the imposed threats on the forest resources.

The properly undertaking of the effective management practices in the forest reserves would ensure sustainable management of the improved forest condition. Since the study is going to address the current status of the reserve, if the reserve is less stocked, then there is degradation, but if is the opposite then the forest is described as well stocked implying status of the management as well.

The proper undertakings of the effective management practices will definitely minimize human induced threats and improve the forest condition by improved stocking and controlled natural threats like floods and strong winds. The effective interventions on management in the forest reserves results to sustainable forest management which lead to high level in curbing illegal activities as a result forest condition will be improved and biodiversity well managed also water quality and quantity will be improved ensures sustainable management of forest resources and.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Threats towards Biodiversity Loss

Loss of biodiversity in terms of number and varieties is high despite the fact that measures are taken to safeguard these valuable national resources. Among many other reasons, human population residing near these areas are putting a lot of pressure on these resources majority of which are owned by Government (Lovett and Poc′s, 1993).

Tanzania like many developing countries is predominantly depending on land-based economy, so is largely depending on the exploitation of the natural resources particularly land, forest and water and that agriculture forms the basis for economic development of the country. As a state Tanzania is having area coverage of 942 800km^2, out of which 6% is covered by water bodies while the forest and woodland resources occupy about 38.8 million hectares, which is about 41% of total land area (MNRT, 2002). The area occupied by forest reserve is estimated to be about 13 million hectares out of which only total of 1.6 million hectares (about 12% of the total land area) has been designated as catchment forests (MNRT, 1998) and 9.2 million hectares of the total forested land and woodland designated as Ramsar site/wetlands. In terms of ownership, Tanzania's forests are classified as Government (central and local) forests, general land forests, community/village, and private forests. Before independence, the forest cover was more than 50%, which gradually decreased to 45% in late 1970's and about 30% to date (Luoga *et al*., 2000).

Heavy disturbance of coastal forests reduces their biodiversity value as plant diversity and habitats of rare plant species are lost. Similarly Ndziku (2002) study showed that, the

Maasai Mara National Reserve in Kenya has since 1970 lost 50-80% of its wildlife species due to the spread of commercial cultivation, which has converted critical areas such as migration routes and calving grounds to mechanized agriculture.

Many of the gazetted forest reserves containing naturally occurring species of important catchment areas. They are managed for both conservation and production purposes and the larger part are Miombo woodlands. These reserves are very valuable for the country in terms of soils, water and biodiversity conservation and for sustainable production of valuable timber, fuel wood, and non timber products (MNRT, 1998).

Like many developing countries, Tanzania is also facing or experiencing high rate of deforestation which is estimated at 400 000 ha per year (NAFORMA, 2013). Most of the forest both local and central Government reserves are highly encroached and degraded as a result of poor control, shortage of manpower, corruption, retrenchment of staff and constraints (Kajembe and Kessy, 2000). These problems have ultimately caused rampart pit sawing, animal hunting and honey collection using poor technique leading to forest fires. Also overgrazing, charcoal making, cutting trees for building materials, annual fires and forest reserves encroachment for settlement and agriculture expansion becomes the major threats to Tanzania forests. Species composition and vegetation have changed drastically because of human activities on some of these forests.

Human activities in the reserves have been fuelled by increased demand for land for the agriculture, increased required for forest products and services which is parallel to the increased population by the rate of 2.8% per year (MNRT, 1998). According to frontier Tanzania (2001) the pressure in natural resources included establishment of *Tectona grandis* plantations that have replaced the Miombo woodlands, timber logging of *Millicia*

excelsa–, increased livestock rearing on the flood plains and wetlands , wildlife hunting and overfishing in the Kilombero river valley.

Hall and Rodgers (1986) did a study in Kimboza, Pande and Pugu forest reserves and they revealed that more than 50% of the poles in the easily accessible areas have been cut for different uses. The (UNEP, 1996) found that Pugu reserve, plant species disturbances through human activity was found to be 75% in the sampled areas.

Mung'ong'o *et al*. (1995) and Kajembe *et al*. (2000), stipulated that problems of forest management in Tanzania today largely sprung from Institutional arrangement and the related to shift in decision making about land and other natural resources related issues from local to National levels. Before the colonial era the elders were responsible for guiding the society and regulations governing the management of natural resources were based on customary laws. The tribal rules and regulations regulated the land uses and enforced cultivation regulations (Kajembe *et al.*, 2003a).

According to FAO (1990) those rules were fairness ethics and did not require formal enforcement since were embodied in the cultures of all people. Some of the rules were so fundamental and appeared to be taken for granted as inviolable and were widely respected by all people (Otieno, 2002).

2.2 Management and Conservation Initiatives in Forest Reserves

All protected areas being National parks, game reserves, all other protected areas and forest reserves whether privately or Government owned are all suffering from being disturbed from exploitation. It is not true that there are no measures being taken to safeguard these reserves, there should be a built in spirit in the society to take role in the

management and therefore assumes being part in order to become responsible. There are many factors that are to be put in place in order to win this battle. It has been stipulated that, government has failed to provide adequate protection and management of the forest estates because of declining budgets and retrenchment of workers leading to forest degradation and deforestation (MNRT, 1998; Kajembe and Mgoo, 1999).

It has been a tendency to involve adjacent communities as the guardian of the forest resources which eventually has led to Participatory Forest Management (PFM) strategy (Kajembe *et al*., 2003b). In such collaboration particular emphasis was put on the need to link planning for protected areas with surrounding land users. The problem comes that they are both actors in both extraction and monitoring (Peters, 1994). Community should have enough knowledge in conservation and also be given an opportunity to get the alternative source of their daily requirements before they are left in their own.

It is so far the determination of the government to involve local communities in biodiversity conservation by making adjacent people to natural resources the guardians of these resources. This option stemmed from the need to better target people's needs, incorporate local knowledge and to ensure equitable sharing of benefits between government and communities. In the course of implementing JFM, problems and challenges came in that there is a gap between policy and practice, clear definition of rights and responsibilities, poor understanding of the community's incentive structure difficulty in defining community's benefits and costs from forest management.

Joint Forest Management is the current practice apart from difficulties in implementation, example of the forest reserves are Kitulangalo, Ufiome and Gologolo. Still it appears that more incentives are needed to persuade local communities from degrading or destroying

the co- managed forest reserves (Kajembe *et al*., 2004). However, study done in Duru-Haitemba on the other hand had a positive impact on resource base and people's livelihood. Nevertheless strengthening patrols and other management practices should be in place so that resources are secured and utilized sustainably.

2.3 Status of the Forest Reserves in Tanzania

Tanzania's economy is basing largely on land, water, and natural resources which naturally exist. It is on these lines that the economy of the country as it depends on them, this leads to resources being highly exploited. According to MNRT (2002), Tanzania covers an area of 942 800 km^2 from which the woodland resources takes about 38.8 million hectares which is about 41% of the total land area. These woodland resources has been decreased from time to time as has been cited by Luoga *et al*.,—(2000), before independence, the forest cover was more than 50%, which decreased gradually to 45% in late 1970's and about 30% to date. The area occupied by forest reserve is estimated to be about 13 million hectares, only a total of 1.6 million hectares (about 12% of the total land area) has been designated as catchment forests (MNRT, 1998) and 9.2 million hectares of the total as forested and woodlands. Forest reserves are managed for wood production, water catchment, biodiversity conservation and soil protection. These reserves are very valuable for the country for the sustainable serving the above intended purposes.

According to MNRT (1998) explain that most of the gazette forest reserves contain naturally occurring species which are important in catchment areas. However Tanzania like other developing countries is experiencing a high rate of deforestation which is estimated at 91 200 hectare per year (FAO, 2001; MNRT, 2002). Encroachment, degradation as a result of poor control, shortage of manpower, corruption, retrenchment of staff and financial constrains were marked as the reason for degradation to both Central and local government forest reserves.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1Size and location

The study was conducted in the Rau Catchment Forest Reserve located in Moshi District Kilimanjaro region having an area of 570 ha. It is located 3^0 $23^{!}$ S $37^0 22^{!}$ E, 3 km south east of Moshi (Figure 2). According to Lovett and Poc's (1993) the reserve used to have an area covering 809 ha of natural ground water forest but decreased significantly to the 570 ha. It has a boundary length 13.6 km being lowland forest, it is situated at about 720 metres above sea level. Moshi municipal is situated to the North of Rau Forest Reserve.

As a fauna habitat, Rau catchment forest reserve plays an important role in biodiversity conservation. Its watershed provides also resource for human being subsistence and existence. Several birds are found with the borders of the forest that is surrounded by farms whose main crops are maize, rice and banana. This forest reserve is also preferential for primates that sometimes face threats from farmers and also from shrinking habitat. With rare endemic and vulnerable species of *Oxystigma msoo* in the area, the catchment should be well protected and efforts to establish the species by plantation should be a priority (Goncalo, 2001).

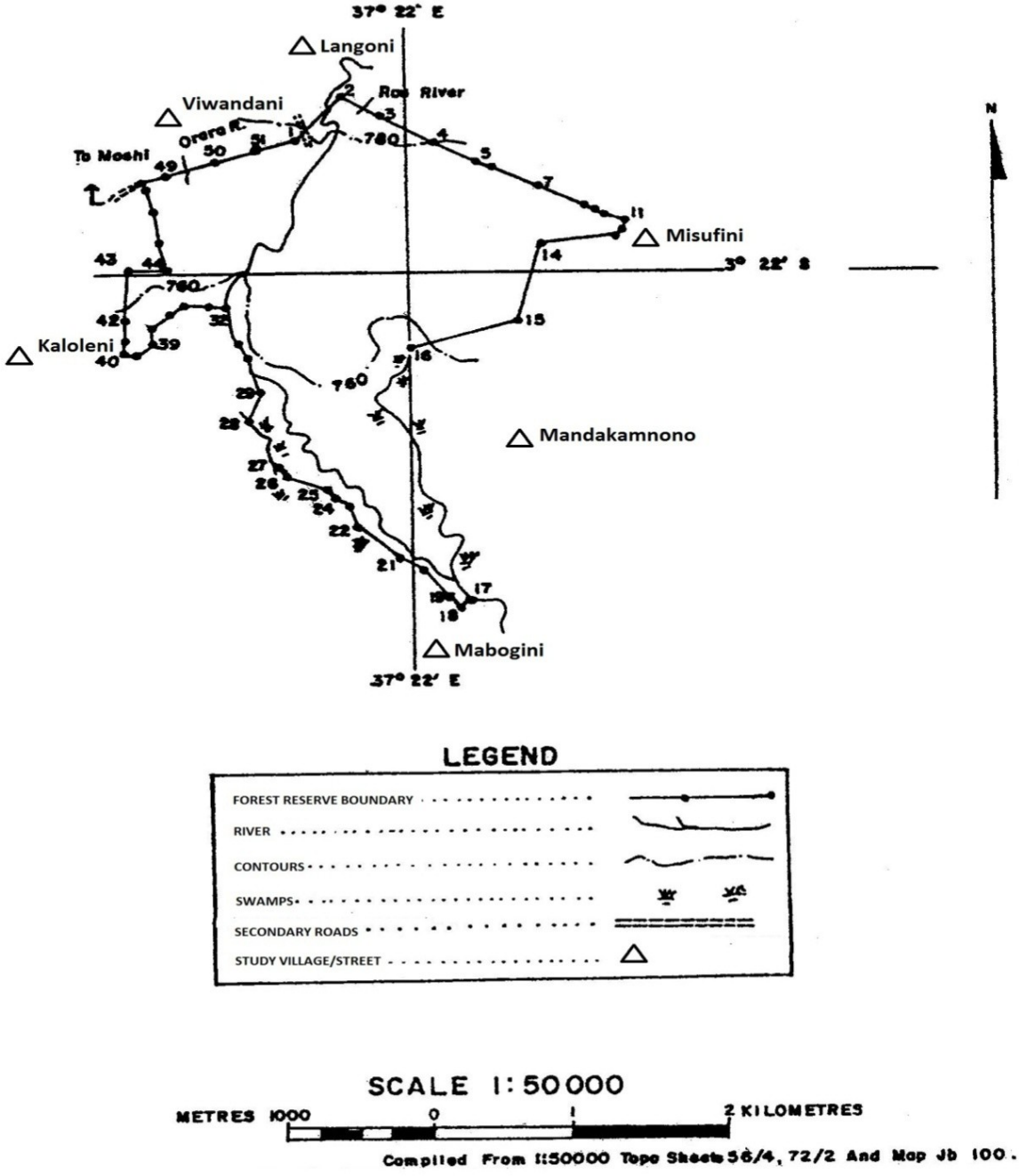


Figure 2: Map of Rau Catchment Forest Reserve, Moshi District, Tanzania

3.1.2 Climate

The climate of this area is tropical in nature, a typical lowland forest, the area receives oceanic rainfall with continental temperatures. Nearest Annual mean rainfall is estimated as 870 mm/year. Dry season temperatures range between a maximum of 26^0C and a minimum of 21^0C.

3.1.3 Vegetation

In the north near Njoro on deep well drained soils there is a stand of 40 to 50 metres tall *Lovoa swinnertonii* with *Albizia schimperiana, Ficus synchomorous, Newtonia buchananii* and *Tabaenemontana ventricosa* forest. To the south there is 15-18 metres tall *Macaranga kilmandscharrica* forest probably originating from the formerly disturbed/ exploited *Lovoa swinnertinii* forest. In the eastern side a tall *Oxystigma msoo* occurs with *Condyla africana, Ficus synchomorous, Newtonia buchananii, Rauvolfia caffra, Syzigium guineese* and *Trichilia emetica* forest in the lower canopy. Where the water level changes and salt probably accumulates, *Acacia xanthophloea* dominates with occasional *Phoenix reclinata* especially on water logged areas. In the Eastern central part of the reserve up to 50 metres tall *Millicia excelsa* forest occurs.

3.1.4 Population and economy of adjacent communities

Kilimanjaro region is not one of the fastest growing populations in Tanzania. According to Tanzania URT (2012), Moshi municipal and Moshi rural had population growth rates of 4.0% and 4.2% respectively. Although these two districts are above Nation growth rate (2.7%) regional wise Kilimanjaro (1.8%) is below, and is ranked number 24 out of 30 regions in the United Republic of Tanzania. Local community living adjacent to RCFR and Moshi municipal and rural are largely engaged in Agriculture (56%) which among other occupations ranks higher. Other activities are petty business and some are employed in different disciplines.

3.2 Sampling Procedures

3.2.1 Ecological survey

Forest condition data was collected through forest inventory. A total of 114 rectangular plots measuring 10 m x 50 m were systematically established within the forest to cover as much of the area as possible using a sampling intensity of 1%. Total area of the reserve is 570 ha and sampling intensity being 1%, then the total area to be surveyed was 5.7ha. From the above area (5.7ha) to be covered 114 plots of 500m^2 were established. Plots were established along transects starting at the forests edge and the first plot at a distance of 20 metres from the road and 10 meters inter-plot distance.

Information recorded from each plot was number of live trees and poles, number of naturally dead trees/poles/, number of newly cut trees/poles.(note: a tree is a woody plant with stem of at least height of 3 m and diameter 15 cm and above, while a pole was defined as woody standing trunk of at least 2 m height and diameter between 5 and 14 cm). Stumps were also assessed as whether they are newly cut (should appear fresh not blackened and an old cut trees/poles (which in this case the cut should be blackened), Fallen trees, branches and or woody plant less than 5cm diameter were not included. All trees in a plot were identified and measured for their respective diameter at breast height (dbh) using caliper and for unidentified trees voucher specimens were collected for further identification.

3.2.2 Sampling for threat data

Questionnaire survey was used to collect threats data from the adjacent community and their dependence on different resources from the reserve. The socio-economic data brought the picture on the way adjacent communities depend on the resources from the

reserve. The set questions in the questionnaire focused on the nature of the feedback required, where some were closed ended and some open ended. Data collected were on community dependence, forest condition and intervention measures. Thirty (30) households were sampled from each village making a total sample of 180 households from all six villages adjacent to the reserve. According to Boyd *et al*. (1981), the total number of household sampled would not be less than 5% of the total house hold in the area or a minimum of 30 households. The selection of the interviewers was based on random number systems. Six villages/streets were involved, in data collections which are Kaloleni, Mabogini, Mandakamnono, Langoni, Misufini and Viwandani. In each village the village register was used as a sampling frame from which the sample for questionnaire was drawn and 30 households were randomly selected for interview from each village.

3.2.3 Management Effectiveness Assessment (MEA)

A focus group discussion was used for collecting information on management effectiveness. This followed the World Commission on Protected Areas (WCPA) 'framework' for assessment of the effectiveness of the management practices in protected areas and protected area systems (Hockings *et al*., 2000; Persha, 2004; Madoffe and Munishi, 2005). A checklist of questions, as indicators showing different items to be assessed was used to collect data from the management or the Authority currently managing the Rau forest reserve. The focus group is the one believed to be involved in all activities in the management of the reserve, so that at the end the data collected were both reliable and valid. There are stages/steps in this checklist form which reflects the existing threats, allocation of resources, community involvement, management objectives and planning as well as expected outcomes.

The assessment was conducted in the office by the Assistant District Forest Manager (ADFM) who had capacity to address different management issues for Rau Catchment Forest Reserve (RCFR). There were 30 questions to be answered by assigning a score ranging from 0 (poor) to 3 (excellent) management. Four alternative ranking was given for assessor to make judgment as to level of score given. Data on threats were collected from the field observation, discussions and an interview.

3.3.2 Secondary data

Filling the existing gaps in this study, literature search was the main source of secondary data from research findings activity reports and experiences from different studies related fields as well as publications, journals and internet sources.

3.4 Data Analysis

Forest condition data were assessed based on number of live dead, new cut trees and poles. In the analysis of data from tree parameter (diameter) excel was adopted. Qualitative data on household survey was processed using Statistical Package for Social Science (SPSS). In SPSS data was first coded then analyzed.

3.4.1 Vegetation data

3.4.1.1 Tree species composition

–A list of tree species encountered in the field was prepared to form the species composition of the area. Trees and poles along transect were recorded. All trees from 5 cm to 14 cm diameter at breast height (dbh) were treated as poles and which are equal or above 15 cm were treated as trees and their families identified as well as their usefulness.

3.4.1.2 Species diversity

The word diversity is defined as the structural and functional variety of plants and animals at genetic, species, population, community and ecosystem levels (Huston, 1994). According to Misra (1989) diversity has two components; species richness and evenness of the community. Richness implies the actual number of species contained within a community and evenness is the spread of individuals between the species within the community (Kent and Coker, 1992). Species diversity was computed using "Shannon Wiener index" which shows the index of diversity.

Thus; $H' = -\sum^{s}_{I=1} (P_i \log_a P_i)$……...……..(1)

Where; H' =Shannon index of diversity

$\sum$ = the summation of symbol

S =number of species

P_i = is the proportional of individuals or the abundance of species in the sample.

Log_a = is the logarithm to base a (any base of the logarithm can be taken).

__ = is the negative sign multiplied with the rest of variables in order to make the H' positive.

According to Krebs (1989) Shannon-Wiener Index of diversity as a measure of information content of a sample and since information content is a measure of uncertainty, the larger the value of 'H', the greater the uncertainty. It was also stipulated that, as number of species increases the index also increase, practically and biologically the community 'H' value does not exceed 5.0.

3.4.1.3 Stocking (N) and basal area (m^2ha^{-1})

Stems per hectare (density) computed using number of trees in a plot by the plot area and basal area (m^2ha^{-1}) was computed using the following formula; Basal area = $\pi d^2/4$.

where: π = 22/7 (pie) ; d= diameter at breast height(cm), live and dead trees new cut and old cut, number of trees and poles per plots were computed. Edge and interior forest stocking was determined. Levels of disturbance between forest edge and interior were determined, using one way Analysis of Variance (ANOVA).

3.4.1.4 Resource utilization pressure

The resource utilization pressure was determined to understand the intensity in utilizing the resources and ultimately to know current status (Madoffe and Munishi, 2005). The following formula was used to compute the use intensity (i.e. utilization pressure):

U= R/SX100 %……..…….. (2)

Where; U = Use intensity (%)

R = Recently cut trees and poles (number of trees/poles per hectare)

S = Stocking (density-total number of stems per hectare)

3.4.2 Threat Reduction Assessment index (TRA)

All the encountered threats during the survey were identified and there after ranked based on the magnitude of the existing habitat that the threat will affect. There are three things to refer in the cause of analyzing threats that is: urgency, intensity and area. The former refers to immediacy of the threat that is will the threat occur in the near future or in so many years to come, intensity refers to the impact of the threat within a micro-site that means will the threat completely destroy the habitat in a small locality, or will it cause minor changes and 'area' refers to the percentage of the habitats in the site that the threat will affect. The survey team discussed this in the field and ranking predetermined. The information obtained was used to calculate the final TRA Index. The highest received a rank of 5 and the lowest received a score of 1. The TRA approach involved the generation

of a “Thread Reduction Index” [(Raw score/Total Ranking)*100]. According to Persha (2004) and, Madoffe and Munishi (2005) the TRA Index shows the extent of threat to target conservation area has been reduced through management interventions.

3.4.3 Management effectiveness

The management effectiveness, was obtained following the principle laid by World Commission on Protected Areas (WCPA) also (Hockings *et al*., 2000: Persha, 2004; Madoffe and Munishi, 2005). The information collected in this tool of investigation was used to look into various issues related to how effectiveness the management is, among those items to appear on the check list are ; management plan of the reserve, personnel management, boundary demarcation, law enforcement, equipments availability to mention few. Those key ones were highlighted in tabular form.

3.4.4 Socio-economic data

Descriptive and inferential statistics

From the household data, the statistical Package for social Science (SPSS) was used for analyses. These data fall under “descriptive statistic” domain, and includes data about distribution, dispersion and central tendency. Cross tabulation was adopted as is the not only powerful way of communicating but also the commonest form of data presentation (Casley and Kumar, 1988). Logistical regression model was developed to provide the idea about whether the patterns described in the sample were likely to apply in the population from which the sample were drawn (de Vaus, 1986, as cited by Mbwambo, 2000).

Logistic regression differs from linear regression as the former suits models where the dependent variable is dichotomous, while the independent variable can be interval level or categorical. This study used the logistic regression analysis to establish a relationship

(Whitehead, 1998; Pampel, 2000) between dependent variable i.e. forest use which cause disturbance and the independent variable i.e socio-economic and demographic factors (i.e. age, gender, marital status, education, duration of residence in an area and demand for forest product and services).

$$Yi = \frac{1}{1+e^{-z}} \quad \text{……..……...……. .(3)}$$

Where;

- Y_i = the i^{th} probability of event to occur for the dependent variable (existence of human disturbance in RCFR a binary/ dichotomous variable with value of 1 if there is a disturbance on the reserve and 0 otherwise)

$Z_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots\ldots \beta_n x_n + e_i$ (the linear combination)

$Z_i = i^{th}$ observed value of the dependent variables

β_0 = constant term for the model without independent variable (intercept)

β_1-β_n = independent variable coefficient estimates from the data e = is a natural logarithm base approximately 2.718

i = 1,2,…..n; where is the total number of variables

X_i - X_n = independent variables (socio-economic & demographic factors)

X1 = age of the respondent in years

X2 = gender (male/female) - dummy variable

X3 = marital status (married/not married) – dummy variable

X4 = duration of stay (≤ 10 vs> 10 years) – dummy variable

X5 = Education level (formal school vs non-formal school) – dummy variable

X6 = demand for forest products and services ---- dummy variable

The probability of an event not to occur was estimated as:

Probability (No event) = 1- Probability (event)

The hypotheses tested were;

H_o: β = 0 (that regression coefficients are equal to zero and thus there is no correlation between human disturbance in the catchment ~~forest(~~forest (dependent variable) and socio-economic and demographic factors (independent variables)

Against

H_i = β ≠ 0 (implying that the regression coefficient are not equal to zero, and thus there is either positive or negative correlation between human disturbance in the catchment forest and socio-economic and demographic factors)

$H_{0:}$ will be rejected only where P < 0.05.

To test whether the regression coefficients are significantly different from zero, the Wald statistic (or t- value) that asymptotically follows the chi-square distribution in large samples (Guajarat, 1995) was used.

The Wald statistic is distributed as chi-square with degree of freedom (df) equal to number of constrained parameters (r) with simple parameter. The odds ratios represented by Exp. (β) from logistic regression analysis were used in explaining the likelihood of occurrence or non occurrence of human disturbance in the catchment forest reserve in the study area under specified socio-economic and demographic factors.

To assess the goodness of fit of the regression model to data, the model chi-square as suggested by Pampel (2000) was used and was tested at 5% probability level. Chi-square measures how well the independent variables affect the outcome of dependent variable. Also-2log likelihood (-2LL) which indicates that the model fits the data reasonably well, and the overall percentage of correct predictions where the bigger the percent the better the model were used.

Proper interpretation of logistic regression results, involves looking at Wald statistic(t-value) to see whether the effect of a particular independent variable is statistically significant, sign of effect of the logistic regression coefficient (β) to see whether the increase in independent variable increased or decreased the probability of success (in this case occurrence of human disturbance in the catchment forest reserve), magnitude of the similarly measured variables to determine which of the independent variable seems to have a greater impact on the human disturbance in the catchment forest, and the Exp. (β) to see how much a 1 – unit change in X_i changes.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Forest Condition

In this study the condition of the forest is therefore reflected on basal area, stand density, species diversity and tree species composition. The focus will also be on the current forest condition in the edge as compared to interior part of the reserve.

4.1.1 Forest structure

The vegetation of the catchment forest is typical lowland type associated with high water table. Harvesting is strictly prohibited in this area as is mainly protected for biodiversity and water conservation. Since the main objective of preserving this reserve is to cater for the above functions, there is a need to establish a system that will lead to the management objectives. This study concentrated on assessment of forest structure estimation of basal area, stand density, species composition and diversity, number of standing and cut trees and poles, as a measure of forest condition.

4.1.2 Basal area (m^2/ha)

The average stand basal area for this catchment forest is estimated at 30.1 $\pm$2.5 $m^2ha^{-1.}$ (Table1). This is within the range when compared with basal area of 24.10±10.6 m^2ha^{-1}obtained from the lowland forest of Monduli (Neema, 2009). This increase in basal area after three years indicates that always there were changes which are taking place either to degrade or improve forest condition. In this particular case the change was positive meaning that the conservation interventions were in place.

Table 1: Mean stand parameter at the edge and interior in Rau Catchment Forest Reserve

Vegetation		Mean	Standard deviation	Standard error	95 % C. Interval	Min	Max
Basal area (m^2/ha)	Edge	32.0	35.7	6.3	19.1 - 44.9	2.3	189.4
	Interior	22.7	16.4	2.9	16.8 - 28.7	2.1	67.4
Average		**30.1**	**26.2**	**2.5**	**25.2 -34.9**	**2.1**	**189.4**
Density(Stems/ ha)	Edge	276	127	22	230 -321	40	640
	Interior	234	98	17	199 -270	80	500
Average		**306**	**132**	**12**	**281 -330**	**40**	**660**

Forest condition at both edge and interior is bad and does not differ significantly ($p<0.05$). The difference obtained in comparing between forest edge and interior could probably due to the location in the forest, the reserve being bordered by Moshi municipal and rural Districts in north-west and south-east respectively. The communities surrounding the reserve find it safer to perform their illegal actions at the interior of the forest. Basal area showed no significant difference ($p<0.05$) between forest edge and interior probably due to diameter variation.

4.1.3 Stand density (stems/ha)

The average stand density was estimated to be 306 ± 12 stems/ha see Table1. This result is comparable with the results obtained in another study 310±145 – 440±213 stems/ha (Neema, 2009) in Selela lowland forest reserve in Monduli.

4.1.4 Tree species composition

A total of 38 tree species belonging to 22 different families were identified. The most prevalent families Meliaceae, Myritaceae, Moraceae, Bignoniaceaeand Mimosaceae were 8%. The less prevalent families Euphorbiaceae, Apocynaceae, Verbenaceae,

Caecalpiniaceae, Anacardiaceae, and Rubiaceae were 6%. Those which are not well represented ~~propotional~~proportional are Ulmaceae, Fabaceae, Boragnaceae, Arecaceae, Flacortiaceae, Annonaceae, Ebenaceae, Combretaceae, Lutaceae,Celastraceae and Santalaceae were 3% (Appendix 1).

4.1.5 Species diversity

Species diversity in this study was 2.99 which ~~is~~are very close to 3 and this means that ~~RFR is~~RFR is not poor in terms of species diversity. According to (Rwamugira, 2008 cited in Munishi, 2007) the medium value of the species diversity index, is 4 and the maximum value does not exceed 5.

4.2 Utilization Threats and Human Induced Disturbance in Rau Catchment –

- **Forest Reserve**

The forest reserve being surrounded by an urban settlement is always under high utilization pressure from the adjacent communities. The communities living adjacent to the reserve depends on fire wood from the forest for both domestic and other uses.

4.2.1 The human induced disturbance in Rau Catchment Forest Reserve

4.2.1.1 Forest disturbance

According to results shown in table 2 bellow, a total of 838 stems were sampled in the forest edge of which the average removal was114stems/ ha equivalent to 13.6% equivalent to 3.9 m^2 /ha In the forest interior a total of 337stems were sampled and the average removal was 73 stems equivalent to 21.7% of the sampled stems which is equivalent to basal area 6.2 m^2/ha. The total number of poles at the forest edge was 633 stems and the removal was 62 stems equivalent to 12.8% of the total surveyed poles. The new cuts was 3 equivalent to 0.4% and1 cut equivalent to 0.3% in forest edge and interior respectively,

while the old cut was 92 equivalent to 10.9% and 68 equivalent to 20.2% respectively. For the live trees, the total sampled trees in forest edge were 724 which is (87%) of the total surveyed stems. In the forest interior, a total of 337 trees were surveyed and live trees were 264 with removal of 73 stems, which (79%) and (22%) of the total stems surveyed respectively. A total of 191 poles were sampled in the forest interior part of which is 162 which is (85%). The total removal was 29 stems/ ha which is (16%) of the total surveyed poles. New cut was 8 poles/ ha (5%), old cut poles were 19 poles /ha (10%). The dead poles were 2/ ha (2%). Dead trees recorded the highest in forest edge with 19 stems/ ha (3%) and the lowest was 4 stems /ha (2%). trees in forest edge was recorded. The average new cut for trees was 3 stems/ ha (1 %) for poles in forest interior, the lowest was 1 stems/ ha (1%) for trees in the forest interior. For old cut trees the highest was 92 stems /ha (11%) recorded in forest edge l and lowest was 68 stems/ ha (21%) in poles in the interior location (Table 2).

Table 2: Forest Disturbance in the Rau Catchment Forest Reserve

Location	Type of product	Trans Length (m)	Totalarea (ha)	Totalnumber	Live of total	Average live/ha	Dead of total	Averagedead/ha	New cut of total	Av.newcut/ha	Old cut of total	Av.oldcut/ha
Edge	Tree	5700	5.7	838	(86.4) 724	127	(2.3) 19	4	(0.4) 3	1	(10.9) 92	17
	Poles	5700	5.7	633	(90.2) 571	100	(0.2) 1	1	(2.8) 18	4	(9.8)43	8
Interior	Tree	5700	5.7	337	(78.3) 264	46	(1.2) 4	13	(0.3)1	1	(20.2) 68	12
	Poles	5700	5.7	191	(84.8) 162	28	(1.1) 2	6	(4.2)8	2	(9.9) 19	4

(a) Disturbance level in forest edge and forest interior

The disturbance level in the forest interior and forest edge differ significantly for new cut, old cut trees and poles. There is a significant difference ($p < 0.05$) in forest edge and interior in terms of trees and poles, as the comparable situations are the dead, new cut and

dead trees. These showed significant difference ($p < 0.05$) between edge and interior (Table 3).

Table 3: Mean forest disturbance level in forest edge and interior in Rau Catchment Forest Reserve

Type of Product	Forest Vegetation	Dead	Mean Std error	New cut	Mean Std error	Old cut	Mean Std error
Trees	Edge	11	3	2	1	51	7
	Interior	3	1	1	1	43	10
Poles	Edge	1	1	11	4	27	6
	Interior	1	1	5	2	12	3

There was higher disturbance for old cut (51±7 stems ha^{-1}) at the forest edge than the forest interior (4±10 stems ha^{-1}). Similarly there was higher disturbance at the forest edge (2±1 stems ha^{-1}) as compared to the interior (1±1 stems ha^{-1}) for trees. Furthermore for dead trees the forest edge had higher disturbance level (11±3 stems ha^{-1}) when compared to the forest interior (3±1stems ha^{-1}) while no significant difference ($p< 0.05$) was observed in neither new cut nor old cut though dead trees showed significant difference ($p< 0.05$) for dead trees.

The disturbance was significantly higher on the forest edge as shown by the number of cut poles (27± 6 stems ha^{-1}) compared to forest interior (23± 12 stems ha^{-1}). In the case of new cut poles the forest edge had significantly higher disturbance (11±4 stems ha^{-1}) than that on the forest interior (10±5 stems ha^{-1}) . For dead poles forest interior showed significantly higher disturbance (2±1 stems ha^{-1}) than the edge (1±1 stems ha^{-1}). Old cut showed significant difference ($p< 0.05$) but neither dead nor new cut showed a significant difference ($p< 0.05$) between the forest edge and forest interior.

(b) Level of disturbance for trees in forest edge and interior

The comparison between forest edge and interior show that old cuts are relatively higher in both forest edge and interior old cut is higher in the forest interior than in forest edge. Whereas the density of new cut trees is higher in forest interior than forest edge, the dead trees showed to be higher on forest edge than on forest interior (Figure 3). The new cut in forest edge is quite minimum as people go further inside fearing to be easily seen. This situation does not differ from Mialla *et al*. (2004) who argued that timber cutting is declining following exploitation in the past, but pole cutting seems to be leading in terms of the rate of tree cutting in the forest. Pit holes were observed in the north- eastern side which resulted from digging out dry roots of *Senna siamea* which is claimed to be strong and persistent in domestic use.

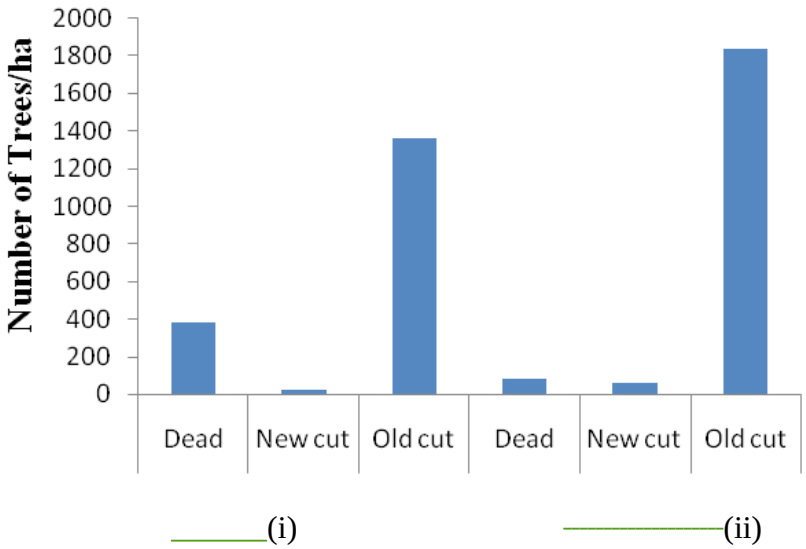
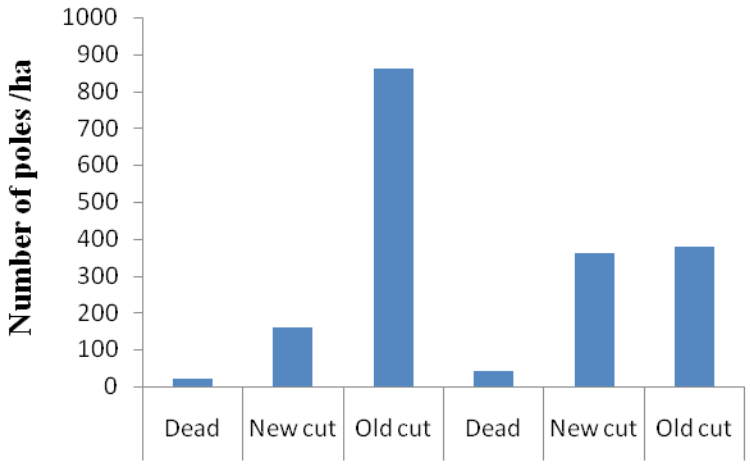


Figure 3: Levels of disturbance for trees (i) forest edge (ii) forest interior in Rau Catchment Forest Reserve

(c) Levels of disturbance for poles in forest edge and interior

The results indicated in ~~(figure~~(Figure 4) shows higher extraction rate of poles in forest edge than in the interior, the fact remains that there were higher demand for poles for different activities. On the other hand the new cut is higher in forest interior given the fact that there is more accessibility today than in the past. Again dead poles are higher in the forest interior than at the edge thus dead poles are easily collected on the forest edge due to easy access to forest edge.



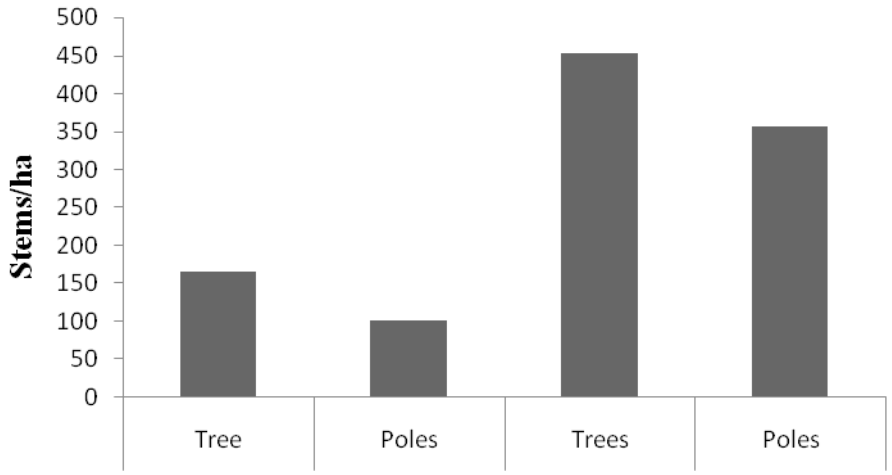
(i) (ii)

Figure 4: Levels of disturbance for poles (i) forest edge (ii) forest interior in Rau Catchment Forest Reserve

(d) Levels of forest disturbance for forest interior and forest edge plots in Rau Catchment Forest Reserve

Field observations revealed that in general, forest edge had higher stock of both poles and trees than the interior part of the reserve (Figure 5). Though this does not reflect good future forest status as the stocking in poles is lower than the trees. Field observations revealed that forest disturbance is distributed and is not specific to certain areas. Agricultural encroachment, pole cutting, fodder collection and grazing are among threats

also affecting RCFR, (Newmark, 1998). These activities could lead to further forest fragmentation which is considered to be one of the major sources of biodiversity loss.



(i) (ii)

Figure 5: Levels of forest disturbance for (i) interior plots and (ii) edge plots in Rau Catchment Forest Reserve

(e) Forest utilization pressure

(i) Utilization pressure in the forest edge and forest interior

The stocking on the forest edge was 127 trees ha^{-1} for trees and 100 ha^{-1} for poles in the forest edge (Table 4).The extraction was very low in forest edge with use intensity of (0.4%) for new cut trees and 12.8% for old cut trees. In terms of poles it was higher for old cuts (7.6%) than new cuts (3.2%). It was also observed that the stocking was higher in forest interior with 46 trees and 28 poles ha^{-1}. The use intensity was higher for old cut (26.1%) than new (0.4%) cut. Trees in forest interior the use intensity for poles was also higher in old cuts (12%) than in new cuts (5%).

Table 4: Percentage of forest utilization pressure in forest edge and interior in Rau Forest Reserve

Forest Vegetation	Type of product	Density (stems/ha)	Average new cut/ha	Use Intensity (%)	Average old cut/ha	Use intensity (%)
Edge	Trees	127	1	0.4	17	12.8
	Poles	100	4	3.2	8	7.6
Interior	Trees	46	1	0.4	13	
26.1						
	Poles	28	2	5	4	12

(ii) Comparison of utilization pressure between forest edge and forest interior

The new cut and old cut observed in the assessment which has shown the utilization pressure is now subjected when comparing the use intensity in forest edge and interior vegetation. These two showed statistically significant difference ($p<0.05\%$) between the forest edge and interior (Table 5). Comparison of use intensities for trees between forest edge and interior showed higher use intensity in edge (53 ± 7%) than the interior location (44 ± 10 %.) The use intensity for poles was also significantly lower in forest interior (17 ± 4%) than in the forest edge (38±7%). Generally there was significant difference ($p<0.05$) in use intensities between forest edge and interior.

Table 5: Mean percentage of use intensity in forest edge and forest interior vegetation in Rau Catchment Forest Reserve, Moshi District, Tanzania

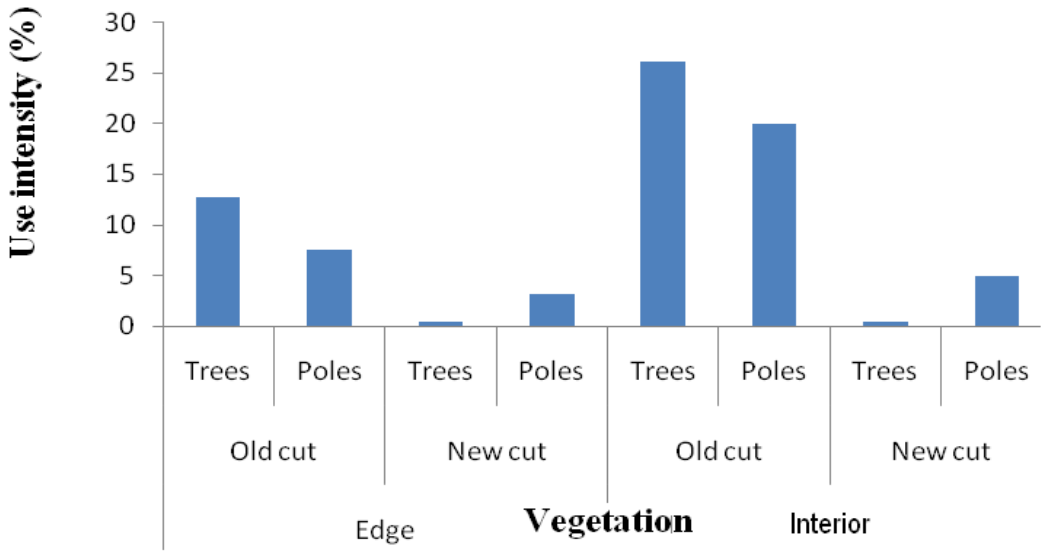
Type of Vegetation	Forest	Mean[1]	Std. Dev.	Std. Error	95% Confidence Level	Min.	Max.	Product
Trees	Edge	53	2.9	7	(39 – 68)	0	140	

	Interior	Interior	44	59	10	(23 – 65)	0 260
Poles	Edge	38	42	7	(23 – 53)	0	140
	Interior	Interior	17	22	4	(9 – 25)	0 100

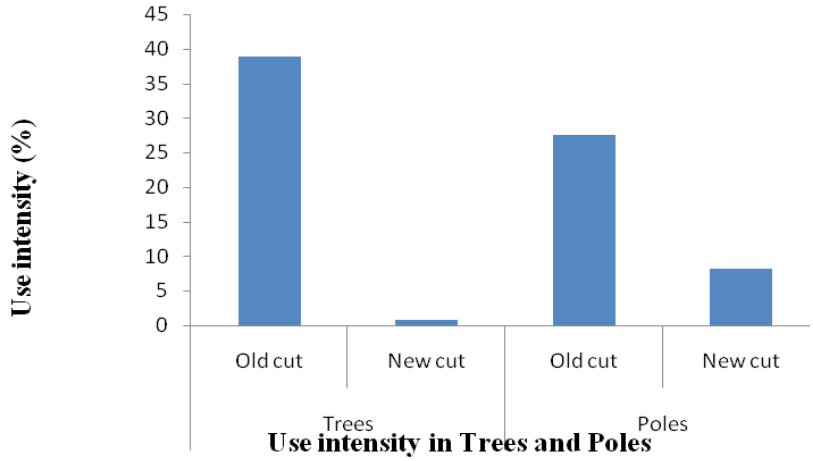
Mean[1] = Percentage of New cut and Old cut trees and poles

(f) Use intensity for both trees and poles

Findings from the study show that there is higher extraction in the forest interior compared to the forest edge (Figure 6(a) giving an alarm that the existence of the reserve is threatened. This trend does not differ from the results by Frontier –Tanzania (2005) that in the Uluguru North Forest Reserve there has been decrease in extraction of timber resource, while more poles are being cut now and is more prevalent where access is easier Fig. 6 (b). This figure shows a relatively higher extraction rate for poles currently than in the past. As pointed out by Critchley (1991) one of the reasons for the present state of deforestation is population growth. The growing population and ultimately leading to high demand of wood resource has elevated the need for more wood material this increasing deforestation and forest degradation. According to Njana (1998) communities living adjacent to natural resources such as forest and wildlife will continue to rely (legally or illegally) on them for their livelihood and for economical survival, which will lead to forest degradation hence environmental consequences.


Use intensity (%)
30
25
20
15
10
5
0
Trees
Poles
Trees
Poles
Trees
Poles
Trees
Poles
Old cut
New cut
Old cut
New cut
Edge
Vegetation
Interior

(a)


Use intensity (%)
45
40
35
30
25
20
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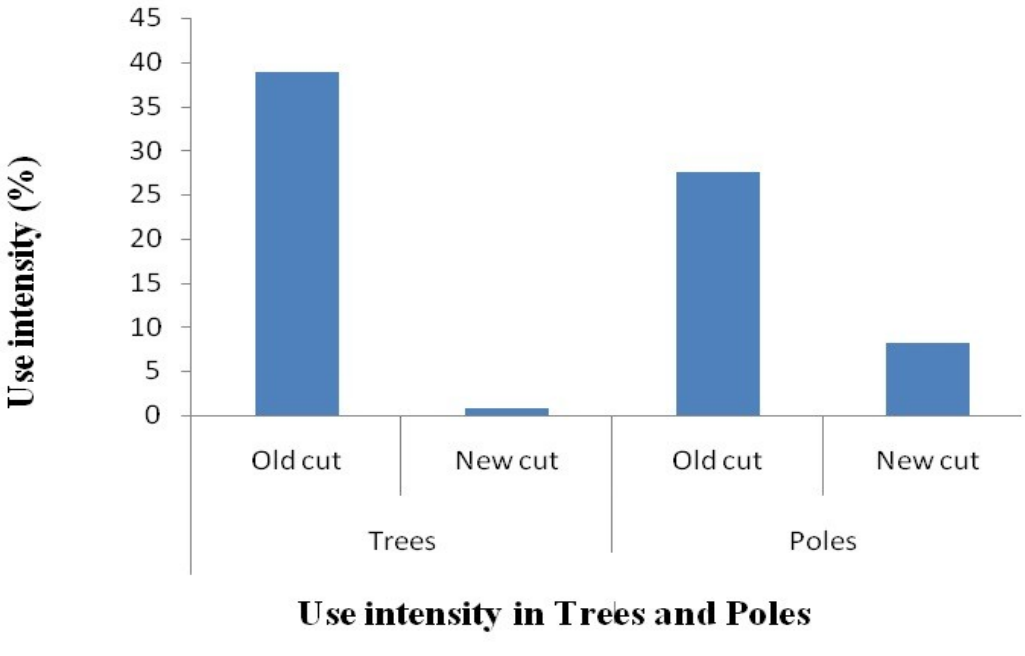
5
0
Old cut
New cut
Old cut
New cut
Trees
Poles
Use intensity in Trees and Poles


Use intensity (%)
45
40
35
30
25
20
15
10
5
0
Old cut
New cut
Old cut
New cut
Trees
Poles
Use intensity in Trees and Poles

(b)

Figure 6: Mean percentage of use intensity between (a) forest edge and interior vegetation (b) trees and poles in Rau Catchment Forest Reserve, Moshi District, Tanzania

4.2.1.2 Forest threats in Rau Forest Reserve

(a) Utilization threats facing the catchment forest

Analysis done on threats interfering conservation measures in the catchment forest indicated that the TRA index for the reserve is 19% (Table 6). During this study prominent threats observed were nine (Table 6). This result shows that the reserve is highly threatened by illegal activities. The major threats are encroachment, firewood collection, damping wastes, local brew making, pole cutting, timber, fodder, grazing and corruption (misconduct).

Table 6: Threats Reduction Assessment (TRA)

Location	Threats	Forest location	Direct threat	Row score	TRA (%)	Index
FE1	Encroachment	13	10	1.3		
FE2	Fire wood	12	15	1.8		
FE3	Damp	6	30	1.8		
FE4	Local brew	4	25	1.0		
FE5	Pole cutting	11	15	1.7		
Sub total		**46**		**7.6**	**16.5**	
FI1	Local brew	7	20	1.4		
FI2	Timber	10	15	1.5		
FI3	Fodder	4	30	1.2		
FI4	Grazing	6	30	1.8		
FI5	Corruption	8	20	1.6		
Sub total		**35**		**7.5**	**22.1**	
Grand total		**81**		**15.1**	**19**	

FE –Forest Edge Threats (i.e. those occurring within 100m from the forest edge)

FI –Forest Interior Threats (i.e. those occurring inside forest more than 100m from the forest edge.

TRA Index – Percent Threat Reduction

A detailed account of these threats, types and intensity of the threats facing the study area is given in Appendix 3. According to Persha (2004) and Madoffe and Munishi (2005) the lower the TRA percentage the higher are the threats and vice versa. The above mentioned TRA according to this study is relatively low and this signifies that the reserve is highly threatened. Similar study by Madoffe and Munishi (2005) in the Eastern Arc Mountains Forests revealed that most of the forests had TRA ranging between 30 – 39% which show that most of the forests are highly threatened

(i) Encroachment: In this study the encroachment basically was due to cultivation at the edge of the reserve. Cultivation on the forest edge causes erosion and heavy siltation to the water intake towards the lower part of the reserve. DANIDA (1999) urged that human impact is increasing rapidly as human population grows through high birth rate.

(ii) Illegal fire wood collection: Firewood collection is one of the major threats in Rau Catchment Forest. The collected firewood is used for domestic, local brew making and for bricks curing. The day to day rise in costs of electricity has lead to all these especially in urban areas with substantial disturbance in forest ecosystems and Rau in particular. Forest Resources Management Project (1996) revealed that on average $18m^3$ of wood from live trees is used to cure1000kg of tobacco in areas like Tabora. However firewood collection for household use may not be regarded as one of the major sources of deforestation and loss of biodiversity as local people collect dry wood in favour of green wood. However in some cases green wood is cut and left to dry before collection. Firewood collection ranked the first of the eleven (11) when uncontrolled threats the reserve. It has been argued that firewood collection may result into massive forest destruction, loss in biodiversity, soil erosion and poor forests (Njuguna and Ongungo, 2004).

(iii) Waste disposal in the reserve: This is an emerging threat in Rau as solid waste is directed to the reserve. This occurs in the eastern part of the reserve, where the waste material including solid waste that cannot degrade easily is dumped. All types of pollution- air, water and soil pollutants have an impact on living environment. There are also some chemicals that add pollution to downstream rivers in particular Oraro river which is dangerous to both humans and other living organisms. As pollution is defined as the release of contaminants into the environment and land can become contaminated by activities such improper waste disposal in RCFR is the existing current problem causing pollution.

According to Irina (2008) contamination of crops grown in polluted soils brings up problems with food insecurity. The irrigation using water from RCFR is now endangered by the pollution associated with improper disposal of wastes. However this effect will result in soil pollution which is closely linked to water pollution. Many effects of soil contamination appear to be similar to the ones caused by water contamination since this forest reserve is a catchment area and source of water used for irrigation in the downstream its effect is likely to be felt in the near future if a waste disposal is not controlled. Pollution effects are indeed many and wide-ranging. There is no doubt that excessive levels of pollution are causing a lot of damage to human and animal health, tropical rainforests as well as the wider environment (EPEH,, 2014). Trees and other plants may absorb soil contaminants and pass them up the food chain. The pollutants alter plant metabolism and reduce crop yields, disrupts photosynthesis in aquatic plants thus affect ecosystems that depend on these plants. Plants may be killed by herbicides in water and further it may cause soil acidification which eventually affects plants. The RCFR pollution causes forest disturbances may contribute to consequently loss of biodiversity and forest degradation.

(iv) Illegal local brew making: Illegal local brew making in RCFR is one of the threats that may leave the left fire uncontrolled to burn the forest. Local brew making sometimes use the leftover of tires which gives a very heavy smoke making wide range pollution to the atmosphere and surroundings. Local brew making also demands wood materials and these materials are of considerable diameter for getting strong fuel to heat the drums used in the process of alcohol distillation. These actions are subject to causing destruction to the reserve in terms of fuel wood cut from the forest as well as uncontrolled fire. In a place where these actions take place there is no room for underneath growth to flourish as they are suppressed, there is also pollution to water downstream from the leftovers in due process.

(v) Pole cutting: Pole cutting as building material is among threats to the reserve. These are used to build both permanent and temporary huts. Rau forest is not isolated in this threat. The study done in Kimboza, Pande and Pugu forests indicated that poles have been cut for different purposes/ uses and it amounted to about 50% of the entire harvested product from those forests (Hall and Rodgers 1986). It has been noted by Frontier-Tanzania (2001b, 2002); Madoffe and Munishi (2005) that, tree and poles cutting were as well done in Eastern Arc Mountains border areas within proximity of villages. In Rau people tend to go further inside to avoid being easily caught thus why the interior is more affected than the edge locations of the reserve.

(vi) Illegal Timber harvesting: Harvesting of timber becomes more serious when the volume of the whole tree biomass is falling and affects all small regenerating species. This illegal exercise normally is done by extracting wood logs from the forest. Some logs are collected from wind fall which is now becoming a natural disaster disturbing the reserve.

The pattern of decrease in stocking of valuable timber conforms to the optimum foraging theory that depicts that human foragers as actors maximize their net rate of return per unit of foraging time (Smith, 1983 cited by Kajembe *et al*., 2004). The resource switch can further ascertain the optimum foraging concept as people now obtain timber from formally lesser- utilized tree species. Logging and forest conversions for agriculture are key drivers to the disappearance of Malawi's forest and deterioration of the country's National Parks (Chizyuka, 2006). Whether logs are sawn within forest or are ferried outside forest reserve this will lead to biodiversity loss and ultimately forest degradation.

(vii) Grazing: Grazing is prohibited in Rau as other catchment forests. Particularly during drought period of the year grazing is illegally practiced. Grazing causes siltation as well as killing new regeneration in the reserve leading to habitat degradation and loss of preferred species. Grazing is becoming a problem especially on the edge of the forest reserve. These areas are intensively used for livestock grazing especially during dry season. According to Frontier-Tanzania (2002); Madoffe and Munishi (2005) there is a significant grazing pressure in most of EAMs forests.

Despite the fact that grazing causes loss of biodiversity, affect the forest composition status, it might go further to affecting soil to the extent of bringing soil erosion and siltation downstream.

(b) Threat ranking in Rau Catchment Forest Reserve

The leading high ranked threats in this study are firewood (25.5%). illegal timber harvesting (14.3%). pole cutting (11.7%), fodder collection (9%) grazing (8.2%), encroachment (7.9%), The same threat in the Eastern Arc resulted into a total score of (64.5%), and included; pole cutting (17.5%), encroachment (13.5%), grazing (12.5%),

illegal timber harvesting (10.5%) and firewood (10.5%), Madoffe and Munishi (2005). From this study the respondents showed (Figure 7) the leading threats mentioned covered about (67.6%) they are not significantly different from the Eastern Arc Mountains threats (64.5%). From the above observation it is clear that the types of illegal activities do not vary much between or among forests. The only difference comes from how heavy or light (impact) that the threat is affecting the forest reserve, Madoffe and Munishi (2005). From the above observation it clear that the types of illegal activities do not vary much between or among forests.

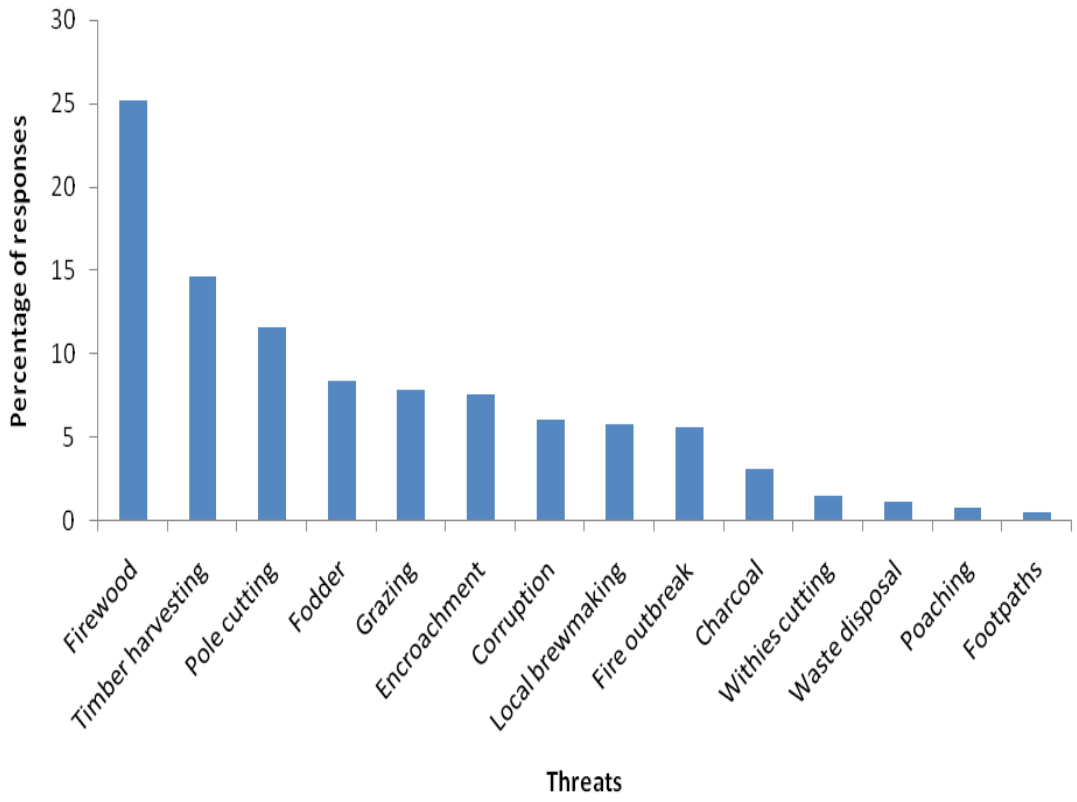


Figure 7: Ranking of threats for Rau Catchment Forest Reserve

4.3 Management Effectiveness and Conservation Initiatives in Rau Catchment

Forest Reserve

Evaluation of management effectiveness in Rau forest reserve was conducted to provide the basis for monitoring programme. The framework provided the outcome from the

desired management objectives, together with the range of performance areas and indicators that could provide evidence about the extent of achievement in each outcome as desirable. The final score was calculated as a percentage rating, that means the higher percentage the more effective the management is and if low percentage that is the indicator of weak management in a particular forest (Hockigs *et al*., 2000; Madoffe and Munishi, 2005). The management effectiveness of Rau Forest Reserve was 29%, Table 7. This signifies that the forest is poorly managed. This result does not differ from the EAMs which in Central Government forests management effectiveness between 27% and 29%. The ranking given could have been contributed by the resource shortages as well as lack of seriousness among forest staff. The shortage could have been working gears, (vehicle and staff oriented protective gears to protect them in such harsh forest environment), funds, and staff number and training. According to Chizyuka (2006) the plight of Malawi's forests is exacerbated by poor management regime on the part of forest authorities.

Table 7: Selected critical management issues for Rau Catchment Forest Reserve, Moshi District, Tanzania

Issue	Score
1.Legal status	3
2.Management plan	0
3.Staff number and training	2
4.Protected area boundary demarcation	1
5.Current budget	1
6.Awareness and Education	0
7.Access assessment	1
8.Resource inventory	1
9.Local community inputs	0
10.Condition assessment	1
11.Equipments/ working gears	1
12.Monitoring and Evaluation	1

Scores: 0 = poor; 1 = fair; 2 = good; 3 = excellent

(i)Legal status: Rau forest reserve is a gazzeted forest, owned by central Government under Tanzania Forest Service (TFS), despite of the forest being gazzeted the reserve is encroached and some other illegal activities are still taking place.

(ii)Management plan: This document is among necessary items that any forest should have its own. Unfortunately Rau catchment lacks this important document. The reserve is being run using only Annual Plan of Operation (APO) for a particular financial year. Since the reserve is running short of this tool for management it reflects that only few and irregular operations are being carried on currently. It is well known that management plan is extremely important in identifying the predicted outcome thus become helpful to project the future. According to Madoffe and Munishi (2005). The same has been observed in

some forests of the Eastern Arc Mountains. WWF (2004) reported that for all protected forests worldwide only 12% in 200 protected areas in 34 countries have no approved management plan in place. From previous discussion it is equally very unsafe to continue with this weakness if we are gearing towards having an effective management leading to well conserved biodiversity. Therefore instead of using an APO for effective management, Management Plan has to be urgently prepared and used as a yardstick for a particular period of time in years which have to be therein indicated.

(iii) Protected area boundary demarcation: Boundary resurveying and consolidation is an important activity wherever need arises. In Rau Catchment Forest Reserve this situation is experienced since the forest boundary is encroached. It is promising that the management has started taking measures like having regular patrols in order to minimize illegal activities. Although the established boundary is acknowledged by both management and surrounding community, it was required to be resurveyed and beacons be replaced where not found. Findings from KwaZulu –Natal indicated that some of the protected areas had no clear boundary demarcation while others have boundaries but not appropriately maintained (Goodman, 2003). There is positive move in Rau Catchment Forest Reserve that currently they are working on that threat.

(iv) Staff number and training: For the staff to give optimum output in terms of performance, regular training is prerequisite apart from their qualifications. There is a total of 36 staff having different academic qualifications in Moshi district, Rau in particular had 6 staff , 2 graduates as overall supervisor and 4 forest attendants, requires of 1diploma holder and 2 certificate holders . Given the way the forest is situated, surrounded by urban and rural communities the number of staff is not adequate and it requires that shifts predominate so that at any time guards are there to safeguard the reserve. The current staff

is not adequate, there is still a need for 2 graduates, 2diploma holder and 4 certificate holders. The study by Madoffe and Munishi (2005) who also observed that, in the EAMS, all forests have either inadequate number of staff or below optimum level which contributes to poor management in most of these forests.

(v) Current budget: Adequate and timely funding is necessary for smooth undertaking of forest operations. It has been noted that funds given were not adequate and at the same time are not timely, so what is reflected here is poor performance in executing forest operations. This scenario by itself explains why the forest is not well managed or is not effectively managed. According to Chizyuka (2006) inadequate funding results in understaffing and lack of capacity to implement management plans, monitoring and law enforcement which put protected area open to illegal actions which degrade the reserve. The office received about 18million annually which is not enough, the requirement is about 50 million annually, and therefore there was a deficit.

(vi) Awareness and education: It has shown good cooperation and spirit of belonging to managing forests if the community surrounding the reserve is kept aware of what is taking place and have some knowledge on conservation issues. Contrary to that serious illegal practices will be experienced. Education on conservation, showing the outcome if the reserve is poorly managed and the subsequent benefits whether tangible or intangible that the community will accrue from conserving should be well understood to adjacent residence. In Rau Forest Reserve this is different, respondents are not aware on what is actually taking place and no education programmes focused to make them aware on conservation. According to (FBD, 2001; Madoffe and Munishi, 2005) conservation education and awareness creation to the local communities adjacent to the forest is considered as an important tool for forest management and conservation.

(vii) Access assessment: Access to the forest encourages destruction of varying magnitude, therefore systems have to be designed to reduce illegal practices. Activities that are non destructive like beekeeping, voluntary patrol among others are to be encouraged for sustainable management. Protection systems are only partially effective in controlling access or use of the reserve in accordance with designated objectives (Madoffe and Munishi, 2005). There are many foot paths in the reserve as some people use them to go and attend their gardens/ on the other side of the reserve and also the illegal local brew making has created such paths. The only way to reduce this effect in the reserve is to have control gates as they have started in Rau catchment forest reserve, and mostly to have many and regular patrolling.

(viii) Local community inputs: Participatory forest management has proved good in areas where practiced. If local community is well involved in forest operation they feel belonging to, but it is not the case with Rau catchment forest reserve where there is no element of involvement currently taking place. There is therefore a gap between the management and the local community and this makes it difficult to smoothly conserve the resources. The only part the community are involved is where an activity arises they are taken as casual labour. This does not create motivation among adjacent population so makes the work more difficult to execute operations, hence leads to poor performance and low quality forest in terms of biodiversity. Non involvement of local community in conservation was seen as a weakness by Goodman,; (2003) expressing that it lowers management effectiveness. On the other hand improved communication with local communities is likely to lead to a much better understanding of the value of the protected area, a greater degree of participatory management and acceptance of the protected area and hence improved management effectiveness. Involving local community should not be

overlooked as Kaboggoza (2000) reported that, community living adjacent or at proximity to natural resources such as forest and wildlife will continue to rely (legally or illegally) on them for their livelihood and for economic survival. To involve local community reduces the impact of illegal action as the community adjacent feel ownership of the resources.

(ix) Condition assessment: The main objective of keeping these forests is among others making sure that the present biodiversity are intact and the ecosystem is not disturbed and destructed. Rau in particular has been disturbed despite some current efforts in place. The biodiversity is degraded to some extent and taking the siltation in the intake shows that the former objective of the paddy project which was sponsored by Japan is not running in the right direction. The amount of water downstream has decreased and encroachment has further caused siltation of the water intake of the irrigation system.

(x) Equipments /Working gears: Equipments are discussed in terms of numbers and condition. For the case of Rau catchment forest reserve neither number nor condition is perfect. For the field work to be efficiently done particularly patrols, a standby vehicle is prerequisite. Some vehicles were not in good working condition. These shortcomings lead to poor management and hence loss of biodiversity. In Rau Catchment Forest Reserve happen to have four vehicles and eight motorcycles but most were grounded only one vehicle and two motorcycles were in good condition.

(xi) Resource inventory: There is minimum information on the resource that could be found in Rau catchment forest reserve. Information on the resource status of any forest is an important prerequisite for effective management. According to Malimbwi and Zahabu (2000) there is a need to know what is in the forest reserve in terms of vegetation and other biodiversity. There is a need to be up- to- date in terms of resource information in

the forest reserves. Goodman (2000) argues that in Kwazulu-Natal, although respondents felt that there were up- to- date natural resources inventories in place, almost 40% felt that these were inadequate for their protected areas, thus, calling for more efforts to address this need. It is equally not possible to be very effective if at all the question of what have you is difficult to answer or can be inadequately answered.

(xii) Monitoring and evaluation: Any good working system must have an element of monitoring and evaluation. It is during this exercise that the obstacles may easily be observed and solutions onset of the problem. The case with Rau is different since the management has no even management plan, they are being lead by few and irregular patrols. Therefore where there are illegal acts is where the efforts are directed to. In practice planned monitoring and evaluation ensures promptly solving of obstacles of management as they arise hence high efficiency. The study by Madoffe and Munishi (2005) argued that monitoring and evaluation ensures that management obstacles are discovered and solutions sought promptly. In order to avoid further degradation, the problem cropping up should be dealt with immediately to rescue the resource including biodiversity loss.

4.4 Socio Economic Factors and Their Roles in Influencing the Utilization of Rau– Catchment Forest Reserve

4.4.1 Socio economic factors influencing human disturbance in the catchment forest

The utilization of the catchment forest and resulting to forest disturbance comes as an outcome of uncontrolled and unregulated utilization of resources following demand for such goods and services from the forests. Natural resources are the basis for development, but to genuinely alleviate poverty they must be managed sustainably so that they can continue to form part of the complex web that supports all life on earth (Birdlife

International, 2005). Mostly the livelihood of local communities runs smoothly from the fact that, its improvement largely depends on the socio-economic factors that do play an important role in the resource and their management. At this level a relationship has to be established between the factors that influence utilization as a basis for decisions on utilization. The socio-economic factors earmarked were age, marital status, gender, education and duration of stay in the village and the demand for forest products.

4.4.1.1 Socio-economic factors influencing utilization

Of the five factors i.e. age, education, marital status, duration of stay and land ownership (tenure), only two i.e. age and education were statistically significant in influencing forest utilization.

Table 8: Socio-economic factors influencing human disturbance to Rau Catchment Forest Reserve

Variable	B	SE	Wald	D.f.	P value	Exp(β)	95 C.I. for Exp(β)	
							Lower	Upper
Intercept	-5.5576	0.9077	-1.72		0.0862	0.00386	0.0355	1.2479
Age	3.2823	0.9291	3.53	1	0.0004*	26.6367	4.3116	164.5476
Education	-1.3433	0.5499	-2.44	1	0.0146*	0.2609	0.0888	0.7668
Marital status	0.1285	0.2852	-0.45	1	0.6524	0.8794	0.5029	1.5380
Duration of stay	0.4814	0.2647	1.82	1	0.0689	1.6183	0.9634	2.7186
Land ownership	-0.3341	0.3289	-1.02	1	0.3098	0.7160	0.3758	1.3642

*= Statically significant at 0.05 level of significance

Number of cases = 180

B = estimated logit coefficient

SE = Standard Error of the coefficient

Wald statistics = $\{\beta/SE\}^2$

Exp (β) = odds ratio of the individual coefficient (Probability of success/Probability of failure = e^{β} ; Where e = 2.71818 andβ as defined above.

Hint: [If odds ratio >1 then the odds ratio for disturbing the forest reserve increases and if < 1 then a decrease in disturbance]

(i) Duration of stay: Duration of stay of the respondent in the village showed positive logit coefficient (0.4814). From the observed value it shows that an increase in one man headed household increases the odds ratio for the forest utilization and in the reserve by factor of (1.6183) (Table 8). Therefore from this trend it shows that increase in number of years of residence of the households in the village adjacent to forest reserve increases forest disturbance. As this community is not stagnant, the population is growing, as it

grows the elevation of illegal action will also increase since the demand for forest products and services will grow too. However from this study the effect of the duration of stay adjacent to forest reserve was not statistically significant ($p>0.05$). The household size determines the rate of degradation as they have to exploit in order to meet their needs while also undermining their very sources of livelihood (IRA, 2001; Mahinya, 2005; and Paulo, 2004). This is reflected by the fact that people tend to go for their immediate subsistence living than caring much about biodiversity conservation measures. (Table 8)

(ii) Marital status: Marital status showed positive logit coefficient of (0.1285) which was not significant ($p > 0.05$) (Table 8). Of the interviewees, the married individual were77% of all the respondents, respondents were 22% who were single and the divorced were only 1% of the total respondents.

(iii) Land ownership: The area of the land owned by an individual can as well determine the level of disturbance in the reserve. In this study land ownership of the respondent in the community showed negative logit coefficient (-0.3341). From the observed value it reflects that decrease in land owned by an individual increases dependently on the forest by factor of 0.03098 (Table 8). However land ownership was statistically insignificant ($p>0.05$).

(iv) Age of respondent

The influence of age of the respondent on forest disturbance was statistically significant ($p<0.05$). The implication over this scenario is that old aged individuals as household heads contribute significantly to chances of reducing forest disturbance in the catchment forest. The “Age” of the respondent shows positive logit coefficient of 3.2823 the

implying that, an increase in age decreases the odds ratio of forest disturbance in the reserve by a factor of 26.6 (Table 8).

In the interviewees the age varied from 18 and 45years with most (58%) of the respondents having the age between18 to 45years while older ages above 45years were 42% of the total population (Table 8). It is believed that different age groups respond differently towards existence of the forest and its importance/uses. According to Mbwambo (2000) old people are pro-forest conservationist while young people are after economic benefits out of the forest thus anti-conservationists.

(v) Education

The influence of education was statistically significant ($p<0.05$).This implies that educated individuals in the community adjacent to the reserve have more influence in increasing forest disturbance as they show negative logit coefficient of -1.3433. The implication over this scenario is that as members of the community surrounding the reserve acquire formal education, the odds ratio of forest disturbance increases by a factor of 0.2609 ($P =0.0146$). This means those having informal education are less detrimental to the reserve (Table 8). It was further declared that education improves the relationship between local communities and the protected area authorities.

Table 9: Respondent characteristics in village adjacent to Rau Catchment Forest Reserve, Moshi District, Tanzania

Information/ Issue	% respondents						Overall % of respondents
	Kaloleni (n=30)	Mabogini (n=30)	Mandakamnono (n=30)	Langoni (n=30)	Misufini (n=30)	Viwandani (N=180)	
Age							
18 – 45 years	40	57	43	57	73	80	58
Above 46years	60	43	57	43	27	20	42
Gender							
Male	60	40	53	23	37	27	40
Female	40	60	47	77	63	73	60
Marital status							
Married	90	77	83	70	70	73	77
Single	3	0	0	0	0	0	1
Divorced	7	23	17	30	30	23	22
Education							
No. For. Educ.	10	3	3	13	3	3	6
Formal educ.	90	97	97	87	97	97	94
Duration of stay							
Least 10 yrs	17	10	10	43	40	70	33
Above 10 yrs	83	90	90	57	60	30	67
Occupation							
Farmer	64	80	100	23	54	18	56
House wife	0	0	0	30	13	3	8
Employed	13	3	0	13	10	25	11
Business	23	17	0	33	23	54	25

4.4.1.2 Perception on the current state and condition of Rau Catchment Forest Reserve

About 91% of the respondent perceived that the current condition of the forest is poor and is not well managed (Table 10). Only 9% of the respondents took it otherwise. About 27% attributed the poor condition of the forest reserve to encroachment where the forest edge is being encroached by farmers. On the other hand 39% attributed the deteriorating condition to collection of construction material especially pole cutting, firewood cutting contributed to poor state of the forest by 86% and is the number one driver of forest degradation. Respondents noted to have suffered from the problem of mini-corruption, an emerging misconduct which contributed about 21% of the causes of poor condition of the forest. According to Drigo (1998), the change in forest cover between 1980 and 1990 in Africa is largely the result of forests being cleared for small farmer agriculture and permanent agriculture/ pastures, with slow, progressive degradation occurring from firewood collection. Rural populations were attributed to be the main driving force behind these changes.

Table 10: Local people perceptions on the current state of Rau Catchment Forest Reserve, Moshi District, Tanzania

Information/issue	% respondents						
	Kaloleni (n=30)	Maboghini (n=30)	Mandakomnono (n=30)	Langoni (n=30)	Misufini (n=30)	Viwandani (n=30)	Overall % of respondents (N=180)
Current state of Forest reserve							
Good	13	10	3	10	7	10	9
Poor	87	90	97	97	90	93	90
91							
Degradation							

Causes							
Encroachment	46	20	8	2	4	20	27
Pole cutting	31	14	24	10	13	8	39
Firewood cutting	15	17	19	14	16	19	86
Grazing	23	25	21	6	8	17	27
Local brew making	6	6	48	11	6	23	19
Corruption	2	14	27	31	18	8	21

About 91% of the respondents asset that in order to improve the effectiveness of the management, patrolling has to be given more weight (Table 11). Boundary consolidation was the second management action that could reduce encroachment thus a measure in conserving the reserve's biodiversity. Gap planting was the third management action opinion that wherever there is a gap in the reserve it has to be filled with suitable tree species. Community involvement was also seen as a measure to reduce human impacts by 19 – 20% of the respondents. The National Forest Policy (1998) also stresses on active and effective local community participation in conservation and management of natural resources. Involving community has another advantage of reducing overall costs of management as it is expected to be the best option, more effective, viable and long lasting in solving the degradation problems (Kajembe *et al*., 2003b). According to Joshi (1998) conflicts between foresters and community will eventually decrease if the forest cover will be improved and able to satisfy the demand for the forest products.

Table 11: Responses at the management intervention to reduce forest degradation and improve biodiversity status in Rau Catchment Forest Reserve, Moshi District, Tanzania

Information/ Issue	**% of respondents**						
	Kaloleni (n=30)	**Mabogini (n=30)**	**Mandakamnono (n =30)**	**Langoni (n=30)**	**Misufini (n=30)**	**Viwandani (n=30)**	**Overall% of respondents (N=180)**

Gap planting	67	50	47	17	30	47	42
Patrolling	90	93	90	93	87	97	91
Boundary consol.	86	33	53	27	33	37	45
Education	23	15	29	6	12	15	19
P FM	14	17	19	14	22	14	20

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Rau Catchment Forest Reserve is in bad condition due to human disturbances which threatens the biodiversity in this Forest. Measures are to be in place to maintain or further improve conservation strategies for the forest.

The major forest edge and interior threats are fire wood collection, illegal poles cutting and encroachment. Threat Reduction Assessment Index is very low (19%) implying that the reserve is highly threatened by illegal human actions.

The major socio economic factors influencing local utilization were education and age in which increase age and education level increases the likelihood of an individual taking action to conserve the forest.

The Management effectiveness was low (29%), showing that this forest reserve is poorly managed. The need for proper management plan, adequate and timely funds and other

resources, clear boundary demarcation, participatory management education and law enforcement are important if the reserve is to be managed properly and effectively.

5.2 Recommendations

The following recommendations are proposed from the findings in this study for improving forest condition, reduce threats and effective management be in place.

i. Management plan for Rau Catchment Forest Reserve is to be prepared, this will show the direction to take, when, how, which work /operation to be done in future as annual plan of operation is not adequate as it caters for hardly a year.

ii. Degradation has to be controlled by participatory approaches to management and design an alternative energy sources and non consumptive uses of the forest such as beekeeping and ecotourism.

iii.

iv. Boundary resurvey and consolidation recently done has to be accompanied with regular visit, patrol as regular practice rather than special assignment.

REFERENCES

Akitanda, P.C. (1998). Proposal for the Management Plan for Rau Forest Reserve. 52pp.

Attiwill, M.P. (1994). The disturbance of forest ecosystem: The ecological basis for conservation management. *Forest Ecology and Management* 63:247-300.

Beazley, M. (1995). The Last Rain Forests. Mandarin Offset Limited, Hongkong. ~~Pp?.~~ 200pp.

Beentije, H.J. (1994). Kenya Trees, Shrubs and Lianas. Nairobi: National Musiums of Kenya. 772pp.

Birdlife International, (2005). The Birdlife Partnership "Water Sustain Life, Sustaining livelihoods". [Joint Statement- tcm5-53869.pdf] site visited 12~~.~~/8~~.~~/2005.

Boyd, H.K.R., Westfall, E., and Stasch, S. F. (1981). Marketing Research, Text and cases, Illionois, Richard, D. Publisher. 813pp.

Brenam, J.P.M. and Greenway, P.J. (1949). Checklist of the Forest Trees and Shrubs of the British Empire No.5,Tanganyika Territory – Part II.

Casley, D.J. and Kumar, K. (1988). *Thecollection, Analysis and Use of Monitoring and Evaluation Data* (4th Impression, July, 1995).Published for the World Bank. The Johns Hopkins University Press, Baltimore and London. pp 174-177.

Charles, D. (2012). Sustainable Management of Tropical Ecosystems. Drivers of Degradation and Deforestation in Tropical Ecosystem.

Chizyuka, H. (2006).*WWF Assessment Reveals Uncertain Future for Malawi's Forests*: Rapid Assessment and Prioritization of Protected Area Management Effectiveness in Malawi. World Wide Fund for Nature. Newsroom 06 June 2006.

Critchley, W. (1991). Looking after our land soil and water conservation in dry land Africa. Oxfarm, UK. 84 pp.

DANIDA, (1999). Project Document: Sustainable and Intergrated Mmanagement Mffectiveness of the Malagarasi- Muyovozi Ramsar Site (SIMMORS), Tanzania. 73pp.

De Vaus, D.A. (1986).Survey in Social Research. Contemporary Social Research. Department of Sociology, La Trobe University, Melbourne Australia.

Drigo, R. (1998). Unpublished Personal Communication, Forest Resources Assessment Programme, Forest Resource Division, FAO, Rome, Italy.

EPEH (2014). [http://wwwtropical-rainforest-animals.Com/ pollution – effects. Html] site visited on 13.6. 2014.

FAO (1990).Community Forest. Harder Decision Making in Natural Resources Managementin Arid and semi-Arid Africa. Community Forest Note No 4 FAO. Rome. 87pp.

Food and Agriculture Organization - FAO, (2001).*Global Forest Resources Assessment 2000*. Main Report.FAO Forestry Paper 140. Rome, Italy. 479pp.

FBD - Forest and Beekeeping Division, (2001). Community Based Forest Management Baselines. Ministry of Natural Resources and Tourism, DSM, Tanzania.86pp.

Forest Resources Management Project-FRMP, (1996). Tobacco Production and Royalty Collection in Tabora and Urambo Districts. Technical Report. Forestry and Beekeeping Division. 24pp.

Frontier Tanzania, (2001). Kilombero valley Integrated Environmental Management Progr amme (KVIEMP). In proceedings of the Rufiji River Basin Upstream and Downstream linkage workshop. (Edited by Rufiji Environment Management Project), Morogoro, Tanzania. Technical Report No. 30pp.

Frontier-Tanzania, (2002). Mgambo Forest Reserve. In: A Biodiversity Survey. East Usambara Conservation Area Management Programme. (Edited by Oliver, S.A., Bracebridge, C.E., Fanning, E. and Howell, K.M.), Technical Paper No.59.Frontier-Tanzania; Forestry and Beekeeping Division and Metsahallitus Consulting, Dar es Salaam, Tanzania and Vantaa, Finland. 95pp.

Frontier-Tanzania, (2005). Uluguru North Forest Reserve. In: *Uluguru Component Biodiversity Survey (Volume III).* (Edited by Bracebridge, C.E., Fanning, E., Howell, K.M. Rubio, P. and St. John, F.A.V.), Society for Environmental Exploration and the University of Dar es Salaam: CARE Tanzania, Conservation and Management of the Eastern Arc Mountain Forests (CMEAMF): Uluguru C0mponent, Forestry and Beekeeping Division of the Ministry of Natural Resource and Tourism, GEF/UNDP:URT/01/G32.117pp.

Goncalo, D.B. (2001). Rau Forest Reserve Inventory; Edited by Akitanda, P.C. 22pp.

Goodman, P.S. (2003). Assessing Management Effectiveness and Setting Priorities in Protected Areas in KwaZulu-Natal, South Africa. *BioScience*.Vol.53 No. 9: 843-850.

Guajarat, D.N. (1995).*Basic Econometrics*. Third Edition. McGraw- Hill Inc., New York,London. 838 pp.

Hall, J., Burgess, N.D., Lovett, J., Mbilinyi, B. and Gereau, R.E. (2009). Conservation implications of deforestation across an elevated gradient in Eastern Arc mountains, Tanzania. *Biological Conservation* 142: 2510-2521.

Hall, J.B. and Rodgers, W.A. (1986).Pole cutting pressure in Tanzania Forest. *Forest Ecology and Management.*14: 133-140.

Hocking, M., Stolton, S. and Dudley, N. (2000).*Evaluating Effectiveness: A Framework for Assessing the Management of Protected Areas*. IUCN, Gland Switzerland and Cambridge, UK. 121pp.

Holmes, J. (1995). Natural Forest Handbook for Tanzania. *Forest Ecology and Management* 1:520.

Husch, B., Beers, W.T. and Kershaw, A.J. (2002).Forest Mensuration. [http://books.google.se/books?id=pOv3m8PaukCandpg=PA178anddq=stocking/ stand+parameters+forest%3Fandsource=blandots=LEHOriFAWsandsig= 6penKSKJVgrQYasaoGwRmhPaQhl=svande=8ZeSsCbK8P5 Ab9r4DhDAandsa =Xandoi=book result and resnum=1] site visited on 16/7/2009.

Husch, B., Miller, I.C. and Beers, W.T. (1972). Forest Mensuration. The Ronald Press Company. New York.

Huston, M.A. (1994).*Biological Diversity. The Coexistence of Species on Changing Landscapes.* Cambridge University Press. Cambridge. 681pp.

IRA (2001). Baseline Study of Lakes Sagara and Nyamangoma Wetlands and the Surrounding ~~Environment~~ Environment in the Muyowozi/Malagarasi Ramsar Site, Western Tanzania. Report Submitted to SIMMORS Wildlife Division, Ministry of Natural Resources ~~and Tourism~~and Tourism, Dar es Salaam Tanzania. 139pp.

Irina, G. (2008). Environment Pollution Effects on Wider Environment. Tropical – Rainforest – Animals. Com. Updated October 2012.

James, K. and Henk, B. (2012).Conservation Checklist of the Trees of Uganda. 235pp.

Jayaraman, K. (2000). *Statistical Manual for Forestry Research*: FORSPA- FAO Publication. No. 25/2000. Bangkok. 240pp.

Joshi, A. (1998). Progressive Bureaucracy: An Oxymoron? The case of JFM in India. *Rural Development Network.*

Kaboggoza, J.R.S. (2000). Forest resource-Based Conflicts in Uganda. In: *Community Based Forest Resource Management in East Africa* (Edited by Gombya-Ssmbajjwe, W.S. and A.S. Banana). Makerere University Printer.pp.55-62.

Kajembe, G.C. (1994). ~~Indiginous~~Indigenous Management Systems as a Basis for Community Forestry in Tanzania. Case study of Dodoma Urban and Lushoto Districts. Tropical Resource Management Paper 6, Wageningen Agricultural University, The Netherlands. 194pp.

Kajembe G.C. and Mgoo J.S. (1999). –Evaluation of Community Based Forest Management Approach in Babati District: Case of Duru-Haitemba Village Forest Reserve. Orgut Consulting AB, Dar es Salaam, Tanzania.pp.34-51.

Kajembe, G.C. and Kessy, J.F. (2000).Joint forest management in Urunwa forest reserve, Tabora, Tanzania, process in making in chiefs and peasant in Africa. local management of natural resource in Tanzania. Zimbabwe and Mozambique. (edited by Virtanen, P. and Nummelin, M.) *Silva carelina*34: 141-158.

Kajembe, G.C. and Luoga, E.J. (1996).Socio-Economic aspects of Tree Farming in Njombe District. Consultancy Report to the Natural Resource Conservation and Land Use Management Project (HIMA- NJOMBE). For Consult, Sokoine University of Agriculture. Tanzania. 126pp.

Kajembe, G.C., Kinasa, S.F., Monela, G.C. and Zahabu, E. (2000).The role of local institutions in the management of natural resources in Tanzania. Case study Kahama District, Tanzania. *Journal of Forestry and Nature Conservation* 73: 9-16.

Kajembe, G.C., Luoga, E.J., Kijazi, M.S. and Mwaipopo, C.S. (2003a). The role of traditional institutions in the conservation of forest resources on East Usambara. Tanzania. *International Journal on Sustainable Development World Ecology* 10: 101-107.

Kajembe, G.C., Monela, G.C. and Mvena, Z.S.K. (2003b). Making Community-Based Forest Management Work: Case study from Duru-Haitemba Village Forest Reserve Babati, Tanzania. In: *Policies and Governance Structures in Woodlands of Southern Africa.* (Edited by Kowero, G., Campbell. B.M. and Sumaila, U.R.). The Center for International Forestry Research (CIFOR), Jakarta, Indonesia.pp16 -17.

Kent, M. and Coker, P. (1992).*Vegetation Description and Analysis*, A practical Approach. Belhaven Press, 25 Floral Street, London. 363pp.

Krebs, C.J.; (1989). Ecological methodology–. Harper Collins publishers, New York, 554pp.

Lovett and P0c's, T. (1993). Assessment of the condition of the catchment forest Reserves a botanical appraisal. 300pp.

Lovett, J.C., Ruffo, C.K., Gereau, R.E. and Taplin, J.R.D. (2006). *Field Guide to the Moist Forests Trees of Tanzania.* The society for Environmental Exploitation, London. 303pp.

Luoga E.J., Witkowski, E.T.F. ~~Witkowski~~ and Balkwill, K. ~~Balkwill,~~ (2000). Economies of Charcoal Production in Miombo Woodlands of Eastern Tanzania: Some Hidden

Costs Associated with Commercialization of the Resource. *Ecological Economics* 35: 243-257.

Madoffe, S.S. and Munishi, P.K.T. (2005). Forest condition assessment of Eastern Arc Mountains Forest in Tanzania. Forestry and Beekeeping Division, Dar es Salaam.

Malimbwi, R.E. and Zahabu, E. (2000). Report on Reconnaissance Inventory of Chome Forest Reserve. FORCONSULT, Faculty of Forestry and Nature Conservation, SUA.16pp.

Malimbwi, R.E., Zahabu, E., Madadi, L.M., Monela, G.C., Misana, S. and Jambiya, G.C. (2004). Energy Crisis Forest Destruction: Tree Species Preference, Volume Estimation and Charcoal Kiln Efficiencies in Eastern Tanzania Miombo Woodlands. In : *Proceedings of the 18th Annual General Meeting of Tanzania Association of Foresters,* 28-30 October 2004, Morogoro .Tanzania. pp.35-39.

Maliondo, S.M.S., Malimbwi, R.E., Temu, R.P.C., Constantine, E. and Zahabu, E. (1980). Fire impact on population structure and diversity of tree species in West Usambara Camphor zone forests. *Journal on Tropical Forest Science* 12(3): 472-491.

Maliondo S.M.S. (1997). Forest management in Tanzania: past, present and future research contribution to sustainable management of natural forests. In: *setting forestry research needs and priorities.* (Edited by Ruokonen, Masayanyika and Mbwambo), 22-24 April , 1997. Morogoro, Tanzania. pp. 39 - 44.

Mayeta, L. (2004). The Role of Local Institutions in Regulating Natural Resource Use and Conflict Management in Mpanga/Kipengere Game Reserve,

Iringa, Tanzania. Dissertation for Award of MSc. Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 132pp.

Mbwambo, S.J. (2000). The Role of Local Communities and Organizations in Sustainable Conservation of Biodiversity: Case Study of Udzungwa Mountains, Tanzania. 133pp.

Mbwambo, L., Valkonen, S. and Kuutti, V. (2008). Structure and Dynamics of Miombo Woodland stand at Kitulangalo Forest Reserve, Tanzania. In Varmola, M., Volkonnen, S. and Tapaninen, S. (eds). Research and development for sustainable Management of Semi – Arid Miombo Woodlands in East Africa. Working Papers of Finish Forest Research Institute 10-19pp.

Mehta, V.K., Sulvan, P.J., Walter, M.T., Krishnaswamy, L. and DeGloria, S.D. (2008). Ecosystem impacts and disturbance in dry tropical forest in Southern Inida. *Ecohydrology* 1 (2): 149-160.

MNRT, (2002).Forestry in Figures. Forestry and Beekeeping Division. Ministry of Natural Resources and Tourism, Dar es Salaam, Tanzania. 15pp.

Mgeni, A.S.M. and Malimbwi, R.E. (1990).*Natural forest resources of Tanzania and their Management needs.* Faculty of forestry. Sokoine University of Agriculture. Record No. 43.pp 67-76.

Mialla, Y.S., Kajembe, J.C., Malimbwi, R.E. and Nduwamungu, J. (2004). Participatory and Conventional Forest Assessments: Case Study of Monduli-Mlimani Catchment Forest, Monduli District, Tanzania: *In Proceedings of the IFRI East African Regional Conference on Institutions, Incentives and Conflicts in*

Forest Management: A Perspective. (Edited by Shemweta, D.T.K., Luoga, E.J., Kajembe, G.C. and Madoffe, S.S.) 12-13 January 2004, Moshi. pp 67-79.

Misra, K.C. (1989). Manual of plant ecology .3rd Ed. Oxford and IBH Publishing Co. Pvt Ltd, New, New Delhi. 491pp.

MNRT (1998).National Forest Policy. Ministry of Natural Resources and Tourism, Dar es Salaam, Tanzania.

Mung'ong'o, C.G., Kauzeni, A.S. and Shechambo, F.C. (1995). Source of socio economic Pressure on Coastal Forest. Some pleliminary observation from Mikindu Forest Reserve. In Proceedings of a Workshop on Coastal Forest Biodiversity. (Edited by Howell, K.M., Muturi, F.A. and Urassa, F.M.). University of Dar es Salaam, Tanzania. pp21-22.

Munishi, P.K.T. (2001). The Eastern Arc Mountains Forest of Tanzania: Their role in Biodiversity, Water Resource Conservation and Net Contribution to Atmospheric –Carbon. PhD. Dissertation. 28-29pp.

NAFORMA (2013). Naforma Key Findings; Workshop held in Morogoro, June 2013.

Nduwayezu, J.B., Ruffo, C.K., Minami, V., Munyaneza, E. and Nshutiyayesu, S. (2009). Know Some Useful Trees and Shrubs for Agricultural and Pastoral Communities of Rwanda. Institute of Science and Technological Research (IRST) Rwanda.

Ndziku, T. (2002). Tanzania's Green campaign. Kakakuona No 24pp 5-6.

Neema, M.D. (2009). Impact of Community Based Forest Management on Resource Base Governance and Livelihood of Communities around Selela Forest Reserve. Monduli, Tanzania. MSc. For. Dissertation. 141pp.

Newmark, W.D. (1998). Forest Area, Fragmentation and Loss in the Eastern Arc Mountains: Implications for the Conservation of Biological Diversity. *Journal of EastAfrican Natural History.* Vol. 87: 29-36.

Njana R. N. (1998).Prospects of Local People's Involvement in the Management of Catchment Forest Reserves: A case study of the North Mahiwa Kisara Catchment Forest Reserve, Morogoro Tanzania. Unpublished Dissertation for Award of MSc. (For.) of — Sokoine University of Agriculture, Morogoro, Tanzania.137 pp.

Njuguna, J.W. and Ongungo, P.Oo O. (2004). Charcoal Production in Kenya Natural Forests: Legal Status and its Implications. In: proceedings of the IFRI East African Regional —Conference on Institutions, Incentives and Conflicts in Forest Management: A Perspective. (Edited by Shemwetta, D.T.K., Luoga, E.J., Kajembe, G.C. Madoffe, S.S.), 12-13 January 2004, Moshi.pp.138-144.

Otieno, N.J. (2002). Biomass inventory and potential of indigenous Medicinal plants. Case study of Duru-Haitemba Community Forest, Babati, Tanzania. Dissertation for award of MSc. Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 145pp.

Pampel, F.C. (2000). Logistic Regression: A Primer. Quantitative Applications in the Social Sciences. Sage University Papers Series. Thousand Oaks, CA. 96pp.

Penzari, L. and Marco, T. (2009). Myolo and Tove Environment Risk Analysis ~~A~~a Study on the quality of water in Tove-Mtwango Project. 3pp.

Persha, L. (2004). Threat Reduction Assessment (TRA) Notes and Methodology Changes. FAO- UNDP-GEF Biodiversity Project." Reducing Biodiversity Loss at Cross Border Sites in East Africa". [http://xborderbiodiversity. tripod.com/ disc16htm] site visited~~]~~ ~~–~~on 15/02/2005.

Peter, C.M. (1994). *Sustainable Harvesting of Non-Timber Plant Resources in Tropical Moist Forest: An Economic Primer;* Biodiversity Support Program USA. xxp.

Rakthi, D.K.K., Ashllata, D.K., Ashsh, P. and Khan, M.L. (2005).Population structure and Regeneration status of Medicinal trees. *Illicium griffithii* in relation to disturbance gradients in Temperate broad leaved forest of Amnachal Pradesh. *Current Science* 89(4): 673-676.

Ruffo, C.K., Birnie, A. and Tegnas, B. (2002). Edible Wild Plants of Tanzania.766 pp.

Ruffo, C.K., Suleiman, B.C. and Charles, K.M. (1996).Catalogue of Lushoto Herbarium. Tanzania. Tanzania Forestry Research Institute and Tanzania National Tree Seed Programme. 467pp.

Rwamugira, S.P. (2008). Impact of mining on forest ecosystem and adjacent Communities of E astern Arc Mountains: A Case Study of Ruvu Catchment Forest Reserve, ~~Morogoro~~ Morogoro, Tanzania.

Sheil, D., Jennings, S. and Savill, P. (2000). Long term permanent plot observation of vegetation dynamics in Budongo a Ugandan rainforest. *Journal of Tropical Ecology* 16:765-800pp.

Tayor, D., Hamilton, A.C., Lewis, S.L. and Nantale, G. (2008). Thirty eight years of change in the tropical forest. Plot data from Mpanga forest reserve, Uganda. *African Journal of Ecology*~~.~~ 47: 65-71.

United Nations Environmental Program - UNEP, (1996). *Regional Workshop on the use of Database to Support Decision-Making in Biodiversity Conservation in East Africa*, 27-28 June 1996, Nairobi, Kenya. 169pp.

URT (1998). The National Forest Policy. Ministry of Natural Resources and Tourism, Dar es Salaam, Tanzania.

URT (2009a). MANAGEMENT PLAN FOR KILOMBERO NATURE RESRVE. Forest and Beekeeping Division. Ministry of Natural Resources and Tourism. 116pp.

URT (2009b). *Management Plan for Nilo Nature Reserve*. Forest and Beekeeping Division. Ministry of Natural Resources and Tourism.159pp.

URT (2012).Tanzania Bureau of Statistics; Population Distribution by Administrative Units. 2012- Population and Housing Census. Volume 1.

Whitehead, J. (1998). Willingness to Pay for Bass Fishing Trips in the Carolinas. Department ~~of Economics~~of Economics East Carolina University. 5pp.

World Resource Institute (WRI). The World conservation Union, United Nations Environmental Program (1992). Global Biodiversity Strategy. Guidelines for Action to serve study and use Earth's Biotic Wealth sustainably and Equitably. WRI, IUCN, UNEP, Washington. 244pp.

WWF. (2004). For a Living Planet. [http://www.panda.org.za/article.php?id=286] site visited on 07/01/2005.

Zahabu, E. and Malimbwi, R.E. (2008). Package for inventory data analysis. Workshop held at88 Motel, Morogoro. Department of Forest Mensuration and Management SUA-Morogoro. 12pp.

Zahabu, E., Eid, T., Kajembe, G.C., Mbwambo, L., Mongo, C., Sangeda, A.Z., Malimbwi, R.E., Katani, J.Z., Kashigili, J.J. and Luoga, E.J. (2009). Forest land Tenure Systems in Tanzania. An overview of Policy changes in relation to Forest Management. INA- Fragraport No. 14, Department of Ecology and Natural Resource Management, Norwegian University of life sciences. 24pp.

APPENDICES

Appendix 1: Checklist of identified tree species and their uses in Rau Forest Reserve, Moshi District, Kilimanjaro Region, Tanzania

No.	Local/ vernacular name	Species name	Family name	Uses
1	Mfurufuru	Croton macrostachyus	Euphorbiaceae	Fd, Agr.,F,M
2	Mwembe	Trichilia emetic	Meliaceae	M,Fr,Sh,T
3	Mkungwina	Brideliamicrantha	Myritaceae	T,F,Fr
4	Mkarati	Tabaenamontanaholistii	Apocynaceae	M,Sh,F
5	Mtiki	Tectonagrandis	Verbenaceae	T,P,F
6	Mpesi	Tremaorientalis	Ulmaceae	F,Wd,Wc
7	Mfuruanji	Albiziaschimperiana	Fabaceae	T,Sh,Nf,Bf
8	Makaranga	Makarangakilmandischaric a	Euphorbiaceae	F,Sh,M,T
9	Mzambarau	Syzigiumcuminii	Myritaceae	Fr,T,M,Sh
10	Mkuyu	Ficussyncomorous	Moraceae	Wc,F,Sh,Fr,Ca,B,Fd, M
11	Msasa	Ficusexasemperata	Moraceae	F,P,T,Sp
12	Mkangazi	Khayaanthotheca	Meliaceae	T,Sh,F,P,H,M
13	Msesewe	Rauvolfiacaffra	Apocynaceae	T,F,M,Bf
14	Msoo	Oxystigmamsoo	Caecalpiniaceae	T,P,F,Fr
15	Mwerezi	Cedrellaodorata	Meliaceae	T,F,Sh,Bf
16	Mvule	Milicia excels	Moraceae	T,Sh,M
17	Mringaringa	Cordiaabyssinica	Boragnaceae	T,F,Sh,Orn,Ca,M
18	Mtalawanda	Makhamialutea	Bignoniaceae	F,Arg.,P,Bf,Orn.,M, T
19	Mpera	Psidiumguajava	Myritaceae	Fr.,F,P,M
20	Mgunga	Acacia sp	Mimosaceae	F,P,Nf
21	Mlala	Phoenix reclinata	Arecaceae	Orn.,Bf.,Wc,Fib.,R
22	Mjohoro	Sennasiamea	Caecalpiniaceae	F,Sh.,Ch
23	Mfudufudu	Gmelinaarborea	Verbenaceae	T,Ply.,Plp.

24	Lusina	Leucaenaleucocephala	Mimosaceae	Fd.,F,Agr.,M,Sh.,D
25	Mkufi/Mnyasa	Newtoniabuchananii	Mimosaceae	F,T,Agr.,Nf.,P
26	Mjakaranda	Jacaranda mimosifolia	Bignoniaceae	T,Orn.,P,F,H,Bf
27	Mgola/ Mmango	Dovyalisabyssinica	Flacortiaceae	Fr.,He.,F
28	Mtopetope	Annonasenegalensis	Annonaceae	Fr.,F,Orn.
29	Mtikiza	Sorindeiausambarensis	Anacadiaceae	Fr.,T,Sh.,Fd
30	Mkwinini	Cinchona sp.	Rubiaceae	M,F,P,Sh.
31	Mdaa	Eucleadivinorum	Ebenaceae	M,D,H,F,Sh.
32	Kimaroro	Combretummolle	Combretaceae	F,P,M,Ch,H,Bf.
33	Mtua	Fagaropsis sp.	Lutaceae	T,F,Sh.,P
34	Mlegea	Kigelia Africana	Bignoniaceae	F,T,Fd,Fr.,Orn.,Sh.
35	Mviru	Vangueriainfausta	Rubiaceae	Fr.,F,P,M,H,Fd.,Bf.
36	Msasame	Maytenus sp.	Celastraceae	F,P,M
37	Msandali	Osyrislanceolata	Santalaceae	T,Ca.,F,Per.,M,Fr.
38	Mwembe	Mangiferaindica	Ancardiaceae	Fr.,T,M

Uses: T=Timber— Ca=Carvings M=Medicine —H=Handles —Ta=Tannin— Nf=Nitrogen fixation — Fr=Fruits Ch=Charcoal –R=Ritual –P=Poles R=Ropes — Fd=Fodder– Bf=Bee forage— Bh=Beehives –F=Firewood —Fib=Fibre_Agr.=_ Agroforestry –Sh=Shade – ——Plp=Pulp ——Orn=Ornamental He=Hedge Per=Perfumes —Ply=Plywood

Appendix 2: Forest Reserve Threat Reduction Assessment Index in Rau Forest Reserve, Moshi District, Tanzania.

Forest Location	Direct Threat	Area ranking	Intensity rank	Urgency ranking	Total ranking	% Met	Raw TRAIndex Threat score
FE1	Encroachment	5	4	4	13	10	1.3
FE2	Fire wood collection	4	4	4	12	15	1.8
FE3	Damping place	2	1	3	6	30	1.8
FE4	Local brew making	2	1	1	4	25	1.0
FE5	Pole cutting	4	4	3	11	15	1.7
Sub-total					**46**		**7.6**	**16.5**
FI1	Local brew making	2	3	2	7	20	1.4
FI2	Timber harvesting	3	3	4	10	15	1.5
FI3	Fodder collection	1	1	2	4	30	1.2
FI4	Grazing	2	2	2	6	30	1.8
FI5	Corruption	2	3	3	8	20	1.6
Sub-total					**35**		**7.5**	**22.4**
Grand Total					**81**		**15.1**	**19%**

Where:

Raw score = Total ranking x % threat met **TRA** = (Total score/Total ranking) x 100%

FI = Forest Interior Threats (100 metres from the forest edge**)**

FE = Forest Edge Threats (within 100 metres from the forest edge

FE1= Encroachment (this is more serious in Easternandsouthernpart bordering Kaloleni and Mabogini villages respectively, efforts have started to reclaim the encroached area).

FE2 = Fire wood collection-(It has been done for quite long time and to date is still a problem except in the southern part where bigger diameter logs/poles are preferred for brick making ,the rest takes normal small size fire wood).

FE3 = Damping place- has recently started to put some waste to ,so far the present damping place is very close to forest reserve.

FE4 = Local brew making – Preparation of local brew (gongo) started too long and is still going on in small scale along the streams best for distillation process in so doing they cause a lot of pollution along streams and sometimes they cause the same by using a used tires as fuel, as a result very strong black smoke pollute the environment.

FE5 =Pole cutting – Poles are being cut for erecting small huts in farms and in homestead for tamed animals including cows ,chicken goats sometimes as kitchen slums.

FI1= refer **FE4**

FI2 = Timber – Normally this is done by taking felled logs and saw them outside forest, is ,not regularly happening these days, now days there is a natural catastrophe of windfall , it has affected forest by suppressing saplings and killing small size trees.

FI3 =Fodder – Majority of people keeping cattle in Municipal they practice "Zero grazing" so they go for fodder in the forest reserve.

FI4 = Grazing- for those having bigger herds particularly from Mabogini and Kaloleni they graze in the reserve, during data collection we observed a group of 23 cows grazing in the reserve , goats are also grazing in the reserve.

FI5 = Corruption – There is a behaviour (to be ascertained) of some unfaithfully staff to violate good conduct, there is an environment which give such sign to few bad behavior individuals practicing such a bad behaviour.

Appendix 3: (a) Data sheet for reporting progress in Management Effectiveness in Rau Forest Reserve, Moshi District, Tanzania.

Date assessment carried: 19 /2 /2014

Name of the Assessor: Peter Nyahende – Assistant District Manager - Moshi.

Name of the Protected Area ——————Rau Catchment Forest Reserve		
Location of the protected Area (district, Region and if possible Map reference)	District: Moshi; Region: Kilimanjaro	
Date of Establishment (distinguish between gazzeted and agreed) Gazzeted : 25 /5 /1959		
Ownership Details (i.e. Owner, tenure rights)	CENTRAL GOVERNMENT	
~~Management~~~~Authority~~Management Authority GOVERNMENT (MINISTRY OF NATURAL &RESOURCES & TOURISM		
Size of the protected Area (ha)	570 ha	
Number of Staff	Permanent 08	Temporary
Budget	TSHS	(TFS)
Designation (IUCN Category, World Heritage Site, Ramsar		TFS
Reasons for Designation	PROTECTION OF BIODIVERSITY AND WATER SPRINGS	
Brief Details of World Bank funded Project(s) in Protected Area ----------		
Brief Details of WWF funded Project or Projects in Protected Area		----------
Brief Details of other Relevant Projects in Protected Area		Beekeeping
List two primary protected Area Objectives		
Objective one (1)	CONSERVATION OF BIODIVERSITY	
Objective two (2)	INCOME GENERATING ACTIVITIES i.e. BEEKEEPING	
List two most important threats to the protected Area (and indicate reasons why these were chosen)		
Threat one (1) ~~*Encroachment*~~~~It~~*Encroachment* It is detrimental to the environment as it causes siltation downstream		
Threat two (2) *Tree cutting for different uses* → Loss of Biodiversity, lower water catchment capacity		
List top two critical Management activities l		
Activity One (1) BOUNDARY RESURVEYING AND CONSOLIDATION Activity two (2) PATROLLING AND LAW ENFORCEMENT		

Appendix 3(b): Management Effectiveness form for Rau Catchment Forest Reserve - Moshi District-Tanzania

SERIAL No.	ISSUE	MAXIMUM SCORE	ACTUAL SCORE
I	Context		
1	Legal status-Does the Protected Area have Legal status?	3	3
2	Protected Area regulations.		
	-Are inappropriate land uses and activities _____ (eg. poaching, illegal timber harvesting fishing, encroachment ,livestock grazing) controlled	3	0
3	Law enforcement		
	Can staff enforce protected area rules well enough	3	1
4	Protected Area Boundary demarcations		
	-Is the boundary known and demarcated	3	1
5	Resource Inventory		
	-Do you have enough information to manage the Area	3	1
II	Planning		
6	Protected Area Objectives		
	-Have objectives been agreed	3	1
7	Protected Area Design		
	-Does the protected area need enlarging, corridors etc. to meet its objectives	3	1
8	Management Plan		
	-Is there a management plan and is it being implemented	3	0
9	Planning outputs – Regular work plan		
	-Is there an Annual Work plan	3	2
II	Inputs		
10	Research		
	-Is there a programme of management oriented survey and research work?	3	0
11	Staff numbers		
	-Are there enough people employed to manage the	3	2

	protected Area		
12	Staff training		
	-Is there enough training for staff?	3	1
13	Current budget		
	-Is the current budget sufficient	3	1
14	Security for budget		
	-is the budget secure	3	1
15	Resource management		
	-Is the protected area adequately managed (for fire, invasive species, poaching, encroachment, illegal timber harvesting, fishing, livestock grazing)	3	1
16	Personal management		
	-Are the staff managed well enough?	3	1
17	Management of budget		
	-Is the staff managed to meet critical management needs?	3	1
18	Equipment		
	-Is the current equipment adequate	3	1
19	Management of equipment		
	-Is equipment adequately maintained	3	1
20	Education and awareness programme		
	-Is there a planned education programme	3	0
21	State of commercial neighbours		
	-Is there cooperation with adjacent land users	3	1
22	Indigenous people		
	-Do indigenous and tradition people or resident or regularly using the protected area have input to management decisions?	3	0
23	Local communities		
	-Do local communities residents or near to protected area have input to management decisions	3	0
24	Commercial tourism and hunting		
	--Do commercial tour operators and hunting companies contribute to protected area management	3	0
V	Output		
25	Visitor facilities		

	-Are visitor facilities (for tourism, hunters, pilgrims etc.) good enough?	3	1
26	Fees		
	-If fees (tourist, hunting, fines) are applied, do they help protected area management	3	1
VI	Outcomes		
27	Condition assessment		
	-Is the protected area being managed consistent to its objective	3	1
28	Access assessment		
	-Are the available management mechanism working to control access or use	3	1
29	Economic benefit assessment		
	-Is the protected area providing economic benefits to local communities	3	0
30	Monitoring and Evaluation (PLANNING/PROCESS)	3	1
	TOTAL SCORES	90	26

Overall Management Effectiveness = 26/90 x100% = 28.8 ≈ 29 %

Scores: 0 = Poor; 1= Fair; 2 = Good; 3 = Excellent

Rank: >15%=very poor~~;15~~; 15-30%=Poor~~;31~~; 31-45%=Average~~;46~~; 46-60%=~~Good;~~Good;~~>60~~> 60%=very good

Appendix 4: Location of forest disturbance plots and their status in Rau forest Reserve, Moshi District, Kilimanjaro Region

		Trees				Poles								
Transect number.	**GPS begin of plot**	**Live**	**Dead**	**New cut**	**Old cut**	**Live**	**Dead**	**New cut**	**Old cut**	**GPS end of plot**	**Transect length(m)**	No of plots	Effective distance (m)	Remarks
1	Alt 778m 37M0317173 E UTM9627059 N	196	1	0	31	124	1	2	2	Alt 783m 37M0318194 E UTM 9627056N	890	15	750	
2	Alt.781m 37M0318194 E UTM9627056 N	163	5	0	31	107	1	0	8	Alt. 776 37M0318225 E UTM9627143 N	950	16	800	
3	Alt. 809m 37M0317309 E UTM9627126 N	153	10	4	21	76	0	0	5	Alt. 788m 37M0318207 E UTM9627202 N	720	13	650	
4	Alt.786m 37M0317157 E UTM9627109 N	136	3	0	41	60	0	1	7	Alt.792m 37M0317347 E UTM9627056 N	830	14	700	
Sub. Total		648	19	4	124	367	2	3	22		3390	58	2900	
Transect Number	GPS begin of plot	Live	Dead	New cut	Old cut	Live	Dead	New cut	Old cut	GPS end of plot	Transect length (m)	No of plots	Effective distance (m)	Remarks
5	Alt.747m 37M0317207 E UTM9627177 N	99	0	0	6	64	0	0	4	Alt.788m 37 M0318154E UTM9627229 N	890	15	750	
6	Alt. 781m 37M0317635 E UTM9627259 N	129	3	0	3	152	1	18	14	Alt. 783m 37M0319207 E UTM9627963 N	1320	22	1100	
7	Alt.788m 37M0317082 E UTM9627951 N	112	1	0	27	150	0	5	22	Alt.792 37M0318415 E UTM9627981 N	1130	19	950	
Sub Total		**340**	**4**	**0**	**36**	**366**	**1**	**23**	**40**		**3340**	**56**	**2800**	
Grand Total		**988**	**23**	**4**	**160**	**733**	**3**	**26**	**62**		**6730**	**114**	**5700**	