EFFECT OF REFUGEES ON PLANT DIVERSITY, FOREST STOCKS AND FOREST COVER IN NORTH-EAST MPANDA FOREST RESERVE, MPANDA DISTRICT, TANZANIA

BY

LUCAS SOTERY NYAMBALA

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ABSTRACT

This study on the effect of refugees on plant diversity, forest stock and forest covers was conducted in North-East Mpanda Forest Reserve (NEMFR), Mpanda District. Specifically, the study aimed at assessing refugees' forest-based activities, quantifying effect of refugees' disturbances on forest stocks, assessing the effect of refugees on plant diversity and quantifying the forest cover changes between 1972/73-1994 and 1994-2009. Structured interview and checklist were used to collect socio-economic data from Katumba refugee camp villages and one village from native community. Biophysical data was collected through forest inventory procedures and remote sensing and GIS techniques. The forest was stratified into disturbed and undisturbed strata of 33 and 135 sample plots respectively. Descriptive statistics were established through SPSS software whereas, content analysis was used to analyse qualitative data. Inventory data was analysed by Microsoft excel. Satellite imageries covering a period from 1972/73 to 2009 were analysed by GIS techniques using Arc View GIS and ERDAS. Results revealed that refugees illegally accessed NEMFR mainly for agriculture, residences, fuelwood and poaching. Stand density was 595±26.01 (SE), 663±25.07 (SE) and 254±58.5 (SE) stems/ha for the whole NEMFR, undisturbed and disturbed strata respectively. Basal area was 15.68±0.76 (SE), 18.62±0.71 (SE) and 2.12±0.59 (SE) m^2/ha for NEMFR, undisturbed and disturbed strata respectively. Volume was 151.60±8.22 (SE), 182.10±8.17 (SE) and 17.45±5.76 (SE) m^3/ha for NEMFR, undisturbed and disturbed strata respectively. Statistically, the above three parameters with reference to undisturbed and disturbed strata were significantly different ($p<0.0001$) implying disturbed strata was less stocked attributable to anthropogenic activities. Shannon-Wiener indices were 3.26±0.007 (SE), 3.24±0.007 (SE) and 2.73±0.05 (SE) for NEMFR, undisturbed and disturbed strata respectively. Cover change analysis deduced a widespread forest cover changes attributable to refugees disturbances. The study concluded that legal residence

of refugees in NEMFR has significantly resulted into reduced wood stocks, plant diversity and forest cover.

DECLARATION

I, Lucas Sotery Nyambala, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been submitted nor concurrently being submitted in any other institution.

.... 02/09/2013

Lucas Sotery Nyambala
(MSc Candidate) Date

The above declaration is confirmed:

.... 02/09/2013

Prof. Emmanuel J. Luoga
1[st]Supervisor Date

.... 02/09/2013

Dr. Japhet J. Kashaigili
2[nd]Supervisor Date

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DEDICATION

This work is dedicated to the Almighty God and my demised beloved wife Alice Agustino Chonya whose tolerance to my absence and lonely care of our children during my studies laid a base for the accomplishment of this work.

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LIST OF ABBREVIATIONS AND SYMBOLS

Dbh	Diameter at breast height
FAO	Food and Agriculture Organization
FBD	Forestry and Beekeeping Division
FGD	Focused Group Discussion
G	Basal area of trees per hectare
ha	Hectare
KIR	Key Informant Respondent
MNRT	Ministry of Natural Resources and Tourism
MoHA	Ministry of Home Affairs
N	Number of stems per hectare
NGO	Non-Government Organization
PRA	Participatory Rural Appraisal
SE	Standard error
SUA	Sokoine University of Agriculture
UN	United Nations
UNEP	United Nations Environmental Program
UNHCR	United Nations High Commission for Refugee
URT	United Republic of Tanzania
V	Volume of trees per hectare
USA	United States of America
UDSM	University of Dar Es Salaam

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Tanzania Mainland has a total land area of 94.5 million hectares out of which 88.6 million hectares is landmass and 5.9 million hectares is inland water (URT, 2009). Out of the 88.6 million hectares 39.8% (35.3 million hectares) is covered by forests and woodlands (FAO, 2010). About 13 million hectares of forested land has been set aside as permanent forest reserves under central government and 1.6 million hectares is protected forests for catchments and biodiversity functions (URT, 1998a). Collectively, these forests provide productive and protective functions to human life and serve in important ecological processes. Productive functions of the forests include provision of fodder, medicinal plants, honey, mushrooms, timber, poles, wild fruits and fuelwood which are vital for supporting livelihoods of nearly 87% of the poor rural Tanzanians. The protective functions offered by these forests include conservation of biodiversity and water sources, carbon sequestration, regulation of atmospheric and climate condition. They also provide habitat and habitat resources for valuable wildlife.

Despite the importance of these forests they are under heavy pressure of disappearing due to deforestation and degradation. The deforestation was estimated at 412 000 ha per annum between 1990 and 2005 equivalent to 1.1% of the country's total forest area (URT, 2009). The anthropogenic drivers for deforestation include increased agricultural activities, livestock grazing, wild fires, over-exploitation, and subsequent abandonment, selective harvesting of trees and other human activities (Luoga, 2000). These drivers are due to population increase, which has a direct relationship with the demand pressure on forest resources (Carr *et al.*, 2005). Internal population growth is not the only cause of extra demand and pressure on natural forests in Tanzania; refugees have also been another cause of existing pressure on natural forests leading to deforestation (UDSM, 2005; Njahani, 2009). An example of refugees' deforestation is Katumba Refugees Camp within Northeast Mpanda Forest Reserve (NEMFR) which was opened in 1972 by hosting 64 000 Burundian refugees (Anthony, 1989). Study by UDSM (2005) shows that the camp has expanded by 44.7 % from its original size, implying conversion of forest land into other land uses. Parallel to this conversion, anthropogenic activities elsewhere in Tanzania are said to deplete most saleable tree species from the forest thence, changing the plant diversity of forests (Luoga *et al*., 2002).

1.2 Problem Statement and Justification

1.2.1 Problem statement

Katumba refugee camp, which is circumscribed by the NEMFR, was established in 1972 where international relief agencies were supplying most of the necessary needs to refugees. Refugees had been self-sufficient in food, cash crop and animal products within five years of running the camp. After five years the camp was handed over to Tanzania Government on 30 June, 1978 and the relief agencies reduced their supplies to about 20% (Anthony, 1989; Nderumaki, 1995).

Being self-sufficient implies meeting socio-economic needs such as energy, funds and food on individual basis from any possible source. The nearest source for meeting these needs was NEMFR since by rule, refugees were allowed to move within a four to ten kilometres radius around the camp in order to get amenities (UDSM, 2005; UNHCR, 2005). For the case of Mpanda district, this automatically permitted them to have free access into forest reserve which was against Section 26 subsections a-s of the forest Act No 14 of 2002 (URT, 2002a).

Firewood is one of the sources of energy for refugees. Studies show that refugee firewood consumption rate is as high as 2.8 kg/person/day which is higher than that of local communities which stands at 1.7 kg/person/day (UNEP, 2005). During the socioeconomic survey it was reported that the higher rate of fuelwood consumption was due to their tendency of not putting off fire after cooking to reduce consumption of kerosene and matches for lighting fire. Charcoal making business is also practised by refugees as their source of income due to its low investment costs and hence easily opted by people residing close to natural forests (Luoga *et al.*, 2000). Other forest based refugees activities include farming and grazing (UDSM, 2005). Collectively, these activities cause degradation of NEMFR. Studies by Luoga (2000), Mafupa (2006), Chikira (2008) and Njahani (2009) in selected miombo woodlands show that there is a relationship between human disturbances and forest degradation. These studies however, do not show the effect of refugee influx on forest reserves particularly when refugees legally reside within the forest reserve. Therefore, there was a need to undertake this study in order to establish the effect of legally allowing human settlements within forest reserve on plant diversity, forest stocks and forest cover in NEMFR.

1.2.2. Justification

NEMFr has been cited as a very vulnerable protected area, due to the presence of refugee camp in the forest reserve. Among the most critical environmental problems associated with refugees is deforestation due to tree cutting for fuelwood, poles and agriculture. Other environmental problems are destruction of grass lands and wild animal habitats, environmental pollution and other health related problems (Gurman, 1991 in Bouchardy, 1999).

NEMFR is part of Ugalla ecosystem where Mtambo, Msaginya and Nsanda Rivers originate and drain water into Ugalla River. Ugalla River drains water into Malagalasi-Muyovozi wetland system draining into Lake Rukwa and Lake Tanganyika (UDSM, 2005). Being part of the broader drainage system, disturbances in the NEMFR affect the Ugalla ecosystem, catchments of Mtambo, Mnyamasi and Nsanda rivers, Malagalasi-Muyovozi wetland system, and Lake Tanganyika and Lake Rukwa systems. The findings from this study provide scientists and decision makers with scientific information on the effects of refugee settlements within forest reserve on plant diversity, forest stock and forest covers of the forest for informed decision making. Again, these findings will contribute towards sustainable forest management of the NEMFR and other forests in similar situation.

1.3 Objective

1.3.1 Main objective

The main objective of this study was to assess the effect of refugee influx on plant diversity, forest stock and forest covers in NEMFR.

1.3.2 Specific objectives

The specific objectives of this study were to:-

i. Identify refugees' forest-based activities in NEMFR.

ii. Quantify the effect of refugees' disturbances on forest stocks.

iii. Assess the effect of refugees settlements on plant species diversity.

iv. Quantify the forest cover changes between 1972/73-1994 and 1994-2009.

1.3.3 Research questions

The research questions underlying this study were;

i. What are the socio-economic activities taking place in NEMFR?

ii. What is the effect of refugees on forest stocks?

iii. What are the common tree species present in NEMFR?

iv. What are the common tree species which have disappeared from the forest?

v. What are the forest cover changes which have occurred between 1972/73-1994 and 1994-2009?

1.4. Conceptual Framework

The conceptual framework depicts the relationships between degradation of NEMFR and drivers of deforestation (Fig. 1). The drivers of deforestation are socio-economic activities conducted by refugees in NEMFR making the forest have low plant diversity, forest stocking and forest cover. These human disturbances in forest reserves occur as a result of a number of interacting factors including socio-economic, demographic and policy issues (Luoga *et al.*, 2000). Therefore, this conceptual framework links refugees' socio-economic activities and deforestation in NEMFR.

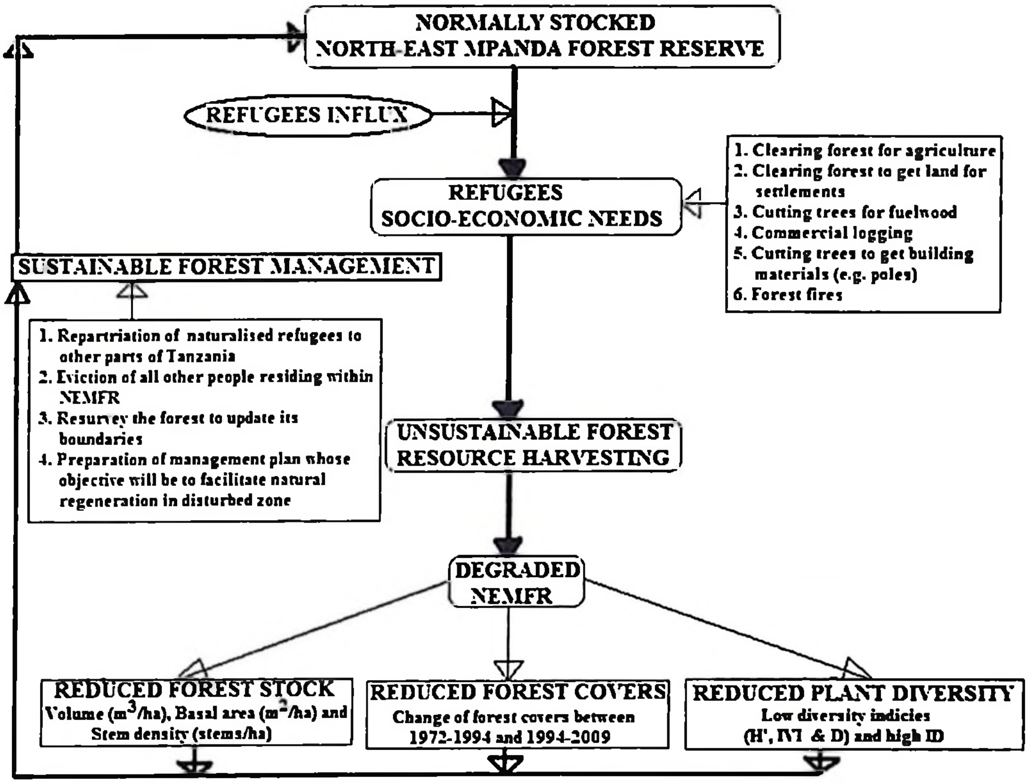


Figure 1: The conceptual framework underlying this study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Basic Concept on Carrying Capacity

2.1.1 Carrying capacity of land

Carrying capacity of land is the maximum ability of a given piece of land to support a given population size for a given period of time in terms of natural resources carried on it including the lands' capacity to produce agricultural food to feed the population in context (Mena *et al.*, 2006). Carrying capacity explains the relationship between demographic growth and population pressure on land, the impact of population growth on food production and agricultural income. This will eventually result into property rights concerns on land (Kalipeni, 1992).

2.1.2 Population-environment relationship

The Malthusian and Boserupian perspectives are the viewpoints on population-environment relationships. In 1803 Malthus postulated that, human population has a tendency to grow geometrically, while the agricultural production of food grows arithmetically (Malthus, 1803). Again, weighing of the demographic growth and agricultural productivity, shows that population growth tends to outstrip the productive capabilities of land resources (Carr *et al.*, 2005). The difference in growth reaches a point of limit at which natural resources fail to support the geometrical growth of population where a natural check takes place restricting further population growth. The restriction happens due to the limited ability of land to produce food and other natural resources, as when the levels of human use of biological resources exceed their capacity for the renewal, the diversity and productivity of the system may be reduced (Luoga, 2000). At such a situation, the land is said to reach its carrying capacity implying that land has

2.1.3.2 Multiplicative perspectives

Apart from Malthusian and Boserup theories *per se*, multiplicative perspectives are in press examining the relationship between population growth, technological change in agriculture and environmental impacts. Population, in the dimensions of size, growth, density and distribution interacts in multiplicative way with other factors. These factors are the level of consumption of agricultural products, technology by which agricultural products are obtained, and their impacts on the environment. These factors are presented in the multiplier approaches' equation as follows (Barbier, 1997).

"I=PAT" ....(2)

Where; I = Total environmental impacts

P = Population size

A = Affluence level or per capita consumption

T = Level of technology.

The implication of this equation is that total environmental impacts (I) is the function of population size (P), the level of affluence or per capita consumption (A), and level of technology (T) used in the production of and consumption of agricultural products.

2.1.3.3 Mediating perspectives

Mediating perspectives emphasize that social, cultural and institutional factors play a mediating role in determining population-environment relationships. Collectively, mediating perspectives was found to engulf two other perspectives namely Latin American perspectives and dependency perspectives. A Latin American perspective specifies the mediating effects of socio-economic and institutional factors on population-environment relationships. This was specified by formulating a framework that specifies the mediating effects of social-economic and institutional factors on population-environments relationships (Carr *et al.*, 2005). However, development processes mediate population and the environment relationships in the so called dependency perspective (Jolly, 1991 in Henrik, 2005). Mediating perspective shows the importance of including socio-economic surveys in studies related to population-environment relationship.

2.2 Refugees Influx and their Effect on the Environment

Tanzania Refugees Act No 9 of 1998 under Sections 4(c) and 9(1), defines a refugee as any non Tanzanian person entering or who is within Tanzania, whether lawfully or otherwise and who has immediately and not later than seven days after entry report himself/herself to the nearest authorized officer, village executive officer, or a justice of peace and apply for recognition as a refugee (URT, 1998b).

A total of 17 084 100 asylum seekers, refugees and displaced persons were worldwide reported in 2004. Out of these 6 187 800 were in Asia, 4 285 100 in Africa and the rest from other regions of the world (UNEP, 2005). Currently, refugees population in Tanzania stands at 334 862 people (MHA, 2008). Such population causes deforestation, for example, Katumba refugees' camp in Mpanda district extends beyond the camp boundaries through shifting cultivation. Refugees farmlands have extended to the east of Kambuzi Halt Village, South of Msaginya river, northeast of Uruwila village, northwest of Nsanda river, and to the eastern side of Mtambo river, encroaching the NEMFR (UDSM, 2005).

2.3 Biodiversity and Disturbance Theories

2.3.1 Plant diversity

Diversity is defined as the structural and functional variety of plants and animals at genetic, species, population, community and ecosystem levels. Plant diversity refers to the number of plant species and their spread within a community. Collectively, this is a biological diversity (Biodiversity) since it refers to structural and functional varieties of flora and fauna which are living organisms (Kent and Coker, 1992). Biodiversity is made of three components, composition, structure and function (Lamont, 1995). Biodiversity is a distinct feature of natural resources which is said to be a natural capital to human beings (Neumayer, 1998); because they provide human beings with material and non-stop flow of goods and services (Lamont, 1995).

2.3.2 Disturbance theory

Spatial and temporal heterogeneity in the structure and dynamics of any natural vegetation are largely influenced by disturbances (Luoga, 2000). Disturbance regime of a given ecosystem determines the dynamic nature of biological resources (Pickett *et al.*, 1992; Silvertowm and Lovett-Doust, 1993). Factors of disturbances are the most important in determining species composition in miombo woodlands especially when the edaphic factors are similar (Sousa, 1984). When relating disturbance to stocking and biodiversity at community level, Bazzaz (1983) observes that some species are favoured while others are disfavoured by same disturbance. Such disturbances include agriculture (Misana *et al.*, 1996), settlements (Njahani, 2009), Livestock production/overgrazing (Mpiri, 1994; URT, 1998c), commercial logging, encroachment, haphazard clearing of forests and burning practices (Kaoneka, 1990).

Biological resources can be used on sustainable bases when sustainable management practices are employed because of their renewability characteristic. Renewability characteristic of biological resources is within the limits of being exploited for human use. When exploitation level exceeds these limits, their capacity for renewal may fail leading to the reduction of diversity and productivity of the resource (Luoga, 2000).

2.3.3 Intermediate disturbances hypothesis

Pickett and White (1985) define Intermediate disturbance hypothesis as a situation where disturbances renew resources at a rate or intensity sufficient to allow continued recruitment and persistence of species that would otherwise be excluded. At this level, under periodic or recurrent disturbance, pioneer and primary species are perpetuated since species with different life history and strategies can co-exist. This level has higher species richness. However, if the disturbance intensifies beyond this level only colonising species with high growth or dispersal rates, pioneer species and mid-seral species will be able to co-exist. The community in this situation will have lower species diversity. If there is a decrease in disturbance frequency/intensity only the fittest will survival and the community will attain a climax stage (Luoga, 2000).

2.4 Concept of Basic Stand Parameters and Plant Diversity

2.4.1 Determination of wood stock

Wood stock is determined by forest inventory; traditionally forest inventory refers to timber estimates (Malimbwi, 1997). This is done by measuring basic stand parameters which are DBH (diameter at breast height or 1.3 m above the ground), tree height (Ht) and counting of the number of stems. Using these parameters, the number of stems per hectare (N), volume per hectare (V) and basal area per hectare (G) are computed (Zahabu and Malimbwi, 2008).

2.4.1.1 Number of stems per hectare (N)

The number of stems per hectare is one of the basic stand parameters which influence forest stand characteristics. It is quantified by counting the number of trees within a sample plot and then divide by the size of a single sampling unit (Philip, 1994; Malimbwi, 1997). However, literature shows that N is directly proportion to the stand age. 2075

2.4.2 Determination of species diversity

2.4.2.1 Shannon-Wiener index of diversity (H')

Shannon-Wiener Index of Diversity (H') is the measure of species' information contained in a sample by means of their species richness and evenness. The Shannon-Wiener index is the most widely used index of diversity which is not affected by a sample size. Its calculation incorporates the ratio of the number of individuals of a species under observation within a sample divided by the total number of individuals of all species (Kent and Coker, 1992). The value of Shannon index range from 0 to 5, and the higher the Shannon index the more the diversity is the stand and vice versa.

2.4.2.2 Importance Value Index (IVI)

Importance Value Index of diversity (IVI) is the sum of relative density (Rd), relative dominance (Rb) and relative frequency (Rf) divided by three (Kent and Coker, 1992). The Rd is a ratio of total number of individuals of a species in a sample to the total number of all individuals of all species. Again, the Rb is a ratio of the total basal area of a species in a sample to the total basal area of individuals of all species. Whereas, the Rf is a ratio of the total frequency of occurrence of a species in sample plots to the total frequencies of all species in all sample plots. Therefore, IVI defines the importance of a given species over others within same community. The higher the IVI value the more the importance of a species in the community.

2.4.2.3 Similarity index (S) and Species richness (D)

Similarity Index is the spread of individuals between species within the community. Again, species richness is the number of species contained in a community (Kent and Coker, 1992). When comparing values of S and D for two different strata or stands we consider the number of species contained in each of the strata/stands by sorting out the number of species contained in say stratum 'A' and stratum 'B' and then sort out the number of species that are common to both strata. The computation is then done using the formulae developed by Ambasht (1990).

2.5 Remote Sensing Technology

2.5.1 Meaning of remote sensing

Remote Sensing is the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon in question (Kashaigili, 2006). Remote sensing involves techniques that use sensors to detect and record signals emanated from the target of interest not in a direct contact with the sensors. Remote sensing systems integrate cameras, scanners, radiometers, radar and other devices. The system deals with the collection, processing, and distribution of large amounts of data (King, 1984). Remote sensing today is mainly applied to satellite imageries: the use of satellite imageries has powerful capabilities which make the observation of Earth on a global scale faster and easier (Petcu *et al.*, 2009).

2.5.2 Remotely sensed data and forest cover change detection

2.5.2.1 Process of remote sensing

The sun which is the natural source of radiations emits radiation to the earth's surface. The earth's surface reflects or emits the radiations back to the atmosphere. Remote sensing data measures reflected or emitted radiation from surfaces in different parts of the electromagnetic spectrum like visible, ultraviolet, reflected infrared, thermal infrared and microwave (King, 1984). Multiband or Multispectral data from a sensor consist of sets of radiation data that individually cover intervals of continuous wavelengths within some finite parts of the electromagnetic spectrum. Each of such intervals make up a band or channel which is used to produce images of earth's surface and atmosphere or to serve as inputs to complex analysis programs (Bouchardy, 1999). Objects differ from one another depending on the reflectance, absorption or emittance properties of surfaces.

2.5.2.2 Image processing

Image processing involves a computer manipulation of imagery in three major categories namely image restoration, image enhancement and extraction of information from imageries (Petcu *et al.*, 2009). Image restoration is the process which recognises and compensates for data error, noise and geometric distortion. Geometric distortions are usually introduced in imageries during scanning and transformation processes. Image enhancement is designed to intensify a particular feature on imagery or produce the most overall information in a visual image (Petcu *et al.*, 1999). After the restoration and enhancement have been completed the image is classified so as to extract information required (Kings, 1984).

2.5.3 Application of remote sensing technology

Remote sensing technology is widely applied in natural resources planning and management. These applications based on satellite data are mainly grouped into at least six disciplines: (1) agriculture, forestry and range resources in vegetation type, vigour and stress, biomass, soil conditions, or forest fire detection; (2) land use and mapping for classification, cartographic mapping, urban areas, or transportation networks; (3) geology for rock types, delineation, landforms, or regional structures detection; (4) water resources for water boundaries, surface, depth, volume, floods, snow area, sediments, or irrigated fields detection; (5) oceanography and marine resources for marine organisms, turbidity patterns, or shoreline changes detection; (6) environment for surface mining, water pollution, air pollution, natural disasters, or defoliation detection (Petcu *et al.*, 2009).

Based on first and second discipline; remote sensing technology is used to determine forest cover changes for a given period of time as well as determination of deforestation rate (Kashaigili *et al.*, 2004). To compute forest cover change the area of the forest covered by trees at the beginning of the period and the area of a forest covered by trees at the end of the period are computed. The determination of the area is usually done using computer software such as ERDAS imagine v9.3 and Arc View v3.2 through image classification as it was done by Kashaigili (2006); Mafupa (2006) and Njahani (2009).

CHAPTER THREE

3. 0 MATERIAL AND METHODS

3.1 Location

3.1.1 Study area description

The study was carried out at NEMFR in Mpanda District, Rukwa Region, Tanzania. The district is about 246 km north of regional headquarters Sumbawanga. The district lies between latitudes 5^{o} 15' to 7^{o} 03' S and longitude 30^{o} 00' to 33^{o} 31' E. NEMFR is accessible by road and pathways at about 32 km from Mpanda town between latitudes 5^{o} 36' to 6^{o} 23' S and longitude 30^{o} 41' to 31^{o} 27' E where the altitude ranges from 95 to 115 m a.s.l. The forest has a total area of 502 590.67 hectares (URT, 2002b). NEMFR was gazetted by the Government Notice No. 296 of 1946 (URT, 2002b). The main objective was protecting forest for soil, water and biodiversity conservation and management. The forest encircles the Katumba Refugees' Camp which was officially opened in August 1973 (Fig. 2). The camp is made of 31 villages whereas five native villages surround the NEMFR. Out of these only three villages namely Kambuzi Halt, Ivungwe 'A' and Kambuzi 'A' were sampled as study population/Villages (Fig. 2).

3.1.2 Vegetation

The vegetation of the study area is miombo woodlands dominated by tree species of the family *Fabaceae*, sub-family *Caesalpinioideae*, particularly in the genera *Brachystegia*, *Isoberlinia* and *Julbenardia* (Malimbwi *et al.*, 2005).

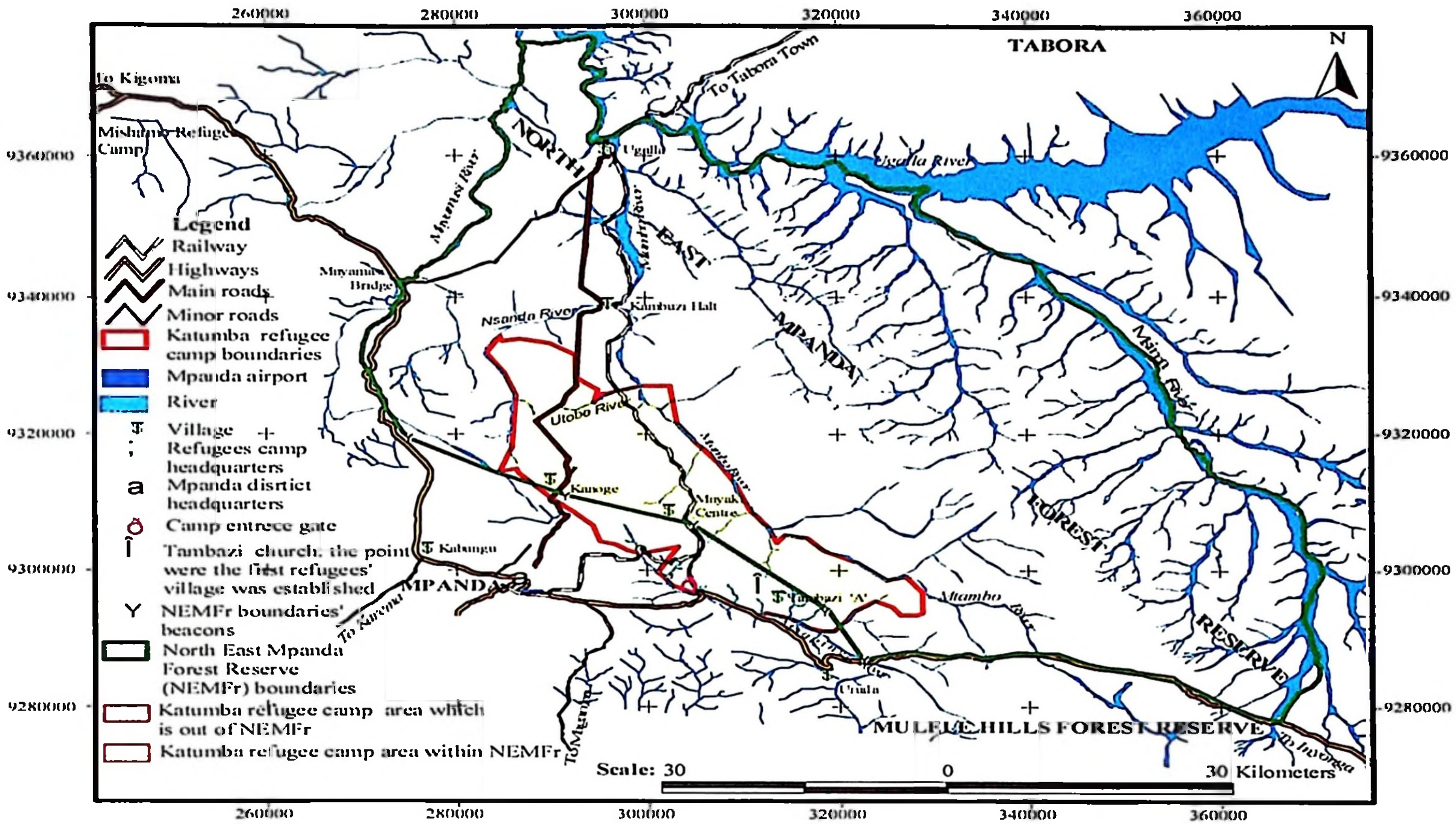


Figure 2: Katumba refugees settlements in Northeast Mpanda Forest Reserve, Mpanda district, Tanzania

Source : A mosaic of five satellite images taken in September 1972, June 1973, August 1973, September 1994 and June 2009 respectively.

3.1.3 Climate

Temperatures range between 15°C during rain season and 30°C during dry season which was described within the larger eco-region. Rainfall ranges between 800 mm and 1400 mm which normally received in only one rain season (Malimbwi *et al.*, 2005).

3.1.4 Demography

Mpanda district population was 442 683 as per 2002 census, whereas 51% of the population were refugees (MDC, 2005; URT, 2003). The population growth rate was estimated to be between 3-5%.

3.1.5 Socio-economic activities

The communities around the study area mostly depend on farming, fishing, livestock keeping, beekeeping, small scale mining and forestry resource harvesting for their livelihood (Malimbwi *et al.*, 2005). On farming, both crops and food crops are grown. Cash crops grown include tobacco, groundnuts, rice paddy and cassava. Main food crops grown in the area are maize and beans.

3.2 Data Collection Methods

3.2.1 Socio-economic survey

3.2.1.1 Sampling design

A total of three villages were included in the survey. The three villages were Kambuzi Halt, Kambuzi 'A' and Ivungwe 'A'. Time frame, financial constraints and closeness of a village to NEMFR were the main factors which limited number of villages to be included in the survey. Out of these three villages Kambuzi Halt came from local community or Tanzanians villages. Selection of native community/Tanzanians village was done purposively. Purposive selection was opted so as to avoid picking a village which was far from the NEMFR which could have little information about the subject matter. Kambuzi Halt was the Tanzanians' village which was selected and included in the study basing on its close proximity to the forest. On the other hand, 31 refugees' settlement villages were considered out of which only two villages (Ivungwe 'A' and Kambuzi 'A') were sampled at random and be included in socio-economic survey.

Random Sampling procedure was used to select households included in the sample whereby village registers from each of the three villages were used as sampling frame. In accordance with Boyd *et al.* (1981) for socio-economic studies, a sampling intensity of at least 5% of the study population was considered. Out of 1 160 households in a study population; a total of 90 households (30 households from each of the three villages) were involved in the study. However, in accordance with the village registers number of villagers in Kambuzi Halt, Kambuzi 'A' and Ivungwe 'A' villages were 450, 246 and 464 respectively. Therefore, the interviewees constituted 7.76% of the study population. Again, due to the reasons mentioned earlier, the number of households interviewed per village was limited to 30 because this was the minimum number of samples (**n**) which is statistically allowed (Kothari, 2004).

3.2.1.2 Data collection

A questionnaire (Appendix 2) was used as a tool in the collection of socio-economic data from the households. The questionnaire was pre-tested during a reconnaissance survey so as to find out whether the study population shares the intended interpretation of the questions. Household heads were key speakers since they are the ultimate decision makers for households (Kajembe, 1994). Discussions with 8 key informant respondents (KIR) were held separately. The KIR were people who had enough knowledge on the subject matter and they were willing to share their knowledge. They were purposively selected as the community was aware of their knowledge about the context. A Focused Group Discussion (**FGD**) with 15 people was carried under the guidance of a checklist (Appendix 3). The small number of FGD members was found to be reasonable for smooth handling of their discussion. Participatory Rural Appraisal (PRA) was conducted in each of the three villages sampled during the socio-economic survey. A specific technique employed during PRA was pair wise ranking matrix (Rusell, 2001). Number of PRA participants ranged between 10 and 15 for each of the three villages.

Secondary data were obtained from private and government offices, publications, internet and SUA National Agricultural Library.

3.2.2 Biophysical survey

3.2.2.1 Inventory data collection

3.2.2.1.1 Pilot study

A pilot study was carried out so as to obtain the number of sample plots that would be used in the main inventory. The data from a pilot study were used to compute for basal area per hectare whose variance was used to calculate standard deviation and mean. Standard deviation and mean were then used to compute Coefficients of Variation (**CV**) and sampling error (SE). Through iteration process (Appendix 4) the obtained **CV** and **SE** were substituted in the formulae below (Philip, 1994), so as to get the number of sample plots (**n**) required for the main inventory to give a desired precision. This kind of approach was also used by Zahabu (2008).

$$n = \frac{CV^2 t^2}{SE^2} \qquad \text{.....................................(1)}$$

Where; CV = Coefficient of variation

t = the value of t obtained from the student t-distribution table at degree of freedom of the pilot study plots at which $\chi = 0.01$

SE = Sampling error

n = number of sample plots to be used in the main inventory.

A sampling error of 22% and 168 number of sample plots was obtained. Therefore, a sampling intensity of 0.5% (Synnott, 1979) was not reached.

3.2.2.1.2 Reconnaissance survey

A reconnaissance survey was done to facilitate stratification of the forest stand, the establishment of transect lines and laying down temporary sample plots on NEMFR map. Post stratification was carried out into undisturbed and disturbed homogenous strata, basing on the level of disturbances and canopy cover per cent. The post stratified strata were then checked on Landsat (TM) satellite image of 2009. Disturbed strata were ranked further into highly disturbed (A), medium disturbed (B) and less disturbed strata (C).

Sampling procedures

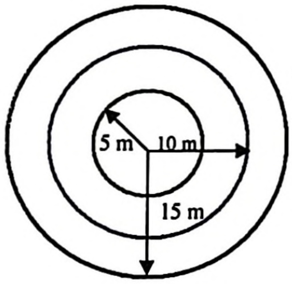
Systematic sampling design was used to lay down sample plots in such a way that strata had no single consolidated area but rather separate parts with definable identity of stand/vegetation structure (Phillip, 1983). A total of 12 transects were laid down on a map at a distance of 8.55 km apart basing on the width of the NEMFR. A total of 168 sample plots were laid at a distance of 3.6 km apart along the transect lines obtained after dividing total transect length by the number of sample plots estimated during pilot study (Fig. 3). The first transect was laid at a distance of 4.3 km from the forest edge.

Again, the first sample plot was located at a distance of 1.8 km from the starting point along transect. The starting points 4.3 km and 1.8 km are the half distances of the distance between transects and half the distance between sample plots. These were placed at the respective points so as to reduce the effects of anthropogenic activities on the forest boundaries. The procedure for allocating first sample plot was repeated throughout the inventory work when locating the first sample plot in a new transect line. Out of 168 sample plots, only 33 sample plots were located in the disturbed strata while the rest were in the undisturbed stratum (Fig. 3). Furthermore, due to time and resource limitations only 157 sample plots were dealt with. Out of 157 assessed sample plots, only 27 sample plots fall under disturbed stratum.

Sample plot shape and size

Circular sample plot shape with two nested sample plots within the main plot of 15 m radius was adopted for this study. The nested two sample plots had radii of 10 m and 5 m for the middle and innermost circles respectively (Fig. 4). The respective areas for the circles were 0.07 ha, 0.03 ha and 0.01 ha. Similar sample plot shape was used by Zahabu (2001); Luoga *et al.* (2005); Malimbwi *et al.* (2005); Mafupa (2006) and Chikira (2008).

The reason for the adoption of the circular sample plots was to reduce measuring error since only one parameter (radius) was employed during the sample plot layout (Philip, 1983; Malimbwi, 1997). Again, the use of circular concentric plots was aimed at measuring approximately the same number of trees in a plot for each diameter class. This idea comes from the fact that a natural forest has many small trees than larger trees resulting into an ideal reversed J-shaped diameter distribution graph. The ideal reversed "J" shaped distribution of stems density in natural forest is due to the variation of age, size and species implying that the number of stems decreases with an increase of trees' dbh sizes and vice versa (Philip, 1994). The equipments used in the inventory work were Global Position System (GPS), callipers, Suunto hypsometer, marking tapes, a rope and measuring tapes. In each sample plot trees were measured for Dbh (diameter at 1.3 m above the ground) and height of a sample tree. A sample tree is a tree closest to the plot centre. Also, tree identification, tree counting and collection of information on human disturbances were done.



- 5 m radius: all trees with dbh 5 - 10 cm were measured
- 10 m radius: all trees with dbh 10.1 - 20 cm were measured
- 15 m radius: all trees with dbh above 20 cm were measured

Figure 3: Concentric circular shaped plot of nested sample plots.
Source : Malimbwi, (1997).

All information was recorded in the inventory field form (Appendix 5). Trees with Dbh less than 5 cm which include seedlings, saplings and ground covers were not measured since these were much affected by forest fires, and NEMFR was not an exception to fire attacks. Similar omission was done by Luoga *et al.* (2005) in the study whose objective was to assess growing stock and species diversity in Kilimanjaro mountain forest.

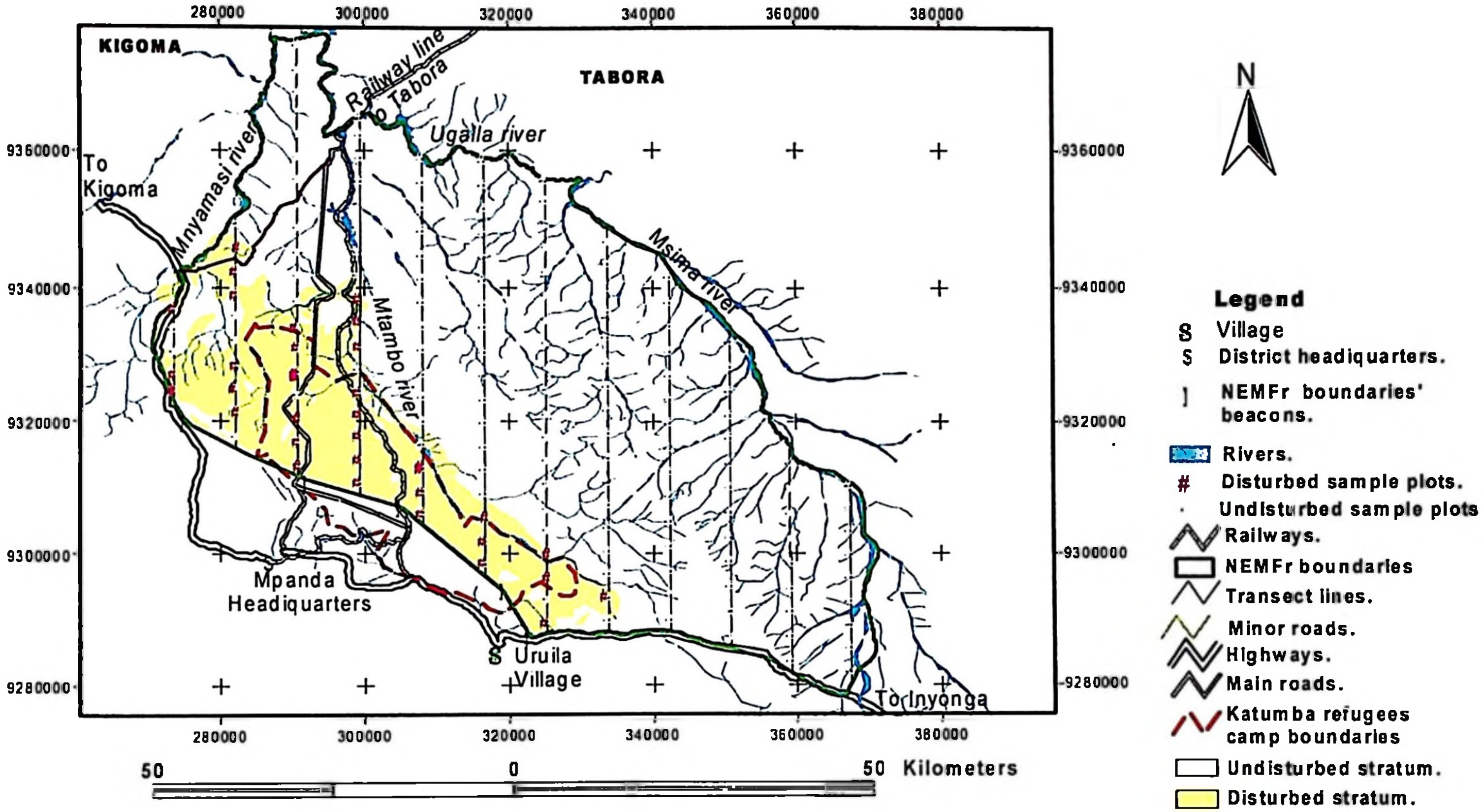


Figure 4: Sample plots layout in undisturbed and disturbed strata in NEMFR, Mpanda district.

Source : A mosaic of five satellite images taken in September 1972, June 1973, August 1973, September 1994 and June 2009 respectively.

Table 1: Specification of satellite imageries for NEMFR area, Mpanda district

Type		Temporal			Spatial	
Sensor	Channel	Year	Path	Row	Acquisition date	Bands
Landsat	Multispectral sensor (MSS)	1972(3)	183	065	11/09/1972	3, 2, 1
			183	064	19/08/1973	3, 2, 1
			184	064	09/06/1973	3, 2, 1
Landsat	Thematic Mapper (TM)	1994(1)	171	064	13/09/1994	7,6,5,4,3,2,1
Landsat	Thematic Mapper (TM)	2009(1)	171	064	10/06/2009	7,6,5,4,3,2,1

Note: *Numbers in parentheses are number of image scenes enough to cover the NEMFR area.*

3.2.2.2 Data collection for forest covers detection

3.2.2.2.1 Acquisition of satellite images

Satellite images were purchased from the Institute of Resource Assessment (IRA) of the University of Dar es Salaam. The acquired images were Multispectral sensor (MSS) of 1972 and 1973, Landsat Thematic Mapper (TM) of 1994 and of 2009 (Table 1). During the selection of the images to be purchased, special consideration was taken on temporal and spatial resolution, presence of cloud cover and availability and cost of images needed. Therefore, the acquired images were taken during the dry seasons of the year because this period had minimum cloud cover but had good spectral and spatial resolution.

3.2.2.2.2 Ground truthing

The collection of ground truthing data was done in line with inventory work. The points described during ground truthing were purposively located because the points to be described were under researcher's interest based on their use in the distortion restoration, classification and interpretation of satellite imageries. This was done with the help of hand held GPS which was used to locate various points being described. Features and actual situation of vegetation were recorded in the form prepared for this purpose (Appendix 6). The features and vegetation of the selected points were described and coordinates of the points were recorded so as to assist during data analysis. Information collected was categorised on the bases of their final use during image analysis (Table 2).

3.2.3 Data analysis

3.2.3.1 Analysis of socioeconomic data

The analysis of socioeconomic data employed both quantitative and qualitative methods. Quantitative data were analysed using Statistical Package for Social Sciences (SPSS) v16 for windows and qualitative data were analysed by content analysis techniques.

3.2.3.1.1 Quantitative data analysis

Data from questionnaires were coded, entered in a computer and analysed for descriptive and inferential statistics. The summaries were in frequencies, percentages and cross tabulations. These outputs were analysed to get socioeconomic status of refugees living within NEMFR which depicted their forest based activities in the forest reserve.

Table 2: Classes identified during ground truthing in NEMFR, Mpanda district

Category	Features/classes	Ultimate use
Varying features	(1) Settlements (+bare land)	Image Pre processing, Image interpretation and classification
Land covers/land uses	(2) Forest, (3) Closed woodland, (4) Open woodland, (5) Shrubs (6) Grassland/(+ Farms) (7) Wetland	Image interpretation, classification, land cover/land use status and change detection

Note: *Numbers in brackets are serial numbers forming a list of classification classes.*

Pearson's Chi square (χ^2) test was used to test how the observed results differ from the expected results as described by Kothari (2004).

$$\chi^2 = \sum \frac{(Observed - Expected)^2}{Expected} \qquad \text{.........................(2)}$$

Where; χ^2 = Pearson's Chi square

Observed = Observed results

Expected = Expected results

$\sum$ = Summation symbol

3.2.3.1.2 Qualitative data analysis

Participatory Rural Appraisal (PRA)

PRA data from each of the three villages were analysed in the field using pair wise ranking matrix and prioritisation of forest resource utilisation. Results of the so ranked matrix and forest resource utilisation are communicated back to the members of PRA groups in a form of a list.

Focussed Group Discussion and Key Informant Respondents

Information gathered from Focussed Group Discussion (FGD) and Key Informant Respondents (KIR) was put together and analysed by content analysis technique. In such analysis, all components of verbal discussion with KIR and FGD were broken down into smallest meaningful themes (Kajembe, 1994).

3.2.3.2 Analysis of biophysical data

(a) Inventory data analysis

Microsoft Excel spreadsheet software was used in the analysis of data. Again, various standard mensuration formulae were used to derive basic stand parameters. The stand parameters derived from data collected from field were:

(i) Number of stems per hectare (stems/ha)

(ii) Basal area per hectare (m^2/ha)

(iii) Volume per hectare (m^3/ha) which was obtained after the estimation of total tree height (m)

(iv) Diversity indices

A list of all tree species with local names identified by a local botanist was prepared prior to the computation of stand's basic parameters matching tree local names (vernacular names) with scientific names (Appendix 6).

Number of stems per hectare (N)

The number of stems per hectare was computed from the following formula (Zahabu and Malimbwi, 2008):

$$N = n / a_i \, (ha) \qquad \text{..................................... (3)}$$

Where; N = number of stems per hectare (stems /ha)

n = number of stems occurred in a sample

a_i = area of a plot or nested circular plots within a plot

Basal area per hectare (G)

Basal area per hectare which is a tree basal area divided by the sample plot area in hectare was computed by the formula (Philip, 1983):

$$g = \Pi \frac{D_i}{4}^2 \qquad \text{.. (4)}$$

Where; g = the basal area of a single tree (m^2)

D_i = the diameter at breast height of a i^{th} tree

Π = Pie (3.142857)

To get basal area per hectare 'g' was divided by the respective areas of the sample plot concentric circles (0.07, 0.03 and 0.01 ha) as thus:

$$G = g / a_i\,(ha) \qquad \text{.. (5)}$$

Where; G = basal area per hectare (m^2/ha)

g = basal area of a single tree (m^2)

a_i = area of a plot or nested circular plots within a plot

Volume per hectare (V)

During data collection only sampled trees were measured for the total height using Suunto hypsometer. A total of 142 trees were measured for height (Appendix 7). Heights of the rest of the trees were estimated using the general Dbh-height regression model given below:

$$H_i = b_0 + D_i^{b1} \qquad \text{.. (6)}$$

Where; H_i = total height of a i^{th} tree (in m)

D_i = diameter at breast height (1.3 m) for i^{th} tree (in cm)

b_0 & b_1 = constants

Using Microsoft excel programme, regression analysis was done to yield coefficients of H_i and D_i (Table 3) which gave the following formula as height estimator.

H_i = Exp. (**1.18434+ (0.49505*ln D_i)**)

Table 3: Regression analysis output summary

Number of observation (N)	Precision Level	Coefficients of H_i and D_i b_0	b_1
142	$R^2 = 0.73$ SE = 0.20	1.184	0.495

Note: *N is number of observation, R^2 is a coefficient of determination and SE is the standard error of estimate.*

Estimation of the total volume of a tree was done using the following local allometric equation for miombo woodland which was developed by Malimbwi *et al.* (1994):

$$v_i = 0.0001 D_i^{2.032} H_i^{0.66} \quad \text{.............................(7)}$$

Where; V_i = total volume of i^{th} tree in m^3

D_i = is the Dbh of i^{th} in cm

H_i = is the total height of i^{th} tree in m

The computed basic stand parameters (N, G and V) were then clustered in seven Dbh classes (Table 4). Diameter classes had a class width of 10 which was obtained by the use of Sturgge's equation (Kothari, 2004):

$$(K = 1 + 3.22 \log n) \quad \text{....................................(8)}$$

where, **K** = the estimated class width,

n = the number of trees whose Dbh were clustered.

Microsoft Excel v2007 data analysis summary is presented in Appendixes 8, 10 and 12.

Table 4: Diameter classes for trees measured in NEMFR, Mpanda District

Size class	Dbh range (cm)
I	5 -15
II	15.1- 25
III	25.1 – 35
IV	35.1 – 45
V	45.1 – 55
VI	55.1 - 65
VII	> 65

Diversity indices

Five main diversity indices were computed namely: Shannon-Wiener Index (H), Index of Dominance (Simpson index) (ID), Important Value Index of diversity (IVI), Species similarity (S) and Species Richness (D) (Appendixes 9, 11, 13 and 14). All these together were computed to assess plant species diversity attributable to refugees influx within NEMFR.

(i) Shannon-Wiener Index of diversity (H)

The analysis of data for Shannon-Wiener Index of diversity employed the equation bellow (Kent and Coker, 1992);

$$H' = -\sum_{i=1}^{s} (P_i \ln \quad P_i) \qquad \text{..............................} (9)$$

Where, **H'** = Shannon index of diversity

P_i = is the proportion of individuals of a species to total number of species in the sample

ln = natural logarithm

$\sum$ = summation symbol

\- = negative sign multiplied by P_i to make it positive

(ii) Index of Dominance (Simpson index) –(ID)

The index of dominance was calculated as the summation of squares of the proportion of the number of individuals of a species (**n**), divided by the total number of individuals for all species in a sample (N): expressed as $(\mathbf{n/N})^2$ (Misra, 1989).

(iii) Important Value Index of diversity (IVI)

The **IVI** was calculated by summing up the relative frequency (Rf), Relative dominance (Rb) and Relative Density (Rd). The three constituents were computed as thus (Kent and Coker, 1992);

$$Rf = \left(\frac{\text{Frequency of occurrence of a species}}{\text{Frequency of occurrence of all species in a sample}}\right)x100 \quad \ldots\ldots (10)$$

$$Rd = \left(\frac{\text{Number of individual of a species}}{\text{Number of individual of all species in a sample}}\right)x100 \quad \ldots\ldots (11)$$

$$Rb = \left(\frac{\text{Total basal area of a species}}{\text{Total basal area of all species in a sample}}\right)x100 \quad \ldots (12)$$

In the analysis IVI was categorised according to tree species utilisation. The categories were; 1) Trees harvested for valuable timber, 2) Trees harvested for building materials, fuelwood and carving, 3) Trees whose parts are taken as fruits/food and 4) Other trees. Similarly, because the disturbed strata were ranked into three ranks depending on disturbance levels: IVI in the three ranks were treated separately to quantify their contribution to the stratum (Appendix 14).

(iv)*Similarity Index (S) and Species Richness (D)*

Similarity index was computed using the following formula; (Ambasht, 1990): **2C/(A+B).** Where; **A** is the numbers of species present in undisturbed stratum, **B** is the number of species present in the disturbed strata and **C** is the number of species common to undisturbed and disturbed strata. Species richness on the other hand was computed by counting all the species present in **A** and **B** strata (Fig. 5).

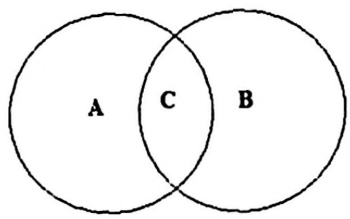


Figure 5: Illustration of species richness in NEMFR. Mpanda District.

3.2.3.2.2 Forest covers data analysis

(i) Image processing for change detection

The initial tasks for the analysis of the acquired satellite images were image pre-processing, image rectification/restoration and image enhancement as summarised in Fig. 6. This process was done using the ERDAS imagine v9.3 and Arc View v3.2 with the help of Image analyst extension software.

Image rectification

The rectification of images involved the correction of geometric distortion and radiometric correction. The images were dealt with to remove variations and error that made the images geometrically distorted. Images were geo-coded to match with national topographic maps systems of coordinates and mapping by converting them into UTM co-ordinate zone 36 South Spheroid Clarke 1880, Datum Arc1960. Radiometric distortion and noise occur as a result of variation in pixels' intensity. Radiometric distortion also implies the distortion of the relative brightness of a pixel from band to band with the characteristics of spectral reflectance of corresponding site on the earth's surface (Kashaigili, 2006). Hence, its correction was done by varying pixel intensities that are not caused by the object or the scene being scanned (Kimaro, 2008). The correction ensures the accurate identification of temporal changes and geometric capability with other sources of information related to this study (Kashaigili, 2006).

Image enhancement

Image enhancement is the treatment of satellite image to improve the imagery appearance. Improving the appearance of imageries assists in the visual interpretation and analysis. In this stage, enhancement of image characteristics namely radiometric, spectral and spatial was done so that features and information of interest to this study became easily identified through a visual look. Therefore, a colour composite of 1994 and 2009 images (Table 1) was generated by stretching their contrast using Gussian distribution function. To enhance visual interpretation further, a 3 x 3 high pass filter was applied to the colour composite to make linear features and pattern clearer. The imageries had linear features like rivers, roads and railways. Types of patterns present were settlements and farms (old, cultivated and fallowed farms).

Image classification

Image classification was done to make distinction of various ground features and land uses. Automated classification was employed during classification of imageries, in which case supervised image classification was used by the help of ground data collected from the field during ground truthing. A total of seven cover classes were identified during ground truthing.

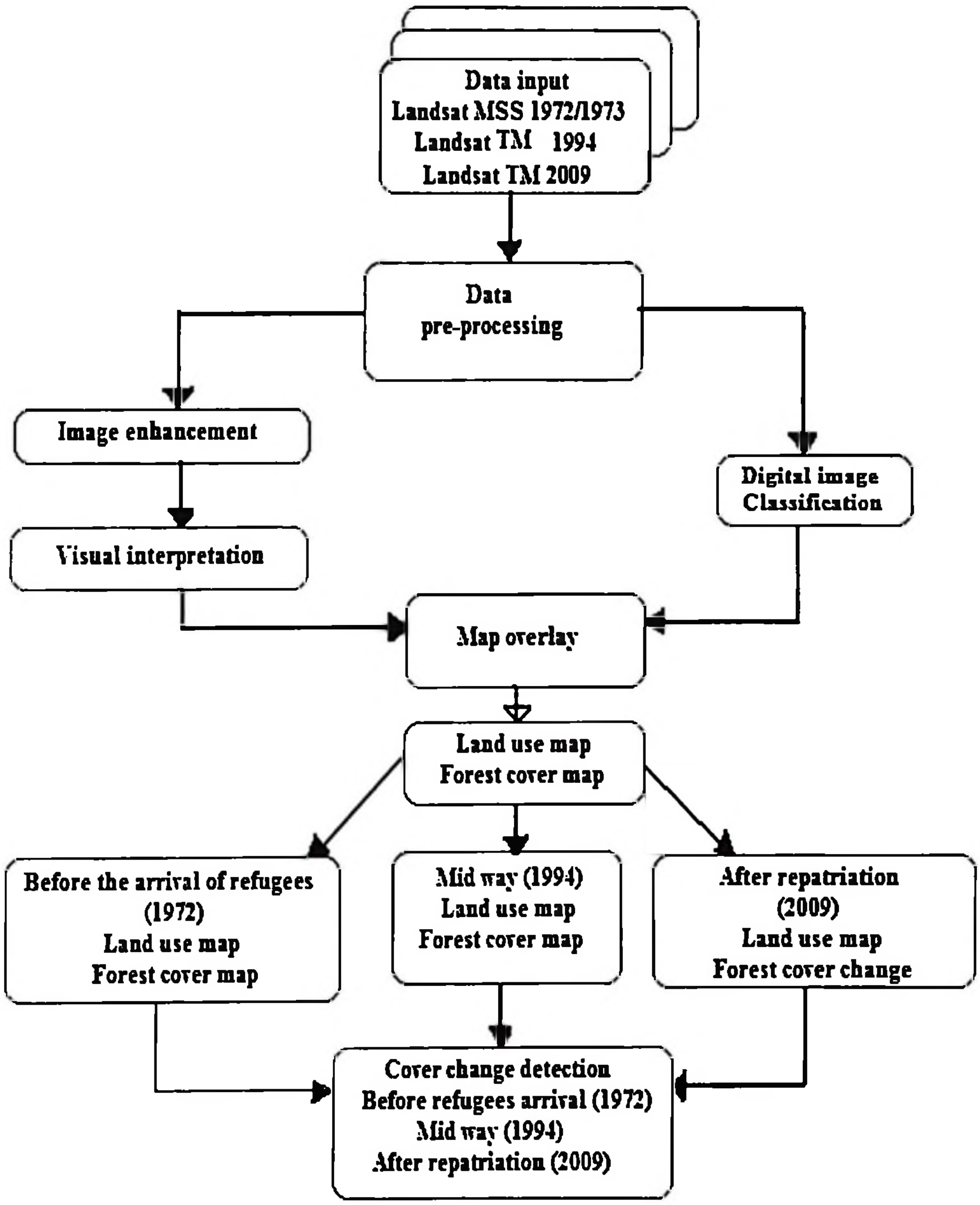


Figure 6: Image analysis flow chart; adopted from Kashaigili (2006)

(ii) Detection of forest covers change

Rate of forest cover change

The rate of forest cover change between two different intervals was computed. For the purpose of this study, the rate of forest cover change is referred to as the rate of deforestation/reforestation. The intervals were between the year 1972 and 1994 and between the year 1994 and 2009. The two intervals were named change I and change II respectively. The intervals had three reference years namely year 1 (1972), year 2 (1994) and year 3 (2009). Cover changes were calculated described by Dirzo *et al.* (1992):

$$r = \left[\frac{A_{year_x} - A_{year_{x-t}}}{A_T * t}\right] x 100\,\% \qquad \text{.................. (13)}$$

Where; r = is the rate of cover change between two specified years

$A_{year\ x-t}$ = is the area of the forest at the beginning of the period

$A_{year\ x}$ = is the area of the forest at the end of the period

A_T = is the area of the whole NEMFR

t = the time between the two periods

Percentage change of the forest covers

The change in the area of the forest cover was computed and expressed in percentage. The change was computed as follows (Kashaigili *et al.*, 2004).

$$\Delta_x\% = [(A_{year_x} - A_{year_{x-t}})/(A_{year_x})] \ x \ 100 \qquad \text{......... (14)}$$

Where; Δ_x = is the *% change* of the forest covers.

$A_{year\ x-t}$ = is the area of the forest at the beginning of the period.

$A_{year\ x}$ = is the forest area at the end of the period.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Population and Refugees Forest-based Activities in NEMFR

4.1.1 Socio-economic attributes of study population

The study population included three villages namely Kambuzi Halt, Kambuzi 'A' and Ivungwe 'A'. The last two villages are in Katumba refugees' camp while the first is outside. The socio-economic aspects focused on sex, age, marital status, nationality, education levels, occupation, household size, duration of stay and land ownership (Table 5).

4.1.1.1 Description of study population

The results show that more male participated in the survey compared to females. The proportion of the respondents' sex was 78.9% and 21.1% for male and female respectively. This was due to the fact that the focus of the study was the heads of households: therefore, the results show that most sampled households were headed by men. The respondents' ages range was from 18 to 50 years old whereby 24.4% of all the respondents were above 50 years old. The rest of the residents above 50 years of age were looked after by their children: thence they were counted as household members. Therefore, respondents' population constituted the most active segment of the population structure.

Table 5: Socioeconomic characteristics of respondents in the villages surrounding NEMFR, Mpanda district

Socio-economic characteristics	Respondents responses								Chi-square test
	KAMBUZI-A		KAMBUZI-HALT		IVUNGWE-A		TOTAL		Chi-square (p-value)
	$n_i=30$	%	$n_i=30$	%	$n_i=30$	%	$n_i=90$	%	
Sex									
Male	24	80	22	73.3	25	83.3	71	78.9	0.934
Female	6	20	8	26.7	5	16.7	19	21.1	(P=0.627)
Sub total	30	100	30	100	30	100	90	100	(df=2)
Age									
18-35	8	26.7	15	50	11	36.7	34	37.8	
35-50	13	43 3	10	33.3	11	36.7	34	37.8	3.77
50<	9	30	5	16.7	8	26.7	22	24.4	(p=0.438)
Sub total	30	100	30	100	30	100	90	100	(df=4)
Marital status									
Single	0	0	2	6.7	2	6.7	4	4.4	3.071
Married	29	96.7	28	93.3	27	90	84	93.3	(p=0.546)
Widowed	1	3.3	0	0	1	3.3	2	2.2	(df=4)
Sub total	30	100	30	100	30	100	90	100	
Nationality									
Tanzanian	15	50	30	100	7	23.3	52	57.8	37.257
Refugee	15	50	0	0	23	76.7	38	42.2	(p=0.0001)
Sub total	30	100	30	100	30	100	90	100	(df=2)
Education									
Informal	7	23 3	2	6 7	3	10	12	13.3	
Primary	22	73.3	25	83	25	83.3	72	80	5.75
Secondary	1	3.3	1	3 3	1	3.3	3	3.3	(p=0.452)
Others	0	0	2	6 7	1	3 3	3	3.3	(df=6)
Sub total	30	100	30	100	30	100	90	100	
Occupation							0		
Farmers	28	93.3	29	96.7	28	93 3	85	94.4	2.524
Employed	1	3.3	0	0	0	0	1	1.1	(p=0.640)
Others	1	3.3	1	3.3	2	6 7	4	4.4	(df=4)
Sub total	30	100	30	100	30	100	90	100	
Household size									
1 to 6	11	36.7	16	53.3	8	26.7	35	38.9	8.533
7 to 10	15	50	14	46.7	16	53.3	45	50	(p=0.074)
Above 10	4	13.3	0	0	6	20	10	11.1	(df=4)
Sub total	30	100	30	100	30	100	90	100	
Years of stay									
0-18	10	33.3	23	76.7	6	20	39	43.3	28.402
19-35	5	16.7	7	23.3	8	26.7	20	22.2	(p=0.0001)
35<	15	50	0	0	16	53.3	31	34.4	(df=4)
Sub total	30	100	30	100	30	100	90	99.9	
Land ownership (ha)									
0 to 4	5	16.7	8	26.7	11	36.7	24	26.7	5.764
5 to 10	20	66.7	13	43.3	14	46.7	47	52.2	(p=0.2170
Above 10	5	16.7	9	30	5	16.7	19	21.1	(df=4)
Sub total	30	100.1	30	100	30	100	90	100	

4.1.1.2 Respondents' sex, age and marital status

Most (93.3%) of the respondents were married while, 2.2% of the respondents were widowed. This was normal as the study aimed at interviewing household heads with 18 years old and above. Likewise, a study by Kadala (2008) in Njombe noted similar population characteristics. Collectively, a chi square test on respondents' population characteristics across the three villages showed a similar trend. This indicated no variation in respondents' characteristics in terms of age and marital status across villages (Table 5).

4.1.1.3 Nationality of the respondents

The respondents belonged to two nationalities of Burundians (refugees from Burundi) and Tanzanians (local communities). Of these two nationalities, 42.2% were refugees and the remaining 57.8% were Tanzanian natives from Kambuzi Halt. The reasons for the low proportion of refugees respondents were repatriation and the legal presence of Tanzanians within Refugees Camp. Tanzanian residents were Government workers because it was legal for them to reside in the camp as their working post (URT, 1998b). Therefore, random picking of households to be included in the survey selected even Tanzanian natives to be among the respondents (Table 5). Due to this reason, a chi square test revealed inequality across the villages ($p<0.0001$).

4.1.1.4 Education levels of respondents

The results show that most of the respondents had primary education. About 80% of the respondents had primary education while 13.3% had informal education (Table 5). This big per cent of informal education implies that the success of respondents' livelihoods struggle did not depend on education. Similar observation was noted by Zahabu (2001) in Gwata and Maseyu villages at Kitulangalo in Morogoro. A Chi Square test showed similar trend among the three villages ($p=0.452$) across all the education levels. Generally, this situation shows that education was not among their priorities. Usually, education level reflects capability of people to grasp technological know-how in the use of natural resources. As stated earlier, in multiplicative perspective: the total environmental impact varies inversely with the level of technology. While, population size and natural resources consumption rate has been increasing, technological know-how (education) remained constantly low. Consequently, refugees presence had more impact on the NEMFR.

4.1.1.5 Occupation of respondents

The results reveal that main occupations of the respondents were farming and government employment. About 94.4% of the respondents were farmers, while 1.1% were government employees and the others 4.4%were engaged in other occupations such as commercial lumbering, fuelwood and beekeeping. Average farm size for farmers was found to be 8.42±0.29 (SE) ha per farmer (Table 6). None of the refugees was employed as the respondents whom were employed came from Kambuzi Halt village which had no refugee (Table 5). This was due to the international rules and laws on refugees that refugees were not allowed to be employed in the host country (URT, 1998b). According to the chi square test (p=0.640) indicated that all villages had similar trend as far as their respondents occupation was concerned.

Table 6: Average sizes of respondents' household and farms, in Mpanda District, Tanzania

Description	Household size (ha) n = 90	Farm size (ha) n = 90
Mean	7	8.42
Standard Error	0. 92	0. 29
Confidence Level (95.0%)	0.58	1.83

Similarly, Tanzanian communities around the forest reserve are mainly involved in forest based activities rather than other activities. This type of occupation results into an increased pressure on the forest reserve (Mafupa, 2006). According to Boserup's hypothesis on agricultural intensification and Neo-Malthusian theories on synergistic link, more labour was pushed into farming so as to increase production of agricultural products by increasing quantity of land under agriculture. This is due to the decrease of land productivity to feed the prevailing population. Again, this implies less harvest per unit piece of land. Therefore, more land was required to produce the required amount of food.

4.1.1.6 Household size

Household size ranges between 1 and 10 family members per household with an average of 7±0.92 (SE) (Table 6). About 50% of the households had household size range of 7-10. This was experienced in Kambuzi 'A' (50%) and Ivungwe 'A' (53.3%) (Table 5). There was a relationship between marital status, education level, age distribution and household sizes. For example, in Ivungwe 'A' village 90% were married refugee farmers out of which 83.3% had primary school education level. Again, their 73.3% of the respondents had household sizes above 6 (Table 5). Similar kind of refugees' marital status, age distribution and household size trend was reported by Njahani (2009) at Nyarugusu refugee camp in Kasulu district. There were similar trends across the villages and along household size classes (p=0.074) when a t test was employed. Usually, this kind of household sizes was noted in the larger study population. This might be one of adaptation strategies over the decreasing productivity of land which needs large labour-land ratio to facilitate expansion of agriculture. Increased household size and agricultural expansion imply increase in forest degradation. Therefore, these forests based activities affect NEMFR.

4.1.1.7 Duration of stay in the area

The study found that 34.4% of the respondents had stayed in the study area for more than 35 years. Another, 43.3% of the respondents had stayed in the study area for at most 18 years. Of all these respondents there was no respondent from Ivungwe 'A' and Kambuzi 'A' villages who had stayed in the study area for less than 18 years (Table 5). Results on duration of stay showed a big variation between villages when their significance were tested by χ^2 test (χ^2=28.402; p=0.0001) (Table 5).

Similar, findings were reported by Whitaker (1999); UDSM (2005) in the same Refugees Camp. The reason behind was that their duration of stay was much affected by the introduction of the Katumba refugees camp. All of the respondents were adults (at least 18 years) so their stay ought to be not less than 18 years. Kambuzi Halt village emerged as an expansion of Railways post after the arrival of refugees. The results depict the real history of the villages as related to the introduction of the Katumba refugees Camp in 1973 about 36 years ago (Whitaker, 1999). This duration of stay was too long for the survival of natural resources safety. As community continue to stay around the forest for a long time more disturbances occur within a given forest (Mafupa, 2006). This implies that due to the long stay of refugees at Katumba refugees camp have caused more degradation and deforestation in the NEMFR.

4.1.1.8 Land ownership

It was found that 52.2% of the respondents own between 5 and 10 hectares of land. This was particularly so in Kambuzi 'A' village (a refugees' village) where 66.7% of her people reported to own land of that size (Table 5). There was insignificant difference land ownership across villages as confirmed by Pearson's Chi-Square test (χ^2 = 5.764; p=0.2170) across villages. This was because refugees had equal chances in land acquisition and ownership similar to local communities. Again, on their arrival every refugee was given a maximum of 5 ha of land. Therefore, there was equitable distribution of land sizes among refugees within the camp (Anthony, 1989). Extra piece of land they owned acquired from either forest reserve or neighbouring villages. During socioeconomic survey of this study some key respondents reported the presence of land conflicts between refugees and native communities such as Ikondamoyo and Kambuzi Halt natives' villages. This is similar to the observation by UDSM (2005) that there were no clear guidelines to control refugees' movements in and out of the camp boundaries. When refugees land sizes were not enough for their household use they supplemented it from NEMFR as their land sizes varies inversely due to the desire to encroach the land (Mafupa, 2006).

4.1.2 Refugees socio-economic activities carried out in NEMFR

4.1.2.1 Uncontrolled movement of refugees

A discussion with focused groups revealed that besides the fact that Katumba Refugees Camp was sited within NEMFR (Fig. 3) yet, refugees were freely allowed by the refugee camp authority (Camp Commandant) to encroach further into the forest reserve. Refugees could move up to 10 km in search of forest resources for their livelihoods. The reason was that, on their arrival refugees were provided with clothes, food, and other social services for free. However, in 1978 the United Nations High Commission for Refugees (UNHCR) stopped the support: therefore, their livelihood relied on forest resources from NEMFR in uncontrolled manner. Other studies revealed similar trend, for example, Njahani (2009) at Nyarugusu refugees' camp in Kasulu district and UDSM (2005) in Katumba refugees. There was rampant movement of refugees further into the NEMFR resultant to severe deforestation and degradation through tree cutting. Specific areas suffering from tree cutting were along Lwago, Mtambo, and Upese rivers. As stated earlier on the mediating perspective: institutionalization of Katumba Refugees Camp, social and cultural behaviour of Hutu refugees, played a role in mediating the effects of their anthropogenic activities on the population-environment relationships. So, the institutionalization within Katumba Refugees Camp facilitated refugees' anthropogenic activities causing more disturbances in NEMFR environments.

4.1.2.2 Awareness on the presence of NEMFR

About 90% of the respondents were aware that the forest in which they were residing (NEMFR) was a reserved forest (Table 7). The awareness was contributed by the Government officials monitoring activities conducted around their areas. A χ^2 test showed that the responses were not equal throughout the three sampled villages ($p<0.0001$). The variation was brought by the response of few respondents (70% from Ivungwe A village) who were not aware of the presence of the forest reserve. Usually, refugees were conscious of the presence of refugee camp boundaries from which they were seeking for permits to go out. The permission was meant to allow them to enter farther into the NEMFR. The focussed group discussion held at Mpanda town by UDSM (2005) found that refugees were aware of the reservation but due to their rule of practice they felt free to encroach further into the reserve: some of refugees accessed the forest through river Mtambo (Plate 1). Generally, the respondents were aware that the forest in which they were residing was a reserved forest and that there were rules and laws that control their movements within the forest reserve.

Plate 1: A pore crossing Mtambo River within NEMFR, Mpanda District, Tanzania.
Source: Photo taken on February 2011 during data collection in the study area.

4.1.2.3 Awareness on ownership, boundaries and restriction to access NEMFR

It was found that 53.3% of the respondents knew that NEMFR was owned by the Government of Tanzania, while 10.1% claimed that they did not know whether the forest was owned by the government or not. The respondents from Kambuzi Halt reported that the forest belongs to them (Table 7). This was caused by confusion on Participatory Forest Management (PFM) practice. Whereas, under PFM practices villagers were tuned psychologically to consider the forests around them as theirs so they had to take a good care of it in collaboration with the government (MNRT, 2007; Zahabu, 2008). That was why the response on NEMFR ownership was not common to all villages as Chi Square also test revealed (χ^2 = 23.415; p=0.009). Forest based activities were conducted by the community living within and around the NEMFR knowing that the forest was not under a common pool regime but rather it was under a given authority.

Boundaries of NEMFR were known to about 64.4% of the respondents. On village bases, more than 73% of the respondents in Kambuzi A and Kambuzi Halt villages knew that the forest reserve boundaries pass along rivers which were the actual boundaries of NEMFR. Only 3.3% thought that forest reserve boundaries pass along Katumba Refugees Camp boundaries (Table 7). Such findings were similar to that by UDSM (2005). There were no variation in responses across the sampled villages (χ^2 = 12.288; p=0.056). The respondents were mentioning rivers to describe NEMFR boundaries because the forest boundaries follow the flow of river Msima, Ugalla and Mnyamasi. This was correct in accordance with the Government Notice number 296 of 1946 (UTR, 2002b). On the other hand, of Camp boundaries were considered as temporary common boundaries between the Katumba Refugees Camp and NEMFR. Therefore, NEMFR boundaries were known to the communities living within the vicinity of the forest reserve.

Restriction to access NEMFR was known to about 69% of the respondents (Table 7). The respondents interpreted restrictions in terms of their illegal presence in the forest reserve area other than within the Camp boundaries.

Table 7: Respondents response on socio-economic activities being carried in NEMFR, Mpanda District, Tanzania.

Socioeconomic attributes	Respondents responses								Chi-square (p-value) (df)
	Kambuzi -A		Kambuzi Halt		Ivungwe -A		Total		
	n_i=30	%	n_i= 30	%	n_i = 30	%	n_i = 30	%	
Awareness on NEMFr									
Yes	30	100	30	100	21	70	81	90	20.000
No	0	0	0	0	9	30	9	10	(p<0.0001)
Sub-total	30	100	30	100	30	100	90	100	(df=2)
Owner of NEMFr									
Village	5	16.7	11	36.7	1	3.3	17	18.9	
District	4	13.3	4	13.3	3	10	11	12.2	23.415
Government	17	56.7	15	50	16	53.3	48	53.3	(p=0.009)
Refugees	1	3.3	0	0	0	0	1	1.1	(df=10)
Do not know	2	6.7	0	0	7	23.3	9	10.1	
Others	1	3.3	0	0	3	10.1	4	4.4	
Sub-total	30	100	30	100	30	100	90	100	
Awareness on boundaries									
Along rivers	23	76.7	22	73.3	13	43.3	58	64.4	12.288
Along cam boundaries	0	0	1	3.3	2	6.7	3	3.3	(p=0.056)
Do not know	5	16.7	5	16.7	14	46.7	24	27	(df=6)
Others	2	6.7	2	6.7	1	3.3	5	5.6	
Sub-total	30	100.1	30	100	30	100	90	100	
Permission to access NEMFr									
Yes	21	70	25	83.3	14	51.9	60	69	6.603
No	9	30	5	16.7	13	48.1	27	31	(p=0.037)
Sub-total	30	100	30	100	27	100	87	100	(df=2)
Presence of illegal activities									
Yes	26	86.7	28	93.3	17	60.7	71	80.7	10.933
No	4	13.3	2	6.7	11	39.3	17	19.3	(p=0.004)
Sub-total	30	100.0	30	100.0	28	100.0	88	100.0	(df=2)
Types of activities									
Farming	16	59.3	2	7.1	6	31.6	24	32.2	
Hunting and beekeeping	7	25.9	14	50.0	2	10.4	23	31.1	28.05
Lumbering and poaching	2	7.4	9	32.1	6	31.6	17	23.0	(p=0.002)
Fuelwood	1	3.7	0	0	1	5.3	2	2.7	(df=10)
Others	1	3.7	3	10.7	3	15.8	7	9.5	
Do not know	0	0	0	0	1	5.3	1	1.4	
Sub-total	27	100	28	100	19	100	74	100	
Reasons for illegal activities									
Fertile soils	1	3.7	0	0	2	11.1	3	4.0	7.079
Fuelwood	0	0	2	6.7	2	11.1	4	5.3	(p=0.314)
Source of income	25	92.6	27	90	14	77.8	66	88.0	(df=6)
Others	1	3.7	1	3.3	0	0	2	2.7	
Sub-total	27	100	30	100	18	100	75	100.0	
Gender most accessing NEMFr									
Males	16	53.3	20	66.7	4	13.3	40	44.4	
Females	2	6.7	7	23.3	6	20.0	15	16.7	26.8
Both	8	26.7	2	6.7	10	33.3	20	22.2	(p<0.0001)
Do not know	4	13.3	1	3.3	10	33.3	15	16.7	(df=6)
Sub-total	30	100	30	100	30	100	90	100	

However, besides the restriction, the camp was already engulfed in NEMFR, so movements were still there (UDSM, 2005). This is why a Chi Square test showed the presence of variation in responses from one village to another (χ^2 = 6.603; p=0.037). The communities in the study area were aware of the forest rules and laws that govern the management of NEMFR. The reason for their encroachment was decrease in facility of their agricultural land as well as rapid increase of their population while the camp area remains the same.

4.1.2.4 Refugees forest based activities within the NEMFR

The findings of this study showed that 80.7% of the respondents were involved in illegal forest based activities within the forest reserve. With the exception of Ivungwe A village (60.7%), more than 86% of the respondents from other villages knew forest based activities that were carried out in NEMFR (Table 7; Fig. 7). This caused the variation in respondents' responses across villages (p=0.004). Main refugees' forest based activities in NEMFR were found to be farming (Plate 2), charcoal making (Plate 3), lumbering (Plate 4), firewood collection for tobacco carrying (Plate 5), cutting trees for poles (Plate 6), poaching and clearing forests for residences (Plate 6). Farming was the main activity carried out in the forest mentioned by 32.2% of the respondents. The extent of fuelwood collection was seen to be less (Fig. 7) because it was performed in a complimentary way with clearing forest for farms, settlements and cutting trees for poles. When these activities are carried out, one of their by-products was firewood collected for domestic use, tobacco carrying and charcoal making.

Plate 2: Clear felled forest for farming activities in NEMFR, Mpanda district.

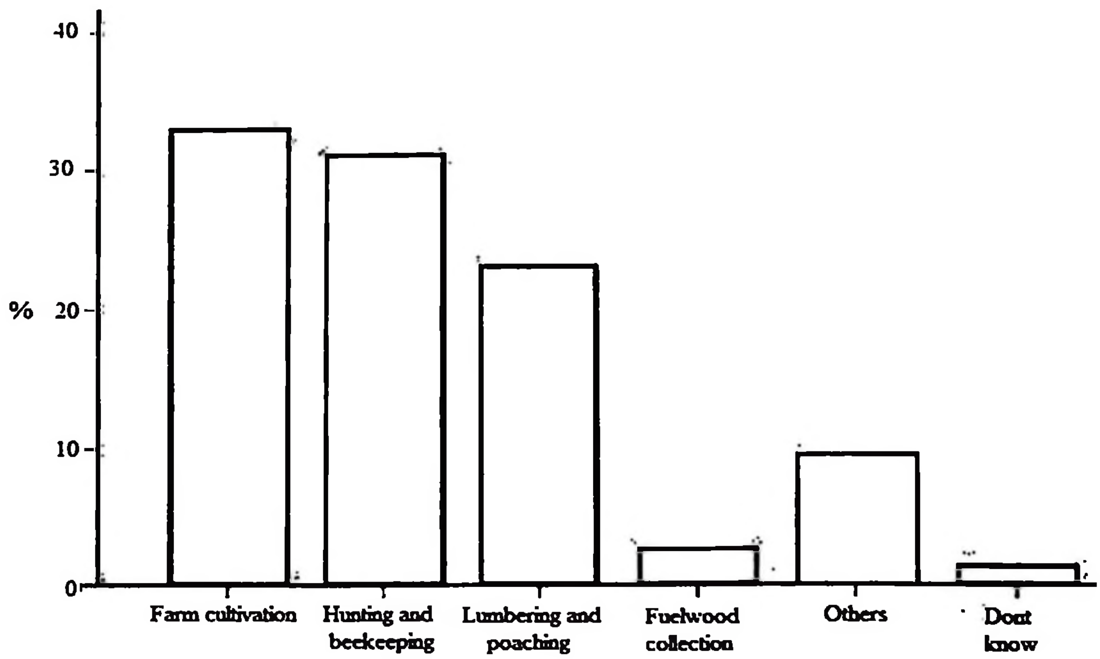


Figure 7: Socioeconomic activities carried in NEMFR, Mpanda district, Tanzania.
Source: Photo taken on February 2011 during data collection in the study area.

Plate 3: Charcoal making in NEMFR, Mpanda district, Tanzania.

Plate 4: A pit used by refugees for illegal logging in NEMFR, Mpanda district, Tanzania.

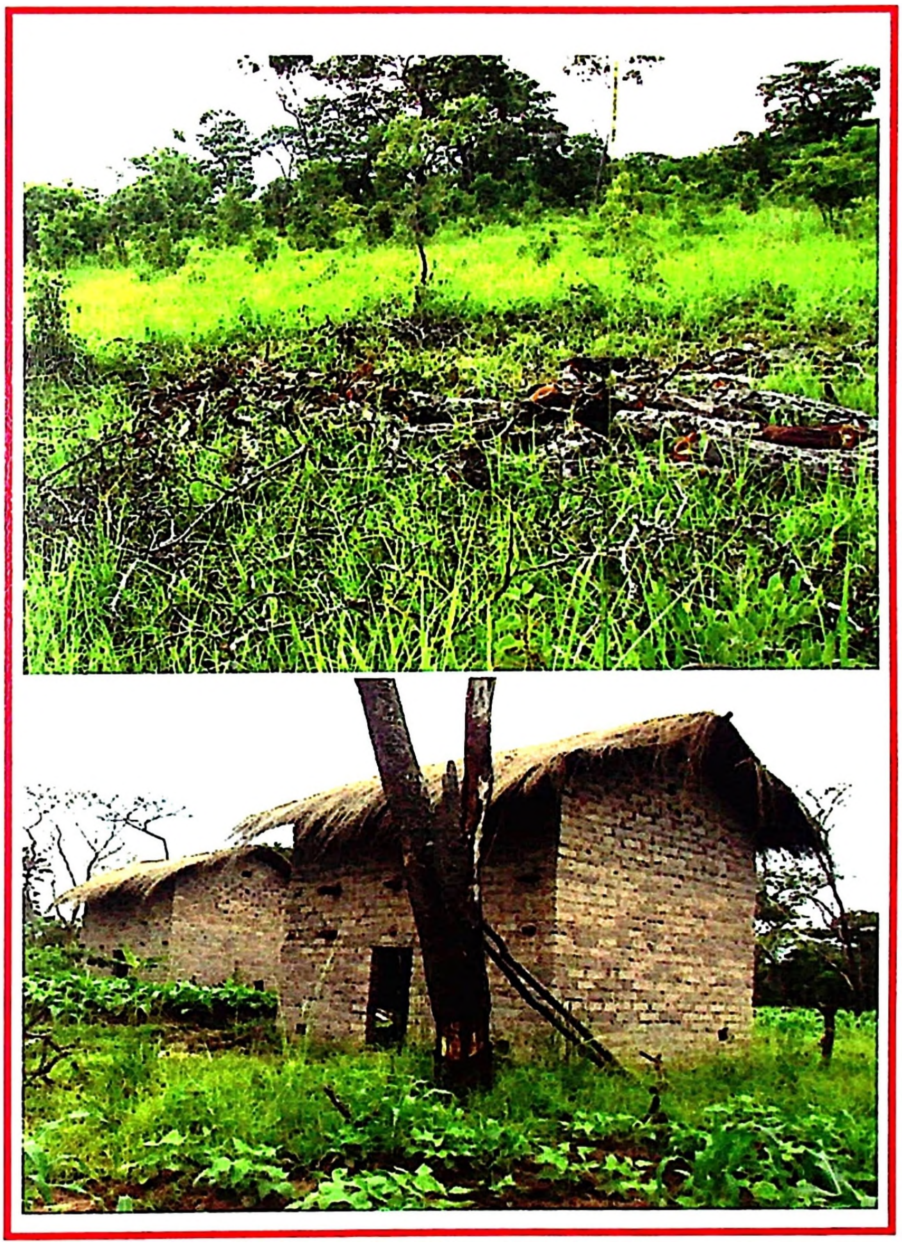


Plate 5: Illegal tree cutting for tobacco currying in NEMFR, Mpanda district, Tanzania.

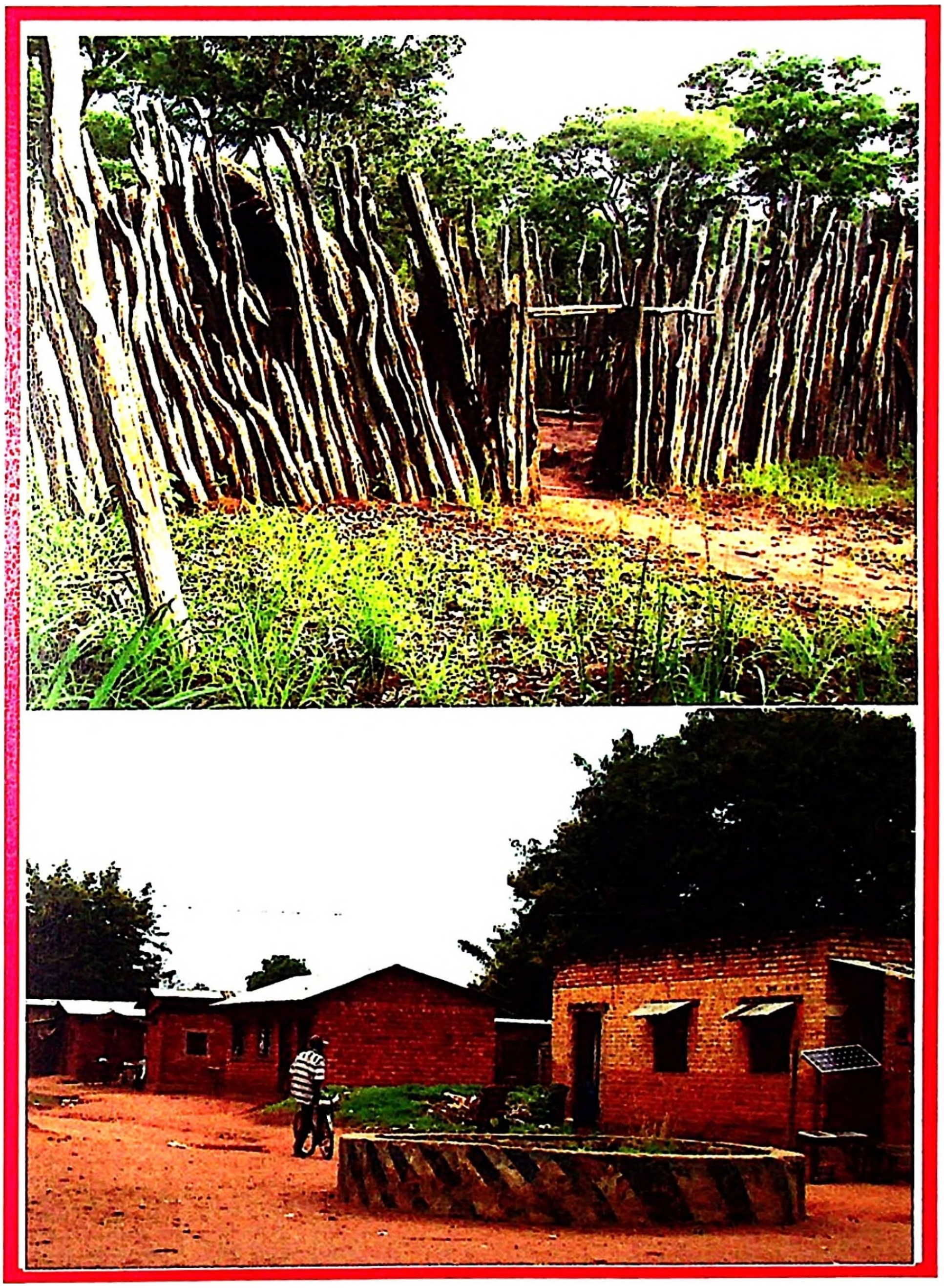


Plate 6: Tree cutting for poles paving land for residences in NEMFR Mpanda district, Tanzania.

However, response trend was not common to all villages (p=0.002). The variation arisen because some of Tanzanians were involved in legal hunting and beekeeping, while, refugees was more interested in farming. Again, refugees were mostly involved in farming because agricultural crops had market within the camp already. The main agricultural crops cultivated were tobacco (Plate 7), cassava (Plate 8), maize (Plate 9) and rice paddy. Given the climate of the study area, these crops were the most suitable crops for the area. This implies that communities living around the NEMFR have been accessing the forest reserve to carry out various forest based activities illegally. About 88% of the respondents said that the main reason for carrying out such illegal activities include searching for natural resources as a source of income. Response trend was similar for all the villages as confirmed by a chi square test ($p=0.314$). The equality in the test statistics was because these were common occupation to most of the respondents.

The existence of illegal activities in NEMFR was unequivocal due to the geographical positioning of the Camp/settlements. Yet, footpaths in and out of the forest and a number of patches of cultivated land in the forest reserve were observed. The activities within NEMFR were illegally carried out by refugees so as to generate income to sustain their livelihoods. A study by Luoga *et al.* (2005) at Kitulangalo forest reserve in Morogoro reported human disturbances which depicted a decline of disturbances as the distance from the village to the forest reserve was increasing.

About 44.4% of the respondents cited men as notorious in carrying out illegal activities. However, this was not unique to all the villages as most Ivungwe A respondents (33.3s%) who knew about gender participation agreed that there was no gender difference in carrying out forest based activities ($p<0.0001$). On this basis therefore, men were more involved than women in carrying out forest based activities.

4.1.3 Changes occurred in NEMFR

4.1.3.1 Comparison of NEMFR status before and after refugees arrival

About 80.9% of the respondents admitted that the situation at NEMFR was worse during the period after the repatriation of refugees as compared with the situation before their arrival (Table 8). Chi square test shows that all villages had similar response (p=0.611) as expected. The similarity was due to the fact that a change of the forest reserve was very obvious to respondents in all surveyed villages.

Plate 7: Tobacco farm within NEMFR in Mpanda district, Tanzania.

Plate 8: Katumba refugee's cassava farm within NEMFR in Mpanda district.

Plate 9: Maize farm at the middle of a dense forest in NEMFR, Mpanda district.

The discussion with FGD explored how various areas of the forest which were previously covered with dense forest. During this survey it was seen that those forest have been cleared by refugees for settlements and farming activities within the forest in which they were residing. Whereas, the area of the forest which was bordered by native communities remained as intact as it was in 1970s. Similar observation was reported by Njahani (2009) in Kasulu district when comparing between Mgombe village forest reserve (non-refugee impacted) and Nyarugusu forest reserve (refugees impacted) where it was found that refugees imposed negative changes in the latter forest. There were distinctive changes in the NEMFR when general comparison was made between the periods before the arrival of refugees (1972) and after the repatriation (2010). The changes included presence of settlements within the forest, deforestation and disappearance of some tree species of economical values.

4.1.3.2 Disappearance of endangered plant species in NEMFR

About 86.5% of the respondents acknowledged some plant species disappeared from the forest. The response trend was similar in all the sampled villages (p=0.367): as noted by at least 80% of the respondents in each of sampled villages (Table 8). The similarity in their responses might be due to the even distribution of tree species in the forest in which they were residing such that they easily noted the disappearance. Similarly, a closely related result from a study carried out at Kitulangalo forest reserve in Morogoro found that the density of *P. angolensis*, which was one of the endangered species in the forest, was decreasing as one moves closer to Maseyu village (Luoga *et al.*, 2002). Therefore, there was disappearance of some endangered plant species in NEMFR to the extent of being easily noticed by the community living within the forest reserve.

4.1.3.3 Land use changes over time

Forest cover was found to have been reduced in 2010 compared to 1970s before the arrival of refugees. The NEMFR was formerly covered with densely matured trees was found to be different by being occupied by settlements (Katumba Refugees Settlements) and farms (Plate 10). On its establishment (1973), the Camp covered a total area of 1 500 km^2. In 2000s the Government of Tanzania increased 1 000 km^2 bringing the total area to 2 500 km^2. Following the expansion of the Camp area Kabulonge, Bulembo, Lukama and Kabuga villages were added. Forest reserve area was substituted by a rapid population increase. The area expansion took place towards the forest reserve. This is against the Nation Forest Policy of 1998 and Forest Act No 14 of 2002 (URT, 1998a and URT, 2002a).

4.1.3.4 Respondent opinions on rescuing the NEMFr from further degradation

Respondents recommended that in order to rescue the NEMFR, the government should take serious measures which include: enhancement of patrols (40%), provision of education/extension (14%), introduction of Participatory Forest Management-PFM (12%) and refugees' repatriation (7%) (Table 8). The core activity in law enforcement was the patrol so the respondents themselves appreciated that the patrols contributed to the conservation of NEMFR. Most of these respondents' opinions were among the recommendations put forward in the study by UDSM (2005). Therefore, rehabilitation and improvement of the forest status needs a proper forest management plan.

Table 8: Changes of forest status and species disappearance in NEMFR, Mpanda district, Tanzania.

Socio-economic attributes	Respondents responses: Kambuzi-A		Kambuzi Halt		Ivungwe-A		Total		Chi-square (p-value)
	n_i=30	%	n_i=30	%	n_i=30	%	n_i=30	%	
Comparison									
1. Better now	0	0	0	0	1	3.4	1	1.1	
2. Worse now	22	73.3	27	90.0	23	79.3	72	80.9	
3. Same	2	6.7	1	3.3	1	3.4	4	4.5	6.325
4. Don't know	5	16.7	2	6.7	4	13.8	11	12.4	(p=0.611)
5. Others	1	3.3	0	0	0	0	1	1.1	(df=8)
Sub-total	30	100	30	100	29	100	89	100	
Whether spp are disappearing									
1. yes	25	86.2	28	93.3	24	80	77	86.5	
2. No	3	10.3	1	3.3	2	6.7	6	6.7	4.301
3. Don't know	1	3.4	1	3.3	4	13.3	6	6.7	(p=0.367)
Sub-total	29	100	30	100	30	100	89	100	(df=4)
Disappearing spp:									
1. *Pterocarpus angolensis*	16	64	24	88.9	11	45.8	51	67.1	
2. *Afzelia quanzensis*	1	4	0	0	0	0	1	1	
3. *Brachystegia boehmii*	6	24	1	3.7	10	41.7	17	22.4	16.633 (p=0.034)
4. *Albizia antunesiana*	1	4	1	3.7	0	0	2	2.6	(df=8)
5. Others	1	4	1	3.7	3	12.5	5	6.6	
Sub-total	25	100	27	100	24	100	76	100	

4.2 Effect of Refugees' Disturbances on Forest Stock

Basic stand parameters were used to express stands' wood stocking for quantification. Tree density per hectare, Basal area per hectare and Volume per hectare were computed separately for the whole forest, undisturbed stratum and disturbed stratum. The results for the last two strata were then compared to each other.

4.2.1 Number of stems per hectare (N)

The study found that the whole forest (NEMFR) had stand density of 595±26.01 (SE) stems per hectare (Table 9). The general trend of diameter distribution showed the reversed J-shaped in which the stem density decreases as the tree diameter at breast heights increases (Fig. 8). For undisturbed stratum on the other hand, the study deduced an average of 663± 25.07 (SE) stems per hectare (Table 9). Like in the whole forest, the diameter distribution depicted the reverse J-shaped plot (Fig. 9). The found mean was higher than that of the whole NEMFR because the effects of the disturbed strata have been removed. The mean for disturbed stratum was found to be as low as 254±58.5 (SE) stems per hectare (Table 9). A t-test (Two-Sample Assuming Unequal Variances) at 0.05 was used to compare the two strata and found to be significantly deferent (P< 0.0001) (Table 10). The diameter distribution in the disturbed stratum disobeyed the reversed J-shape. The reason for this shape was the over exploitation of trees for poles which was used as building materials. Diameter classes 15.1–25, 25.1 –35 and 65< were much affected by the exploitation (Fig. 10). The low stems density was due to the level of anthropogenic disturbances in the strata. Diameter distribution differences between disturbed and undisturbed strata are illustrated for comparison in Fig. 11.

Plate 10: Invasive tree species (*Senna siamea* and *S. spectabilis)* planted at Mtambo Road I (*Barabara ya I*) within NEMFR, Mpanda district.

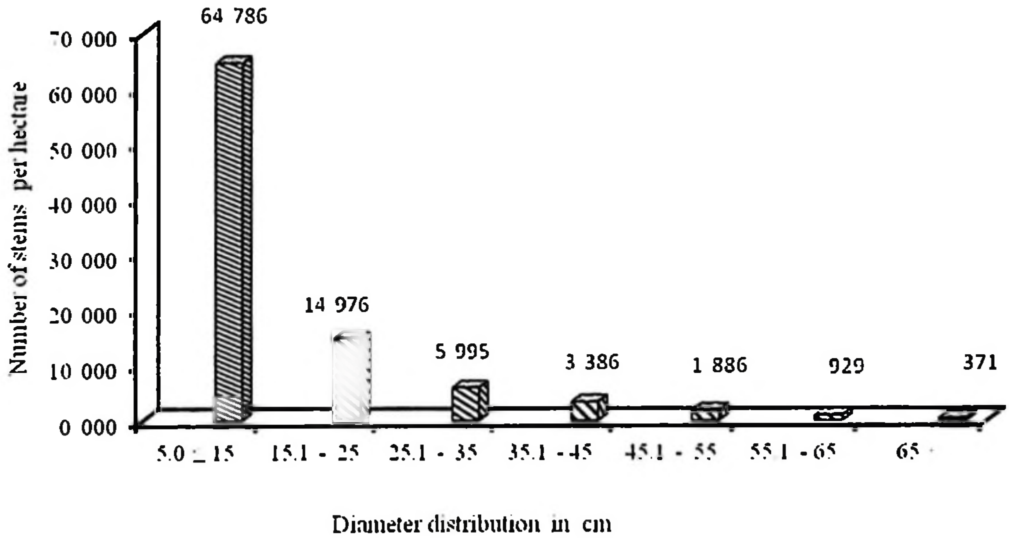


Figure 8: Number of stems per hectare in the whole NEMFR, Mpanda district, Tanzania.

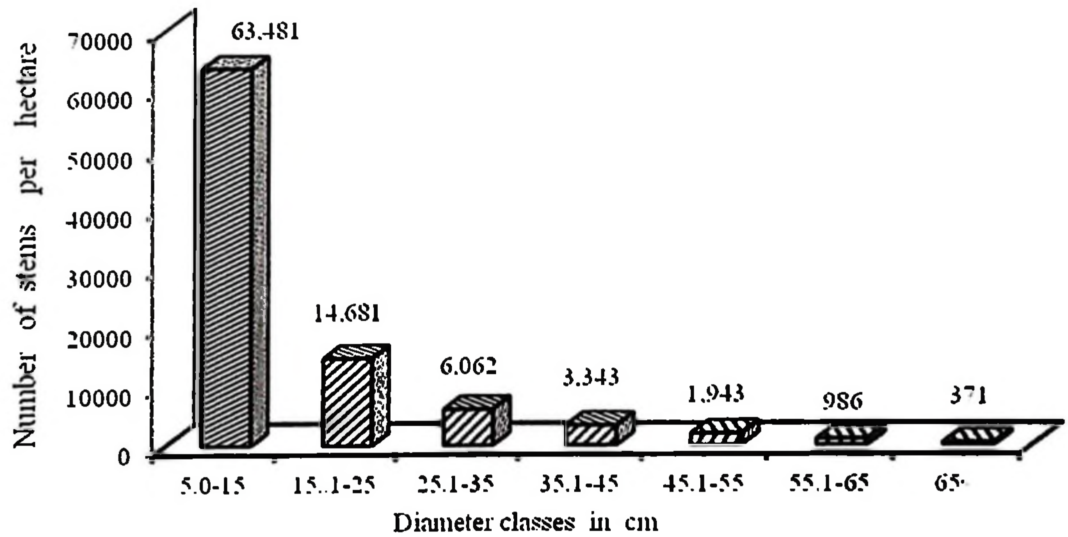


Figure 9: Number of stems per hectare in undisturbed stratum of NEMFR in Mpanda district.

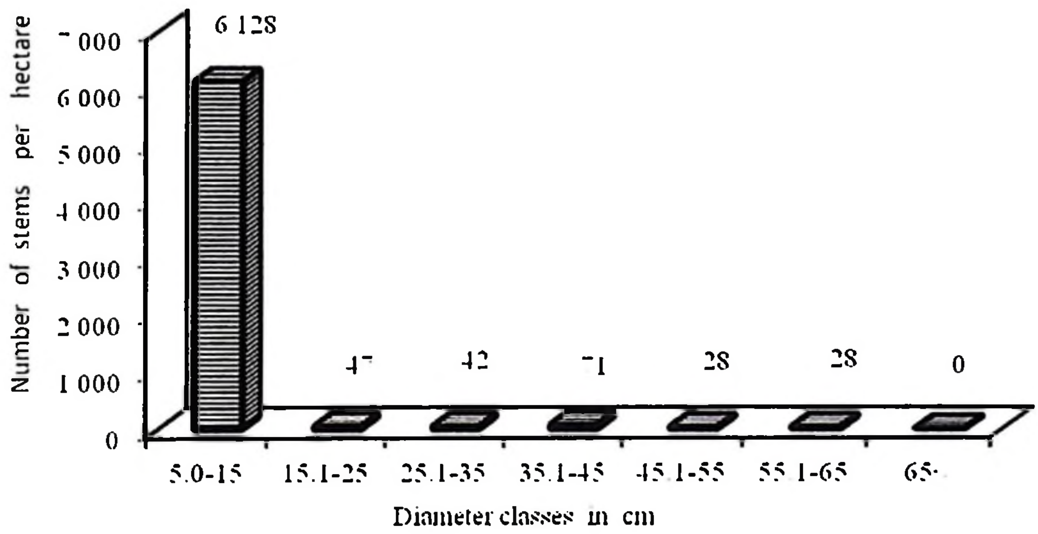


Figure 10: Diameter distribution of trees in the disturbed strata of NEMFR in Mpanda district.

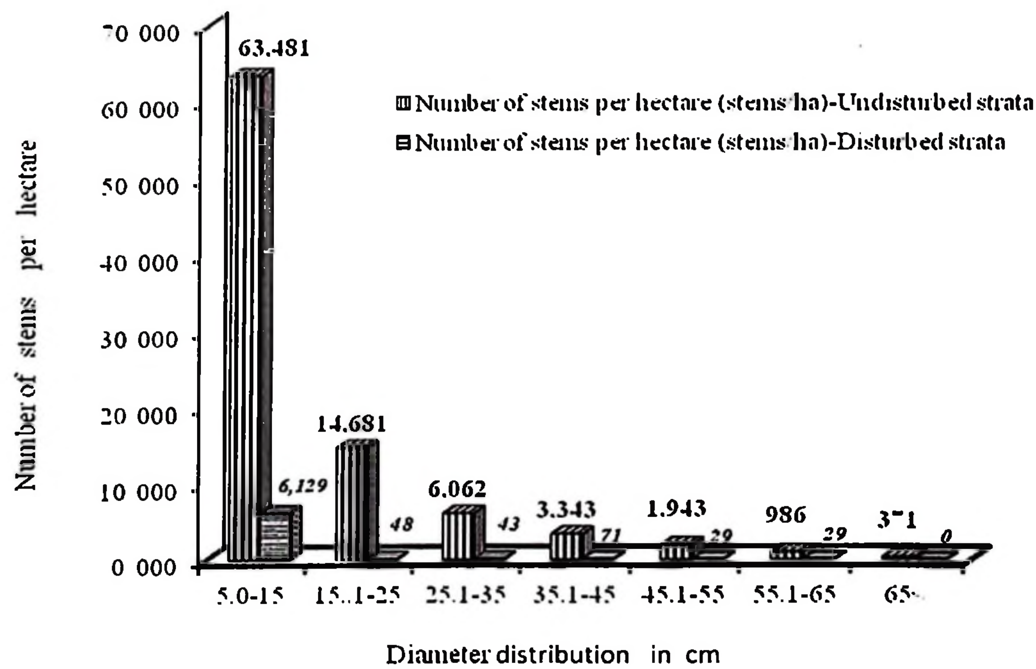


Figure 11: Comparison of disturbed and undisturbed strata of NEMFR based on N.

Table 9: Basic stand parameters for both Undisturbed and disturbed strata in NEMFR, Mpanda district, Tanzania.

Description	BASIC STAND PARAMETERS								
	Stems per hectare (stems/ha)			**Basal area per hectare (m^2/ha)**			**Volume per hectare (m^3/ha)**		
	Whole Fr (157)	**Undisturbed Fr** (130)	**Disturbed Fr** (27)	**Whole Fr** (157)	**Undisturbed Fr** (130)	**Disturbed Fr** (27)	**Whole Fr** (157)	**Undisturbed Fr** (130)	**Disturbed Fr** (27)
Mean	595	663	254	15.68	18.62	2.12	151.60	182.10	17.45
Standard error	26.04	25.07	58.50	0.76	0.71	0.592	8.22	8.17	5.76
Confidence limit	51	50	120	1.49	1.4	1.22	16.24	16.17	11.85

Table 10: Comparison between undisturbed and disturbed strata of NEMFR, Mpanda district

Description	Basic Stand Parameters					
	Stems per hectare (stems/ha)		Basal area per hectare (m^2/ha)		Volume per hectare (m^3/ha)	
	Undisturbed Fr (130)	Disturbed Fr (27)	Undisturbed Fr (130)	Disturbed Fr (27)	Undisturbed Fr (130)	Disturbed Fr (27)
Mean	663	254	18.62	2.12	182.10	17.45
Standard error	25.07	58.50	0.71	0.592	8.17	5.76
Confidence limit	50	120	1.4	1.22	16.17	11.85
Df	36		109		130	
t – stat	6.42		17.89		16.47	
P value	<0.0001		<0.0001		<0.0001	

Likewise, studies by Luoga *et al.* (2002) at Kitulangalo public land forest; Malimbwi *et al.* (2005) at Northeast Mpanda Forest reserve and Mafupa (2006) at Igombe river Forest reserve showed a range of stand densities. The number of stems per hectare in these studies showed stand density variations of 364; 532; 722 and 1 085 stems per hectare respectively (Table 11). This implies that a stand density varies depending on the stand age. When a stand is at lower ages tends to have higher stem densities and vice versa. For example, studies by Zahabu (2008) at Haitemba old miombo forest reported a value of 744 stems per hectare and that of Warib regrowth miombo forest reported as higher as 1 479 stems per hectare (Table 11). Therefore, the findings on this study imply that NEMFR might be considered to be old miombo woodlands.

Table 11: Similar findings for N, G, and V of miombo woodlands in Tanzania

Sn	Description	Stand parameters			Author
		N	G	V	
1	KSUAT Fr	691	10.2	71	Nduwamungu (1996)
2	KSUAT Fr	619	9	78	Zahabu (2001)
3	Igombe river forest reserve (D)	150	2.44	21.111	Mafupa (2006)
4	Igombe river forest reserve (Ud)	722	11.24	87.14	Mafupa (2006)
5	Haitemba old miombo	744	13.5	156.7	Zahabu (2008)
6	Mgombe Village Fr	998	19.81	139.01	Zahabu (2008)
7	Nyarugusu refugees forest reserve	702	14.69	75.25	Njahani (2009)

Source: *Compiled from studies done by respective authors indicated in the last column. D= disturbed, Ud = Undisturbed. Units are stempha^{-1}, m^{2}ha^{-1} and m^{3}ha-1 for N,G and V respectively.*

4.2.2 Basal area per hectare (G)

The study found that the basal area per hectare for NEMFR was 15.67±0.76 (SE) m^2 per hectare. The results for undisturbed stratum and disturbed stratum were found to be 18.62±0.71 (SE) m^2 per hectare. While, results for the disturbed stratum were 2.12±0.59 (SE) m^2 per hectare (Table 9). A t-test showed a significant difference ($P<0.0001$) between undisturbed and disturbed (Table 10). The results show that the basal area for the disturbed strata was smaller than the basal area of the undisturbed strata as a result of human disturbance in the latter.

Similar findings were recorded in selected miombo woodlands reported mean basal area as ranging between 2.44 to 19.81 m^2 per hectare within which the results of this study fall (Table 11). The disturbed stratum was quite different from undisturbed stratum in terms of mean basal area per hectare i.e. disturbed stratum was 2.12±0.59 (SE) m^2 per hectare whereas undisturbed stratum was 18.62±0.71 (SE) m^2 per hectare. The deference was due to refugees disturbances in the disturbed stratum.

4.2.3 Volume per hectare (V)

The mean stand volume per hectare in the whole NEMFR was 151.60±8.22 (SE) stems per hectare. The mean volume per hectare value for undisturbed stratum was 182.10±8.17 (SE) m^3 per hectare while, that of disturbed stratum was found to be 17.45±5.76 (SE) m^3 per hectare (Table 9). The mean volume of the whole stand was a bit lower than that of undisturbed stratum because the former incorporates effect found in the disturbed stratum. These findings are similar to the findings in the studies by Zahabu (2008) in Haitemba old miombo which reported an average of 156.7 m^3 per hectare in undisturbed forest (Table 11). The results of disturbed and undisturbed strata were significantly different when tested by a t test ($p<0.0001$) (Table 1), implying that refugees' disturbances in the NEMFR affected the forest stocks in terms of stand volume per hectare.

4.3 Effect of Refugees' Disturbances on Plant Diversity

This sub section presents results on refugees' disturbances on plant diversity which was quantified by plant species' diversity indices. The diversity indices used in this study were

Shannon-Wiener Index of Diversity (H), Index of Dominance (Simpsons' index) (ID), Importance Value Index of Diversity (IVI), Species richness (D) and Species Similarity (S) .

4.3.1 Shannon-Wiener Index of Diversity (H)

The study revealed that Shannon-Wiener Index of diversity for the whole forest was 3.26±0.007 (SE) while, that of undisturbed and disturbed strata were 3.24±0.007 (SE) and 2.73±0.05 (SE) respectively (Table 12; Appendix 9, 11 and 13). This implies that there was higher plant diversity in the undisturbed stratum than that of the disturbed stratum. This is due to the presence of human disturbances in the disturbed stratum. Similar results were reported by Zahabu (2001) at Kitulangalo forest reserve (3.13) and at Kitulangalo public land forest (2.9). Again, Malimbwi and Mugasha (2002) at Mkindo forest reserve reported index of diversity (H') of 3.162 for woodlands part and 3.202 for lowlands parts of the forest. However, these findings are in contrast with a similar study by Mafupa (2006). The study deduced that undisturbed stratum in Igombe forest reserve in Tabora had index of diversity (H') of 2.9. This was the opposite of the findings from this study whereby the same index of diversity (H') was found for the disturbed strata. A comparison of these results between undisturbed and disturbed results showed a significant difference ($p=0.003$) (Table 12).

4.3.2 Index of Dominance (ID)

The results showed that the ID of species for the whole forest was 0.062±0.0004 SE). The ID for the undisturbed stratum and disturbed stratum were found to be 0.063±0.0004 (SE) and 0.096±0.002 (SE) respectively (Table 13; Appendixes 9, 11 and 13). The small difference between undisturbed and disturbed strata (0.033) was also reported by

Nduwamungu (1996) and Chikira (2008). The differences reported in these studies were 0.03, 0.04 and 0.06 for diameter classes <10, 10-20 and 20< respectively; at Kitulangalo SUA training forest reserve Morogoro. General differences in these studies were 0.044 and 0.036 for undisturbed and disturbed strata respectively.

A t-test (at 0.05) of ID for the two strata undisturbed and disturbed strata revealed that the results were not statistically different at p = 0.217 (Table 13). Similar findings were reported by Chikira (2008) in Tong'omba forest reserve in Kilwa district, indicating. These results indicated that the two strata had same species richness. The meaning was that refugees disturbances had no effects on species distribution. This implies that the probability of picking two individuals belonging to the same species was the same in both strata. Hence, plant communities of the stand under study have equal diversity in trees species. However, this similarity did not imply equal disturbance or no disturbances in the disturbed strata. The similarity only implies that the disturbance type in the disturbed stratum affected all tree species equally. As clearing of forest for cultivation and settlements was not species selective. Therefore, **ID** was not affected by refugees' disturbances.

Table 12: Diversity indices in undisturbed stratum, disturbed stratum and NEMFR in Mpanda district

Description	Shannon-Wiener Index of Diversity (H')			Index of Dominance (ID)			Important Value Index of diversity (IVI)		
	Whole Fr (68)	Undisturbed Fr (68)	Disturbed Fr (27)	Whole Fr (68)	Undisturbed Fr (68)	Disturbed Fr (27)	Whole Fr (68)	Undisturbed Fr (68)	Disturbed Fr (27)
Mean	0.048	0.047	0.101	0.001	0.001	0.004	4.412	4.412	11.111
Total	3.26	3.24	2.73	0.062	0.063	0.096	300.0	300.0	300.0
Standard error	0.007	0.007	0.05	0.0004	0.0004	0.002	1.278	1.141	2.06
Confidence level	0.015	0.02	0.03	0.0008	0.0008	0.004	2.55	2.28	4.23

Table 13: Comparison of diversity indices between undisturbed and disturbed strata of NEMFR, Mpanda district

Description	Shannon-Wiener Index of Diversity (H')		Index of Dominance (ID)		Important Value Index of diversity (IVI)	
	Undisturbed Fr (68)	Disturbed Fr (27)	Undisturbed Fr (68)	Disturbed Fr (27)	Undisturbed Fr (68)	Disturbed Fr (27)
Mean	0.047	0.101	0.001	0.004	4.412	11.111
Total	3.24	2.73	0.063	0.096	300.0	300.0
Standard error	0.007	0.05	0.0004	0.002	1.141	2.06
Confidence level	0.02	0.03	0.0008	0.004	2.28	4.23
Df	39		28		43	
t stat	-3.14		-1.26		-2.85	
P value	0.003		0.217		0.007	

4.3.3 Importance Value Index of species (IVI)

Basing on their uses the IVI of trees that were harvested for valuable timber become more vulnerable to tree removal. Thence they will had very high contribution to the total IVI (Table 14). The contributions were found to be 180.9 (60%) and 100.23 (57%) of the total IVI in undisturbed and disturbed strata respectively (Fig. 12). The level of IVI contribution was very low for the disturbed stratum (Appendixes 9, 11, and 13). Also, the same status was depicted when the disturbed stratum was dealt with separately basing on the disturbances levels (Appendix 14). The reason for this difference was over exploitation of trees for commercial logging through selective tree cutting. When IVI looked up on the bases of individual dominant tree species illustrated disappearance of some species. Some species had higher IVI while others had low IVI when observation was done across the strata. On this base it was found that species' IVI for dominant trees harvested for commercial logging were higher in undisturbed stratum than for the disturbed stratum (Fig. 13). The results presented in Fig. 13 indicate that dominant tree species in the NEMFR were *Brachystegia spiciformice, Brachystegia boehmii, Pterocarpus angolensis, Pericopsis angolensis* and *Albizia antunesiana.* Similar results were also reported by Malimbwi *et al.* (2005) in the same forest reserve (NEMFR) and Zahabu (2001) at Kitulangalo SUA training forest reserve (in both public and forest reserves). The higher IVI for *A. antunesiana* which was appeared in the disturbed stratum was due to the regrowth which took place after forest clearance in the past. When looked at on the basis of diameter distributions, trees in Dbh class 5.0-15 had more IVI contribution.

Table 14: Species' IVI contribution in respective strata of NEMFR, Mpanda district

Utilisation category	IVI Components				Diversity Indices			
					H'	ID	IVI	
	(n/N)	Rf	Rb	Rd			Value	%
The whole forest								
A	0.51	58.99	68.52	68.52	1.28	0.05	196	65.34
B	0.03	3.53	3.08	3.08	0.12	0.001	9.7	3.23
C	0.08	6.89	5.19	5.19	0.37	0.001	17.28	5.76
D	0.37	30.58	23.2	23.2	1.48	0.009	76.99	25.66
Grand total	**1**	**100**	**100**	**100**	**3.26**	**0.062**	**300**	**100**
Undisturbed stratum								
A	0.523	59.04	52.31	69.74	1.3	0.052	181.1	60.36
B	0.049	5.19	4.93	4.74	0.22	0.001	14.86	4.95
C	0.086	6.93	8.58	5.28	0.38	0.001	20.79	6.93
D	0.342	28.85	34.18	20.24	1.35	0.009	83.27	27.76
Grand total	**1**	**100**	**100**	**100**	**3.24**	**0.063**	**300**	**100**
Disturbed strata								
A	0.358	34.94	35.78	29.51	0.682	0.065	100.2	33.41
B	0.081	7.229	8.112	7.561	0.244	0.005	22.89	7.63
C	0.101	14.46	10.05	28.04	0.395	0.002	52.54	17.51
D	0.461	43.37	46.06	34.89	1.41	0.024	124.3	41.44
Grand total	**1**	**100**	**100**	**100**	**2.73**	**0.096**	**300**	**100**

Note: *A = Trees harvested for timber; B = Trees harvested for poles, building materials and medicine; C = Tree that produce fruits/food and D = Other trees.*

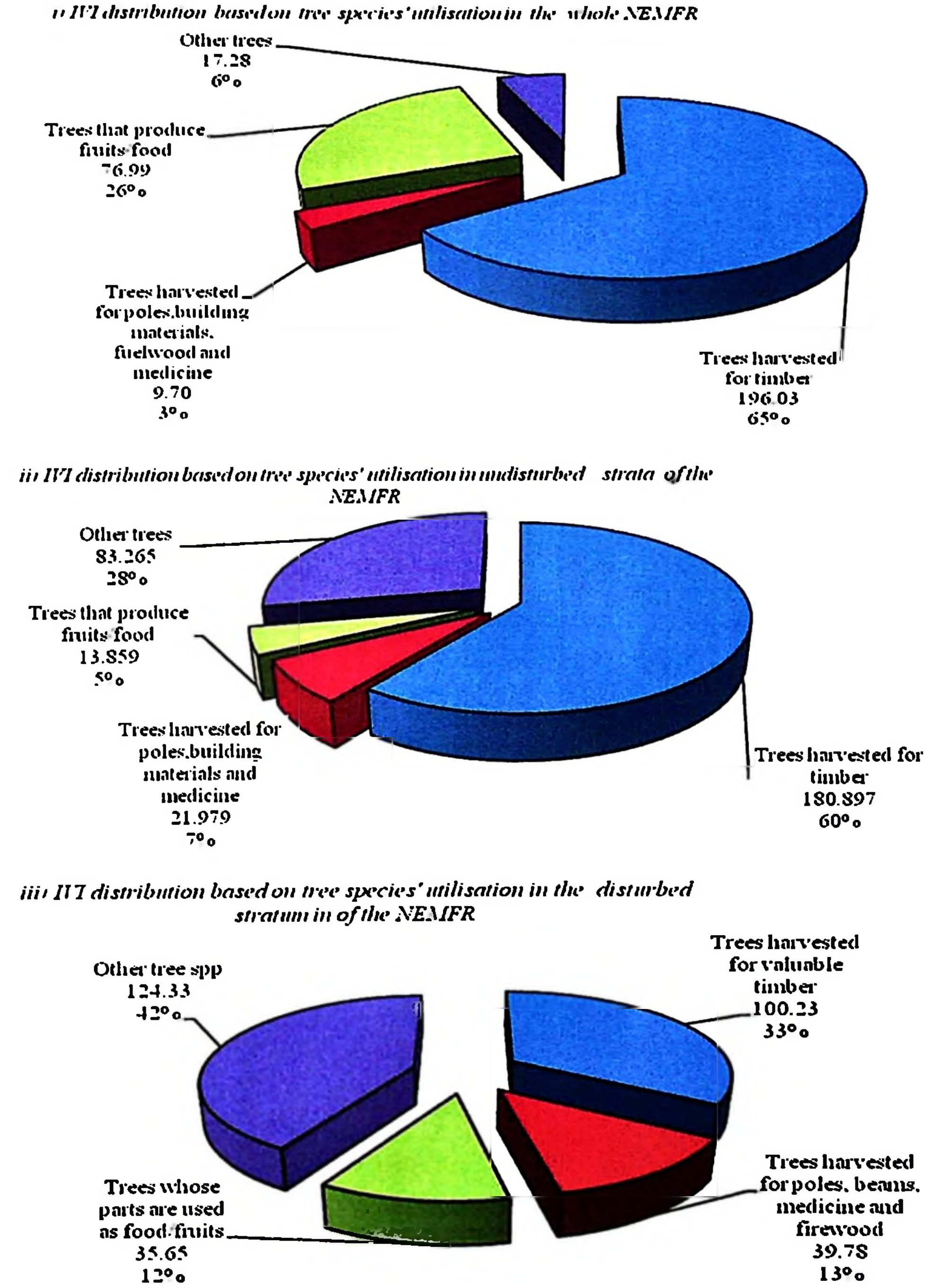


Figure 12: Comparison of species' IVI composition between the whole NEMFR disturbed and undisturbed strata, based on species utilization.

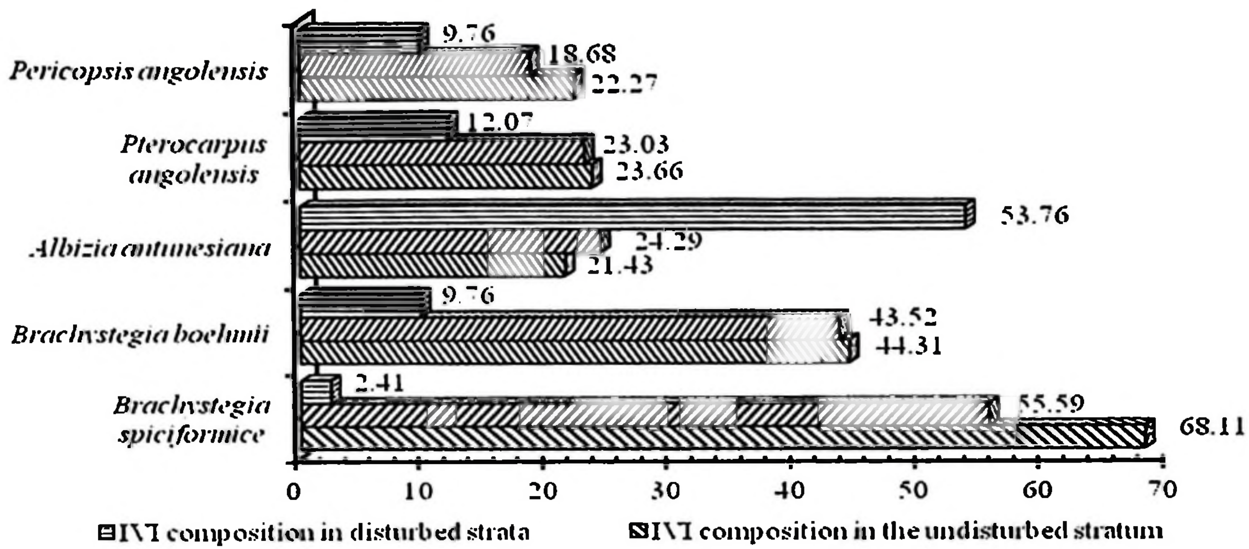


Figure 13: Comparison of valuable tree species' total IVI across strata in NEMFR, Mpanda district

4.3.4 Tree species richness (D) and similarity (S)

The distribution of 2 292 trees between undisturbed and disturbed strata was found to have species richness of 68. These species were distributed such that 68 species were found in the undisturbed stratum, 27 species were found in the disturbed stratum and 27 species were found to be common to both strata. Therefore, there was a difference of 41 tree species which were found in the undisturbed stratum only and lacking in the disturbed stratum. A small number of tree species in the disturbed stratum might be attributed to human disturbances.

Similarly, study by Chikira (2008) at Tong'omba forest reserve in Tabora reported higher species richness compared to the findings of this study. The species richness found in these studies was 148 and 154 respectively. Usually, miombo woodlands have high species richness. Therefore, the species richness found in this study was significantly low. Referring to the disturbance theories (Intermediate disturbances hypothesis), this situation shows that there was high disturbance intensities which was beyond the intermediate level of disturbances. At this level only few species co-exist in the community. The disturbances which were equally distributed throughout the NEMFR might have been caused by severe fires experienced in the NEMFR and neighbouring forest reserves within the western ecological zones (Luoga, 2000). On the other hand, species similarity was found to be 0.54. The value of similarity implies that, only 54% of tree species within the disturbed and undisturbed strata are similar. This was similar to the results reported by Chikira (2008) at Tong'omba forest reserve which showed a similarity index of 0.54.

4.4 Forest Cover and Land Use Changes in NEMFR

This sub chapter presents the results on the forest cover changes between the two temporal periods under consideration namely 1972/73 and 1994; and 1994 and 2009. The former period represent change between 1972/73 and 1994 while the latter represent change between 1994 and 2009.

4.4.1 Description of land cover and land uses status in NEMFR

4.4.1.1 Land cover/land uses status in 1972/73

The classified satellite images for the year 1972/73 show how land uses were distributed in the NEMFR before the arrival of refugees (Fig. 14). The results indicate that up to 1972 there were no settlements in the forest reserve. Also, Ugalla and Kambuzi Halt railway stations had settlements for Tanzania Railways Co-operation workers during its gazettement. Forest was the land use class which occupied largest part of NEMFR (187 371.04 ha) followed by closed woodland (141 156.01 ha) and open woodland (91 908.28 ha). Wetlands were found to occupy about 60 358.22 ha in the form of rivers, dams and swamps. Whereas, grassland and shrubs occupied small parts of the forest reserve (Table 15).

Table 15: Land cover/ land uses, rates and percentage of cover changes in NEMFR, between 1972/73 and 1994

Land cover/land use classes	Coverage in 1972/73 (ha)	Coverage in 1994 (ha)	Cover change (ha)	Cover change (%)	Rate of cover change (%/yr)	Rate of cover change (ha/ yr)
Forest	187 371.04	129 211.06	-58 159.98	-11.57	-0.0053	-2 643.64
Closed woodland	141 156.01	149 656.19	8 500.18	1.69	0.0008	386.37
Open woodland	91 908.28	103 471.22	11 562.95	2.30	0.0010	525.59
Shrubs	10 530.92	76 260.60	65 729.68	13.08	0.0059	2 987.71
Grassland (+farms)	2 551.39	9 801.73	7 250.34	1.44	0.0007	329.56
Wetland	60 358.22	25 268.22	-35 090.00	-6.98	-0.0032	-1 595.00
Settlements (+ bare land)	0.00	8 921.69	8 921.69	1.78	0.0008	405.53
Other land uses	40.66	0.00	-40.66	-0.01	0.0000	-1.85
Bare land	8 674.16	0.00	-8 674.16	-1.73	-0.0008	-3 94.28
Total	**502 590.67**	**502 590.67**				

Note: Percentage in this table was computed referring to the total area of NEMFR.

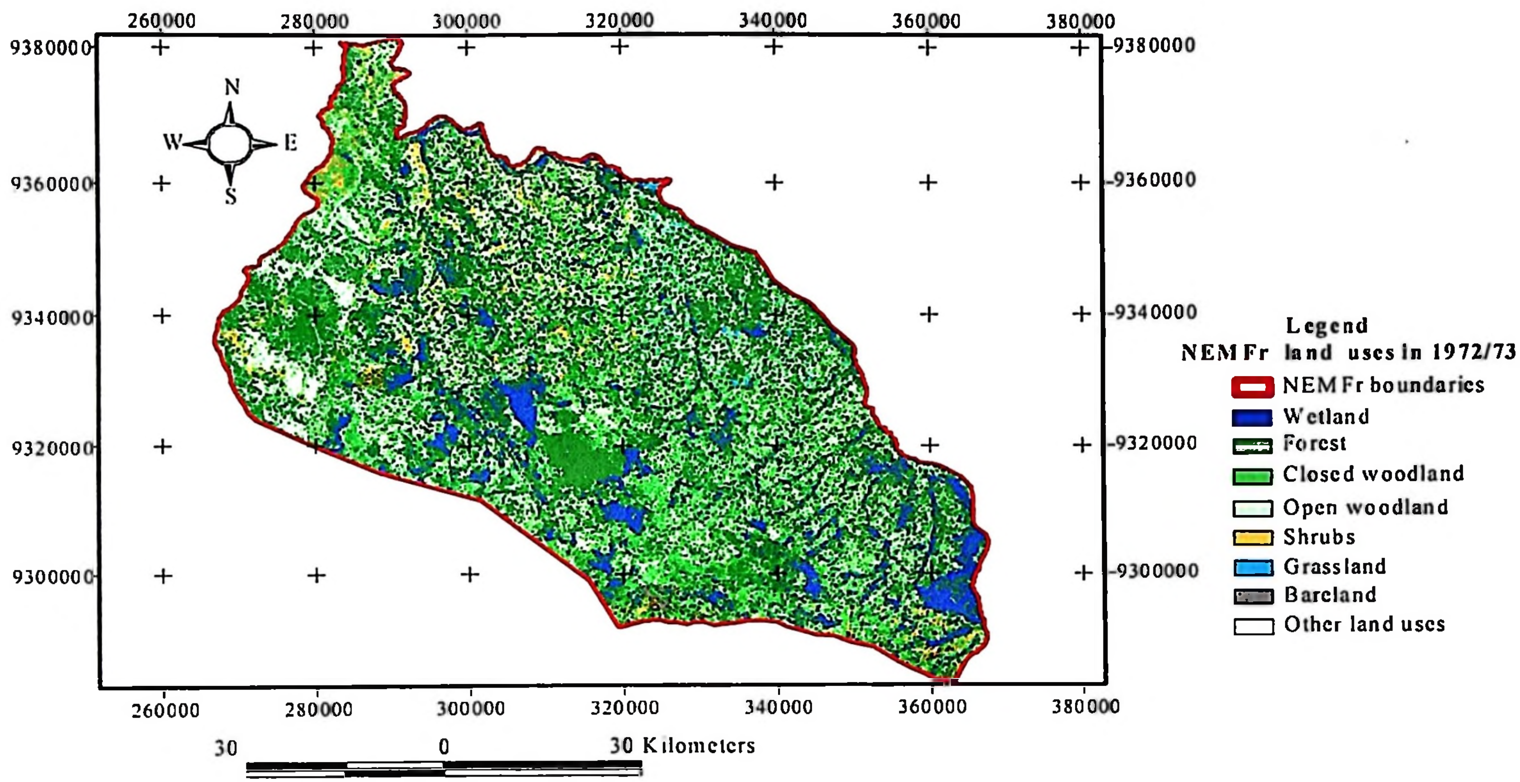


Figure 14: Land cover and land use coverage for NEMFR, Mpanda district in 1972/73
(Source : A mosaic of three images taken in September 1972, June 1973 and August 1973 respectively)

4.4.1.2 Land cover/ land use status in 1994

Satellite image for 1994 incorporated all changes occurred between 1972 and 1994 (Fig. 15). These changes included the introduction of refugees' settlements and its expansion, a decrease of land which was covered by water (wetlands), a decrease of land that was covered by forest and closed woodland. Forest cover was decreased at a rate of 0.0053 % per year which equates to -2 643.64 ha per year. Open woodlands increased at a rate of 386.37 ha per year (Table 15). Increase in open woodland was due to deforestation attributable to refugees' forest based activities. Refugees came from Katumba refugees' settlements which were introduced in the south-west part of Mtambo River in August 1973. Settlements area increased by 100% ha at a rate of 0.0008% per year which was equal to 405.53 ha per year reaching the total area of 8 921.69 ha (Table 15). Again, the introduction and expansion of these settlements resulted into depletion of Mtambo river tributaries (Fig. 15). Depletion of tributaries contributed to disappearance of wetland which disappeared at a rate of --0.0032% per year which equates to -1 595.00 ha per year. Shrubs increased significantly at a rate of 0.0059% per year which was equal to 2 987.71 ha per year. A slight increase in closed woodland area (2.30%) was also noted in this year. Therefore, area covered by water, forest and closed woodland decreased significantly during this period as a results of refugees disturbances (Table 15 and Fig. 15).

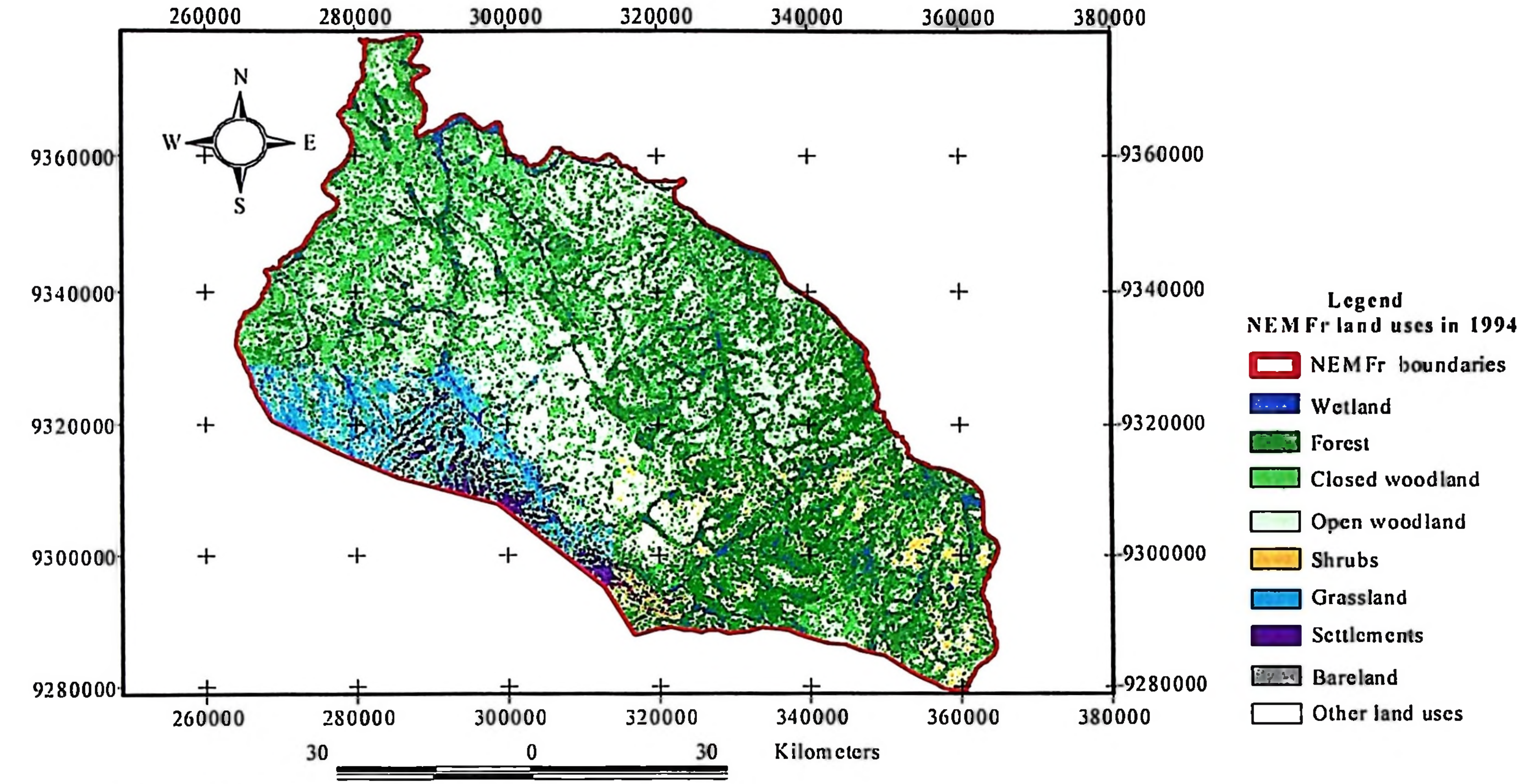


Figure 15: Land use changes in NEMFR, Mpanda district as per 1994
(**Source** : Satellite image take in September 1994)

4.4.1.3 Land cover/ land use status in 2009

The status of land cover/ land uses for NEMFR in 2009 is represented in Fig. 16. General status of the forest in this period depicts significant variation in their distribution since open woodland occupies more area of the forest reserve (246 913.21 ha) than others. Also, forest class occupies 138 702.38 ha while other land use category occupies only 2.73 ha. Whereas, in the past (1972/73 and 1994) forest category occupied more area than the rest (Fig. 15: Table 15). Also, the variation was due to presence of more land cover/ land use categories than those which were found in 1972/73 and1994. Some of the land use categories were not present in the previous years. New land cover/ land uses categories were bare land category which occupied a total of 31 330.28 ha and other land uses category which occupied a total of 2.73 ha. The former new category increased at a rate of 1 424.10 ha per year while the latter increased at a rate of 0.12 ha per year (Table 16).

Furthermore, the variation in land cover/land use status was contributed by increase or decrease of various land cover/land uses at varying rates. These include further disappearance of wetland, settlements expansion and increase of open woodlands. Wetland disappeared by 3.73% at a rate of -851.85 ha per year while settlements increased by 7.89% at a rate of -1 803.25 ha per year. Also open woodland increased by 19.35% at a rate of 4 420.77 ha per year. A significant decrease in shrubs by 15.11% at a rate of -3 452.64 ha per year was revealed. Therefore, land cover/land use status of NEMFR in 2009 was quite different from those of 1972/73 and 1994.

Table 16: Land cover/ land uses, rates and percentage of cover changes in NEMFR between 1994 and 2009

	Rates and percentage of forest cover changes between 1994 and 2009					
Land cover/land use classes	**Coverage in 1994 (ha)**	**Coverage in 2009(ha)**	**Cover change (ha)**	**Cover change (%)**	**Rate of cover change (%/yr)**	**Rate of cover change (ha/ yr)**
Forest	129 211.06	138 702.38	9 491.32	1.89	0.0009	431.42
Open woodland	149 656.19	246 913.21	97 257.03	19.35	0.0088	4 420.77
Closed woodland	103 471.22	11 426.78	-92 044.44	-18.31	-0.0083	-4 183.84
Shrubs	76 260.60	302.57	-75 958.02	-15.11	-0.0069	-3 452.64
Grassland (+farms)	9 801.73	18 791.84	8 990.11	1.79	0.0008	408.64
Wetland	252 68.22	6 527.61	-18 740.60	-3.73	-0.0017	-851.85
Settlements (+ bare land)	8 921.69	48 593.26	39 671.56	7.89	0.0036	1 803.25
Other land uses	0.00	2.73	2.73	0.00	0.0000	0.12
Bare land	0.00	31 330.28	31 330.28	6.23	0.0028	1 424.10
Total	**502 590.67**	**502 590.67**				

Note: Percentage in this table was computed referring to the total area of NEMFR

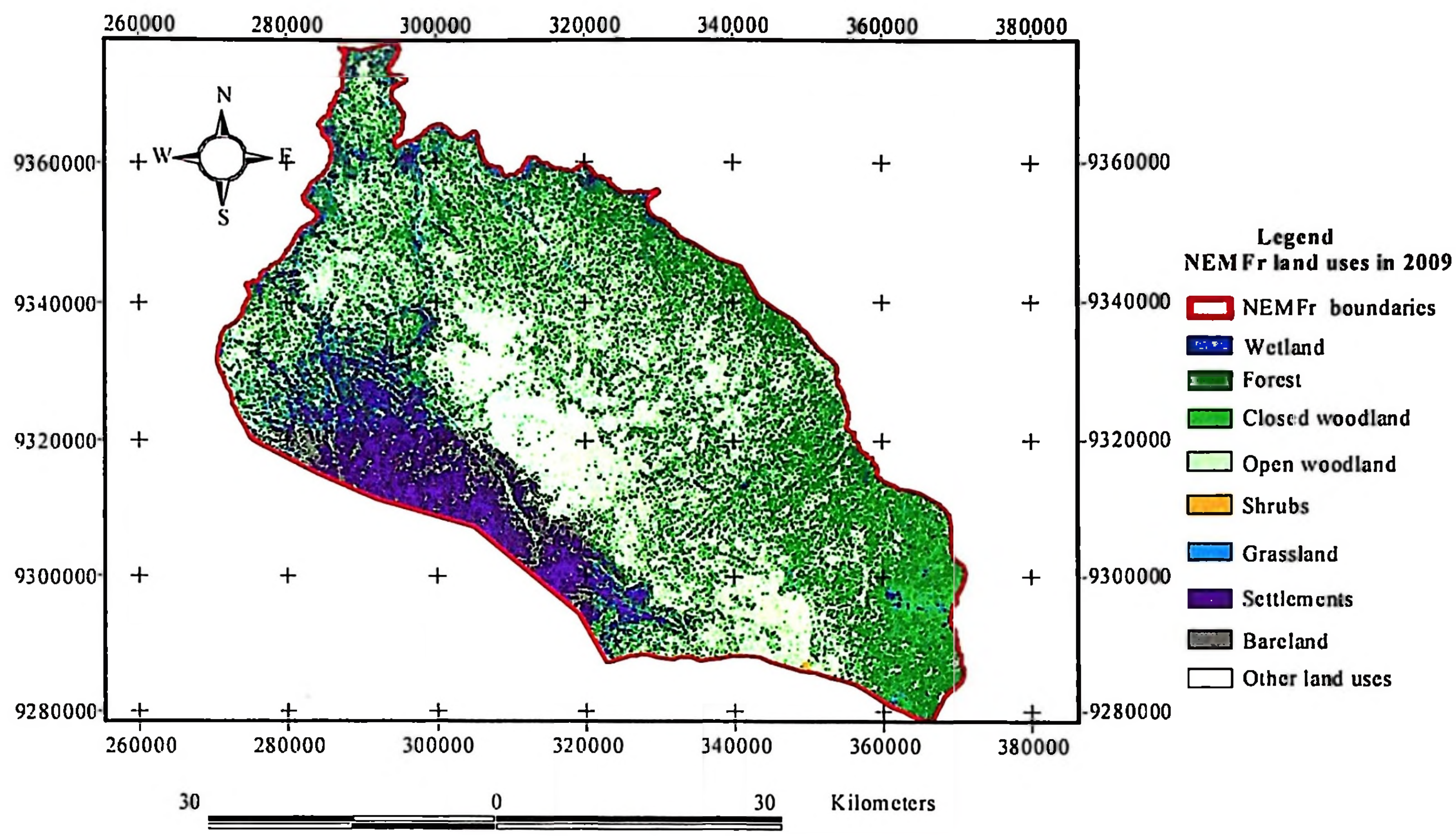


Figure 16: Land use changes in NEMFR, Mpanda district as per 2009
Source: Satellite image taken in June 2009)

4.4.2 Detection of land cover and land use changes in NEMFR

4.4.2.1 Extent of land cover / land use changes between 1972/73 and 1994

The findings of this study deduced that during period between 1972/73 and 1994, NEMFR experienced huge transformation of land covers. This included transformation of forest (173 426.31 ha), closed woodland (123 389.06 ha) and open woodland (88 843.96 ha) to other land uses. During the period 1972/73 to 1994, only 43 064.65 ha, 31 505.03 ha and 24 498.19 ha of forest, closed woodland and open woodland respectively remained unchanged. Furthermore, it was revealed that a total of 142 066.97 ha of various land uses were transformed into settlements (20 130.70 ha), farms/grassland (47 378.03 ha) and shrubs (74 558.24 ha) (Table 17; Fig. 17).

Specifically, 173 426.31 ha of forest was transformed into other land covers/ land uses out of which 43 064.65 ha remained unchanged (Table 17). These changes were due to human activities, as in 1972/1973 same land cover/ land uses (settlements, grassland/farms and shrubs) occupied only 0.00 ha, 2 551.39 ha and 10 530.92 ha respectively. The transformation of various land uses into wetlands (25 251.15 ha) resulted from human activities that removed vegetation (trees and grasses) which formerly covered water bodies (Table 17). Usually, river line forests and grasses in swamps prevent water bodies' surfaces from being sensed direct by satellite sensors.

Similar trend of land cover/ land use changes was detected by Masudi, (2005): in Mahenge village in Mbinga District, where a land use for annual crops increased from 771.16 ha to 818.84 ha between 1991 and 2000 due to human activities. The changes adhered to the Malthusian and Boserup theories in that, population increase due to refugees' influx did not match with farming technology used in producing food to feed the geometrically growing population (Malthus, 1803: Boserup, 1965). As a result the population adapted the situation by either increasing farming areas or practising land abandonment system of farming. Therefore, the direction of the change was either changing of the existing land uses into other new land uses or changing of one of the existing land uses into other existing land use.

4.4.2.2 Extent of land cover/land use changes between 1994 and 2009

The land cover transformation for the period 1994 and 2009 are represented in Table 18. About 36 719.04 ha of grassland were converted into other land uses with 1 842.79 ha remaining unchanged. Also, 18 900.41 ha of the land cover was converted into grassland from various land cover/ land uses. Unlike for the 1972/73-1994 period, different land cover/land uses in the latter period were transformed into forest

(259 209.81 ha), closed woodland (149 651.95 ha) and open woodland (33 596.82 ha). Whilst, only 145 131.93 ha, 122 462.73 ha and 69 805.93 ha of forest, closed woodland and open woodland were transformed into new land cover/ land uses respectively (Table18).

Table 17: Change detection matrix for change between 1972/73 and 1994 in NEMFR

1994 / 1972/73	Land cover/land use classes area (ha)								
	Wetland	**Forest**	**Closed woodland**	**Open woodland**	**Shrubs**	**Grassland (+farms)**	**Settlements (+ bare land)**	**Other land uses**	**Total**
Wetland	3 642.51	15 843.41	14 439.73	10 087.95	9 879.21	4 814.17	8 215.07	0	**66 922.05**
Forest	10 960.25	43 064.65	41 640.20	30 848.33	25 508.76	16 521.81	4 882.31	0	**173 426.31**
Closed woodland	5 604.46	31 505.03	28 540.62	22 413.56	18 186.03	13 206.31	3 933.04	0	**123 389.06**
Open woodland	3 589.53	24 498.19	25 498.77	12 935.15	15 012.08	6 333.22	977.04	0	**88 843.96**
Shrubs	857.68	8 799.85	7 634.19	5 437.42	3 633.16	4 068.51	1 527.69	0	**31 958.49**
Grassland (+ farms)	596.72	4 126.15	3 561.59	2 387.80	2 339.00	1 894.69	469.12	0	**15 375.08**
Settlements (+bare land)	0	1 107.36	490.9	411.72	0	539.32	96.95	0	**2 646.25**
Other land uses	0	0	0	0	0	0	29.48	0	**29.48**
Total	**25 251.15**	**128 944.64**	**121 806.00**	**84 521.93**	**74 558.24**	**47 378.03**	**20 130.70**	**0**	**502 590.67**

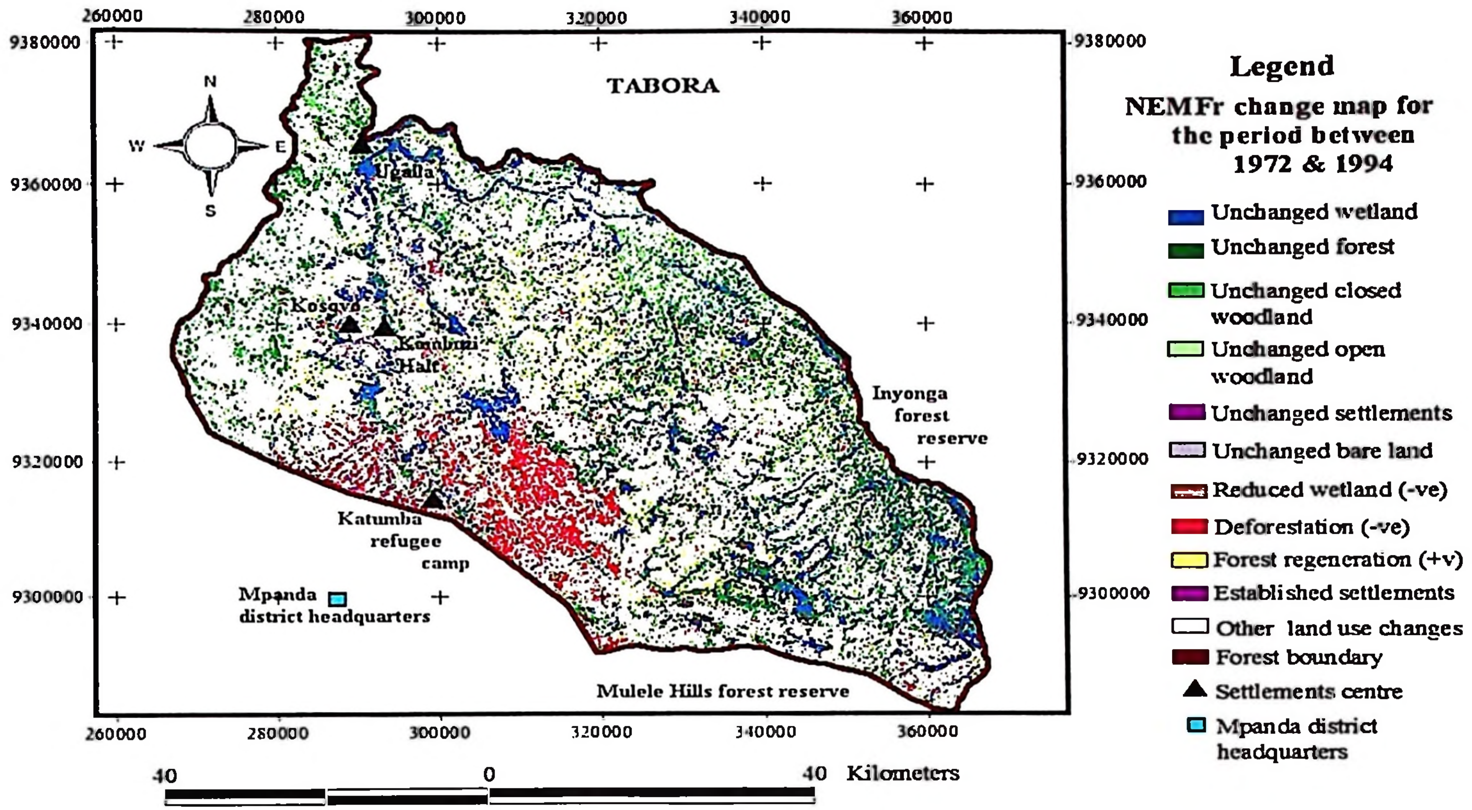


Figure 17: Change map between 1972/73 and 1994 for NEMFR in Mpanda district, Tanzania. (*Note: Settlements were established on deforested land*)

(**Source** : A mosaic of images taken in September 1972, June 1973, August 1973 overlaid with image taken in September 1994)

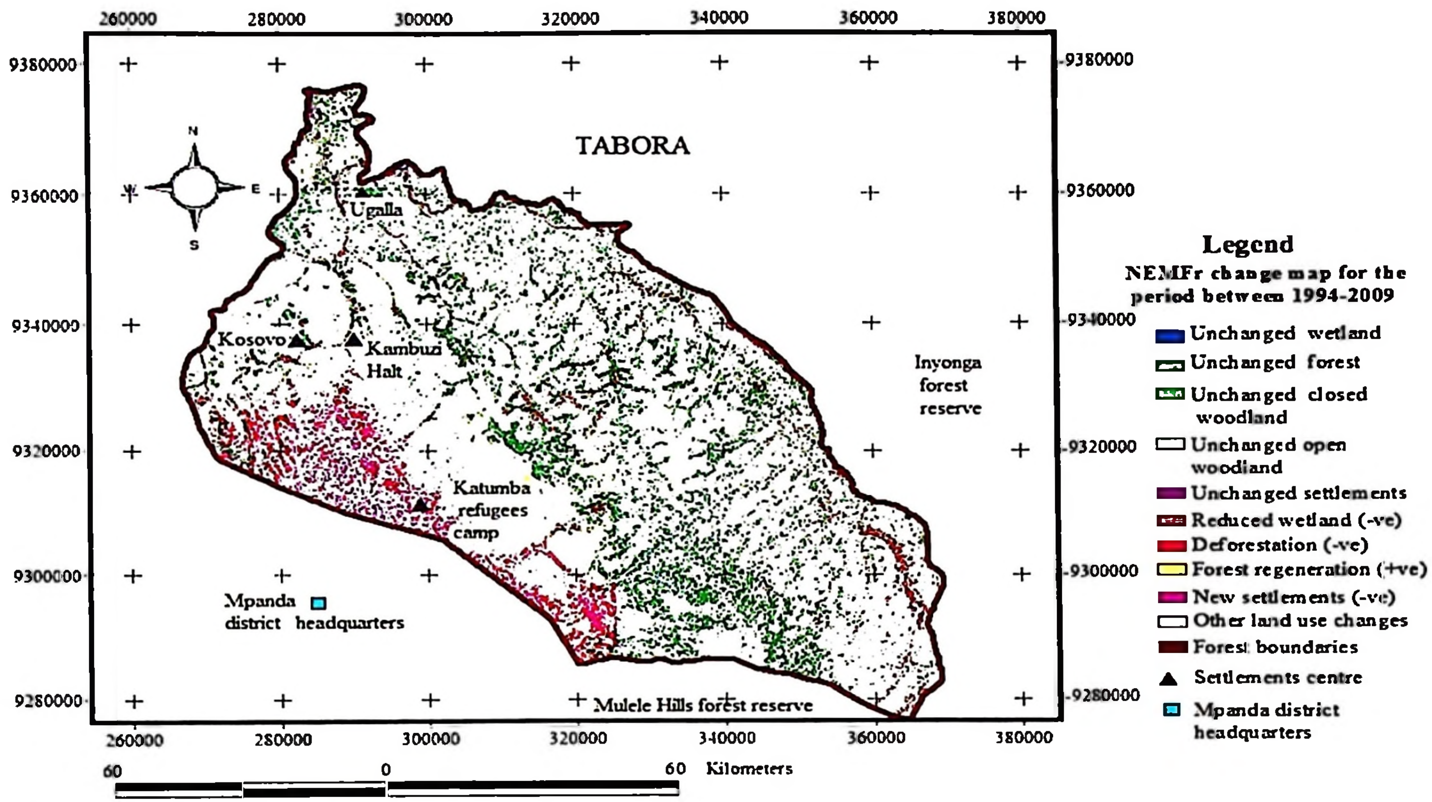


Figure 18: Change map between 1994 and 2009 for NEMFR, Mpanda District, Tanzania. *Note: Settlements were established on deforested land* (**Source:** Overlay of two satellite images taken in September 1994 and June 2009)

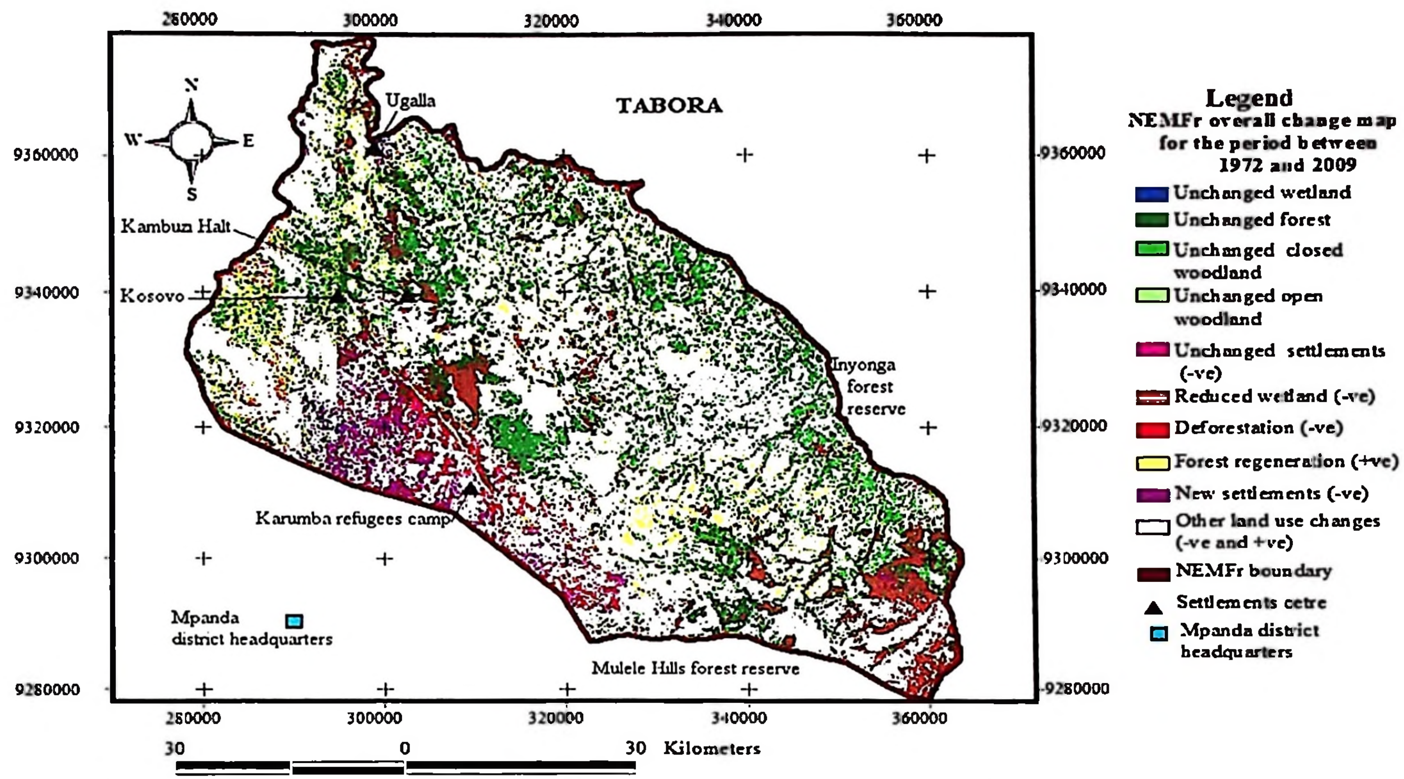


Figure 19: Overall change map between 1972/73 and 2009 in NEMFR, Mpanda District, Tanzania. *(Note: Settlements were established on deforested land)*

(**Source** : A mosaic of four satellite images taken in September 1972, June 1973, August 1973 overlaid with image taken in June 2009)

However, in the latter transformation not all of the mentioned land were converted to other land cover/ land use classes but rather 74 992.19 ha of forest, 36 849.24 ha of closed woodland and 4 889.93 ha of open woodland remained unchanged throughout the period. This kind of change was detected only in the areas which were out of Katumba refugees' camp (Fig. 18). This was due to absence of refugees' disturbances in the south-western parts of Mtambo River since human disturbances decreases as distance from the forest increases (Zahabu, 2001). More wetland (30 601.11 ha) continued to be converted into other land uses. Also, forest land (38 871.09 ha) was occupied by settlements including a total of 1 940.28 ha which accrued during the 1972/73-1994 period and remained unchanged during 1994-2009 period (Fig. 17 and 18). Similarly decrease of wetland and forest was reported by Njahani (2008) at Nyarugusu Refugees Camp area in Kasulu. This was due to the rapid increase in refugees' population which was said to range between 3.8-5% per year (URT, 2003). There are conversion of settlements into closed woodland (722.63 ha) and open woodland (606.78 ha) this might be due to the effect of exotic trees (*Senna siamea* and *S. spectabilis*) planted in the refugees' camp and not natural regeneration of NEMFr (Table 18). However, regeneration observed outside the refugee camp depicted natural regeneration of NEMFR. Natural regeneration might have been contributed by government efforts on controlling refugees' movements between 2004 and 2009. During these years (from 4th June 2004) the Forest Act No 14 of 2002 was enacted (UTR, 2002a).

4.4.2.3 Overall land cover/land use changes between 1972/73 and 2009

Overall change detection deduced two main directions of land cover/land use changes which were positive and negative changes. Deforestation, reduced wetland and established settlements represent negative changes; whereas, positive changes were represented by forest regeneration. Also, there were land cover/ land uses which remained unchanged over the period (1972/73 to 2009) (Table 19: Fig. 19). These are illustrated in the Table 19 where, the bolded numbers which cut the table diagonally from the top left corner of the table represent unchanged land uses. Whereas, from this diagonal line upwards or to the right hand side the areas represented negative changes while the opposite represented negative changes.

The overall change detection revealed that out of 502 590.67 ha of the NEMFR only 126 125.59 ha remained unchanged over the whole period (1972/73 to 2009). Also, the detection deduced that a total of 50 330.24 ha of the forest (including 130.92 ha of the forest which were occupied by settlements before the gazettement of the forest) was converted to settlements while, about 22 741.12 ha of it was converted to grassland/farms. Again, it was found that 11.02% (55 382.69 ha) of wetland in NEMFR disappeared during the entire period (Table 19 and Fig. 19). Conversion of various land cover/ land uses to shrubs was not noted. Because, before 2004 refugees were rampantly moving in and out of their camp boundaries to practice shifting cultivation which resulted into shrubs (74 558.24 ha) (Table 17). When the forest Act No 14 of 2002 was enacted in 2004 their rampancy movement stopped and refugees went back to their former abandoned farms which had already turned into shrubs. This caused them to settle in one area and stopped further of other land uses into shrubs. When refugees settle in one area due to government efforts in law enforcement, started to practice fallowing system of agriculture on same piece of land leading to conversion of 42 727.25 ha of shrubs into grassland and settlements (Table 19). If this conversion process persists the forest will be dominated by grasses as miombo woodlands under intensive cultivation was said to be dominated by grasses (Strang, 1974). Similar increase in cultivated land and grassland was revealed by Mafupa (2006) in Igombe river forest reserve in Nzega-Tabora.

Collectively, the trend of land cover/ land use changes showed more negative changes than positive changes causing disappearance of wetlands and other forest covers. About 25% of forest land experienced transformation of land use due to human disturbances. However, disturbances were not distributed equally throughout NEMFR but were concentrated in the south-west parts of NEMFR where Katumba refugees camp was sited emphasising that the disturbances were attributable to refugees.

Table 18: Change detection matrix for the change between 1994 and 2009 in NEMFR, Mpanda district, Tanzania.

	Land cover/Land use class areas (ha)								
1994 / 2009	**Wetland**	**Forest**	**Closed woodland**	**Open woodland**	**Shrubs**	**Grassland (+farms)**	**Settlements (+ bare land)**	**Other land uses**	**Total**
Wetland	139.81	14 863.38	10 254.53	2 379.84	0	1 141.50	1 822.04	0	**30 601.11**
Forest	345.62	74 992.19	45 941.17	9 364.94	0	4 761.26	9 726.74	0	**145 131.93**
Closed woodland	487.24	65 095.59	36 849.24	7 795.30	0	4 287.80	7 947.55	0	**122 462.73**
Open woodland	511.13	37 212.91	18 009.41	4 889.93	0	3 062.37	6 120.18	0	**69 805.93**
Shrubs	362.74	49 497.78	27 642.35	5 798.31	0	3 328.38	6 998.52	0	**93 628.08**
Grassland (+farms)	480.78	16 824.59	10 341.37	2 913.74	0	1 842.79	4 315.77	0	**36 719.04**
Settlements (+ bare land)	33.02	722.63	606.78	451.55	0	476.20	1 940.28	0	**4 230.47**
Other land uses	0	0.75	7.08	3.21	0	0.35	0	0	**11.40**
Total	**2 360.34**	**259 209.81**	**149 651.95**	**33 596.82**	**0**	**18 900.66**	**38 871.09**	**0**	**502 590.67**

Table 19: Overall change detection matrix for the change between 1972/73 and 2009 in NEMFR, Mpanda district, Tanzania

	Land cover/Land use class areas (ha)								
1972/73 \ 2009	Wetland	Forest	Closed woodland	Open woodland	Shrubs	Grassland (+ farms)	Settlements (+Bare land)	Other land uses	Total
Wetland	**299.84**	3 943.73	7 468.23	5 399.87	0	2 633.43	5 937.42	0	**55 682.53**
Forest	1 275.76	**88 468.71**	55 167.97	13 647.65	0	8 013.87	16 777.62	0	**183 351.58**
Closed woodland	576.32	58 255.26	**32 366.31**	9 526.93	0	6 775.07	15 564.22	0	**123 064.10**
Open woodland	507.47	42 007.32	23 765.90	**4 226.87**	0	2 299.70	5 112.87	0	**77 920.13**
Shrubs	114.13	20 738.30	11 172.97	3 224.30	**0**	2 159.23	5 318.32	**0**	**42 727.25**
Grassland (+ farms)	99.33	7 889.49	5 416.03	1 262.00	0	**632.94**	1 224.94	0	**16 524.72**
Settlements (+Bare land)	0.09	569.29	1 025.79	245.37	0	74.24	**130.92**	0	**2 045.69**
Other land uses	0.41	372.81	305.41	179.47	0	152.64	263.94	**0**	**1 274.67**
Total	**2 873.35**	**242 244.91**	**146 688.60**	**37 712.45**	**0**	**22 741.12**	**50 330.24**	**0**	**502 590.67**

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The refugees' activities particularly, farming, residences, tree cutting for firewood used in tobacco currying and daily domestic use and exploitation of various forest resources resulted into a significant decrease in forest stocking. The decrease in forest stocking was indicated by decreasing stand density (N), Basal area per hectare (G) and volume per hectare (V) in the disturbed stratum as compared to similar attributes in the undisturbed stratum. The study therefore concludes that refugees' disturbances had an effect on biophysical parameters in the North East Mpanda Forest Reserve as indicated by stand basic parameters, plant species diversity and cover changes.

In similar way, refugees' forest based activities have reduced plant diversity in NEMFR, the most affected tree species being *Pterocarpus angolensis, Pericopsis angolensis, Brachystegia boehmii, B. spiciformice*, *Albizia antunesiana* and *Dalbergia melanoxylon* (mpingo). This has been because clearing of forest for settlements and farms and other activities. Also, some exotic tree species have been introduced in the NEMFR which was a natural forest. The exotic tree species include *Senna siamea* and *S. specabilis.*

The study concludes that, refugees' forest-based activities have effects on forest covers including to changes into various land uses as a result of severe deforestation. degradation of the NEMFR. However, the Government efforts in controlling refugees movements into other parts of the forest have resulted in been positive changes in forest cover respectively between 1994 and 2009. The changes include the reconversion of grassland, shrubs and open woodlands cover classes into open woodland, closed woodlands and forest respectively. Such effort needs to be strengthened farther to ensure sustainable management of the forest (NEMFR).

5.2 Recommendations

To rescue the North East Mpanda Forest reserve from further disturbances the study has come up with some recommendations. Principles of Sustainable Forest Management (SFM) are needed as one of the key steps to arrest the on-going disturbances. This should be preceded by repatriation of all people still residing in the forest reserve. The following recommendations will be implemented/considered:

(i) NEMFR boundaries be consolidated and marked with distinctive beacons all around the forest. Boundaries so marked are to be cleared and maintained annually. This will make forest boundaries clearly seen by the communities living around the forest for smooth law enforcement.

(ii) Naturalised refugees should be repatriated to other regions of the country such that the forest left for forest regeneration.

(iii) The NEMFR to be zoned into two zones: Restricted zone (South-western parts of Mtambo River and all catchment points) and Productive zone (Eastern parts of Mtambo River). The restricted zone within NEMFR to be assigned with an objective of forest improvement and rehabilitation. Under this objective, destruction of residential houses and patrols are to be the main activities. A well marked buffer zone in the southern and western parts of NEMFR to be established between residential areas and the forest reserve. NEMFR be excluded from human activities till it is fully regenerated to harvestable status: since the category of the forest was productive. The restriction in all catchment points should be permanent.

(iv) During the gazettement of NEMFR in 1946 there were Railway stations/posts of Ugalla, Kambuzi Halt and Katumba which were already within the forest area. To date the areas have expanded following railway posts. Retired workers and small scale food vendors establishing their residences in the posts. The study recommends that, all such settlement areas are to be deducted from the NEMFR area and prepare a clear boundary map for each post/villages/settlements in a participatory approach.

(v) There is a need to intensify birth control education among communities and minimise more population influx.

(vi) Tree planting practices is to be strengthened through gap filling in the more disturbed forest. This practice should go in line with introduction of tree outside forest to reduce pressure of forest resources towards the NEMFR.

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APPENDICES

Appendix 1: Households Interview Schedule

A. General Information

Village----------------------Sub-village-------------Ward........................

Date of interview --------------------House identification No...................

B. Socio-economic Characteristics of Respondents

1. Sex: 1. Male ☐

2. Female

2. Age........................ 3. Nationality.....................

4. Marital status: 1. Single............... 2. Married................

3. Divorced............ 4. Widowed............. ☐

5. Highest education level reached

1. Non formal 2. Primary school education

3. Secondary school Education 4. College education ☐

5. Others (*specify*)..

6. Number of household members...... ....

7. What is your main occupation? ....

8. How long have you stayed in this village/Camp? ....

9. How many total hectares of land do you own? ....

C. Socio-economic Activities Taking Place in NEMFR

1. Do you know NEMFR? 1. Yes 2. No ☐

2. If yes, to whom does it belongs?

1. Village Government 2. District Council 3. Central Government

4. Katumba Refugees 5. Others *(Specify)* .... ☐

3. Where do the NEMFR boundaries pass?

4. Is community allowed to access NEMFR for various socio-economic activities
   1. Yes 2. No ☐

5. Are you aware that there are some socio-economic activities being carried out in NEMFR? 1. Yes 2. No ☐

6. If yes, what are those socio-economic activities carried out in NEMFR? ....

7. Do you know reasons why some people perform various activities in NEMFR?
   1. Yes 2. No ☐

8. If yes, give reasons...

9. Which gender group is mostly involved in forest-based economic activities?
   1. Male 2. Female 3. Both 4. Don't know ☐

10. Compare the forest cover now (2010) and before the arrival of refugees back in 1972.
    1. Better now, 2. Worse now, 3. The same, 4. Don't know, 5. Others *(specify)*.☐

11. Do you think the government is keen enough in controlling illegal activities in NEMFR? 1. Yes 2. No ☐

12. If no, give reasons...

13. In your opinions, what do you think should be done by the government in order to control illegal activities? ....

Appendix 2: A guiding checklist for Key Informant Respondents and Focus Group Discussion

A] What are the forests based refugees' activities taking place in NEMFR?

1. When did you arrive at Katumba refugee camp/this village?
2. Do you think NEMFR is important for your daily life?
3. Do you have access to the NEMFR?
4. What types of forest activities are being carried out in the forest?
5. What are the main factors that drive refugee community to access NEMFR?

B] How do the NEMFR differs in vegetation status (forest cover change and species composition) between the time of your arrival and now?

1. Compare the current status of NEMFR during your arrive and now.
2. Are there some tree species which previously were present but currently have disappeared?
3. If there are changes in species can you list tree species which have disappeared?
4. What might be the causes of all these changes in No B_1, and B_2 above?
5. Do you think are there some external factors that contribute to degradation of NEMFR?

C] Since the refugees arrival to date how far Government laws met the NEMFR and Katumba Camp management needs?

1. Do you think are there some regulations which control you to access NEMFR?
2. Apart from the government, are there any other stakeholders responsible for the management of NEMFR?
3. Are there any forest resource use conflicts amongst the communities around NEMFR?
4. What should be done in order to ensure that the NEMFR is managed sustainably?

Thank you very much for participating in this very important group discussion.

Appendix 3: Iteration process to get a desired E & **n** for precise results

Na	t-VALUES	Error (E)	Sd	CV = Sd/X	CV^2	t^2	Sd^2	E^2	≈ n
1	1.96	0.02	10.49	1.45	2.11	3.84	110.04	0.0004	20274
2	1.96	0.04	10.49	1.45	2.11	3.84	110.04	0.0016	5068
3	1.96	0.06	10.49	1.45	2.11	3.84	110.04	0.0036	2253
4	1.96	0.08	10.49	1.45	2.11	3.84	110.04	0.0064	1267
5	1.96	0.10	10.49	1.45	2.11	3.84	110.04	0.0100	811
6	1.96	0.12	10.49	1.45	2.11	3.84	110.04	0.0144	563
7	1.96	0.14	10.49	1.45	2.11	3.84	110.04	0.0196	414
8	1.96	0.16	10.49	1.45	2.11	3.84	110.04	0.0256	317
9	1.96	0.18	10.49	1.45	2.11	3.84	110.04	0.0324	250
10	1.96	0.20	10.49	1.45	2.11	3.84	110.04	0.0400	203
11	**1.96**	**0.22**	**10.49**	**1.45**	**2.11**	**3.84**	**110.04**	**0.0484**	**168**
12	1.96	0.24	10.49	1.45	2.11	3.84	110.04	0.0576	141
13	1.96	0.26	10.49	1.45	2.11	3.84	110.04	0.0676	120
14	1.96	0.28	10.49	1.45	2.11	3.84	110.04	0.0784	103
15	1.96	0.30	10.49	1.45	2.11	3.84	110.04	0.0900	90

Appendix 4: Inventory field data collection form

Date...

Field data collection form				
Plot No.	**Stratum category**	**Disturbance level**	**Coordinates**	**Elevation**

Sn.	Innermost circle	Dbh	Sn	Middle circle	Dbh	Sn	Outermost circle	Dbh

Parameters of a tree close to the plot centre			
Tree name		**Tree Dbh (cm)**	**Tree height (m)**
Local name	**Scientific name**		
Information on anthropogenic disturbances			

Appendix 5: Ground truthing form

Date........................

A. Site particulars

Waypoint			**Canopy cover (%)**	**Coordinates**	
Number	**Elevation**	**Description**		**Eastings**	**Northings**

B. Features/vegetation class:

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C. Detailed description of the area:

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Appendix 6: List of tree species' codes for NEMFR, Mpanda district

SPP CODES	SPECIES' NAME		SPP CODES	SPECIES' NAME	
	VERNACULAR NAME	BOTANICAL NAME		VERNACULAR NAME	BOTANICAL NAME
1	Mgumbu	*Lannea schweinfurthii*	36	Mkuwa	*Hexalobus monopetalus*
2	Mtundu	*Brachystegia spiciformice*	37	Mbumbu	*Unknown*
3	myombo/msilanga	*Brachystegia boehmii*	38	mkalya/Mkalya/Mkarye	*Zanha africana*
4	muba/muva/muwa	*Julbernardia globiflora*	40	Mputika	*Scchrebera frinchoclade*
5	Mtunguru	*Pseudolachynostylis maprouncifolia*	41	kapala/mpala	*Hymenocardia acida*
6	Mlama	*Combretum molle*	42	Mkurungu	*Pterocarpus tintorious*
7	Mninga	*Pterocarpus angolensis*	43	Mnembela	*Isorberlinia tomentosa*
8	kibula/kibua /mluzyaminzi	*Combretum adenogonium*	44	mseveye/Mseweye	*Chrysophyllum benguelensis*
9	mgunga/mbombwe/mdungwa	*Accacis nilotica*	45	mpingo/mgembe	*dalbergia melanoxylon*
10	mfynduamboga/mfunduambogo	*Pilliostigma thonningii*	46	Msindwi	*Unknown*
11	mpilipili/mgando	*Albizia antunesiana*	47	Mkusu	*Uapaka Kirkiana*
12	mkora/mkongo/mkola	*Afzelia quanzensis*	49	Kasyenela	*Unknown*
13	kasanda/mnyegenyege	*Swartzia madagascariensis*	50	Mnkundu	*Unknown*
14	mfilafila/mfira	*Trilepisum madacascariensis*	53	mliwamfwengi/mliwafyengi	*Oldflieldia dactylophylla*
15	mbula/Muwala/Muvula	*Perinari curatifillia*	58	mwezya/Mwesya	*Maytenus senegalensis*
16	Mgandokaguva	*Unknown*	59	Mpapa	*Makhamia obtusifolia*
17	mbanga/muvanga	*Pericopsis angolensis*	60	Mbombo	*Unknown*
18	mfulu/mpulu	*Vitex doniana*	61	Kashamongo	*Syzigium guinensis*
20	Msongati	*Diplorhynchos condylocarpon*	63	Mningoningo	*Unknown*
21	msanzambele/Mkozikozi	*crossopteryx febrifuga*	64	Msofe	*Diospyros zombensis*

22	Kapepe	*Brachystegia microphylla*	66	Kapyupyu	*Unknown*
23	Kiponda	*Commiphora mossambicensis*	67	kasunzuru/mtundulu	*Dichrostachys cinera*
24	Masaka	*Pterocarpus sp.*	69	mtopetope pori	*Annona senegalensis*
25	Mnumbula	*Dirospyros kirkii*	72	mtewe/Mtejwe	*Unknown*
26	Mfumbe	*Dombeya rotundifolia*	74	Mkulwa	*Strychnos innocua*
27	kaselenga/mkelenge	*Terminalia mollis*	75	katunguluvaganga/Mtunguru	*Pseudolachynostylis maprouncifolia*
28	Mfuru	*Vitex ferruginea*	77	kashenene/mshenene	*Xylopia antunesii*
29	Kazima	*Terminalia sericea*	78	Munsa	*Treculia Africana*
30	mbalebale/Mvalevale/Mvale	*Lonchocarpus capassa*	84	Mbamba	*Unknown*
31	Mkome	*Sctrichnos punges*	89	kalilolilo/Msalunhunda	*Psorospemum febrifugum*
32	Mkuni	*Berchemia discolour*	91	kagelenge/Kaselenge/Kakelenge	*Terminalia mollis*
33	Mlandala	*Combretum collium*	92	mkame/Mkomalendi	*Grewia bascolor*
34	mgwegwe/Mgwege/Mpandepande	*Strychnos potarum*	93	Ikuya/Ikuja	*Unknown*
35	Mlugala	*Cassipourea mollis*	94	Muva	*Phoenix sp*

Appendix 7: List of sample trees measured for heights in NEMFR, Mpanda district.

SPP CODE	SPECIES' NAME VERNACULAR NAME	BOTANICAL NAME	DBH	HT
3	myombo/msilanga	*Brachystegia bochmii*	27	24.5
8	kibula/kibua /mluzyaminzi	*Combretum adenogonium*	27	16
16	Mgando	*Unknown*	14	11
2	Mtundu	*Brachystegia spciformis*	34	15.5
7	Mninga	*Pterocarpus angolensis*	18	18
22	Kapepe	*Brachystegia microphylla*	46	15
22	Kapepe	*Brachystegia microphylla*	30	21
9	mgunga/mbombwe/mdungwa	*Accacis nilotica*	8	7
20	Msongati	*Diplorhynchos condylocarpon*	14	13
33	Mlandala	*Combretum collium*	16	19
3	myombo/msilanga	*Brachystegia bochmii*	19	11
36	Mkuwa	*Hexalobus monopetalus*	34	25
38	mkalya/Mkalya/Mkarye	*Zanha africana*	36	21
13	kasanda/mnyegenyege	*Swartzia madagascariensis*	12	9
33	Mlandala	*Combretum collium*	25	13
20	Msongati	*Diplorhynchos condylocarpon*	13	11
44	mseveye/Mseweye	*Chrysophyllum benguelensis*	22	15
44	mseveye/Mseweye	*Chrysophyllum benguelensis*	6	7
46	Msindwi	*Unknown*	18	15
7	Mninga	*Pterocarpus angolensis*	19	14
3	myombo/msilanga	*Brachystegia bochmii*	51	13
3	myombo/msilanga	*Brachystegia bochmii*	30	17
13	kasanda/mnyegenyege	*Swartzia madagascariensis*	18	11
7	Mninga	*Pterocarpus angolensis*	19	17
46	Msindwi	*Unknown*	17	13
3	myombo/msilanga	*Brachystegia bochmii*	5	5
7	Mninga	*Pterocarpus angolensis*	37	20
33	Mlandala	*Combretum collium*	24	21
46	Msindwi	*Unknown*	14	16
3	myombo/msilanga	*Brachystegia bochmii*	13	11
2	Mtundu	*Brachystegia spiciformice*	68	25
15	mbula/Muwala/Muvula	*Perinari curatifilia*	6	8
3	myombo/msilanga	*Brachystegia bochmii*	19	13
3	myombo/msilanga	*Brachystegia bochmii*	39	21
13	kasanda/mnyegenyege	*Swartzia madagascariensis*	15	9
13	kasanda/mnyegenyege	*Swartzia madagascariensis*	11	9
94	Muva	*Phoenix sp*	27	17
11	mpilipili/mgando	*Albizia antunesiana*	49	20
3	myombo/msilanga	*Brachystegia bochmii*	63	21
2	Mtundu	*Brachystegia spiciformice*	70	25
36	Mkuwa	*Hexalobus monopetalus*	8	10
7	Mninga	*Pterocarpus angolensis*	47	20
33	Mlandala	*Combretum collium*	31	21
3	myombo/msilanga	*Brachystegia bochmii*	60	22
61	Kashamongo	*Syzigium guinensis*	15	9
60	mbombo	*Unknown*	6	7
11	mpilipili/mgando	*Albizia antunesiana*	18	17
3	myombo/msilanga	*Brachystegia bochmii*	17	18
33	mlandala	*Combretum collium*	9	8
42	mkurungu	*Pterocarpus tintorious*	7	9
7	mninga	*Pterocarpus angolensis*	47	22
33	mlandala	*Combretum collium*	9	12
2	Mtundu	*Brachystegia spiciformice*	41	20
3	myombo/msilanga	*Brachystegia bochmii*	5	7
33	mlandala	*Combretum collium*	21	21
46	msindwi	*Unknown*	17	12
3	myombo/msilanga	*Brachystegia bochmii*	24	18
11	mpilipili/mgando	*Albizia antunesiana*	7	8
75	katunguluvaganga/Mtunguru	*Pseudolachynostylis maprouncifolia*	9	11
9	mgunga/mbombwe/mdungwa	*Accacis niloticai*	28	15
3	myombo/msilanga	*Brachystegia bochmii*	5	9
7	mninga	*Pterocarpus angolensis*	14	15.5
2	Mtundu	*Brachystegia spiciformice*	33	21
33	mlandala	*Combretum collium*	13	16
8	kibula/kibua /mluzyaminzi	*Combretum adenogonium*	27	17
1	mgumbu	*Lannea schweinfurthii*	19	16
58	mwezya/Mwesya	*Maytenus senegalensis*	17	15
11	mpilipili/mgando	*Albizia antunesiana*	18	12
61	kashamongo	*Syzigium guinensis*	16	11
20	msongati	*Diplorhynchos condylocarpon*	33	20
61	kashamongo	*Syzigium guinensis*	20	18
2	Mtundu	*Brachystegia spiciformice*	26	17
3	myombo/msilanga	*Brachystegia bochmii*	17	14
3	myombo/msilanga	*Brachystegia bochmii*	37	20.5
53	mliwamfwengi/mliwafyengi	*Oldfieldia dactylophylla*	8	9
17	mbanga/muvanga	*Pericopsis angolensis*	26	15
3	myombo/msilanga	*Brachystegia bochmii*	21	9
11	mpilipili/mgando	*Albizia antunesiana*	12	14
22	kapepe	*Brachystegia microphylla*	30	21
3	myombo/msilanga	*Brachystegia bochmii*	24	14
7	mninga	*Pterocarpus angolensis*	35.5	23
3	myombo/msilanga	*Brachystegia bochmii*	19	13
22	kapepe	*Brachystegia microphylla*	46	19
13	kasanda/mnyegenyege	*Swartzia madagascariensis*	14	16
1	Mgumbu	*Lannea schweinfurthii*	8	9
7	mninga	*Pterocarpus angolensis*	18	16
42	mkurungu	*Pterocarpus tintorious*	7	9.5
2	Mtundu	*Brachystegia spiciformice*	51	24
7	mninga	*Pterocarpus angolensis*	19	15
46	msindwi		18	13

11	mpilipili/mgando	*Albizia antunesiana*	7	5	44	mseveye/Mseweye	*Chrysophyllum bengulensis*	6	10
11	mpilipili/mgando	*Albizia antunesiana*	13	9	20	msongati	*Diplorhynchos condylocarpon*	13	11
46	Msindwi	*Unknown*	15	10	2	Mtundu	*Brachystegia spiciformice*	28	10
58	mwezya/Mwesya	*Maytenus senegalensis*	11	8	33	mlandala	*Combretum collum*	25	16
3	myombo/msilanga	*Brachystegia bochmii*	5	6	3	myombo msilanga	*Brachystegia bochmii*	27	14
33	Mlandala	*Combretum collium*	40	20	7	Mninga	*Pterocarpus angolensis*	19	9
2	Mtundu	*Brachystegia spiciformice*	22	19	1	Mgumbu	*Lannea schweinfurthii*	9	7
3	myombo/msilanga	*Brachystegia bochmii*	35.5	21	36	Mkuwa	*Hexalobus monopetalus*	16	13
3	myombo/msilanga	*Brachystegia bochmii*	31	21	46	Msindwi		14	17
3	myombo/msilanga	*Brachystegia bochmii*	31	15	2	Mtundu	*Brachystegia spiciformice*	48	20
3	myombo/msilanga	*Brachystegia bochmii*	53	23	11	mpilipili/mgando	*Albizia antunesiana*	18	15
13	kasanda/mnyegenyege	*Swartzia madagascariensis*	6	7	7	Mninga	*Pterocarpus angolensis*	10	13
6	Mlama	*Combretum molle*	10	11	7	Mninga	*Pterocarpus angolensis*	34	21
22	Kapepe	*Brachystegia microphylla*	5	7	3	myombo/msilanga	*Brachystegia bochmii*	47	22
3	myombo/msilanga	*Brachystegia bochmii*	9	10	3	myombo/msilanga	*Brachystegia bochmii*	39	20
11	mpilipili/mgando	*Albizia antunesiana*	29	19	33	Mlandala	*Combretum collium*	40	19
40	Mputika	*Sechrebera frinchoclade*	18	16	3	myombo/msilanga	*Brachystegia bochmii*	50	24
7	Mninga	*Pterocarpus angolensis*	19	17	3	myombo/msilanga	*Brachystegia bochmii*	46	23
15	mbula/Muwala/Muvula	*Perinari curatifilia*	59	22	17	mbanga/muvanga	*Pericopsis angolensis*	28	12
2	Mtundu	*Brachystegia spciformis*	27	19	3	myombo/msilanga	*Brachystegia bochmii*	27	21
12	mkora/mkongo/mkola	*Afzelia quanzensis*	28	19	40	Mputika	*Sechrebera frinchoclade*	19	17
2	Mtundu	*Brachystegia spiciformice*	18	15	3	myombo/msilanga	*Brachystegia bochmii*	37	17
17	mbanga/muvanga	*Pericopsis angolensis*	25	15	17	mbanga/muvanga	*Pericopsis angolensis*	40	21
1	Mgumbu	*Lannea schweinfurthii*	9	8	3	myombo/msilanga	*Brachystegia bochmii*	50	24
7	Mninga	*Pterocarpus angolensis*	12	17	3	myombo/msilanga	*Brachystegia bochmii*	43	23
35	Mlugala	*Cassipourea mollis*	10	13	94	Muva	*Phoenix sp*	18	15

Appendix 8: Diameter distribution of trees in the whole forest (NEMFR), Mpanda district

SPP CODE	SPECIES' NAME	Frq.	DIAMETER CLASSES 5.0 - 15			15.1- 25			25.1 – 35			35.1 - 45			45.1- 55			55.1 - 65			65 <			TOTAL		
			N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V
1	*Lannea schweinfurthii*	47	1700	11.34	71.94	481	12.32	97.6	100	6.85	64.34													2281	30.5	233.88
2	*Brachystegia spiciformice*	407	5367	32.93	207.8	2062	58.92	477	1614	122	1165	1029	137.8	1458	500	98.88	1121	229	64	776	##	111	1472	11043	626.1	6677.53
3	*Brachystegia boehmii*	324	9067	46.53	286.7	1757	54.72	447	857	55.84	522.3	514	65.47	688.4	471	95.76	1085	157	45	538	29	12	150	12852	375.17	3717.2
4	*Julbernardia globiflora*	1							14	1.62	16.62													14	1.62	16.62
5	*Pseudolachynostylis maprouneifolia*	1	33	0.59	4.33																			33	0.59	4.33
6	*Combretum molle*	25	333	1.96	12.45	367	11.73	96.6	86	5.89	55.54													786	19.58	164.62
7	*Pterocarpus angolensis*	179	4300	24.48	155.6	1167	34.77	287	471	31.96	300.1	257	31.76	333.5	186	36.39	411	114	32	386	14	5.8	75.1	6510	197.15	1947.1
8	*Combretum adenogonium*	52	2600	18.28	120.4	133	3.23	25.2	43	2.65	24.24	29	3.07	31.22	14	2.92	33.3							2819	30.15	234.32
9	*Acacia nilotica*	16	1100	5.94	35.8	67	1.7	13.4	14	0.88	7.44													1181	8.53	56.63
10	*Piliostigma thonningii*	3	300	1.51	8.85																			300	1.51	8.85
11	*Albizia antunesiana*	184	6467	34.9	214.2	1505	43.04	348	343	23.32	219.3	214	25.95	269.7	143	27.85	313	43	12	139				8714	166.67	1503.35
12	*Afzelia quanzensis*	47	1400	7.23	44.26	248	6.75	53.7	100	6.29	58.69	43	5.58	58.69	100	20.6	235	43	12	148	14	5.5	70.2	1948	64.21	669.36
13	*Swartzia madagascariensis*	38	1148	9.35	62.59	290	7.47	58.5	57	3.41	31.29	29	3.42	35.5	14	2.92	33.3				14	5.8	75.1	1552	32.4	296.19
14	*Trilepisium madagascariensis*	44	2533	11.1	66.32	310	8.59	68.6	29	2.02	19.07	14	1.54	15.61										2886	23.25	169.62
15	*Perinari curatifillia*	64	1567	10.57	69.84	410	12.63	104	129	8.28	76.92	71	8.04	82.44	29	5.73	65.1	71	21	252				2276	66.19	650.01
16	*Unknown*	2	33	0.51	3.46	14	0.82	7.42																48	1.33	10.88
17	*Pericopsis angolensis*	144	1933	14.69	96.16	895	27.74	227	386	27.23	255.1	343	43.22	453.1	157	34.35	397	143	39	467	29	13	165	3886	198.76	2059.96
18	*Vitex doniana*	3	100	0.28	1.5				29	1.76	16.18													129	2.04	17.67
20	*Diplorhynchos condylocarpon*	90	4800	26.88	168.3	333	8.61	67.9	57	3.89	37.23	114	15.51	164.5	14	3.4	39.8				14	5.8	75.1	5333	64.11	552.71
21	*crossopteryx febrifuga*	2	200	0.57	2.99																			200	0.57	2.99
22	*Brachystegia microphylla*	46	467	1.38	7.69	400	12.29	100	243	16.35	155	100	14.7	150.4	14	3.78	45.1							1224	48.49	458.43
23	*Commiphora mossambicensis*	2	200	0.57	2.99																			200	0.57	2.99
24	*Pterocarpus sp.*	14	400	2.47	15.31	48	1.55	12.9				14	2.48	27.44				57	15	182	14	5.8	75.1	533	27.5	312.18
25	*Diospyros kirkii*	1	100	0.2	0.97	100	2.55	20																200	2.74	20.94
26	*Dombeya rotundifolia*	2	200	0.57	2.99																			200	0.57	2.99
27	*Terminalia mollis*	1	100	0.28	1.5																			100	0.28	1.5
28	*Vitex ferruginea*	1	100	0.28	1.5	14	0.5	4.1	29	1.76	16.18													143	2.54	21.78
29	*Terminalia sericea*	10	600	1.9	10.29	57	3.54	32.6																657	5.44	42.91
30	*Lonchocarpus capassa*	3	43	5.8	61.61																			43	5.8	61.61
31	*Strichnos pungens*	13	967	4.14	24.45	33	0.95	7.56	14	0.82	7.42													1014	5.9	39.44
32	*Berchemia discolour*	14	233	1.49	9.23	100	2.36	18.3	71	5.15	48.8	29	4.35	46.98				14	3.7	43				448	16.99	166.56

33	*Combretum collium*	101	1800	10.71	68.41	1043	30.04	246	229	14.99	140.9	129	15.31	157.6	114	22.41	254	14	4.2	51	3329	97.64	916.97
34	*Strychnos potarum*	2	29	3.41	35.35																29	3.41	35.35
35	*Cassipourea mollis*	15	967	5.47	33.64	100	2.46	19.2	14	0.82	7.42										1081	8.75	60.26
36	*Hemilobus monopetalus*	46	2000	11.22	69.5	295	8.14	65.2	171	11.79	113.7										2467	31.15	248.42
37	*Unknown*	13	100	0.2	0.97	67	1.34	10.1	100	6.49	60.24	29	3.59	37.56				14	3.5	41	310	15.14	150.35
38	*Zanha africana*	7	100	0.39	2.15	48	1.3	10.4	14	1.15	11.08	29	2.91	30.12				14	3.7	43	205	9.39	97.01
40	*Sechrebera frinchoclade*	15	700	1.38	6.81	167	4.44	36.9	14	1.15	11.08	14	1.71	17.67				14	3.8	45	910	12.45	117.54
41	*Hymenocardia acida*	8	133	1.15	7.57	33	0.76	5.82	43	2.98	28.1	14	1.98	21.05	14	2.48	27.4				238	9.35	89.98
42	*Pterocarpus tintorious*	18	533	2.5	14.79	76	2.73	22.8	43	2.93	27.5	29	3.07	31.22	43	7.65	85.2				724	18.88	181.48
43	*Isoberlinia tomentosa*	10				76	2.68	22.4	71	5.92	57.47	14	1.89	19.89							162	10.49	99.72
44	*Chrysophyllum benguelensis*	4	233	0.69	3.71		28.57	1.09	9												242	29.27	4.8
45	*dalbergia melanoxylon*	1	100	0.28	1.5																100	0.28	1.5
46	Unknown	38	767	5.73	38.96	538	14.52	115	100	7.48	71.41				14	2.48	27.4				1419	30.21	253.19
47	*Uapaka Kirkiana*	21	1133	5.52	34.19	129	3.45	27.5	29	1.76	16.21										1290	10.73	77.82
49	Unknown	1	100	0.28	1.5																100	0.28	1.5
50	Unknown	12	433	2.3	13.95	148	3.95	31.4	29	2.3	22.17										610	8.56	67.51
53	*Oldfieldia dactylophylla*	16	700	3.37	20.14	95	2.43	19.2	14	0.76	6.79	29	3.24	33.28							838	9.8	79.46
58	*Maytenus senegalensis*	4	333	1.65	9.53	33	0.76	6.3													367	2.41	15.83
59	*Malbania obtusifolia*	6	67	1.03	7.36	33	0.95	7.56	29	2.44	23.84	14	3.15	36.44							143	7.57	75.19
60	Unknown	6	333	0.89	4.68	67	1.61	12.5				14	2.48	27.44							414	4.98	44.6
61	*Syzigum guinensis*	7	300	2.45	15.77	67	1.72	14.4													367	4.17	30.2
63	Unknown	1							14	0.94	8.79										14	0.94	8.79
64	*Diospyros zombensis*	1							14	1.08	10.28										14	1.08	10.28
66	Unknown	1	100	0.2	0.97																100	0.2	0.97
67	*Dichrostachys cinera*	1							14	0.88	8.09										14	0.88	8.09
69	*Annona senegalensis*	4	300	2.07	12.93	33	0.85	6.66													333	2.92	19.59
72	Unknown	3	233	1.01	6.08																233	1.01	6.08
74	*Strychnos innocua*	1										14	1.54	15.61							14	1.54	15.61
75	*Pseudolachnostylis maprouneifolia*	27	1000	3.72	21.11	329	8.96	71.5	29	2.06	19.58	43	5.5	57.71	14	2.59	28.8				1414	22.81	198.68
77	*Xylopia antunesii*	25	1400	7.23	43.65	281	7.59	60.4													1681	14.82	103.99
78	*Treculia africana*	4	233	0.84	5.04	33	0.95	7.56													267	1.78	12.6
84	Unknown	1	100	0.28	1.5																100	0.28	1.5
89	*Psorospermum febrifugum*	2	200	0.57	2.99																200	0.57	2.99
91	*Terminalia mollis*	1	100	0.28	1.5																100	0.28	1.5
92	*Grewia bicolor*	1				33	0.95	7.56													33	0.95	7.56

93	Unknown	13	200	1.91	12.87	81	2.06	16.2	57	3.78	35.15	29	3.96	42.1										367	11.7	106.33
94	*Phoenix sp*	75	1667	10.41	67.26	381	11.47	93.7	271	20.13	193.7	186	23.35	244.4	43	7.66	85.2							2548	73.02	684.31
GRAND TOTAL		2292	64786	367.9	2338	14976	461.4	3511	5995	419.8	3970	3386	436.6	4588	1886	377.8	4286	929	259	3111	371	164	2158	92328	2486.93	23962.75

Appendix 9: Composition of species' diversity indices basing on their utilisation in the whole forest (NEMFR), Mpanda district

SPP CODE	SPECIES' NAME		TOTAL N.V & G			COMPONENTS OF INDECES					DIVERSIRTY INDICES			
	VERNACULAR NAME	BOTANICAL NAME	N	G	V	Frq.	(n/N)	RFrq	Rb	Rd	H'	ID	IVI	
													Value	%
A. Trees harvested for timber														
2	Mtundu	*Brachystegia spiciformice*	11043	626.10	6677.53	407.00	0.12	17.76	25.18	25.18	0.25	0.014	68.11	
3	myombo/msilanga	*Brachystegia boehmii*	12852	375.17	3717.20	324.00	0.14	14.14	15.09	15.09	0.27	0.019	44.31	
7	Mninga	*Pterocarpus angolensis*	6510	197.15	1947.10	179.00	0.07	7.81	7.93	7.93	0.19	0.005	23.66	
11	mpilipili/mgando	*Albizia antunesiana*	8714	166.67	1503.35	184.00	0.09	8.03	6.70	6.70	0.22	0.009	21.43	
12	mkora/mkongo/mkola	*Afzelia quanzensis*	1948	64.21	669.36	47.00	0.02	2.05	2.58	2.58	0.08	0.000	7.21	
13	kasanda/mnyegenyege	*Swartzia madagascariensis*	1552	32.40	296.19	38 00	0.02	1.66	1.30	1.30	0.07	0.000	4.26	
17	mbanga/muvanga	*Pericopsis angolensis*	3886	198.76	2059.96	144.00	0.04	6.28	7.99	7.99	0.13	0.002	22.27	
18	mfulu/mpulu	*Vitex doniana*	129	2.04	17.67	3.00	0.00	0 13	0.08	0.08	0.01	0.000	0.30	
24	Masaka	*Pterocarpus sp.*	533	27 50	312 18	14.00	0.01	0.61	1.11	1.11	0.03	0.000	2.82	
28	Mfuru	*Vitex ferruginea*	143	2 54	21.78	1.00	0.00	0.04	0.10	0.10	0.01	0.000	0.25	
43	Mnembela	*Isorberlinia tomentosa*	162	10.49	99.72	10.00	0.00	0 44	0.42	0.42	0.01	0.000	1.28	
64	Msole	*Diospyros zombensis*	14	1.08	10 28	1.00	0.00	0.04	0 04	0.04	0.00	0 000	0.13	
Sub total			**47486**	**1704.10**	**17332.32**	**1352.00**	**0.51**	**58.99**	**68.52**	**68.52**	**1.28**	**0.050**	**196.03**	**65.34**
B. Trees harvested for poles,building materials and medicine														
4	muba/muva/muwa	*Julbernardia globiflora*	14	1 62	16.62	1 00	0.00	0 04	0.07	0.07	0 00	0.000	0.17	
45	mpingo/mgembe	*dalbergia melanoxylon*	100	0.28	1.50	1.00	0 00	0.04	0.01	0.01	0.01	0.000	0.07	
78	Munsa	*Treculia africana*	267	1.78	12.60	4.00	0 00	0.17	0.07	0.07	0 02	0.000	0.32	
94	Muva	*Phoenix sp*	2548	73 02	684 31	75.00	0.03	3.27	2.94	2.94	0 10	0.001	9.14	
Sub total			**2929**	**76.71**	**715.02**	**81.00**	**0.03**	**3.53**	**3.08**	**3.08**	**0.12**	**0.001**	**9.70**	**3.23**
C. Trees that produce fruits/food														
58	mwezya/Mwesya	*Maytenus senegalensis*	367	2 41	15 83	4.00	0.00	0.17	0.10	0.10	0.02	0.000	0.37	
61	Kashamongo	*Syzigium guinensis*	367	4 17	30 20	7 00	0.00	0.31	0.17	0 17	0.02	0.000	0.64	
75	katunguluvaganga/Mtunguru	*Pseudolachynostylis maprouncifolia*	1414	22.81	198 68	27 00	0.02	1 18	0.92	0 92	0 06	0.000	3.01	
15	mbula/Muwala/Muvula	*Perinari curatifillia*	2276	66.19	650 01	64.00	0.02	2.79	2.66	2.66	0.09	0.001	8.12	
47	Mkusu	*Uapaka Kirkiana*	1290	10.73	77 89	21 00	0 01	0.92	0 43	0.43	0 06	0.000	1.78	
50	Mnkundu	*Unknown*	610	8 56	67 51	12 00	0 01	0.52	0 34	0 34	0.03	0.000	1.21	
69	mtopetope pori	*Annona senegalensis*	333	2.92	19.59	4.00	0.00	0 17	0.12	0.12	0.02	0.000	0.41	
10	mfynduamboga/mfunduambogo	*Pilliostigma*	300	1 51	8 85	3.00	0.00	0.13	0 06	0 06	0.02	0.000	0 25	

		thonningii												
53	mliwamfwengi/mliwafyengi	*Oldfieldia dactylophylla*	838	9.80	79.46	16.00	0.01	0.70	0.39	0.39	0.04	0.000	1.49	
Sub total			**7795**	**129.11**	**1148.02**	**158.00**	**0.08**	**6.89**	**5.19**	**5.19**	**0.37**	**0.001**	**17.28**	**5.76**
D. Other trees														
16	Mgando	*Unknown*	48	1 33	10 88	2.00	0.00	0.09	0.05	0.05	0.00	0.000	0.19	
42	Mkurungu	*Pterocarpus tinorious*	724	18 88	181.48	18.00	0.01	0.79	0.76	0.76	0.04	0.000	2.30	
84	Mbamba	*Unknown*	100	0.28	1.50	1.00	0.00	0.04	0.01	0.01	0.01	0.000	0.07	
32	Mkuni	*Berchemia discolor*	448	16.99	166.56	14.00	0.00	0.61	0.68	0.68	0.03	0.000	1.98	
37	Mbumbu	*Unknown*	310	15.14	150 35	13 00	0.00	0.57	0.61	0.61	0.02	0.000	1.78	
60	Mhombo	*Unknown*	414	4.98	44.60	6 00	0.00	0.26	0.20	0.20	0.02	0.000	0.66	
1	Mgumbu	*Lannea schweinfurthii*	2281	30 50	233.88	47 00	0.02	2.05	1.23	1.23	0.09	0.001	4.50	
5	Mtunguru	*Pseudolachynostylis maprouncifolia*	33	0.59	4 33	1.00	0.00	0.04	0.02	0.02	0.00	0.000	0.09	
6	Mlama	*Combretum molle*	786	19.58	164.62	25.00	0.01	1.09	0.79	0.79	0.04	0.000	2.66	
8	kibula/kibua /mluzyaminzi	*Combretum adenogonium*	2819	30.15	234.32	52.00	0.03	2.27	1.21	1.21	0.11	0.001	4.69	
9	mgunga/mbombwe/mdungwa	*Accacis nilotica*	1181	8.53	56.63	16.00	0.01	0 70	0.34	0.34	0.06	0.000	1 38	
14	mfilafila/mfira	*Trilepisum madacascariensis*	2886	23.25	169.62	44 00	0.03	1.92	0.93	0.93	0.11	0.001	3.79	
20	Msongati	*Diplorhynchos condylocarpon*	5333	64 11	552.71	90 00	0.06	3.93	2.58	2 58	0.16	0.003	9.08	
21	msanzambele/Mkozikozi	*crossopteryx febrifuga*	200	0 57	2.99	2.00	0 00	0 09	0.02	0.02	0.01	0.000	0.13	
22	Kapepe	*Brachystegia microphylla*	1224	48.49	458 43	46.00	0 01	2.01	1 95	1.95	0.06	0.000	5.91	
23	Kiponda	*Commiphora mossambicensis*	200	0 57	2.99	2 00	0.00	0.09	0 02	0.02	0.01	0.000	0.13	
25	Mnumbula	*Dirospyros kirkii*	200	2.74	20 94	1.00	0.00	0.04	0.11	0 11	0.01	0 000	0.26	
26	Mfumbe	*Dombeya rotundifolia*	200	0.57	2.99	2.00	0 00	0.09	0 02	0.02	0.01	0.000	0.13	
27	kaselenga/mkelenge	*Terminalia mollis*	100	0 28	1.50	1.00	0.00	0.04	0.01	0.01	0.01	0.000	0 07	
29	Kazima	*Terminalia sericea*	657	5 44	42 91	10.00	0.01	0 44	0.22	0 22	0.04	0.000	0.87	
30	mbalebale/Mvalevale/Mvale	*Lonchocarpus capassa*	43	5 80	61 61	3.00	0 00	0.13	0.23	0 23	0.00	0.000	0.60	
31	Mkome	*Sctrichnos punges*	1014	5 90	39 44	13.00	0.01	0.57	0.24	0 24	0.05	0 000	1.04	
33	Mlandala	*Combretum collium*	3329	97 64	916 97	101 00	0.04	4.41	3.93	3.93	0.12	0.001	12.26	
34	mgwegwe/Mgwege/Mpandepande	*Strychnos potarum*	29	3.41	35.35	2.00	0 00	0 09	0 14	0.14	0.00	0.000	0.36	
35	Mlugala	*Cassipourea mollis*	1081	8.75	60 26	15.00	0.01	0 65	0.35	0.35	0.05	0.000	1.36	
36	Mkuwa	*Hexalobus monopetalus*	2467	31 15	248.42	46 00	0 03	2.01	1.25	1.25	0.10	0.001	4.51	
38	mkalya/Mkalya/Mkarye	*Zanha Africana*	205	9.39	97 01	7.00	0.00	0.31	0 38	0 38	0.01	0.000	1.06	
40	Mputika	*Sechrebera frnchoclade*	910	12 45	117 54	15 00	0.01	0 65	0.50	0 50	0.05	0.000	1.66	
41	kapala/mpala	*Hymenocardia acida*	238	9.35	89.98	8 00	0 00	0.35	0 38	0.38	0 02	0.000	1.10	

44	mseveye/Mseweye	*Chrysophyllum benguelensis*	242	29.27	4.80	4.00	0.00	0.17	1.18	1.18	0.02	0.000	2.53	
46	Msindwi	*Unknown*	1419	30.21	253.19	38.00	0.02	1.66	1.21	1.21	0.06	0.000	4.09	
49	Kasyenela	*Unknown*	100	0.28	1.50	1.00	0.00	0.04	0.01	0.01	0.01	0.000	0.07	
59	Mpapa	*Makhamia obtusifolia*	143	7.57	75.19	6.00	0.00	0.26	0.30	0.30	0.01	0.000	0.87	
63	Mningoningo	*Unknown*	14	0.94	8.79	1.00	0.00	0.04	0.04	0.04	0.00	0.000	0.12	
66	Kapyupyu	*Unknown*	100	0.20	0.97	1.00	0.00	0.04	0.01	0.01	0.01	0.000	0.06	
67	kasunzuru/mtundulu	*Dichrostachys cinera*	14	0.88	8.09	1.00	0.00	0.04	0.04	0.04	0.00	0.000	0.11	
72	mtewe/Mtejwe	*Unknown*	233	1.01	6.08	3.00	0.00	0.13	0.04	0.04	0.02	0.000	0.21	
74	Mkulwa	*Strychnos innocua*	14	1.54	15.61	1.00	0.00	0.04	0.06	0.06	0.00	0.000	0.17	
77	kashenene/mshenene	*Xylopia antunesii*	1681	14.82	103.99	25.00	0.02	1.09	0.60	0.60	0.07	0.000	2.28	
89	kalilolilo/Msalunhunda	*Psorospemum febrifugum*	200	0.57	2.99	2 00	0 00	0 09	0.02	0.02	0.01	0.000	0.13	
91	kagelenge/Kaselenge/Kakelenge	*Terminalia mollis*	100	0 28	1.50	1.00	0 00	0.04	0.01	0.01	0.01	0.000	0.07	
92	mkame/Mkomalendi	*Grewia bascolor*	33	0.95	7.56	1.00	0.00	0.04	0 04	0.04	0.00	0.000	0.12	
93	Ikuya/Ikuja	*Unknown*	367	11.70	106.33	13 00	0 00	0.57	0.47	0.47	0.02	0.000	1.51	
Sub total			34119	577.01	4767.39	701.00	0.37	30.58	23.20	23.20	1.48	0.009	76.99	25.66
GRAND TOTAL			92328	2486.93	23962.75	2292.00	1.00	100.00	100.00	100.00	3.26	0.062	300.00	100.00

Appendix 10: Tree diameter distribution in undisturbed stratum of NEMFR in Mpanda district

CODE	BOTANICAL NAME	Frq	DIAMETER CLASSES 5.1-15			15.1-25			25.1-35			35.1-45			45.1-55			55.1-65			65<			TOTAL		
			N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V
1	*Lannea schweinfurthii*	47	1700	11.34	71.91	481	12.32	97.59	100	6.85	64.34													2281	30.5	233.88
2	*Brachystegia spiciformis*	408	5367	32.93	207.8	2062	58.92	476.6	1629	123	1172	1029	137.8	1458	500	98.88	1121	229	64.2	776	243	111	1472	11057	626.92	6685
3	*Brachystegia boehmii*	323	9067	46.53	286.7	1757	54.72	446.8	843	55	514.9	514	65.47	688.4	471	95.76	1085	157	45.2	538	29	11.6	150.2	12838	374.35	3709.6
4	*Julbernardia globiflora*	1										14	1.62	16.62										14	1.62	16.62
5	*Pseudolachnostylis maprouneifolia*	1	33	0.59	4.33																			33	0.59	4.33
6	*Combretum molle*	25	333	1.96	12.45	367	11.73	96.63	86	5.89	55.54													786	19.58	164.62
7	*Pterocarpus angolensis*	179	4300	24.48	155.6	1167	34.77	286.7	471	37	300.1	257	31.76	333.5	186	36.39	410.7	114	32	386	14	5.82	75.06	6510	197.15	1947.1
8	*Combretum adenogonium*	52	2600	18.28	120.4	133	3.23	25.21	43	2.65	24.24	29	3.07	31.22	14	2.92	33.28							2819	30.15	234.32
9	*Acacia nilotica*	16	1100	5.94	35.8	67	1.7	13.38	14	0.88	7.44													1181	8.53	56.63
10	*Piliostigma thonningii*	3	300	1.51	8.85																			300	1.51	8.85
11	*Albizia antunesiana*	183	6167	34.9	214.2	1505	43.01	348.3	343	23.3	219.3	200	24.07	249.8	143	27.85	312.9	43	11.6	139				8700	164.78	1483.5
12	*Afzelia quanzensis*	47	1400	7.21	44.26	214	5.7	45.01	133	7.34	67.37	43	5.58	58.69	100	20.6	235.4	43	12.3	148	14	5.5	70.23	1948	64.21	669.36
13	*Swartzia madagascariensis*	38	1148	9.35	62.59	290	7.47	58.48	57	3.41	31.29	29	3.42	35.5	14	2.92	33.28				14	5.82	75.06	1552	32.4	296.19
14	*Trilepisium madagascariensis*	44	2533	11.1	66.32	310	8.59	68.62	29	2.02	19.07	14	1.54	15.61										2886	23.25	169.62
15	*Parinari curatellifolia*	64	1567	10.57	69.84	410	12.63	104	129	8.28	76.92	71	8.04	82.44	29	5.73	65.12	71	21	262				2276	66.19	650.01
16	*Unknown*	2	33	0.51	3.46				14	0.82	7.42													48	1.33	10.88
17	*Pericopsis angolensis*	144	1900	14.02	91.11	929	28.41	231.5	386	27.2	255.1	343	43.22	453.1	157	34.35	396.9	143	38.9	467	29	12.6	165.3	3886	198.76	2060
18	*Vitex doniana*	1	100	0.28	1.5	29	1.76	16.18																129	2.04	17.67
20	*Diplorhynchus condylocarpon*	90	4800	26.88	168.3	333	8.61	67.86	57	3.89	37.23	114	15.51	164.5	14	3.4	39.76				14	5.82	75.06	5333	64.11	552.71
21	*Crossopteryx febrifuga*	2	200	0.57	2.99																			200	0.57	2.99
22	*Brachystegia microphylla*	46	467	1.38	7.69	400	12.29	100.4	243	16.4	155	57	7.57	80				57	10.9	115				1224	48.49	458.43
23	*Commiphora mossambicensis*	1	200	0.57	2.99																			200	0.57	2.99
24	*Pterocarpus sp*	14	400	2.47	15.31	48	1.55	12.85							14	2.48	27.44	57	15.2	182	14	5.82	75.06	533	27.5	312.18
25	*Diospyros kirkii*	3	67	1.7	13.31																			67	1.7	13.31
26	*Dombeya rotundifolia*	2	200	0.57	2.99																			200	0.57	2.99
27	*Terminalia mollis*	1	100	0.28	1.5																			100	0.28	1.5
28	*Vitex ferruginea*	5	100	0.28	1.5	14	0.5	4.1	43	2.98	28.1													157	3.76	33.7
29	*Terminalia sericea*	10	600	1.9	10.29				57	3.54	32.62													667	5.44	42.91
30	*Lonchocarpus capassa*	3										14	1.45	14.63	29	4.35	46.98							43	5.8	61.61
31	*Strychnos pungens*	13	967	4.14	24.45	33	0.95	7.56	14	0.82	7.42													1014	5.9	39.44
32	*Berchemia discolor*	14	233	1.49	9.23	100	2.36	18.29	71	5.15	48.8	29	4.35	46.98				14	3.65	43.3				448	16.99	166.55
33	*Combretum collinum*	101	1800	10.71	68.41	1043	30.04	245.6	229	15	140.9	129	15.31	157.6	114	22.41	253.8	14	4.18	50.8				3329	97.64	916.97
34	*Strychnos potatorum*	2										29	3.41	35.35										29	3.41	35.35
35	*Cassipourea mollis*	15	967	5.47	33.64	100	2.46	19.2	14	0.82	7.42													1081	8.75	60.26
36	*Hexalobus monopetalus*	36	2000	11.22	69.5	295	8.14	65.2	171	11.8	113.7													2467	31.15	248.42
37	*Unknown*	13	100	0.2	0.97	67	1.34	10.08	100	6.49	60.24	29	3.59	37.56				14	3.52	41.5				310	15.14	150.35
38	*Zanha africana*	7	100	0.39	2.15	48	1.3	10.4	14	1.15	11.08	29	2.91	30.12				14	3.65	43.3				205	9.39	97.01
39	*Schrebera*	15	700	1.38	6.81	167	4.44	36.9	14	1.15	11.08	14	1.71	17.67				14	3.78	45.1				910	12.45	117.54

	frinchoglade																									
41	*Hymenocardia acida*	8	133	1.15	7.57	33	0.76	5.82	43	2.98	28.1	14	1.98	21.05	14	2.48	27.44							238	9.35	89.98
42	*Pterocarpus tintorious*	18	533	2.5	14.79	76	2.73	22.81	43	2.93	27.5	29	3.07	31.22	43	7.65	85.17							724	18.88	181.48
43	*Isoberlinia tomentosa*	10				76	2.68	22.36	71	5.92	57.47	14	1.89	19.89										162	10.49	99.72
44	*Chrysophyllum benguelensis*	4	233	0.69	3.71	29	1.09	9.14																262	1.78	12.85
45	*dalbergia melanoxylon*	1	100	0.28	1.5																			100	0.28	1.5
46	*Unknown*	38	767	5.73	38.96	538	14.52	115.4	100	7.48	71.41				14	2.48	27.44							1419	30.21	253.19
47	*Uapaka Kirkiana*	21	1133	5.52	34.19	129	3.45	27.48	29	1.76	16.21													1290	10.73	77.89
49	*Unknown*	1	100	0.28	1.5																			100	0.28	1.5
50	*Unknown*	12	433	2.3	13.95	148	3.95	31.4	29	2.3	22.17													610	8.56	67.51
53	*Oldfieldia dactylophylla*	16	700	3.37	20.14	95	2.43	19.24	14	0.76	6.79	29	3.24	33.28										838	9.8	79.46
58	*Maytenus senegalensis*	5	333	1.65	9.53	33	0.76	6.3																367	2.41	15.83
59	*Makhamia obtusifolia*	6	67	1.03	7.36	33	0.95	7.56	29	2.44	23.84				14	3.15	36.44							143	7.57	75.19
60	*Unknown*	6	333	0.89	4.68	67	1.61	12.47							14	2.48	27.44							414	4.98	44.6
61	*Syzigium guinensis*	7	300	2.45	15.77	67	1.72	14.43																367	4.17	30.2
63	*Unknown*	1							14	0.94	8.79													14	0.94	8.79
64	*Diospyros zombensis*	1							14	1.08	10.28													14	1.08	10.28
66	*Unknown*	1	100	0.2	0.97				14	0.88	8.09													114	1.08	9.06
67	*Dichrostachys cinera*	1	100	0.2	0.97																			100	0.2	0.97
69	*Annona senegalensis*	4	300	2.07	12.93	33	0.85	6.66																333	2.92	19.59
72	*Unknown*	3	233	1.01	6.08																			233	1.01	6.08
74	*Strychnos innocua*	1										14	1.54	15.61										14	1.54	15.61
75	*Pseudolachynostylis maprouneifolia*	24	1000	3.72	21.11	329	8.96	71.45	29	2.06	19.58	43	5.5	57.71	14	2.59	28.84							1414	22.81	198.68
77	*Xylopia antunesu*	25	100	0.2	0.97																			100	0.2	0.97
78	*Treculia Africana*	4	233	0.81	5.04	33	0.95	7.56																267	1.78	12.6
84	*Mbamba*	1	100	0.28	1.5																			100	0.28	1.5
89	*Psorospemum febrifugum*	2	200	0.57	2.99	100	0.28	1.5																300	0.85	4.49
91	*Terminalia mollis*	1	100	0.28	1.5	33	0.95	7.56																133	1.23	9.06
92	*Grewia bicolor*	1	33	0.95	7.56																			33	0.95	7.56
93	*Unknown*	13	200	1.91	12.87	81	2.06	16.21	57	3.78	35.15	29	3.96	42.1										367	11.7	106.33
94	*Phoenix sp*	75	1667	10.41	67.26	381	11.47	93.72	271	20.1	193.7	186	23.35	244.4	43	7.66	85.21							2548	73.02	684.31
GRAND TOTAL		2292	63480	353.6	2214	14683	421.1	3412	6061	423	3998	3345	425.9	4473	1941	286.5	4379	984	270	3227	371	164	2158	90849	2444.6	23862

Appendix 11: Composition of tree species diversity indices in undisturbed stratum of NEMFR in Mpanda district.

CODE	SPECIES' NAME		TOTAL			Frq.	Pi	IVI COMPONENTS			DIVERSITY INDICES			
	VERNACULAR NAME	BOTANICAL NAME	N	G	V			RF	RD	RB	H	ID	IVI	
													Value	%
A. Trees harvested for valuable timber														
64	Msofe	*Diospyros zombensis*	14	1.08	10.28	1	0.000	0.04	0.02	0.04	0.00	0.000	0.10	
18	mfulu/mpulu	*Vitex doniana*	129	2.04	17.67	1	0 001	0.04	0.14	0.08	0.01	0.000	0.27	
28	Mfuru	*Vitex ferruginea*	157	3.76	33.70	5	0.002	0.22	0.17	0.15	0.01	0.000	0.54	
43	Mnembela	*Isorberlinia tomentosa*	162	10.49	99.72	10	0.002	0.44	0.18	0.43	0.01	0.000	1.04	
24	Masaka	*Pterocarpus sp.*	533	27.50	312.18	14	0.006	0.61	0.59	1.13	0.03	0.000	2.32	
13	kasanda/mnyegenyege	*Swartzia madagascariensis*	1552	32.40	296.19	38	0 017	1.66	1.71	1.33	0.07	0.000	4.69	
12	mkora/mkongo/mkola	*Afzelia quanzensis*	1948	64.21	669 36	47	0.021	2.05	2.14	2.63	0.08	0.000	6.82	
17	mbanga/muvanga	*Pericopsis angolensis*	3886	198.76	2059.96	144	0.043	6.27	4.28	8.13	0.13	0.002	18.68	
7	Mninga	*Pterocarpus angolensis*	6510	197.15	1947.10	179	0.072	7.80	7.16	8.06	0.19	0.005	23.03	
11	mpilipili/mgando	*Albizia antunesiana*	8700	164.78	1483.46	183	0.096	7.97	9.57	6.74	0.22	0 009	24.29	
2	Mtundu	*Brachystegia spiciformice*	11057	626.92	6684.95	408	0 122	17 78	12.17	25.65	0.26	0.015	55.59	
16	Mgando		48	1.33	10.88	2	0.001	0.09	0 05	0.05	0 00	0.000	0.19	
3	myombo/msilanga	*Brachystegia boehmii*	12838	374.35	3709.77	323	0 141	14.07	14 13	15.31	0 28	0.020	43.52	
Sub total			**47533**	**1704.8**	**17335.23**	**1355**	**0.523**	**59.04**	**52.31**	**69.74**	**1.30**	**0.052**	**181.09**	**60.36**
B. Trees harvested for poles, beams, carving and firewood														
4	muba/muva/muwa	*Julbernardia globiflora*	14	1 62	16 62	1	0.000	0.04	0.02	0.07	0.00	0.000	0.13	
45	mpingo/mgembe	*dalbergia melanoxylon*	100	0.28	1 50	1	0.001	0.04	0.11	0.01	0.01	0.000	0 17	
84	Mbamba		100	0 28	1.50	1	0.001	0.04	0.11	0.01	0 01	0.000	0.17	
78	Munsa	*Treculia africana*	267	1 78	12 60	4	0 003	0.17	0.29	0.07	0 02	0.000	0.54	
37	Mbumbu		310	15 14	150.35	13	0 003	0.57	0.34	0.62	0 02	0.000	1.53	
60	Mbombo		414	4 98	44 60	6	0.005	0 26	0.46	0.20	0.02	0.000	0.92	
42	Mkurungu	*Pterocarpus tinctorius*	724	18 88	181 48	18	0.008	0.78	0.80	0.77	0.04	0.000	2.35	
94	Muva	*Phoenix sp*	2548	73 02	684 31	75	0.028	3.27	2.80	2.99	0.10	0.001	9.06	
Sub total			**4476**	**115.99**	**1092.95**	**119**	**0.049**	**5.19**	**4.93**	**4.74**	**0.22**	**0.001**	**14.86**	**4.95**
C.Trees whose parts are used as medicine or food/fruits														
10	mfyruduamboga/mfunduambogo	*Piliostigma thonningii*	300	1 51	8.85	3	0 003	0.13	0.33	0.06	0 02	0.000	0.52	
69	mtopetope pori	*Annona senegalensis*	333	2 92	19 59	4	0.004	0.17	0.37	0.12	0.02	0 000	0.66	
58	mwezya/Mwesya	*Maytenus senegalensis*	367	2 41	15 83	5	0 004	0.22	0.40	0.10	0.02	0.000	0.72	

61	Kashamongo	*Syzigium guinensis*	367	4.17	30 20	7	0.004	0.31	0.40	0.17	0.02	0.000	0.88	
50	Mnkundu		610	8.56	67.51	12	0.007	0.52	0.67	0.35	0.03	0.000	1.54	
53	mliwamfwengi/mliwafyengi	*Oldfieldia dactylophylla*	838	9.80	79.46	16	0.009	0.70	0.92	0.40	0.04	0.000	2.02	
47	Mkusu	*Uapaka Kirkiana*	1290	10.73	77.89	21	0.014	0.92	1.42	0.44	0.06	0.000	2.77	
75	katunguluvaganga/Mtunguru	*Pseudolachynostylis maprouncifolia*	1414	22.81	198.68	27	0.016	1.18	1.56	0.93	0.06	0.000	3.67	
15	mbula/Muwala/Muvula	*Perinari curatifillia*	2276	66.19	650.01	64	0.025	2.79	2.50	2.71	0.09	0.001	8.00	
Sub total			7795	129.11	1148.02	159	0.086	6.93	8.58	5.28	0.38	0.001	20.79	6.93
C. Other tree species														
63	Mningoningo		14	0.94	8 79	1	0.000	0.04	0.02	0.04	0.00	0.000	0.10	
74	Mkulwa	*Strychnos innocua*	14	1.54	15 61	1	0.000	0.04	0.02	0.06	0.00	0.000	0.12	
34	mgwegwe/Mgwege/Mpande pande	*Strychnos potarum*	29	3 41	35.35	2	0.000	0.09	0.03	0.14	0.00	0.000	0.26	
92	mkame/Mkomalendi	*Grewia bascolor*	33	0.95	7 56	1	0.000	0.04	0.04	0.04	0.00	0.000	0.12	
5	Mtunguru	*Pseudolachynostylis maprouncifolia*	33	0.59	4.33	1	0.000	0.04	0.04	0.02	0.00	0.000	0.10	
30	mbalebale/Mvalevale/Mvale	*Lonchocarpus capassa*	43	5.80	61.61	3	0.000	0.13	0 05	0.24	0.00	0.000	0.42	
25	Mnumbula	*Dirospyros kirkii*	67	1 70	13.31	3	0.001	0 13	0.07	0.07	0.01	0.000	0.27	
27	kaselenga/mkelenge	*Terminalia mollis*	100	0.28	1.50	1	0.001	0.04	0.11	0.01	0.01	0.000	0.17	
49	Kasyenela	Unknown	100	0.28	1.50	1	0.001	0.04	0.11	0.01	0.01	0.000	0.17	
67	kasunzuru/mtundulu	*Dichrostachys cinera*	100	0.20	0.97	1	0 001	0.04	0.11	0.01	0.01	0.000	0.16	
77	kashenene/mshenene	*Xylopia antunesii*	100	0.20	0.97	25	0.001	1.09	0.11	0.01	0.01	0.000	1.21	
66	Kapyupyu	Unknown	114	1 08	9.06	1	0.001	0 04	0 13	0.04	0.01	0.000	0.21	
91	kagelenge/Kaselenge/Kakelenge	*Terminalia mollis*	133	1.23	9.06	1	0.001	0.04	0.15	0.05	0.01	0.000	0.24	
59	Mpapa	*Makhamia obtusifolia*	143	7.57	75.19	6	0.002	0.26	0 16	0.31	0.01	0.000	0.73	
21	msanzambele/Mkozikozi	*crossopteryx febrifuga*	200	0 57	2 99	2	0.002	0.09	0.22	0.02	0.01	0.000	0.33	
23	Kiponda	*Commiphora mossambicensis*	200	0.57	2 99	1	0.002	0 04	0.22	0.02	0.01	0.000	0.29	
26	Mfumbe	*Dombeya rotundifolia*	200	0.57	2.99	2	0 002	0.09	0 22	0.02	0.01	0 000	0.33	
38	mkalya/Mkalya/Mkarye	*Zanha africana*	205	9.39	97 01	7	0.002	0.31	0.23	0.38	0.01	0 000	0.91	
72	mtewe/Mtejwe	Unknown	233	1.01	6 08	3	0.003	0 13	0.26	0 04	0.02	0.000	0.43	
41	kapala/mpala	*Hymenocardia acida*	238	9.35	89 98	8	0.003	0.35	0.26	0.38	0.02	0 000	0.99	
44	mseveye/Mseweye	*Chrysophyllum benguelensis*	262	1.78	12.85	4	0.003	0.17	0 29	0 07	0 02	0.000	0.54	
89	kalilolilo/Msalunhunda	*Psorospermum febrifugum*	300	0.85	4.49	2	0.003	0 09	0 33	0 03	0.02	0.000	0.45	
93	Ikuya/Ikuja	Unknown	367	11 70	106 33	13	0.004	0.57	0.40	0.48	0.02	0.000	1.45	
32	Mkuni	*Berchemia discolor*	448	16.99	166 56	14	0.005	0.61	0.49	0.70	0.03	0.000	1.80	
29	Kazima	*Terminalia sericea*	657	5.44	42.91	10	0.007	0.44	0.72	0.22	0.04	0.000	1.38	
6	Mlama	*Combretum molle*	786	19 58	164.62	25	0.009	1.09	0 86	0 80	0 04	0.000	2.75	

40	Mputika	*Scchrebera frinchoclade*	910	12.45	117.54	15	0.010	0.65	1.00	0.51	0.05	0.000	2.16	
31	Mkome	*Sctrichnos punges*	1014	5.90	39.44	13	0.011	0.57	1.12	0.24	0.05	0.000	1.92	
35	Mlugala	*Cassipourea mollis*	1081	8.75	60.26	15	0.012	0.65	1.19	0.36	0.05	0.000	2.20	
9	mgunga/mbombwe/mdungwa	*Accacis nilotica*	1181	8.53	56.63	16	0.013	0.70	1.30	0.35	0.06	0.000	2.35	
22	Kapepe	*Brachystegia microphylla*	1224	48.49	458.43	46	0.013	2.00	1.35	1.98	0.06	0.000	5.33	
46	Msindwi	Unknown	1419	30.21	253.19	38	0.016	1.66	1.56	1.24	0.06	0.000	4.45	
1	Mgumbu	*Lannea schweinfurthii*	2281	30 50	233.88	47	0.025	2.05	2.51	1.25	0.09	0.001	5.81	
36	Mkuwa	*Hexalobus monopetalus*	2467	31.15	248.42	46	0.027	2.00	2.71	1.27	0.10	0.001	5.99	
8	kibula/kibua /mluzyaminzi	*Combretum adenogonium*	2819	30.15	234.32	52	0.031	2.27	3.10	1.23	0.11	0.001	6.60	
14	mfilafila/mfira	*Trilepisum madacascariensis*	2886	23.25	169.62	41	0.032	1.92	3.18	0.95	0.11	0.001	6.04	
33	Mlandala	*Combretum collium*	3329	97.64	916 97	101	0.037	4.40	3.66	3.99	0.12	0.001	12.06	
20	Msongati	*Diplorhynchos condylocarpon*	5333	64 11	552 71	90	0.059	3.92	5.87	2.62	0.17	0.003	12.41	
Sub total			31062	494.68	4286.01	662	0.342	28.85	34.18	20.24	1.35	0.009	83.27	27.76
	GRAND TOTAL		90866	2445	23862	2292	1	100	100	100	3.24	0.063	300.00	100.00

Appendix 12: Diameter distribution of trees in the disturbed strata by sample plots in NEMFR, Mpanda district

LOT DETAILS		Frq.	DIAMETER CLASSES IN CM																					TOTAL		
			5.0-15			15..1-25			25.1-35			35.1-45			45.1-55			55.1-65			65<					
No	Category		N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V	N	G	V
A. Highly disturbed stratum																										
88	Ds-A																							0	0.00	0.00
89	Ds- A																							0	0.00	0.00
91	Ds- A																							0	0.00	0.00
105	Ds-A	0	0	0.00	0.00																			0	0.00	0.00
106	Ds-A																							0	0.00	0.00
107	Ds-A																							0	0.00	0.00
109	Ds-A																							0	0.00	0.00
110	Ds-A																							0	0.00	0.00
111	Ds-A																							0	0.00	0.00
120	Ds-A	0	0	0.00	0.00																			0	0.00	0.00
121	Ds-A																							0	0.00	0.00
122	Ds-A																							0	0.00	0.00
123	Ds-A																							0	0.00	0.00
Sub total		0	0	0.00	0.00																			0	0.00	0.00
B. Medium disturbed stratum																										
46	Ds-B	5	500	1.92	10.94																			500	1.92	10.94
50	Ds-B	8	600	2.81	16.57							14	1.45	14.63				14	3.91	46.92				629	8.17	78.13
69	Ds-B	5	100	0.64	3.89				14	0.82	7.42	43	5.39	56.40										157	6.85	67.71
73	Ds-B																							0	0.00	0.00
112	Ds-B	4	400	1.35	7.44																			400	1.35	7.44
Sub total		22	1600	6.71	38.85				14	0.82	7.42	57	6.85	71.03				14	3.91	46.92				1686	18.28	164.22
C. Less disturbed staratum																										
45	Ds-C	11	1033	3.72	20.59																			1033	3.72	20.59
49	Ds-C	7	100	1.28	8.61	33	1.05	8.53	14	0.76	6.79	14	1.54	15.61	14	4.74	58.97							176	9.37	98.51
60	Ds-C	1	100	0.50	2.95																			100	0.50	2.95
70	Ds-C	8	733	4.31	27.24																			733	4.31	27.24
71	Ds-C																							0	0.00	0.00
86	Ds-C	5	500	1.92	10.94																			500	1.92	10.94
87	Ds-C	11	433	1.86	10.94	33	0.67	5.04	43	2.85	26.66				29	4.75	52.17							538	10.13	94.82
92	Ds-C	5	433	2.00	11.87																			433	2.00	11.87
114	Ds-C	7	614	2.51	14.05																			614	2.51	14.05
Sub total		55	3948	18.10	107.17	67	1.72	13.58	57	3.61	33.45	14	1.54	15.61	43	9.49	111.14							4129	34.46	280.96
GRAND TOTAL		77	5548	25	146	67	1.72	13.58	71	4.43	40.88	71	8.39	86.64	43	9.49	111.14	14	3.91	46.92	0	0.00	0.00	5814	52.74	445.18

Note: Ds-A; Ds-B and Ds-C means: Highly disturbed plot, Medium disturbed plot and Less disturbed plot respectively.

Appendix 13: Distribution of tree species' diversity indices in disturbed stratum in NEMFR, Mpanda district

SPP CODE	SPECIES' NAME: VERNACULAR NAME	SPECIES' NAME: BOTANICAL NAME	TOTAL: N	TOTAL: G	TOTAL: V	Frq.	Pi	IVI COMPONENTS: Rf	IVI COMPONENTS: Rd	IVI COMPONENTS: Rb	DIVERSITY INDICES: H'	DIVERSITY INDICES: ID	DIVERSITY INDICES: IVI	%
A. Trees harvested for valuable timber														
2	*Mtundu*	*Brachystegia spiciformice*	33	0.38	2.56	1	0.01	1.2	0.5	0.7	0.03	0	2.4	
17	*mbanga/mnvanga*	*Pericopsis angolensis*	29	3.83	40.7	2	0	2.41	0.5	6.9	0.02	0	9.8	
7	*Mninga*	*Pterocarpus angolensis*	95	3.19	30	4	0.02	4.82	1.5	5.8	0.06	0	12.1	
3	*myombo msilanga*	*Brachystegia boehmii*	614	2.29	12.8	7	0.1	8.43	9.7	4.1	0.23	0.01	22.2	
11	*mpilipili/mgando*	*Albizia antunesiana*	1500	6.69	39.3	15	0.24	18.1	23.6	12.1	0.34	0.06	53.8	
Sub total			2271	16.4	125	29	0.36	34.9	35.8	29.5	0.68	0.07	100	33
B. Trees harvested for poles, beams and firewood														
4	*muba/mwva/mwva*	*Julbernardia globiflora*	100	0.28	1.5	1	0.02	1.2	1.6	0.5	0.07	0	3.3	
94	*Mtwa*	*Phoenix sp*	414	3.91	31.8	5	0.07	6.02	6.5	7.1	0.18	0	19.6	
Sub total			514	4.2	33.3	6	0.08	7.23	8.1	7.6	0.24	0.01	23	7.6
C. Trees whose parts are used asmedicine or food/fruits														
61	*Kashamongo*	*Syzigium guinensis*	33	0.59	3.49	1	0.01	1.2	0.5	1.1	0.03	0	2.8	
75	*katunguluwaganga/Mtunguru*	*Pseudolachynostylis maprouncifolia*	200	0.92	5.39	2	0.03	2.41	3.2	1.7	0.11	0	7.2	
53	*mliwamfwengi/mliwafyengi*	*Oldflieldia dactylophylla*	200	1.01	5.9	2	0.03	2.41	3.2	1.8	0.11	0	7.4	
47	*Mkusu*	*Uapaka Kirkiana*	100	0.28	1.5	1	0.02	1.2	1.6	0.5	0.07	0	3.3	
50	*Mnkundu*		14	1.15	11.1	1	0	1.2	0.2	2.1	0.01	0	3.5	
58	*mwezya/Mwesya*	*Maytenus senegalensis*	33	0.32	1.72	1	0.01	1.2	0.5	0.6	0.03	0	2.3	
15	*mbula/Muwala/Muvula*	*Perinari curatifillia*	57	11.3	133	4	0.01	4.82	0.9	20.3	0.04	0	26.1	
Sub total			638	15.6	162	12	0.1	14.5	10.1	28	0.39	0	53	18
D. Other spp														
93	*Ikuya/Ikuja*		14	0.94	8.79	1	0	1.2	0.2	1.7	0.01	0	3.1	
1	*Mgumbu*	*Lannea schweinfurthii*	100	0.64	3.89	1	0.02	1.2	1.6	1.1	0.07	0	3.9	
8	*kibula/kibua /mluzyaminzi*	*Combretum adenogonium*	14	1.54	15.6	1	0	1.2	0.2	2.8	0.01	0	4.2	
46	*Msindwi*		67	1.64	12.9	2	0.01	2.41	1.1	2.9	0.05	0	6.4	
72	*mtewe/Mtejwe*		200	0.57	2.99	2	0.03	2.41	3.2	1	0.11	0	6.6	
89	*kalilolilo/Msalunhunda*	*Psorospermum febrifugum*	200	0.57	2.99	2	0.03	2.41	3.2	1	0.11	0	6.6	
29	*Kazima*	*Terminalia sericea*	300	0.95	5.14	3	0.05	3.61	4.7	1.7	0.14	0	10.1	
33	*Mlandala*	*Combretum collium*	81	3.42	33.7	3	0.01	3.61	1.3	6.2	0.06	0	11.1	
77	*kashenene/mshenene*	*Xylopia antunesii*	333	1.49	8.92	4	0.05	4.82	5.3	2.7	0.15	0	12.8	
20	*Msongati*	*Diplorhynchos condylocarpon*	314	2.02	14.3	4	0.05	4.82	5	3.6	0.15	0	13.4	
14	*mfilafila/mfira*	*Trilepisum madacascariensis*	400	1.97	11.7	4	0.06	4.82	6.3	3.6	0.17	0	14.7	
36	*Mkuwa*	*Hexalobus monopetalus*	400	2.11	12.7	4	0.06	4.82	6.3	3.8	0.17	0	14.9	
31	*Mkome*	*Scrichnos punges*	500	1.52	8.14	5	0.08	6.02	7.9	2.7	0.2	0.01	16.6	
Sub total			2924	19.4	142	36	0.46	43.4	46.1	34.9	1.41	0.02	124	41
GRAND TOTAL			6348	55.5	462	83	1	100	100	100	2.73	0.1	300	100

Note: % means contribution of a given tree use category in the total IVI of the stand

Appendix 14: Contributions of IVI of sub strata (disturbance ranks) of disturbed strata in NEMFR, Mpanda district

PLOT No	Frequencies	TOTAL N	G	V	IVI Components Rf	Rd	Rb	IVI	% Composition
Highly Disturbed stratum of the disturbed strata (A)									
88		0	0.00	0.00	0.00	0.00	0.00	0.00	0
89		0	0.00	0.00	0.00	0.00	0.00	0.00	0
91		0	0.00	0.00	0.00	0.00	0.00	0.00	0
105		0	0.00	0.00	0.00	0.00	0.00	0.00	0
106		0	0.00	0.00	0.00	0.00	0.00	0.00	0
107		0	0.00	0.00	0.00	0.00	0.00	0.00	0
109		0	0.00	0.00	0.00	0.00	0.00	0.00	0
110		0	0.00	0.00	0.00	0.00	0.00	0.00	0
111		0	0.00	0.00	0.00	0.00	0.00	0.00	0
120		0	0.00	0.00	0.00	0.00	0.00	0.00	0
121		0	0.00	0.00	0.00	0.00	0.00	0.00	0
122		0	0.00	0.00	0.00	0.00	0.00	0.00	0
123		0	0.00	0.00	0.00	0.00	0.00	0.00	0
73		0	0.00	0.00	0.00	0.00	0.00	0.00	0
71		0	0.00	0.00	0.00	0.00	0.00	0.00	0
Sub total		**0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0**
Medium Disturbed stratum of the disturbed strata (B)									
46	5	71	0.27	1.73	6.02	6.02	6.02	12.90	4
50	8	114	5.76	81.16	9.64	9.85	17.85	37.12	12
69	5	71	6.30	80.17	6.02	6.02	19.52	31.57	11
112	4	57	0.19	1.17	4.82	4.82	0.60	10.24	3
Sub total		**314**	**12.53**	**164.22**	**26.51**	**26.50**	**38.82**	**91.83**	**31**
Less Disturbed stratum of the disturbed strata (C)									
45	11	157	0.70	4.84	13.25	13.25	2.17	28.67	10
49	7	100	8.04	112.81	8.43	8.43	24.89	41.76	14
60	7	100	0.51	3.50	8.43	8.43	1.59	18.45	6
70	8	114	0.72	5.07	9.64	9.64	2.24	21.51	7
86	5	71	0.27	1.73	6.02	6.02	0.85	12.90	4
87	11	157	8.26	103.61	13.25	13.25	25.59	52.10	17
92	5	71	0.39	2.73	6.02	6.02	1.22	13.26	4
114	7	100	0.78	6.63	8.43	8.43	2.43	19.29	6
Sub total		**871**	**19.68**	**240.92**	**73.49**	**73.48**	**60.97**	**207.94**	**69**
Grand total		**1186**	**32.22**	**405.14**	**100**	**100**	**100**	**300**	**100**