CHANGES IN VEGETATION COVER AND TREE BIODIVERSITY OF WETLAND ECOSYSTEMS OF NGUMBURUNI FOREST RESERVE, RUFIJI DISTRICT, COAST REGION, TANZANIA

BY

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ABSTRACT

A Study on the changes in vegetation cover and tree biodiversity of the wetland ecosystems of Ngumburuni forest reserve in Rufiji district was carried out during the period of September 2006 to March 2007 to determine the status of vegetation cover, underlying causes upon its changes and appropriate measures which could be used to stop further degradation of the tree biodiversity within wetland ecosystems. The study was conducted in three closest villages to the forest namely: Umwe north, Mkupuka and Mangwi, whereby sociological information pertaining to uses and threats of forest resources were obtained by using structured questionnaires and focused group interviews. Trees inventory data was collected from a total of 44 sampling plots laid on wetland patches. Finally, a trend of changes in vegetation cover was determined by using Landsand TM satellite images of the years: 1985, 1995 and 2004. The results from this study revealed that the major causes of changes in vegetation cover and tree biodiversity in Ngumburuni forest reserve were the existence of several forest management practices such as shifting cultivation, logging and charcoaling. Similarly, forest inventory data indicated that, there is imbalance of trees species diversity between undisturbed and disturbed forest areas. The results of GIS analysis revealed that there is vegetation cover change in Ngumburuni forest reserve. The changes were more pronounced in the period 1995 to 2004 compared to the period 1985 to 1995. To reduce further degradation of the tree biodiversity within the wetland ecosystem, several measures were suggested such as: command and control approach, establishment of alternative income generating activities and community awareness. In addition to this, it is recommended that, further studies

should be carried out to determine alternative means of household income to community members instead of the current dependence on forest products and cashewnut crop.

DECLARATION

I, JEROME GADI KIMARO, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work, and has never been submitted, nor concurrently being submitted for a degree award in any other university.

Jerome Gadi Kimaro | Date
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The above declaration is confirmed

Prof. L.L.L Lulandala | Date
(Supervisor)

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My work is dedicated to my beloved parents, the late Mr. Gadi Abel Kimaro and Mrs. Margaret Sarakikya Kimaro, who have established a strong academic foundation in my life.

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LIST OF ABBREVIATIONS AND SYMBOLS

CBO	Community Based Organization
DAO	District Agricultural Officer
DBH	Diameter at Breast Height
DEO	District Extension Officer
FAO	Food and Agriculture Organization of United Nations
FR	Forest Reserve
G	Basal area (m^2/ha)
GIS	Geographical Information System
GPS	Global Positioning System
IISC	Idaho Invasive Species Council
ICDPs	Integrated Conservation-Development Projects
IUCN	The World Conservation Union
IVI	Important Value Index
JFM	Joint Forest Management
MKUKUTA	Mkakati wa Kupunguza Umaskini na Kuinua Uchumi Tanzania
MLC	Maximum Likelihood Classifier
MNRP	Management of Natural Resources Program
MNRT	Ministry of Natural Resources and Tourism
N	Forest stocking (stems/ha)
NEM	Northeast Monsoon
NEMC	National Environmental Management Council
NWFPs	Non Wood Forest Products
PFM	Participatory Forest Management
PMs	Project Managers
SEM	Southeast Monsoon
SNAL	Sokoine National Agriculture Library
SUA	Sokoine University of Agriculture
TM	Thematic Mapper
URT	United Republic of Tanzania
V	Stand density (m^3/ha)
WCST	Wildlife Conservation Society of Tanzania
WWF	World Wide Fund for Nature

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

Tanzania is endowed with exceptional wetland resources covering 2.7 million ha, which are estimated to constitute 7% of the total land area (Maltby, 1986). They include areas of permanent or seasonal freshwater swamps, marshes and seasonal floodplains, distributed over most of the country's major river systems (NEMC/WWF/IUCN, 1990), ranging from substantial lake systems to river floodplains and deltaic mangrove formations (Maltby, 1986). Mangroves have dominated the coastal wetlands in Tanzania covering approximately 115 500 ha (FBD, 2000). The Rufiji Delta has the largest stand of mangroves on the entire coast of East Africa accounting for 50% of mangroves in Tanzania (Semesi, 1989i; Hewawasam, 2002).

Wetlands are among the most productive ecosystems of Tanzania, they are multifunctional with diverse values such as agricultural, hydrological, ecological, logistical and social values. According to Hongyu and Shikui (2004), these fabulous resources are continually facing both ecological and socio-economic threats, which escalate the rate of resource base degradation and only rarely are sustainable utilization aspects considered.

Saunders *et al*. (2002) argues that the vulnerability of ecosystems is not due to physical limitations like severe climate and aspect, but also due to human interferences, social and economic systems which include encroachment, overgrazing, illicit cutting of forest trees, wildfire, poor fishing practices, quarrying and mining. This means that natural resources are important to human beings daily life, which is also the case of the Ngumburuni wetland resources to adjacent communities.

Conservation of wetland resources is inevitable although Tanzania still lacks detailed information and data on their importance. There is considerable concern that the entire aquatic ecosystems are now under threat (Dugan, 1990). The Tanzania government vide Government Notice No. 507 of 15/9/1995 imposed a ban on timber harvesting in the catchment forests and declared their management objectives to centre on water, biodiversity and soil conservation (MNRT, 2003). This may be considered as one strategy of effectively conserving these fragile resources. The National Forest Policy of 1998 calls for forest adjacent communities to join hands with the government in managing the forest resources (URT, 1998). It has been noted that with participating community in the forest management, conflicts would be minimized and these resources managed sustainably (Willy, 1995; Kessy, 1998). Local communities in villages around the reserve have started to collaborate with the Rufiji District Council, NGOs such as REMP, WWF and various government authorities in order to effectively protect the forest resources. However, Ngumburuni forest reserve is still disturbed with illegal logging, charcoaling and cultivation. If this situation will remain unchecked, there will be a wide range of long term socio-economic and ecological consequences within adjacent communities and the forest.

1.2 Problem statement and study justification

Several biological and socio-economic researches have been conducted in Ngumburuni forest reserve. However, no study has yet been carried out on the changes in vegetation cover and tree biodiversity in forest wetland patches. Hence, information on the actual causes and extent of the problem is not yet documented. But this information still remains important for effective conservation of wetland ecosystems in the reserve. This study was, therefore, intended to address this need. The information generated in this study will be useful for planning and management purposes by various institutions such as the Forestry and Beekeeping and Wildlife Divisions in the Ministry of Natural Resources and Tourism (MNRT), Tanzania Wildlife Research Institute (TAWIRI), Non governmental organizations (NGOs), local governments, academic institutions and international agencies interested in wetlands biodiversity conservation. The management options proposed in this study will enable local communities and various agencies to collaborate with government authorities more effectively in the proper management of forest wetland resources for the benefit of the present and future generations.

1.3 Objectives

1.3.1 Overall objective of the study

Determination of changes in the vegetation cover and tree biodiversity of wetland ecosystem of Ngumburuni forest reserve, Rufiji district, Coast region, Tanzania.

1.3.2 The specific objectives

- To determine the status of vegetation cover of wetland ecosystems characterizing Ngumburuni forest reserve
- To identify underlying causes of the changes in vegetation cover and tree biodiversity within the wetlands ecosystem
- To determine corrective measures that are required to improve the conservation of wetland ecosystems in the Ngumburuni forest reserve

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Vegetation cover and tree biodiversity

Vegetation dynamics, defined as changes in stand structure and composition over time, are a major aspect of vegetation ecology (Jackson *et al.,* 2001). Studying appropriate forestry variables and parameters and applying them to specific vegetation layers in a certain sequence can generate invaluable data on past, present, and even future vegetation structure dynamics (Poynton, 2003; Ambasht 2001).

Estimates for closed forests in Tanzania vary from about 9 000 km^2 to 16 000 km^2 but the whole country is reputed to be covered by 350 000 km^2 of various woodland types, *i.e.* almost half of the national area (Burgess and Crarke, 2000). The main forest types are varied as they include montane, lowland, coastal, miombo forests (*i.e.* woodlands, thickets and bush lands), mangroves and swamps (MNRT, 2002i, Holmes, 1995 and Barbour *et al.*, 1987).

2.1.1 The miombo woodlands

According to McKenzie (1998) and Seydack (2000), the miombo vegetation can be defined by dominance or high frequency of trees belonging to the legume sub-family *Caesalpiniodeae,* such as *Brachystegia, Julbernadia, Isoberlinia, Baikiaea, Cryptosepalum, Burkea and Colophospermum*. The majority of miombo woodlands are briefly deciduous, many of the dominant tree species only losing their leaves for a short period of the late dry season (Malimbwi, 2002). In drier areas, miombo woodlands may be completely deciduous while in moister areas they may be virtually ever green (Hemp, 2002). There are six key biophysical determinants that pattern miombo woodlands: Long term geological stability; climate with a long dry season lasting over five months; flat topography with relatively poor drainage; old nutrient-poor soils; low level of large mammal herbivores with episodic high level of insect and small mammal herbivory; and frequent fires Obiri *et al*.(2002).

Miombo woodlands span over ten countries from the Congo basin and eastern African savannas west to Angola, covering a total area of approximately 3.6 million Km^2 (Cauldwell and Zieger, 2002). In Tanzania, *brachystegia – Julbernardia* savanna woodlands cover almost two-thirds of the forest land while wildlife protected areas constitute 47% (96 000 km^2) of this zone in Tanzania (Mgoo and Nsolomo, 2000). While, the flora in the miombo woodlands of Tanzania is estimated at around 8 500 species. Gardiner and Tuite (1990) documented 106 tree and shrub miombo species in Ihowanza, Iringa region, while Malimbwi *et al.* (1998) recorded 91 species in Morogoro district.

Acording to Kowjang (2001), four major vegetation types of miombo occur in Tanzania, namely dry miombo, wet miombo, Itigi thickets and wetlands/grasslands. The dry miombo is the most dominant woodland type found in most regions. It is dominated by the *Brachystegia speciformis, B. boehmii* and *Julbernadia globiflora* tree species and is floristically poorer than the wet miombos (Monela, *et al*., 2000). The canopy is generally less than 15m in height and trees are deciduous for a month or more during the dry season. According to Sylla *et al.* (2002), species of Acacia are found on clay soils along drainage lines. Annual rainfall is less than 1000mm and relatively unreliable. The herbaceous layer consist of medium to tall grasses in drier areas, *Julbernardia and Combretum* species become dominant (Luoga *et al.*, 2002).

Wet miombos are mainly found in the west and south-west Tanzania. These are floristically rich woodlands, often dense with a canopy usually greater than 15m high with *Brachystegia* species being dominant (Backéus *et al.,* 2006). The herbaceous layer comprises of tall grasses such as *Hyparrehenia* species. In the wettest areas the dominant trees are only briefly deciduous, the canopy is almost closed and shade tolerant species such as *Rubiaceae* are found in the understorey (Cauldwell and Zieger, 2002).

The Itigi thicket is mainly found in Singida Region. It consists of dry deciduous forest dominated by *Baphia* and *Combretum* species and *Bussea massaiensis* (WWF-SARPO, 2001). Edaphic grasslands, floodplains and wetlands that are included in the Miombo woodland vegetation cover are found in Rukwa, Tabora, Kigoma and Shinyanga Regions. In addition, Afromontane vegetation, consisting of a mosaic of moist evergreen forest and grasslands, is found within miombo woodlands. According to Nduwamungu (1996) in Tanzania, the Afromontane vegetation is found in mountaneous areas in Morogoro, Iringa, Mbeya, Rukwa, Kigoma and Kagera regions. Miombo woodlands also merge with *Acacia-savanna* grasslands, *Acacia-Commiphora* thornbush and coastal thickets (Holmes, 1995; Kojwang, 2001; URT, 2000b).

Several studies had been conducted to reveal the variation in vegetation cover with time. According to Yang, a Landsat Multi-Spectral Scanner (MSS) archive was used to monitor changes in the savanna vegetation between 1972 and 1989 in the South Luangwa national park region. Land-cover types in the region were mapped and major changes in land cover from 1972 to 1989 were detected from MSS data. Woody canopy cover changed significantly in the region from 1972 to 1989 and revealed strong spatial patterns of deforestation in *Colophospermum mopane* woodland on alluvial soils and vegetation regrowth of valley Miombo vegetation and riverine woodland. This information on the spatial patterns of canopy cover changes from 1972 to 1989 suggests certain criteria that any causative process must satisfy. It provides a baseline for the National park and wildlife services to manage the natural resources in the region. The canopy cover estimated from MSS data also provides an important input to biophysical and climatic process models for estimating the impact of vegetation structure on vegetation and climate processes.

2.1.2 The mangrove forest

Mangroves are salt-tolerant forests or swamp ecosystems that occur along tropical and subtropical coastlines, usually in sheltered bays and around river mouths (Wang *et al.,* 2003). Globally, about 75% of low-lying tropical coastlines receive freshwater drainage to support mangrove systems (Francis *et al.,* 2001). Through the action of its roots, a mangrove forest recycles nutrients and traps land-based debris, sediments, and suspended particulate matter carried to the coast by rivers (Anthony, 2004). Mangrove forests function as irreplaceable feeding and nursery grounds for many ecologically and economically valuable fish, shellfish, prawn, and crab species

(Amir *et al.*, 2002). The forests and the roots secure the land, preventing shoreline erosion. Mangroves are also important for the health and water quality of near-shore ecosystems such as sea grass beds and coral reefs that develop best in clear waters (Horrill, 1997).

In Kiswahili, the national language of Tanzania, the mangrove ecosystems or forests are referred to as *kappa* or *kokoni* and the mangrove trees as *mikoko* (Semesi, 1989). Eastern African mangroves encompass mangrove areas found in Mozambique, Tanzania, Kenya, and Somalia (Michelle *et al.*, 2003). The dominant climatic influences on most of the region are the seasonal wind patterns, associated with the Northeast monsoons (NEM) and the Southeast monsoons (SEM), which blow towards the mainland from the northeast and southeast at different times of a year, and which affect the movement of the major coastal currents (Semesi, 1989).

There are two general categories of mangroves: those found in the fringe communities along the open coastline, and creek mangroves, which are found at river mouths (Harding, 2002). Fringe mangroves often indicate the presence of groundwater discharge sufficient to dramatically lower salinity levels, as are found at Mida Creek and the Lamu Archipelago (Semesi, 1989). Mangroves found at river mouths have greater patterns of zonation among species, because the tides, and thus the mangroves, reach further inland (Blasco, 2002). The most developed mangroves are found between the Beira and the Save Rivers in Mozambique, where they extend up to 50 km inland with canopy heights of up to 30 m (Spalding *et al.*, 1997).

Tree biodiversity in mangrove sites is low because few tree species can withstand high salinity, anaerobic sediments, acidic soils, and unstable substrates (Mohamed, 2007). Nine mangrove tree species are found in Tanzania. Of these, *Avicennia marina*, *Rhizophora mucronata*, and *Ceriops tagal* are predominant, while *Xylocarpus mulleccensis* is rare (Semesi and Adelaida, 2000).

According to Stuart *et al.* (1990) Eastern Africa has a greater diversity of mangrove species than West Africa. The species-composition also varies, with those of Eastern Africa related to species around the Indian Ocean, while those of West Africa are similar to those of the Americas (Dugan, 1990). Eight species of mangroves are found throughout the region, the distribution of which is primarily determined by salinity gradients, depth of water table, and the soil's pH and oxygen content (Agusto, 2002). *Avicennia marina* is associated with sandy soils, *Rhizopora mucronata* with muddy soils along rivers and creeks, *Ceriops tagal* with dry areas, *Bruguiera gymnorrhiza* with wet areas, and *Lumnitzera racemosa* and *Xylocarpus granatum* with the landward fringe, where they also indicate the transition to brackish water (Chapman, 1977). *Sonneratia alba* is the pioneer species found on open coasts, with *Heritiera littoralis* and *Bruguiera* often found behind it (Spalding *et al*., 1997). Estimates of existing mangrove area in the region range from 2 555 km^2 to 7 211 km^2 (Ian, 2002). The most extensive areas of mangroves are found in the Rufiji river delta in Tanzania and the Zambezi river delta in Mozambique (Boer, 2004). Protected areas containing mangroves include Mafia island marine park, Jozani national park and Sadaani game reserve in Tanzania; Watamu Marine national park and Ras Tenewi marine national park in Kenya; and Bazaruto marine national park, Ilhas da Inhaca e dos Portugueses fauna reserve, Marromeu game reserve, Pomene game Rreserve, and Maputo game reserve in Mozambique (Semesi, 1990; Horrill *et al*., 2002).

Like other forests in Tanzania, the area of Mangrove vegetation cover has been varying at different periods (Makota *et al.*, 2004). Study by remote sensing of mangrove change along the Tanzania coast determined that mangrove forests occur from Tanga in the north to Mtwara in the south covering approximately 109 593 and 108 138 hectares in the 1990 and 2000 time periods, respectively. The mangrove areas should be 111 792 and 111 817 hectares if salt crust areas are included for the two time periods (Green *et al.*, 2000). Details for each mangrove vegetation location in Tanzania are shown in Table 1.

Table 1: Comparison of mangrove areas of Tanzania (in hectares) between 1990 and 2000

	1990 mangroves		2000 mangroves	
Coastal districts	Mangrove vegetation	If salt crust areas added	Mangrove vegetation	If salt crust areas added
Tanga and Muheza	9 217	9 221	9 313	9 336
Pangani	3 799	3 799	3 799	3 879
Bagamoyo	5 039	5 039	5 051	5 051
Dar es Salaam	2 494	2 494	2 516	2 516
Kisarawe	4 159	4 261	4 092	4 167
Rufiji	49 799	50 968	48 030	50 391
Kilwa	21 826	22 546	21 755	22 552
Lindi	4 034	4 055	4 044	4 065
Mtwara	9 226	9 409	9 458	9 860
Total	**109 593**	**111 792**	**108 138**	**111 817**

Source: Wang *et al*. (2003)

2.1.3 Coastal forests

The eastern African coastal forests, which are sometimes called "forests of Zanzibar – Inhambane regional mosaic" (White, 1983), stretch from the South of Somalia to Mozambique. Formerly, this several hundred kilometers wide strip followed the Indian ocean coast. Nowadays, the coastal forests are quite fragmented and hardly cover 3 000 km^2, half of the estimated extent being in Mozambique (De Klerk *et al*., 2004).

Basically, the coastal forests show dense closed canopy tree stands but they do not encompass the halophytic mangrove forests (Anderson, 2004). There are several differences between the wide spread "miombo" woodlands and the coastal forests. In the first case, the tree crowns may touch but they generally do not overlap as they do in the second one. In woodlands, grasses are well developed while they are sparse or absent in coastal forests, but a shrub and liana layer is normally present (Burgess and Crarke, 2000). Very few of the coastal forest endemic species are distributed through out the range of the forests. Examples are the trees *Dialium holtizii*, *Bombax rhodognaphalon*, *Comiphola zanzibarica* and the marginally endemic *Sterculia appendiculata* (Burgess, 2005). This situation is also true for near-endemics with only the bird Fischer's Greenbul *Phyllastrephus fischeri*, Green Tinkerbird *Pogoniulus simplex,* Spotted Ground trush *Zoothera fischeri* and Tiny Greenbul *Phyllasterphus debilis* having a wide distribution (Burgess and Crarke, 2000).

2.2 Causes of changes in vegetation cover and tree biodiversity

Forest depletion refers to the complete removal of forest cover or to a percentage of less than 10% forest cover (FAO, 1999). The majority of species do not survive very intensive disturbances while few species persist in highly competitive communities that arise when disturbances are very mild. There are certain limits for capability of the forests to withstand environmental changes and beyond these limits they become degraded (Kim *et al.*, 1993)

Current studies on Tanzania forest cover have indicated that between 1970 and 1998, Tanzania lost around 10 million ha of forest land through uncontrolled clearing of forests mainly for agriculture and livestock expansion (URT, 1998; URT, 2001).
Both natural and human induced factors play significant roles in bringing changes in vegetation cover and tree biodiversity. According to Mogaka *et al*. (2001), the sensitivity of the value of the forest goods and services to change in forest varies a great deal according to scale, intensity, and type of these changes, which may be anything from a slight selective logging of undisturbed natural forest to a total clearance of trees and a subsequent transformation of the previous forest site into non forest uses.

According to Kaale *et al.* (2000); Lulandala (2005) the principal direct agents of deforestation in developing countries include agricultural expansion and inappropriate agricultural practices, overgrazing, charcoal production, bush fires, excessive firewood gathering, commercial logging and industrial development. These direct agents are consequences of some underlying factors which include:

Population growth and rural poverty, market and policy failure, state of economy and international asymmetry and demand (Chidumayo, 1987; LLC, 2004).

The United Nations Environment Programme (UNEP) identified the effects of trade liberalization as one root cause of accelerated deforestation, through expanding activities within the sector and related sectors such as agriculture (UNEP, 2001). In many cases, the economic opportunities lost through forest degradation and deforestation is not realistically known (Kaoneka, 2000). The situation has been exacerbated by a decline in government capability to police Forest Reserves over the past two decades due to financial constraints. Wells *et al*. (2000) claimed that whilst economic liberalization policies have facilitated systems of wood supply and trade, it has also reduced the government's ability to control resources exploitation. Indeed, some forest reserves have been completely cleared and turned to agriculture or wasteland (URT, 2001). Generally, the accelerating conversion of tropical forests is occurring for a number of inter-locking socio-economic and political reasons (Araki, 1992).

Degradation of forests and deforestation are taking place both in government Forest reserves and in unreserved forests on public land (Salehe, 1995; URT, 1998). However, forests and woodlands are particularly overexploited on public lands where population pressures for agricultural land and fuel wood have been increasing (Luoga *et al.,* 2002).

According to Chidumayo (1997), the growing rural population in the Chitemene shifting cultivation region of northern Zambia has caused deforestation which has resulted in the reduction of (a) the length of the fallow period from 25 years to 12 years, (b) the per person woodland requirement of 1.1 ha to 0.53 ha and (c) the frequency of clearing new Chitemene gardens from yearly to once in two years. Similar to this, a study conducted by Gadgil (1992) in India show that the resilience of ecosystems has broken down and the land is increasingly deteriorating due to reduction of fallowing cycles.

Clearing and burning of forests lead to a great disturbance in the natural ecosystems, destroying different kinds of insects with their well laid habitat, food supply and the specific environment of their adaptation (Boswell *et al*., 2002; Clausnitzer, 2003; Nair and Graetz, 2004; Munishi *et al*., 2004). Exhaustive clearance of miombo woodlands for short-term agriculture and excessive burning regimes threaten their integrity and therefore the services they provide to people's livelihood and entire ecosystems in general (Sanchez, 1987; Vissoh *et al*., 2000). Large scale and intensive logging is threatening the commercial and ecological viability of some timber species. Trade in forest products, particularly of timber and charcoal, has contributed to the degradation of Miombo woodlands and coastal forests that cover two thirds of the country (Milledge and Kaale, 2005).

Charcoal is widely used as a source of domestic energy in Tanzania, particularly in urban areas (Milledge and Kaale, 2005). Driven by low income amongst the majority of charcoal users and the lack of affordable alternative energy sources, the majority of medium to low income families in urban areas rely upon charcoal as their principal source of domestic energy (Jambiya 1999, Monella *et al*., 1999). This was also observed by Monela *et al.* (1993) who reported that the demand for charcoal was increasing in Dar es Salaam and other urban areas of Tanzania since the majority of the population lack access to, or is unable to afford, electricity for cooking. Research in miombo regions of Coast region showed that the number of people seeking income generation through charcoal production was increasing rapidly, consequently increasing pressure on natural woodlands (Songas, 2003).

Human disturbances in miombo woodlands differ from one place to another depending on their type, intensity and frequency (Getachew *et al*., 2004; Luoga *et al.*, 2004,).

For example, Zambian miombo woodlands are more affected by the agricultural practices of local shifting cultivators than bush fires (Mumeka, 1986). In Zimbabwe browsing by livestock severely reduces coppice re-growth particularly of *Julbernadia globiflora* (Tietema *et al*., 1999).

An impact of elephants on woodlands is among natural factors, which result in major forest cover changes (David and David, 2004). Changes in miombo woodland cover in and around Sengwa Wildlife Research Area (SWRA) were quantified by analyzing aerial photographs between the period 1958 and 1996. Woody cover in SWRA decreased from 95.2% in 1958 to 68.2% in 1996, with the lowest mean of 62.9% in 1983. The annual absolute rate of woody cover change in SWRA increased from −1.1% per annum between 1958 and 1964 to a recovery of 1.6% per annum between 1993 and 1996, while the annual relative rate increased from −1.1% per annum between 1958 and 1964 to 3.3% between 1993 and 1996. There was a strong negative correlation between elephant densities and woody cover in SWRA, suggesting that loss of woody cover was mainly due to elephants. Woodland recovery after 1983 was due to reductions in elephant populations through legal and illegal off-take and reductions in fire frequency. Surrounding areas experienced less woody cover losses than SWRA, mainly due to tree removal by locals whose densities increased after the eradication of tsetse fly in the 1970s.

Research in central Tanzania revealed that the restoration process of degraded miombo woodland through natural regeneration is slowed by the semi-arid climate of the area combined with poor soil nutrient status (Eliapenda, 2000). A maximum increment in standing volume of $7.4m^3$/ha/yr has been recorded for Morogoro district, and an average stand re-growth of $2.3m^3$/ha/yr recorded in the Kitulangalo area (Malimbwi *et al.*, 1998; Malimbwi *et al.*, 2000).

Variation of vegetation cover along Mt. Kilimanjaro in Tanzania for example, is brought about by two main factors, namely altitude and climate (Andres, 2005). There are two wet seasons, short rains from November to December and the long rains from March to May. The driest time is from August to October. Precipitation is inversely proportional to altitude. Mean precipitation is 230cm in the rain forest (up to 1 830m), 130cm at the upper edge of the forest (2 740m), 52.5cm at Horombo hut in the heath zone (3 718m), and less than 20cm at Kibo hut (4 630m), producing alpine desert conditions. Winds are predominantly from the southeast, and consequently the north slopes experience much less rainfall. Diurnal temperature range is large at higher altitudes. Mist frequently shrouds much of the mountain giving a high humidity with low evaporation rates. The major types of vegetation found on Mt. Kilimanjaro can be roughly described as: montane forest, moorland, upland moor, alpine bogs, and alpine desert (Newmark, 1991).

Above about 4 600m, very few plants are able to survive the severe conditions, although examples *of Helichrysum newii* have been found as high as 5 760m (close to a fumarole) and lichens are found right up to the summit. The upland moor consists mainly of heathers and scrub plants, with *Erica arborea, Philippia trimera, Adenocarpus mannii, Protea kilimandscharica, Stoebe kilimandscharica, Myrica meyeri-johannis,* and *Myrsine africana*. Grasses are abundant and *Cyperaceae* form the dominant ground cover in moist hollows. Flatter areas of heathland between the forest and the moor are covered by *Agrostis producta, Koeleria gracilis, Deschampsia sp.,* and *Exotheca abyssinic*a, with occasional bushes of *Adenocarpus mannii* and *Kotschya recurvifolia.*

Various examples of the genus *Helichrysum* are found in the grasslands and two forms of giant groundsel occur on Mt. Kilimanjaro, *Senecio cottonii,* (endemic to the mountain and only occurs above 3 600m, and *S. johnstonii johnstonii* which occurs between 2 450m and 4 000m. At all altitudes groundsel prefers the moist, more sheltered locations. In the alpine bogs it is associated with another highly conspicuous plant, the endemic giant lobelia *Lobelia deckenii*. The southern slopes

(Machame side) are dominated by *Podocarpus spp*. and camphorwood *Ocotea usambarensis* with an understorey of ferns, including tree ferns *Cyathea spp*. and the long-spiked *Lobelia gibberoa*, *Agauria salicifolia,* and *Macaranga kilimanjarica.* On the Mweka route there are *Podocarpus latifolius*, and *Croton macrostachys*. The rain forest stops at about 3 000m. The drier northern slopes are dominated by cedar *Juniperus procera* and olives *Olea sp.* Around the villages there are corn and banana farms with coffee (under the banana trees for shade). The taller Grevillea trees shade the banana and coffee plants and are used for construction.

Presence of invasive species being plants, animals or micro organism, would play a big role in changing or degrading natural condition of a particular place (IISC, 2003). A species is regarded as *invasive* if it has been introduced by human action to a location, area, or region where it did not previously occur naturally and becomes capable of establishing a breeding population in the new location without further intervention by humans, and spreads widely throughout the new location (David and David, 2004). Places like Mahale national park and Usambara natural forest reserves in Tanzania, are vivid examples where by invasive trees species have greatly changed previous ecosystems in terms of vegetation cover and tree biodiversity.

In Mahale national park, *Senna spectabilis* was introduced as an ornamental tree planted around staff houses without understanding or predicting future implications it may cause (Elizabeth *et al.*, 1999). It is now threatening to colonize the entire area occupied by lowland and montane rain forest in Mahale national park, its impacts in Mahale national park ecosystem include:

- Reductions of native plants have a direct impact on the presence, abundance, and activities of native vertebrates and invertebrates since they are dependent on vegetation for shelter and food. Chimpanzees for instance, are social animals which prefer playing and swinging on tree branches for most of their day time. Tall trees with strong branches are ideal for chimpanzee activities contrary to *S. spectabilis.*

  The national park was one of the important bird areas in East Africa, but the popularity is decreasing gradually as some bird species migrate to other places.
- Rare species appear to be particularly vulnerable to the environmental changes that are brought about by non-native species. Therefore, it is very possible that presence of *S. spectabilis* have completely exclude some species from the ecosystem.
- Through its allelopathic capacity, *S. spectabilis* does not allow under growth of low profile plants such as shrubs and grasses which are important in protecting soil from surface water run off thus causing soil erosion and degradation of aquatic life through sediments deposition.

In the early 1900's high demand for forest products led to a planting preference for faster-growing non-native tree species. *Maesopsis eminii* was selected because it has a 40-year rotation age that is considerably shorter than the 80-year rotation age for most native species. *Maesopsis eminii* was first introduced in Amani in 1913 for plantation and growth monitoring plots (Mwasha, 1988). This species tends to spread as a weed in every available gap in the natural forests Christoph *et al*. (2007), observed that, *M. eminii* has deep root system and it is thus competing better for water resources, simultaneously drying out the habitat. From the silvicultural point of view the widespread logging operations at Amani in the 1960’s and 1970’s opened the canopy in numerous places. This disturbance, together with favorable climatic conditions, enabled *M. eminii* to spread easily. It spread extensively in both forests reserves and public lands, creating a monoculture with attendant negative ecological consequences (Rodgers, 1982).

Being one of the important consequences of land use problems, deforestation is a threat to biological diversity and climate (Fearnside *et al.*, 2004). It must be halted in the interest of present and future generation (Mzava, 1983).

2.3 Measures required to improve conservation of wetland ecosystem

There are different view points of undertaking conservation action of natural resources in developing countries, though some are conflicting and therefore take long time to meet a desired solution (Fisher, 1995). According to Burgess and Crarke, (2000), these approaches can be grouped into three broad categories which include:

The social anthropological – where the communities adjacent to a certain natural resources are allowed to use them while they are involved in conservation activities.

The hard-line protectionist – This is the command and control approach whereby adjacent communities are not free with protected areas. Rules and regulations are used to protect the resources, penalties are normally offered to those who break them.

The progressive – This is the more recent approach whereby local people are involved in management of protected areas. In this integration, local people derive enough benefits from the area.

2.3.1 Integrating local communities into the management process

Despite the fact that involving people in forest management has become common all over the world for a long time, Participatory Forest Management (P.F.M) in Africa has been slow to evolve (Amy *et al.,* 2004). Conservation goals should be pursued by strategies that emphasize on the role of local residents in decision making about natural resources (Adam *et al*., 2001). In the early nineties, Gambia was almost the only country which had proclaimed it as a national priority. But from 1995 to 2000, new forestry acts had been promulgated in many African countries, and particularly in Zanzibar, South Africa, Malawi, Zambia, Lesotho and Mozambique. From 2000 to 2003, Kenya, Uganda, Tanzania, Namibia and Swaziland joined the movement. In fact, nowadays, more than forty new national forest policies make participatory forest management an objective in Africa (Alden, 2000).

According to FRMP (1997) and Paulo (2003), good governance in the forestry sector would ensure that positive policy contribution results from implementation of sectoral action plans that are based on existing policies, legal frameworks and institutional structures.

Each country is following its own way, therefore there is a large diversity of management regimes. Thus, Lesotho and South Africa return the national forests to their original owners, hoping at the same time that they will contract specialized agencies to manage the more commercial and valuable ones. Uganda, Ethiopia or Niger have made the choice of developing P.F.M. in their most valuable forest reserves. Tanzania has made the main experiences in currently unreserved areas (Alden, 2000).

Much is expected from these new policies, may be too much, and the donors supported them with important funds. It may be possible to say that the various experiences have not always lived up to the expectations. To be efficient, participatory management must be implemented in favorable socio-political conditions. Particularly, the devolution of laws must be really able to empower the communities (Wiley, 1997). And sometimes things do not go as planned. For example, in the Dwesa-Cwebe forest reserve in the former Transkei region of the Eastern Cape (South Africa), the question of who has the power over decision-making is not solved, despite seven years of negotiations. This relative failure originates in the weakening of traditional leadership. Indeed its traditional authority over the allocation of land and resources has been challenged. On the other hand, the new community institutions lack local legitimacy (CIFOR**,** 2003).

This example demonstrates that successful management needs more than so-called democratic institutional community structures. In Tanzania, this pattern of potential conflict can arise because the democratic structures have been imposed by the Government (Carsten, 2004). Obviously, in Zimbabwe, Rwanda or Burundi, a similar risk exists, increased by the currently tense political situation. Fortunately, success stories also exist, for example in Namibia where four national forest reserves have been demarcated to be transferred to the neighbouring communities (Adam and Hulme, 2001). Some other examples can be found in Tanzania or in Uganda (Alden, 2000). In fact, successful participatory forest management needs strong support from both government and really empowered communities (Hannah and Milla, 2002).

2.3.2 Alternative to destructive forest use

Once the alternative sources of timber, building poles and fuelwood will be obtained, the pressure on the natural forests will definitely decrease (Jules and David, 2004; Mvungi, 2001; Woodcock, 1995). On-farm planting and woodlots of fast-growing exotics, such as teak, *Eucallyptus, Gravillea, Casuarina* and *Senna* can theoretically provide sufficient fuelwood and timber, which can be used or sold for cash. Fuelwood can also be obtained by pollarding scattered trees in farm fields or coppicing live fences (Young, 1987). Several tree nursery projects have been established to provide trees to local communities. For example Kambai Forest Conservation Project (KFCP) provided 90 000 seedlings over two years to farmers who have planted on farms for timber and building poles. In this area, farmers see tree growing as a way to increase income and believe that it goes hand-in- hand with attempts to intensify agriculture (IUCN, 2003).

2.3.3 Encouraging alternative uses and non-timber activities

Forest-adjacent communities use non-timber products for livelihood source at subsistence level and as a real means for making money (Makonda *et al*., 1997). Yet, with regard to protection of the forest, the development of a sustainable extraction of those non-timber products could contribute to the conservation (Maghembe, 1998).

Several non-timber forest products are found from forest ecosystems, these include food (fruits, vegetables, fungi, roots, tubers, game meat and insects), medicine, essential oils, bees wax and honey, gum, tannins, latex, dyes, fibres, fodder and conservation functions (FAO, 2000). Wild foods are important in improving nutrition and increasing food security particularly in poor rural areas and during famine periods (Maghembe, 1994). In pronounced severe food shortages in Tanzania for example, wild vegetables either supplement or substitute staple foods, common in parts of Iringa, Dodoma, Singida and Morogoro (Mvungi, 2001).

The common vegetables during the period include *Adansonia digitata*, *Sesamum* spp *Zanthoxylum chalybeum*, and *Bidens pilosa*. Fruits are used as food, beverages, and sources of cooking oils. The main fruits include *Adansonia digitata*, *Allanblackia* spp., *Parinari* spp., *Azanza garckeana*, *Uapaca kirkiana*, *Vitex* spp.and *Tamarindus indica*. According to Karmann (1998) and FBD (2000), some non wood forest products are important protein sources in Miombo woodlands; these include flying termites, green grasshoppers, mushrooms and bush meat.

The Miombo ecosystems have high potential of producing mushrooms. Over 34 edible species have been identified in Tanzania (Härkonen, 1995), 53 in the Democratic Republic of Congo (Lawton, 1998) and 60 in Malawi (FAO, 2000). Tanzania produces about 138 000 tonnes of honey and 9 200 tones of bees' wax per year, an industry which takes place in miombo woodlands (FBD, 2007). Most of the honey and bees wax produced is consumed locally and only small amounts are exported to Germany, Japan, United Kingdom and the United Arab Emirates (FBD, 2000). Frost (1996) highlighted that beekeeping and honey hunting in the miombo woodlands of Tanzania could be an especially lucrative business.

In the East Usambara lowlands some species are actively exploited locally and are highly palatable especially members of the family *Annonaceae*, but others are collected during times of hardship e.g. drought or hunger and some are regarded as poor mans food (Lawton, 1998). Burgess and Clarke (2000) informs that knowledge of which plants are edible is passed from mothers to their daughters, and all house holds regularly use wild plants in their diet. In Kenya, 60% of people living adjacent to the Arabuko-Sokoke forest use it routinely for fruit collection, mainly for personal consumption (Mogaka, 1992; Wass, 1995).

Bush meat is another source of food to many communities. In Tanzania forests, the most frequently hunted species are Red Duiker (*Cephalonus natalensis),* Suni (*Neotragus moschatus),* Bushbuck (*Tragelaphus scriptus)* and Elephant-shrews (*Petrodromus and Rhynchocyon)* species (FitzGibbon *et al*., 1995).

A case study in East Usambara lowlands shows that the communities do not generally depend on hunted animals as a source of protein, and bush meat is either perceived as an occasional luxury or, by younger generation, as ‘old fashion poor-man’ (Lawton, 1998). However in other areas, bush meat may have a high value to local communities, either through money saved from buying meat at market, or through income gained from selling the meat to others. For example in 1991, the society living adjacent to Arabuko- Sokoke forest in Kenya, harvested about 350 kg meat/km^2 forests, with an estimated value of KSHs. 1 306 000 per annum (FitzGibbon *et al*., 1995).

Medicinal plants are plants used in treating and preventing specific ailments and diseases (Shackleton and Shacklaton, 2004). Medicinal plants are found in a wide range of habitats such as temperate and secondary tropical forests, scrublands, meadows, swidden fallows, agricultural land, and house gardens (Karmann, 1998). According to Hamza (1997), plants medicine account for about 90% of all used treatment worldwide and good amount of income is being made from the sales of traditional medicine. In Tanzania the number is a bit high, for example in Meatu district about 91% of the population rely on medicinal plants for their primary health care (URT, 1990). Heavy reliance on medicinal plants was attributed to their relative accessibility, low prices, local availability and acceptance by local community as well as low number of dispensaries and doctors in rural areas (Carney, 1998). It is estimated that there are between 30 000 and 40 000 traditional healers in Tanzania, compared to 600 western-trained doctors (Hedberg *et al*., 1982). Although nationally medicinal products are not basically recognized as an important source of income, individual people and companies have found this to be one of the areas of economic gain. In 1999 for example Tanzania exported medicinal products which earned the government 21.6 billion shillings (FBD, 2000). To date, with free market economy the country is experiencing economic gain since many people have engaged themselves in this business, and many countries are importing these medicinal plants from Tanzania (FBD, 2000).

Cultural services are non material benefits obtained from ecosystems such as tourism, recreation facilities, aesthetic appreciation, ritual, inspiration, sense of place and educational value (Ashley *et al*., 2002). Tanzania is endowed with many attractions for tourism industry which include different types of wildlife ranging from vertebrates, birds, reptiles, amphibians and millions of insects found in protected areas such as National Parks, Game Reserves, game controlled areas and outside protected areas; a wide variety of plants in natural and planted forests (Kulindwa *et al*., 2001).

Tourists are attracted to rural areas by natural resources such as deserts, wildlife and forests (AWF, 2001). This often referred to as ‘ecotourism’. Ecotourism offers a new source of income. This enables poor rural people to diversify their livelihoods and creates economic incentives to protect natural resources (AWF, 2001). However, the extent to which local people benefit economically depends on the extent to which they control tourism ventures (Nunes *et al*., 2004; Wells, 1992).

Improving relations between protected areas and neighboring communities has become one of the highest priorities on the international conservation agenda. This has led to increasing efforts by protected area managers and conservation organizations to obtain local cooperation, and to the introduction of what David

(2006) and Brandon (1996) have referred to as integrated conservation-development projects (ICDPs).

The Annapurna Conservation Area (ACA) in Nepal is one of the few examples where there are signs of effective integration between tourism, local economic development and protected area management. About 40 000 people of diverse ethnic backgrounds inhabit this rugged, mountainous region, mostly poor rural farmers. Tourism has grown rapidly and 45 000 foreign trekkers now visit the area each year, virtually all of them traveling along one of two trails, and there has been a proliferation of small tea shops and lodges in villages along these trails. Management of the Annapurna Conservation Area Project (ACAP) has encouraged local participation in natural resources management. Special legislation established the multiple-use conservation area - permitting hunting, collection of forest products, and the delegation of management authority to the village level. High priority has been given to reducing the environmental impact of visiting trekkers and increasing the local economic benefits from tourism (Wells, 1993, 1994).

In East African coastal forest, ecotourism is well developed near protected areas for example Jozani national park in Zanzibar, Arabuko-Sokoke forest in Kenya and small numbers in Pugu hills forest in Dar es Salaam (Burgess and Crarke, 2000).

2.3.4 Protection, guarding and enforcement of rules

Any regulatory system, be it external or internal, operates by rules. Who has access to what? What are the exploitation limits? These rules are “commands”. If the commands are to be followed then there has to be a “control” system (Burgess and Crarke, 2000).

In any traditional society, community management –as in most forms of traditional management –had command and control systems (although more kind than government’s rules of laws), but also made use of social ostracism as a powerful force. In a case where a community is heterogeneous, with outsiders forming powerful elites, such self-regulation fails (Matiru, 2002). What has failed is central authority’s command and control system that excluded local people from its governance (Hackel, 1999).

Change is needed, not necessarily in the system it-self, but in its application. People must be involved in planning, implementing and monitoring the system (Ghazala, **2004**). Forest management in India for example has realized that government through its command and control method alone cannot manage the forests successfully and this calls for strengthening alternate options (Gadgil, 1992).

2.3.5 Payment for ecosystem services

Payment for ecosystem services, also called “Payments for Environmental Services” (PES) is a generic term of a variety of arrangements through which the beneficiaries of ecosystem services pay back the providers of those services (Stefano *et al.*, 2005). The ecosystem services in question can be watershed protection, forest conservation, biodiversity conservation, carbon sequestration, landscape beauty in support of ecotourism (Young, 2004). Ecotourism services may be present at any scale, from local to national or international. According to Claire (2005), payments may be through a market type arrangement between willing buyers and willing sellers (e.g. tourist companies paying African communities for the protection of wildlife). It also may be a scheme intermediated by a large private or public entity. For example, part of New York households' water bills are used by the water company to buy watershed protection services from farmers in the vicinity of the water company's intake (James, 2006).

A simple definition describing payment for ecosystem services principle is a voluntary, conditional transaction with at least one seller, one buyer and a well defined environmental service. Conditionality: only to pay if the service is actually delivered (Boumans, 2002).

PES has increasingly become important even in Tanzania during the recent 3-4 years. Efforts have been started through the Conservation and Management of the Eastern Arc Mountain Forests (CMEAMF) to establish PES in Tanzania. Studies have been conducted for the Rufiji River Basin. Also WWF and CARE are working on the Uluguru (Ruvu River) and East Usambara (Zigi River) Mountain Forest Systems trying to establish the willingness of the water authorities to pay (buyers) for the servives and willingness of forest adjacent rural communities to sell or provide (sellers) the environmental conservation services. PES is seen as an alternative funding for conservation activities and additional source of income for the local communities. But it is still a challenge as not many perceive it positively (Dr. F. Kilahama - personal communication, 2006).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Description of the study area

3.1.1.1 Location and climate

Ngumburuni Forest Reserve is located in Rufiji district, Coast region, Tanzania between 7^0 38’ – 7^0 48’ E and 38^0 52’ – 39^0 6’ S. With elevation of 200m from the mean sea level, the forest covers about 10 000 ha to the northeast of Ikwiriri township. From Dar es Salaam city, the forest is located 165 kilometres southwards (REMP, 2003). The easiest way to reach the forest is through the Dar es Salam Mtwara main road.

Ngumburuni forest reserve is characterized by bimodal rainfall where by the major rainfall is during the period of March to May, normally called the long rains or “*Masika”* in Kiswahili, while the short rains start in October to December. Average annual rainfall varies from 900 mm to 1 400 mm. But there are significant daily, monthly and annual fluctuations in rainfall (Burgess and Crarke, 2000). The forests however seem to be well adapted to these variable rainfall regimes.

The air temperature is hot and humid throughout the year ranging between 24 and 31ºC with average of 26 ºC (Semesi, 1990).

The climate is significantly influenced by two monsoon winds: the south-east monsoon blowing northwards from March to September and bringing heavy intermittent rains; from December to March the north-east monsoon blows southwards and influences the hottest temperatures (Jane, 2000).

The soils of the coastal area are predominantly sandy with poor moisture holding capacity, extreme alkalinity and hard subsoil which results in poor drainage (Semesi, 1990).

3.1.1.2 Communities

Six Villages surround Ngumburuni forest reserve, these include Mangwi, Mkupuka, Muyuyu Umwe Centre, Umwe North and Umwe South (Fig. 1). The Ikwiriri township which harbors the majority of newcomers to Rufiji district, also houses among the closest communities to Ngumburuni. The total population in all villages is 12 069 inhabitants (Tab. 2), while the total population of Rufiji district is 203 000 persons (URT, 2003). The main ethnic group is Wandengereko.

Table 2: Distribution of human population in villages around Ngumburuni forest reserve

Village	Population size
Mkupuka	894
Mangwi	2550
Muyuyu	2000
Umwe North	2201
Umwe Centre	2162
Umwe South	2262
Total	**12,069**

Source: Rufiji District Council (2006)

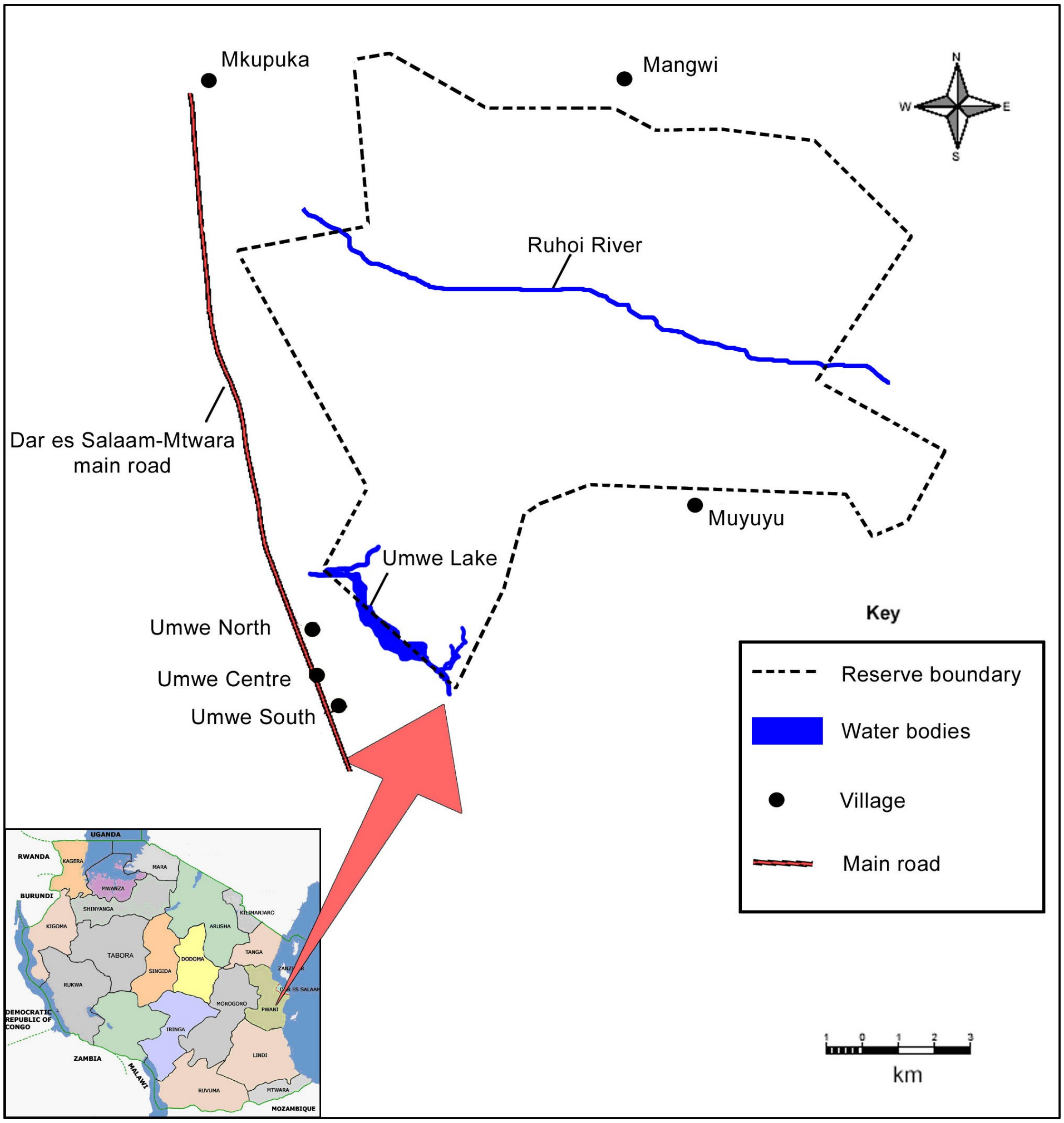

Figure 1: Location map of Ngumburuni forest reserve and surrounding villages

3.1.1.3 Socio-economic status

The adjacent communities to Ngumburuni are agrarian societies whereby agriculture is the main economic activity. Besides agriculture, forest dependent activities such as logging and charcoal production are the major sources of income. Other forest dependant activities include medicinal plants extraction, wild foods, hunting, fishing, carving, pottery, weaving and beekeeping. Livestock keeping especially cattle is not common. As responded by District Livestock Officer (DFO), only local chicken and goats are found in some households. Shifting cultivation is widely adopted land management system due to low human population relative to size of available land which has low soil fertility. Semesi (1990) observed that shifting cultivation in Rufiji district is also contributed by low human population. Besides cashew nuts and simsim which have been grown for a long time for commercial purposes, other crops grown in the villages surrounding Ngumburuni forest reserve are cassava, bananas, cow peas, maize and pumpkins. Most of the seasonal crops are grown within or nearby the forest reserve wetlands commonly known as "*Njacha*" in Wandengeleko language, to take advantage of the higher soil fertility and moisture content available in the area throughout the year.

3.1.1.4 Vegetation

The vegetation of the study area is characterized by four easily distinguished ecological units which include coastal, miombo, woodland and riverine forests.

The coastal forests are very dense and contain a rich biodiversity with rare and endemic species (Burgess and Clarke, 2000). They are adapted to the variable rainfall regimes, varying from 900 mm to 1 400 mm. That means they are obviously able to withstand severe water stresses. They are within the list of 34 world's biodiversity hotspots. The literature records show a presence of 484 different tree species with high level of plant species endemism (Munishi *et al.*, 2004). Similarly, several species of mammals such as bats, shrews, rodents and birds have been known to be endemic in the coastal forests.

The Miombo forest is another important vegetation within Ngumburuni forest reserve. This is wooded savannas where *Julbernardia sp*., *Brachystegia sp.*and *Pterocarpus angolensis* are dominant; The miombo generally occur on nutrient-poor soils with a rainfall range of 650 to 1 400 mm (Campbell, 1996). When the soils are poorer and/or the climate drier, miombo is replaced by open woodlands like *Acacia* savannahs. Due to harshness of dry seasons, faunal richness is lower in the miombo woodlands than in the coastal forests (Kaale *et al.,* 2002). However the high diversity of wildlife in the miombo woodland in Ngumburuni forest reserve is due to overlapping with coastal forests zones.

For past many years, human populations and livestock densities have been low too in this ecological unit. But at present, these densities are increasing near adjacent Ngumburuni forest reserve from which people get a large range of products from food and medicines to timber wood. Human pressure is likely to increase around Ngumburuni forest reserve because of the closeness to villages surrounding the forest.

The savannas woodland vegetation, has smaller and scarcer trees, but has more shrubs with laxurious grasslands (Chidumayo, 1997).

Riverine forest in Ngumburuni forest reserve is mainly found along the Ruhoi river, where they form strips generally characterized by a closed canopy. Since their structure is similar to that of the coastal forests, these two types share a lot of species. But, in the riverine forests the species composition is dynamic due to flooding events and changes in the river course (Backéus *et al*., 2006). The forest ecosystem is important for the biodiversity of nesting birds as well as elephants and buffalos.

3.2 Methods

3.2.1 Sampling procedure

3.2.1.1 Field survey

The topographic cover map of the forest with UTM coordinates was obtained from the Department of Forest and Bee-keeping (FBD), Dar es Salaam. The current Land-sat image showing land use of the forest was obtained at Institute of Resources Assessment (IRA) at the University of Dar es Salaam.

Because the wetland patches were not shown on the image, it was important to carry out the exercise of identifying their type, size and locations within the forest. This task was done with assistance of people who understand well forest conditions. The team involved two forest scouts, a district forest officer and one local farmer. By using GPS, wetland patches coordinates were recorded in order to record their locations and calculating the coverage area.

The number of sample plots was calculated using the following formula:

$$n= T^2. CV2/e^2$$

Where:

T = t-value at a given probability level and degree of freedom (taken as 2),

CV = coefficient of variation

e = degree of error

A sampling error (e) of 15% was considered sufficient since this level of precision is within acceptable limits of natural forests (Malimbwi, 2000)

The coefficient of variation (c.v) of 0.5 for the Miombo vegetation was adopted since these forests have similar condition (Malimbwi, 2000).

Therefore the number of sample plots (n) = 4 x 0.25/0.0225 = 44

3.2.1.2 Use of satellite image

To determine the changes in vegetation cover over time involved the use of Landsat TM Satellites images acquired at different periods whereby the trend of changes of major vegetation covers were for the period 1985, 1995 and 2004 observed. The Landsat TM Satellite images used were obtained from AFRICOVER Project, Nairobi, Kenya.

3.2.1.3 Socio-economic survey

To understand the occurrence of major events and past changes in the Ngumburuni forest reserve wetlands including people's perception on the wetlands, a social survey was conducted to collect information on the changes that people had observed in the past as well as understanding how wetlands are being utilized. Three villages were selected randomly from among the villages surround Ngumburuni forest reserve. From each village a sample of 30 household was again selected randomly, thus making a total sample of 90 households. In addition to these, household information was also sought from special informants in the MNRT and village leadership, extension officials, NGOs and businessmen from among the village local communities.

3.2.2 Data collection

3.2.2.1 Reconnaissance

Observation of some facts was carried through out the study period. Data such as statistics for households, demography, and size of each village were obtained at the village offices registry during my introduction. Similarly, my personal observations were important for obtaining information such as: size of their farm plots, types of crops grown, building materials, number of trees left in the cultivation plots, source of firewood, water etc.

3.2.2.2 Socio-economic survey

Data collected included income sources, knowledge on wetlands resources, non wood forest products (mushroom, ropes, fruits medicinal plants and honey), building materials (timber, poles), involvement to conservation campaign, sources of fire wood, water etc. Tools used in collecting data include:

(a) structured questionnaires

(b) focused Group Discussion

(a) Structured questionnaires

This method was used to collect information from individuals at the household level, such as marital status, number of people, education level, income per month etc as shown in the questionnaire (Appendix II). The structured questionnaire was purposively administered to three villages adjacent to the more affected areas of the forest, which include Mkupuka, Umwe north and Mangwi. In turn, thirty households were randomly selected from each village making the sample size to be ninety households. In this exercise the head of the household was the main respondent.

(b) Focused group discussion

Focused group discussion is a technique guided by a checklist of questions. This method is useful to collect information relating to policies and management issues. A checklist is needed due to limitation of human memory. In the present study, discussions with key informants were guided by a checklist of questions appended in Appendix III. A key informant is an individual who has a great depth of knowledge about the issue in question, is accessible and willing to talk with the outsider. According to Metrick (1993), key informants are not only members of the clientele, but are most often informed outsiders. The present discussions therefore were held with the village leaders, district officers from agriculture and forest departments, project staff such as REMP, WWF and RUBADA, business people as well as village environmental committee members.

3.2.2.3 Field survey

In order to undertake tree biodiversity inventory of the wetland ecosystems in Ngumburuni forest reserve, transect lines were established running east-west direction due to orientation of most wetland patches.

Concentric sample plots of maximum radius of 15m were established at interval of 500 meters in each forest stratum as described below:

(a) Within the inner 2m radius, number and names of all regenerant species were recorded

(b) Within the inner 5m radius, all trees and shrubs with DBH ≥ 4cm, their local and botanical names and frequencies of occurrence were recorded

(c) Within the inner 10m radius, all trees and shrubs with DBH ≥ 10cm, their local and botanical names and frequencies of occurrence were recorded

(d) Within 15m radius, all trees and shrubs with DBH ≥ 20cm, their local and botanical names and frequencies of occurrence were recorded

Other useful information about the plots that were recorded included date of measurement, GPS location, terrain, land use types and associated threats (Appendix I). Also, information such as types of wetlands, surrounding vegetation types and their conservation status were recorded.

3.2.3 Secondary data

This involved published reports from projects/Institutes that had worked in Rufiji district e.g. REMP Project, FBD, IRA, NEMC, also journals and text books from Sokoine National Agriculture Library (SNAL) and Internet were also used.

3.3 Data analysis

3.3.1 GIS analysis

Remote sensed data, processing and change detection

To understand the dynamics of wetland areas and landuse/cover changes with time, analysis of remotely sensed data (satellite images) was done and involved the following;

(i) Image selection and acquisition

For clear visibility of earth surface features, the images were taken during the dry seasons (especially August – November) when there were less cloud covers as compared to wet seasons.

Table 3: The Land Sat images used in the analysis of land cover changes

Image	Date of acquisition	Season	Cloud cover (%)
Landsat TM	August 1985	Dry	8
Landsat TM	Oct 1995	Dry	5
Landsat TM	September 2004	Dry	0

TM = Thematic Mapper

Source: Afri-Cover Project (2006)

(ii) Image processing

Image processing involved three stages. These were: image pre-processing image rectification/geo-referencing and image enhancement.

(a) Image pre-processing

The method for the image analysis required the use of both visual and digital image processing. This involves steps as shown in Figure 2. Prior to image processing, images were extracted from the full scenes using ERDAS Imagine Software, Version 8.3.1 to sub-scenes followed by rectification.

(b) Image rectification

This was done in order to correct image data for distortion or degradation resulting from image acquisition process such as earth rotation effects, panoramic distortions (wide field view) curvature of the earth, atmospheric refractions, relief displacement, attitude and velocity and panoramic effects related to imagery geometry (Lillesand and Kiefer, 1987). To ensure accurate identification of temporal changes, the images were co-ordinated with mapping systems of the national topographic maps, i.e UTM coordinate zone 37 south.

(c) Image enhancement

In order to reinforce the visual interpretability of images, a colour composite (Landsat TM bands 4 5 3) was prepared and its contrast was stretched using a Gaussian distribution function. Furthermore, a 3 x 3 high pass filter was applied to the colour composite to further enhance visual interpretability of linear features e.g. rivers, and patterns such as cultivation. All images processing was carried out using Arc View Version GIS 1.3.

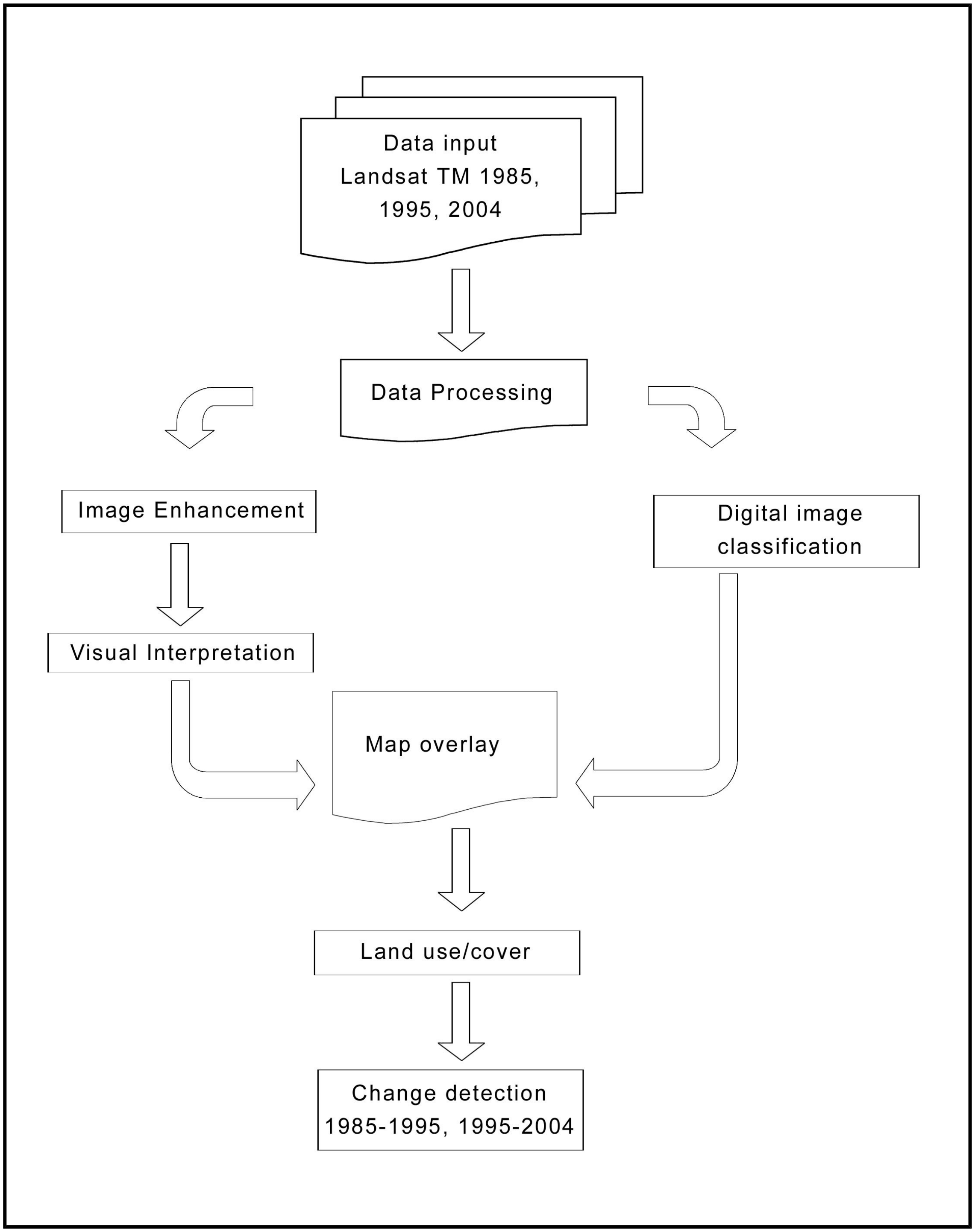

Figure 2: The image analysis flow chart

Source: Yeh and Xia (1996)

(iii) Preliminary image classification

This involves extraction of differentiated land use/cover categories from remotely sensed satellite data to create a base map for ground truthing by using supervised Maximum Likelihood Classifier (MLC). Supervised classification process involved selection of training sites on the images which represent specific land classes to be mapped.

(iv) Ground truthing

This was done in order to verify and modify land covers described in the preliminary stages of image interpretation. From the images acquired on September 2004, a hard copy of colour composite was produced and used as a base map during the ground truthing in the field. A hand GPS was used to locate sampled land cover observations. During this exercise the following major land cover classes were identified: closed woodland, open woodland, bushed grassland, cultivated land, coastal forest and riverine forest.

(v) Change detection analysis

This determines the type, amount and location of land use changes that are taking place (Yeh and Xia, 1996). Post-classification comparison method was used to assess land use and cover changes. The approach identifies changes by comparing independent classified mult-date images on pixel-by-pixel basis using a change detection matrix (Singh, 1989b; Yuan and Elvidge, 1998).

(vi) Estimation of cover rate of change

The estimation of the rate of change for the different covers was computed based on the following formulae.

$$\%\ \text{change}_{\text{years x}} = \frac{Area_{year\ x} - Area_{years\ x+1}\ \text{x}\ 100\%}{Area_{years\ x}\ \text{x}\ t_{\text{years}}}$$

Where:

$Area_{years\ x}$ = area of cover 1 at the first date

$Area_{years\ x+1}$ = area of cover 1 at the second date , and

t_{years} = period in years between the first and second scene acquisition dates

3.3.2 Social economic data analysis

The completed household interviews were coded and data from open ended questions were categorized into groups to enable easy coding and analysis. Quantitative data analysis was done using SPSS (Version 11.5) computer programme. Descriptive statistical analysis was carried out to measure central tendency and dispersion for understanding the distribution of replies from the respondents.

Qualitative data was analyzed by carrying out content analysis. This type of analysis is useful in analyzing details of the components of verbal discussions held with key informants (Kajembe, 1994). The recorded dialogue with the respondents was broken down into smallest and meaningful units of information or themes and tendencies.

3.3.3 Forest inventory data

In order to facilitate the study of the forest, several parameters in terms of stocking (N), basal area (G m^2/ha) and volume per hectare (V-m^3/ha) were calculated based on the 44 plots measured using Microsoft Excel Programme.

(a) Height / diameter and volume equations

As the volume equations require height estimation for each tree, height / diameter equations were calculated using the sample trees for each ecological unit, miombo and coastal forests as shown on Table 4.

Table 4: Height / diameter equations used in Ngumburuni forest reserve

Ecological unit	Height / diameter equation	R^2	Standard error	No of observations
Miombo	**ln(H) = 0.722 + 0.590ln(DBH)**	0.61	0.17	35
Coastal forest	**ln(H) = 1.187 + 0.548ln(DBH)**	0.42	0.23	84

The single tree volumes were calculated using the following equations (Malimbwi, 2000).

Table 5: Single tree volume equations

Ecological unit	Equation
Miombo	**V = 0.00001 . DBH2.032 . H0.66**
Coastal forests	**V = f . SBH . H**

Where:

V = tree volume (m3)
DBH = diameter at breast height (cm)

SBH = tree cross sectional area at breast height (m^2)
H = tree height (m)
f = form factor = 0.5

The information obtained was used to determine the distribution of stand parameters for each forest stratum namely closed forest and disturbed forest.

Mean values of stems per hectare (N), basal area (G) and Volume (V) of degraded forest was compared to that of closed forest to determine magnitude of impact of several land use management systems namely charcoaling, cultivation and timber harvesting. A two tailed t-test at 5% level of significance was used to test if there was significant difference of stocking, basal area and tree volume between the two forest types.

The equation below was used to compare the means, where P<0.05

$$t_{0.05} = (\bar{X}_1 - \bar{X}_2) / \sqrt{S_1^2/n_1 + S_2^2/n_2}$$

Where:

X_1 = Mean values for stratum 1 for N, G, V

X_2 = Mean values for stratum 2 for N, G, V

S_1^2 = Variance for stratum 1

S_2^2 = Variance for stratum 2

n_1 = No. of plots in stratum 1

n_2 = No. of plots in stratum 2

(b) Tree species diversity and richness

Inventory data obtained from sample plots enabled measuring of tree species diversity and richness by using diversity indeces. Diversity indices provide more information about community composition than simply species richness; they also take the relative abundances of different species into account (Mugurran, 1988). Shannon diversity index (H') was employed to measure both abundance (richness) and evenness of the species present in both strata of the forest. The first step was to calculate the Importance Value Index (IVI) of each tree species as the average relative frequency, relative basal area and relative density. The Shannon diversity index was calculated as proportion of species *i* relative to the total number of species (*pi*) and multiplied by the natural logarithm of this proportion (ln*pi*).

The resulting products were summed across species, and multiplied by -1: The Shannon-Wiener function is summarized in the following formula (Kent and Coker, 1992):

$$H = -\sum_{i=1}^{s} p_i \log p_i$$

Where:

H' = the Shannon-Wiener biodiversity index

$\log_e$ = the natural log of p_i

s = total number of species in the community (species richness)

p_i = proportion of s made up of the i^{th} species

The larger the value of 'H' the greater is the diversity and vice versa. The index increases with the number of species in the community but in practice, for biological community it does not exceed 5.0.

Index of Dominance (ID) was used to measure the distribution of individuals among the species in a community. The greater the value of ID, the lower is the species diversity in the community and vice versa. The index of Dominance was calculated using the following equation (Ambasht, 2001).

$$ID = \sum (n_i/N)^2$$

Where:

ID = Index of Dominance

n_i = Important Value Index of all species

N = Total Importance Value Index of all species

(c) Regeneration potential

The regeneration potential of Ngumburuni Forest reserve was analysed from tree species with dbh ≤5 cm measured in the 2 meters radius of the sample plots.

CHAPTER FOUR

4.0 RESULTS

4.1 Status of vegetation cover and tree biodiversity of Ngumburuni forest reserve

4.1.1 Vegetation cover

The results on the vegetation cover characterizing Ngumburuni forest reserve and trend of change of vegetation cover over time are presented in Table 6 and Figures 3 and 4. It will be noted that, there has been a steep degradation of the closed coastal, miombo and riverine forests into open miombo woodlands, grasslands and farmland (Fig. 3 and 4) representing approximately 40%, 31% and 28% degradation in the associated riverine, coastal and miombo forest vegetations respectively (Tab. 6), especially the north-western fringe of the forest reserve (Fig.3 and 4). It was noted further that the most drastic changes took place during the 1995 to 2004 period during which the degradation of the open miombo woodlands to grasslands alone was 1047% (Tab. 6) – probably reflecting the escalation in population growth of the surrounding communities and government permission for commercial timber harvesting.

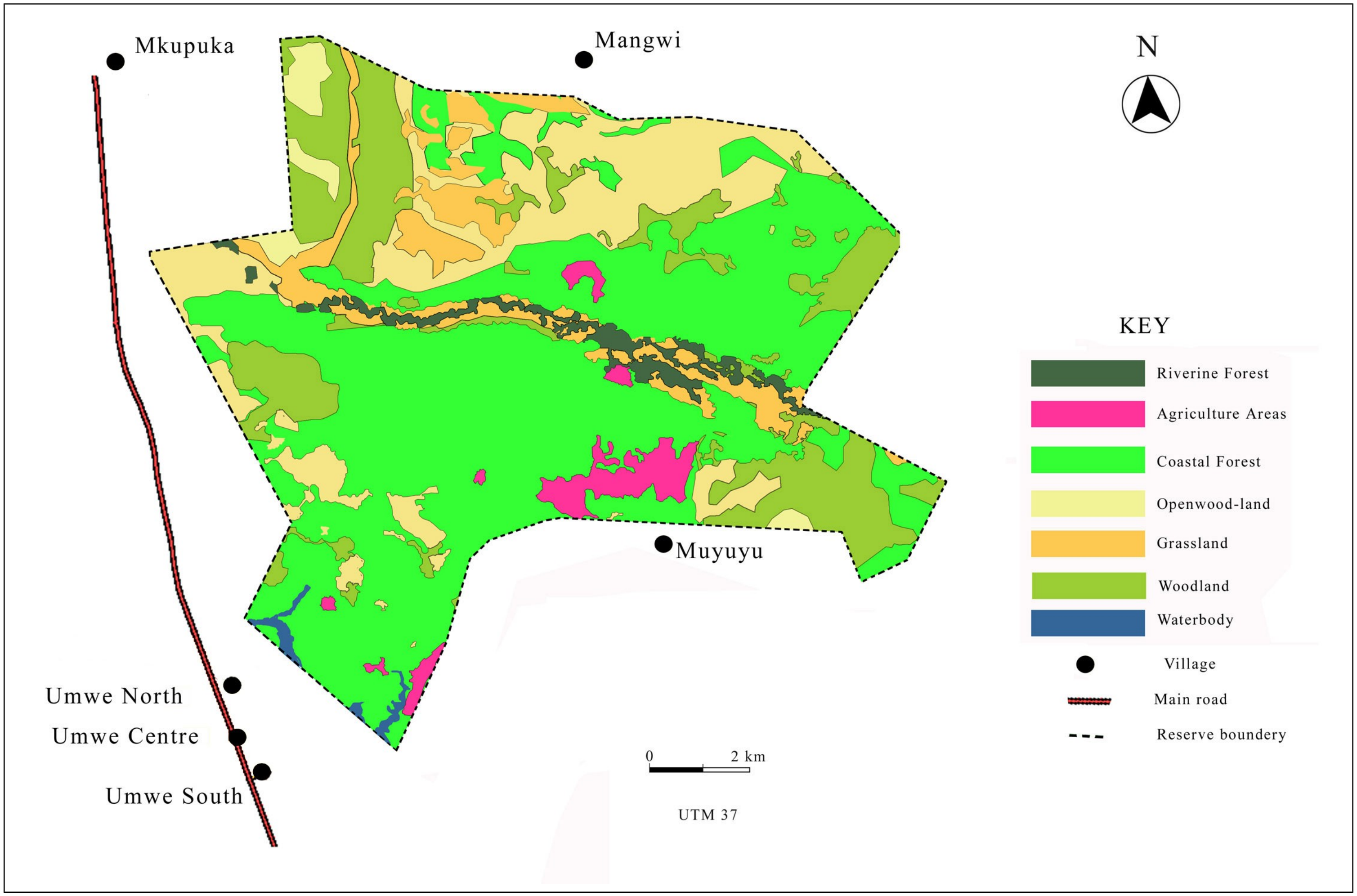

Figure 3: Major forest types of Ngumburuni forest reserve

Source: REMP (2003)

Table 6: Forest cover changes by area in Ngumburuni forest reserve, Rufiji, Tanzania.

Vegetation Stratum	Vegetation cover (ha)			Vegetation cover changes			
				1985-1995		1995-2004	
	1985	1995	2004	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Coastal Forest	7255	6921	5087	-335	-5	-1833	-26
Closed Miombo woodland	3041	2815	2200	-226	-7	-615	-22
Open Miombo woodland and grassland	384	826	2910	442	194	2084	1047
Riverine Forest	1205	1120	750	-84	-7	-370	-33
Cultivation	54	224	1020	170	315	796	4

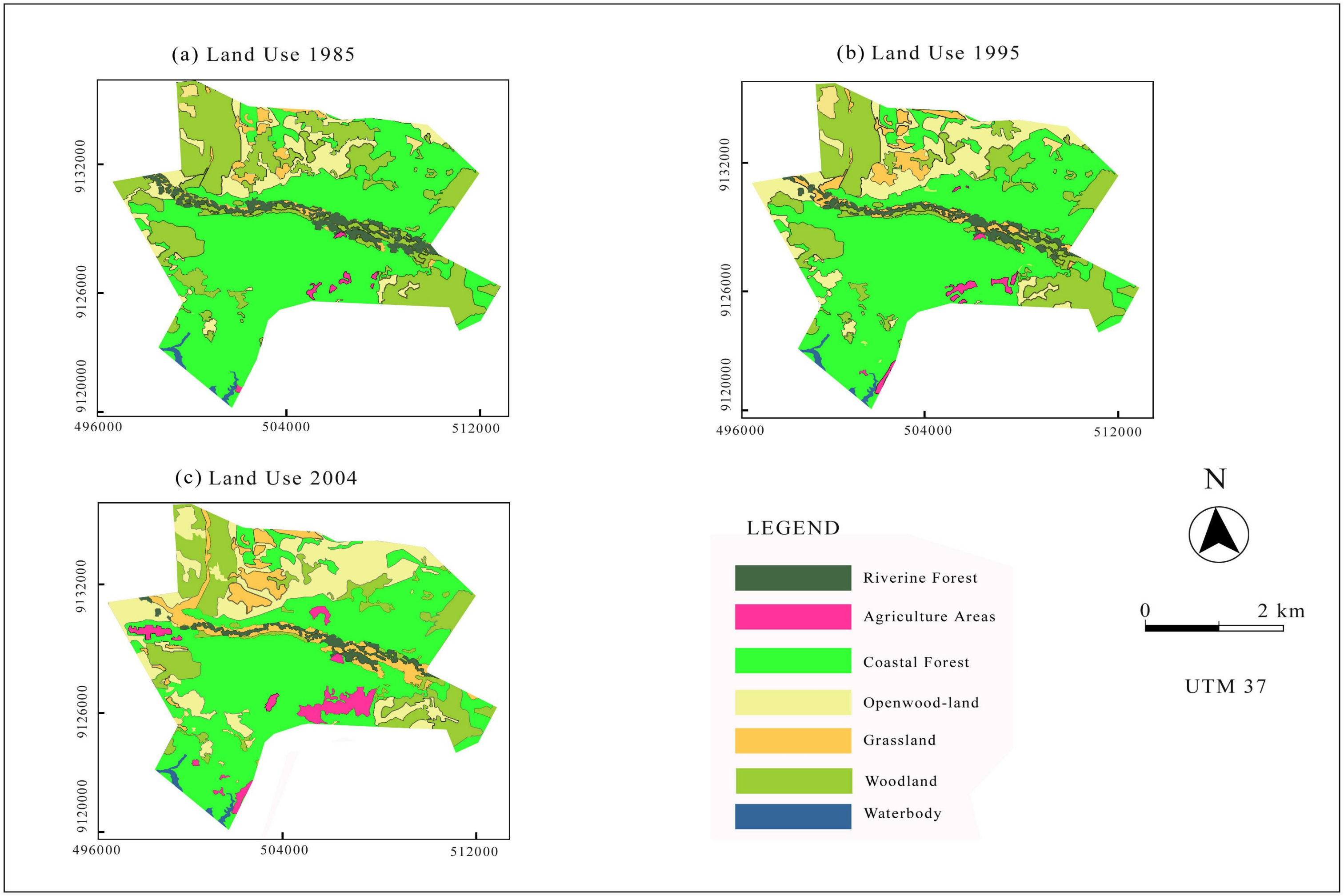

Figure 4: Status of vegetation cover of Ngumburuni forest reserve, Rufiji, Tanzania during the three assessment periods of 1985, 1995 and 2004

4.1.2 Tree biodiversity

4.1.2.1 Tree composition and species abundance

The results on tree composition and species abundance of Ngumburuni forest reserve wetlands are presented in Appendix V. It will be noted that, currently the forest wetlands have a total of 63 tree species with *Hyphanaena compressa* being the most abundant followed by *Vitex doniana*, *Euclea divinorum Sysygium cuminii*, *Acacis nigrescens, Grewia trichocarpa*, *Albizia versicolor* and *Lannea schweinfurthii*. It will also be noted that over 63% of the trees are in the degraded forest while 37% are in the closed forest

4.1.2.2 Species diversity and species dominance

The results on the species diversity and species dominance are presented in Table 7. From the results, it is shown that there is less tree species diversity in closed forest stratum than in the disturbed one - probably this reflects the greater species diversity especially of pioneer ones, characterizing the underground seed bank than what is being indicated by the standing vegetation of the two strata. The lower index of dominance in the disturbed forest further confirms that there is imbalance in species distribution within the disturbed stratum as a result of the differential species preferences in the harvesting, thus selectively concentrating on some species to the extent of extinting some of them.

Table 7: The current species diversity and dominance indices in different management systems in Ngumburuni forest reserve

Type of forest stratum	Shannon-Winner Index Value (H')	Index of Dominance
Closed area	2.0 b	0.090 a
Disturbed area	3.7 a	0.026 b
	L.S.D = 0.02	L.S.D = 0.001

4.1.2.3 The regeneration status of the trees in Ngumburuni forest reserve

The results on the regeneration status of the trees in the forest reserve are presented in Table 8 and Figures 5 and 6. It will be noted that the regeneration in the disturbed forest stratum was only 70% of the closed forest and 40 % of the total (Appendix VII) - indicating that the degradation of Ngumburuni forest reserve is likely to escalate with the continued forest encroachment due to the resulting impairment in the overall regeneration potential and further impacting on the fast degrading tree species diversity (Appendix VII).

Table 8: Distribution of forest strata by distribution percent of regenerants

Forest strata	Distribution (%)
Closed	60 a
Open	40 b
Total	**100**
	L.S.D 4.1

Figures 5 and 6 present the regeneration of the various individual tree species in the two forest strata. It is observed that in both forest strata the most abundant tree species (i.e. *V. doniana*, *H. compressa* and *M. obtusifolia*) are proportionally dominating the regeneration populations – probably reflecting their proportionally greater disposition of the germplasms. The apparently higher regeneration in the closed than in the disturbed strata possibly reflects the consequence of human interferences.

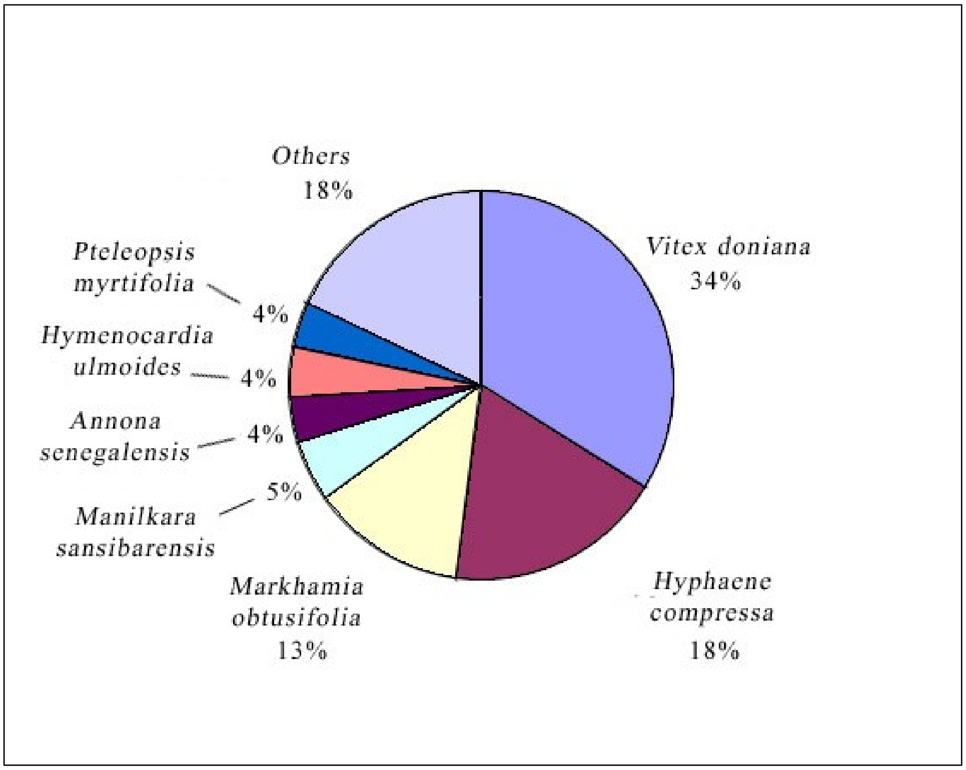

Figure 5: Percentage distribution of regenerants in the closed forest stratum of Ngumburuni forest reserve

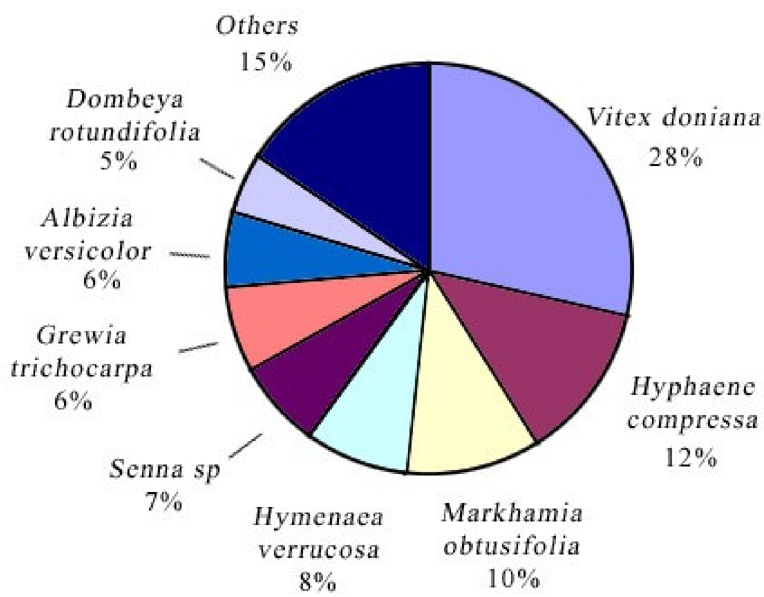

Figure 6: Percentage distribution of regenerants in the degraded forest stratum of Ngumburuni forest reserve

4.2 Causes of changes in vegetation cover and tree biodiversity

The results on the causes in vegetation cover and tree biodiversity of Ngumburuni forest reserve are presented in Table 9. The status of vegetation covers and of tree biodiversity within wetland areas of Ngumburuni forest reserve are changing. In the first place, while closed miombo, coastal forest and riverrine forests are decreasing in coverage, grassland and open woodland forests coverage are increasing. For the case of tree biodiversity, its status seems to decrease more drastically in disturbed areas.

Following responses from key informants, data on previous studies done in the study area and my personal observations, it is indicated that the main causes of changes in the vegetation cover and tree biodiversity are land management practices which involve; logging, charcoaling and cultivation. Other causes include frequent forest fire and population growth. However, there are possibilities for fire to escape during farm clearing and charcoaling activities and affect large parts of the forest.

Table 9: Causes of vegetation cover change and tree biodiversity of Ngumburuni forest reserve

Causes of vegetation cover change and tree biodiversity	Mean %
Logging	76 a
Agriculture	75 ab
Charcoaling	73 d
Frequent fire	60 bc
Population growth	55 c

LSD = 2.64

It will, also, be noted that as a result of differential human influences on the forests, there are significant variations in the associated forest characteristics such as timber productivity (Tab. 9). Thus, there are very significant variations in the stocking (number of stem per hectare), basal area and volume between the closed and open forests ($p<0.01$) - the differences are even more dramatic in the per hectare basal areas and volumes with the degraded forest systems consistently showing lower production values. Table 11 indicates the most important population characteristics of the surrounding communities that have made conservation efforts not to work effectively in Ngumburuni forest reserve with the low education level (79%) and low household income (76%) being the most important.

Table 10: Results of productivity conditions in various management systems of Ngumburuni forest reserve

Forest type	Parameter		
	Stem per hectare	**Basal area m^2/ha)**	**Volume (m^3/ha)**
Closed forest stratum	554 **a**	15 **a**	94 **a**
Degraded	390 **b**	2 **b**	9 **b**
Average	463	10	68
$t_{0.01}$, df	3.6	5.8	7.7
t- tabulated	2.3	2.3	2.3
Significance	0.002**	0.000**	0.000**

s.e.d = 1.2

Table 11: Factors of changes in vegetation cover and tree biodiversity

Factors for vegetation cover change	Mean %
Low education level	79 a
low household income	76 a
Poor extension services	70 a
Main economic activities	69 a
Large household size	55 a

s.e.d 2.31

4.3 Corrective measures required to improve the conservation of tree biodiversity in wetland ecosystem in Ngumburuni forest reserve

The results on the corrective measures required improving the conservation of the tree biodiversity in wetland ecosystem in Ngumburuni forest reserve as provided by the respondents and personal observations are presented in Table 12 and 13. Some of these measures are already being implemented by the government e.g. access to loans, and should improve with the improvement in the accessibility of the country’s southern zone.

Table 12: Corrective measures required to improve conservation of tree biodiversity in Ngumburuni forest reserve wetland ecosystem

Suggested corrective measures	Means %
Initiate alternative sources of income and food security	70 a
Law enforcement	68 b
Access to small scale loans	65 b
Increase conservation awareness	62 b
Revision in forest policy on commercial timber harvesting	*
Improvement in cashew nut marketing	*
Reduction in wastage during exploitation of wood products	*

* Personal observation/opinion LSD = 2.2

Table 13: Description of activities allowed and not allowed in the Ngumburuni forest reserve

Forest uses	Should be stopped (highly damaging)	Could be sustained	Could be increased (less damaging)
Timber	x		
Charcoal production	x		
Settlements	x		
Shifting cultivation	x		
Fuelwood collection		x	
Beekeeping		x	
Collecting Wild honey			x
Collecting wild food		x	
Collecting building poles		x	
Roofing materials collection		x (if palms)	
Weaving and dying materials		x	
Medicine collection		x (roots and barks)	
Hunting	x		
Clay for pottery		x	
Tourism		x (has not been tried)	
Ritual uses			x

CHAPTER FIVE

5.0 DISCUSSION

5.1 Status of vegetation cover and tree biodiversity of Ngumburuni forest reserve

The results on the status of vegetation cover and tree biodiversity of Ngumburuni forest reserve are presented on Tables 6, 7, and 8, Figures 3, 4, 5 and 6 and Appendices IV, V VI and VII. The decrease in forest vegetation cover in some ecological units such as coastal forest, closed Miombo woodlands and riverline forests revealed that Ngumburuni forest reserve is facing serious disturbances especially on the northwestern side. The likely reasons for this may be due to high human population in Mangwi villages (Tab. 1) and the nearby huge population from Kibiti Ward which is far placed from the forest reserve and surrounded by few highly degraded public forests. According to FBD (2000), it has been observed that one of the very crucial factors in deforestation is human population growth reinforced by various underlying causes such as poverty and unequal access to land. Kaoneka (2000) observed that the growing population is fed partly by expansion of cropped area, and much of this expansion is at the expense of the miombo woodlands.

On the other hand, the northwestern part of the reserve is bordered by the Dar es Salaam – Mtwara highway which could quite easily develop pathways into the reserve especially during the dry seasons. Kaale *et al.* (2000) urges that there is strong link between road construction and deforestation whereby the then remote forests are later accessible through road building and create avenue for activities such as agriculture, logging and settlements.

Drastic changes on forest cover areas especially during the period between 1995 and 2004 could likely be associated with infrastructural development and emergency of free trade and globalization policy. In the first place, since late 1990s the effective rehabilitation of Dar es Salam - Mtwara main road started followed by completion of Mkapa bridge crossing Rufiji river at Ikwiriri in 2003. This development has increased accessibility of people to Rufiji district from near-by towns especially Dar es Salaam, who are looking for business opportunities and cheap fertile land suitable for agriculture domestication and establishment of new settlements.

Due to free trade and liberalization policy, colossal quantities of timber from southern Tanzania including Ngumburuni forest reserve have been exported to Asia and Europe. The increase in market of hard wood from Tanzania especially to China has been a lucrative business to every one who is involved from felling trees upward to transportation. China’s standing as the largest importer of round logs in the world has increasingly had an impact on Africa, which is now supplying almost a quarter (22.5%) of hardwood logs imported into the country (LLC, 2004).
All these changes brought impact to forests resources in Rufiji district including Ngumburuni forest reserve.

It was noted that ongoing land use activities resulted to variation of tree species diversity between disturbed and undisturbed forest wetland areas. The values of tree species diversity indices from this study revealed that both strata have high level of species richness. According to Barbour *et al.* (1987), Shanon's Index value of >2 has been assigned as medium to high diversity. The higher value of diversity index in degraded stratum than closed one implies that management activities in Ngumburuni forest reserve opens the canopy, thereby creating favourable conditions for emergence of new species or re-growth of suppressed species. In the degraded stratum new fifteen emergent tree species have been found and probably contributed to the higher diversity.

However, it was surprising to note that the regeneration potential of the closed forest was higher than that of degraded stratum. Malimbwi *et al.* (2000), found that, the regeneration of tree species were decreasing from near the Dar es Salaam- Morogoro main road towards the centre of the forest reserve at Kitulangalo, meaning that the regeneration in the miombo woodland is expected to be higher in the open system than the closed ones. The frequently occurring fire in the disturbed forest areas was likely to cause death of some seed in the soil. Getachew *et al*. (2004) in Harenna forest in Ethiopia, similarly observed that, the proportion of germinating seeds from unburned soil sample was higher than in the burned one. It can be realized therefore that, many trees at Ngumburuni forest reserve are regenerating by means of seeds which are susceptible to frequently occurring fires.

The values of index of dominance from this study indicate that, few species in the closed stratum dominated others. These include the following tree species:

Hyphanaena compressa, Euclea divinorum, sysygium cuminii, Antidesma vernosum and Albizia versicolor.

According to Ambasht (2001), the higher value of indices of dominance implies that some species contribute to the community more than others, while the lower value shows that each species in a community contribute relatively evenly. The values of indices of dominance in degraded strata compare well with values of 0.005 and 0.04 in the Usambara and Ulugurus respectively (Munishi *et al*., 2004). These forests have been subjected to human disturbances such as logging and encroachment in the past.

According to Obiri *et al.* (2002), high level extraction of live wood tends to affect forest composition and structure that lead to alteration of forest ecosystem functions and imminent successional collapse. Similarly it has been reported by the MNRT (2002), that permanent or repeated cultivation in miombo woodlands of Eastern Tanzania has resulted in reduced species richness because it involves a complete change of land use. McKenzie (1998) and Seydack (2000) also observed that harvesting of poles, which take place primarily in the regenerative, and non-reproductive understory tree stage, may lead to succession collapse where the natural cycle of succession is disrupted.

Not all tree species within an ecosystem are equally important, despite there being dominant species which have more usefulness due to their sheer number. Species which maintain major functions of the ecosystems are referred to as keystone species. Removing few of these species tend to affect functioning of ecosystems (Jackson *et al.*, 2001).

The closed forest stratum of Ngumburuni forest reserve still harbours important biodiversity, and constitutes a unique habitat for rare or threatened species. During the Songas pipeline survey *Afromomum orientale*, a plant endemic to Rufiji and Mkuranga districts and two orchids, *Microcoelia exilis* and *Microcoelia megalorrhiza*, were found (Songas, 2003). The forest is also a shelter for elephants, antelopes and Black-and-white *Colobus*, for example. Exceptional biodiversity is present for birds (Boswell *et al*., 2002) with the discovery of the second known population of the *Puguensis* race of the Pale-breasted Illadopsis, the presence of red-listed species such as Southern Banded Snake Eagle and East Coast Akalat, occurrence of the rare African Pitta and a host of East Coast biome species such as Tiny Greenbul, Fisher's Greenbul, Little Yellow Flycatcher, Chestnut-fronted Helmet Shrike, Uluguru Violet-backed Sunbird, Kretschmer's Longbill, Brown-breasted Barbet, and Black-breasted Starling. The very recent discovery of the dragonfly *Teinobasis alluaudi* in the Ruhoi floodplain is exciting, as it is only the second record of the African mainland (Clausnitzer, 2003).

5.2 Causes of changes of vegetation cover and tree biodiversity

The results of the causes of changes of vegetation cover and tree biodiversity of Ngumburuni forest reserve are presented on Tables 9, 10 and 11, Figures 8, 9, 10, 11, 12 and 13, and plates 1, 2, 3, and 4.

It has been determined that the major causes of forest degradation in Ngumburuni are human activities rather than natural causes. It has been observed that, fire has been a common feature almost in every activity being undertaken in the forest reserve, such as clearing bush for logging, clearing vegetation for farms, production of charcoal and escaping fires during activities such as harvesting honey, bush meat hunting, etc. According to David and David (2004), Elipenda (2000) and Andress (2005), various natural factors have been observed to cause changes on vegetation cover and tree biodiversity of several forest ecosystems elsewhere. Forest fires may escape and affect larger parts of forests than expected.

Logging in Ngumburuni has been done at varying scales from extraction of few building poles for individual house construction to massive cutting of large diameter trees for commercial export.

Expansion of human population in villages around Ngumburuni forest reserve coupled with abject poverty is likely to escalate exploitation of trees as the cheaply available building materials. The respondents revealed that an average quantity of 15 - 20 poles per week is harvested by one pole harvester.

According to URT (2001) substantial quantities of pole are extracted from the forest for house construction where there are no alternative sources. Indeed, the poles are not only cut among the shrub species but also among the regeneration stems of tree species (Burgess and Clarke, 2000). According to Mzava (1983), poles are collected in two size classes, one which are 2cm in diameter and 2.5 m long, and others which are 10-15cm in diameter and 2.5 - 3m long. The former are used for withies in the house walls and the later are used for vertical poles and roof beams. Roughly 300 poles are needed for an average-sized rural house, which lasts between three and ten years.

Formerly, villagers were harvesting poles from forest mainly for individual house construction, but currently this activity has become a commercial and lucrative one. The poles are sold between Tsh. 150 – 200 per pieces for the big ones and Tsh. 300 – 400 by batches of 25 – 30 poles for the small ones (Burgess and Clarke, 2000). Therefore the rate of building poles extraction from Ngumburni forest reserve is likely to increase with time.

Communities around Ngumburuni prefer tree species that are durable, straight and insect resistant such as *Dombeya rotundifolia*, *Acacia nigrescens*, *Spirostachys africana*, *Pteleopsis myrtifolia*, *Dalbergia melanoxylon*, *Markhamia obstusifolia*, *Casusrinas livingistonei.*

Apart from extraction of building poles, production of sawn wood is one of important economic activity to communities around Ngumburuni forest reserve. Personal observation at Ikwiriri town revealed on-going production of sawn wood conducted by four sawmills which are located few kilometers from the reserve and other small ones around the forest. It is likely that the raw materials for these factories are obtained from Ngumburuni forest reserve. As responded by key informants, smuggling of logs from the reserve is still undertaken especially during the night when forest patrol is less active. Harvesting pressure on the reserve is also contributed by illegal pit-sawing which is conducted inside the reserve and harvesting of undersize trees which are sold as so-called off-cuts or "*viringu*" in Kiswahili language.

Plate 1: One of the Sawmills at Ikwiriri town

The study conducted by REMP (2003) in the reserve determined that, thirteen species of trees were frequently used for sawn wood production whereas Mninga and Mvule species were particularly appreciated for furniture making. Following the barn of these tree species in Rufiji, the saw-millers developed the exploitation of other species, for example Mtondoro or Mpangapanga (Midgedge and Kaale, 2005).

Presence of criss-cross roads in the southern part of the forest as observed by URT (2001) revealed the existence of illegal logging in Ngumburuni forest reserve.

Similar to this, Midgedge and Kaale (2005), reported that large scale timber dealers in Rufiji district use several techniques to avoid payment of royalties, among them include; utilization of off-road truck routes to avoid official check points, travelling at knight, locking trucks to avoid inspection, and hiding timber under other product (e.g. salt).

Plate 2: A truck carrying logs near Kibiti checkpoint

Source: Traffic-WWF (2003)

Data regarding harvesting areas and relative harvesting pressure in Rufiji district between 2000-2001 (Fig. 10) revealed that the area of highest harvesting pressure was Ngumburuni. This indicates that, for many years logging has been one of the main causes of disturbances in the Ngumburuni forest reserve.

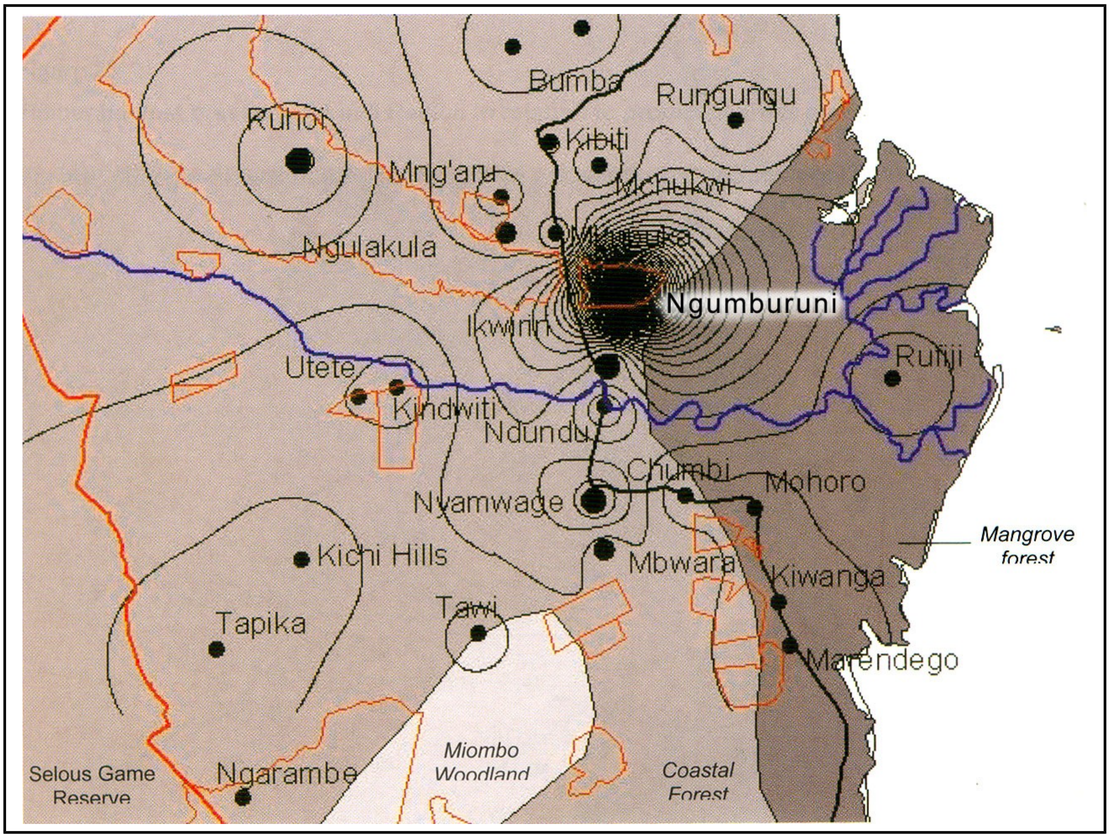

Figure 7: Timber harvesting pressure in Rufiji district

Source: Traffic-WWF (2003)

Global market forces change and infrastructural development in the southern Tanzania corridor are likely to accelerate logging in Ngumburuni. Participation of Tanzania into free market and globalization policy opened avenues to international companies to exploit natural resources in the country including other forests from southern Tanzania. In turn this was perceived as a quick way of generating income among villagers and other Tanzanians who were involved from cutting to transportation of logs.

Lack of permanent crossings across the Rufiji River, particularly during rain seasons was the limiting factor preventing road improvement in southern Tanzania

(Midgedge and Kaale, 2005). However, completion of the Mkapa Bridge in August 2003 has not only provided a more reliable river crossing throughout the year, but also enabled many large trucks to reach Rufiji district easily. Many large trucks have capacities of carrying wood products of up to three times as much as before.

Apart from logging, charcoaling is another major cause of forest degradation in Ngumburuni. During fieldwork several charcoal kilns and stumps of cut trees were seen which revealed existence of charcoal production activities.

Plate 3: Bags of charcoal ready for transportation from charcoal kiln sites

Low household income among villagers around Ngumburuni forest reserve was shown to be the major driving force towards charcoaling activity (Tab. 12). As informed by key informants, majority of villagers obtain less than Tsh. 50 000 per month from agriculture activities This amount is not sufficient to meet necessary household demands such as buying food, clothes, kerosene, transportation etc. Therefore, involvement into charcoaling has been considered as the immediate solution for income generation. As responded by charcoal business men, the current price of one charcoal bag is Tsh. 3 000 in the field and between Tsh. 3 500 to Tsh. 5 000 on the tarmac roadside.

These findings directly compare with those reported by Monela *et al*. (1993) who observed that the number of people seeking income generation and employment opportunities through charcoal production was increasing rapidly, consequently increasing pressure on natural woodlands. High level of charcoal production in Rufiji district is heavily influenced by the high demand from Dar es Salaam, whereby 65% of households use charcoal as main source of cooking energy (Jambiya, 1999).

According to Midgedge and Kaale (2005) charcoal production has increased by 49% per year in Rufiji district between the period 2000-2001. This rate is likely to have been increased in recent years due to increase in human population and improvements in the infrastructural network in southern Tanzania. Charcoaling prefers species which burn slowly and smokeless, although where exploitation is intense, all woody species are cut (Burgess and Clarke, 2000).

Similar to logging and charcoaling, agricultural practices were also observed another important destructive land use activity in Ngumburuni forest reserve. Field observations revealed several newly opened and abandoned farm plots, an indication of existence of shifting cultivation in the reserve. Slush and burn which involves the clearing parts of the forest; collecting smaller trees, unused branches, litter and grass into small heaps or spread evenly on the surface and burnt to form ash to fertilize the soil is widely used (Chidumayo, 1987).

Wetlands favour better performance of several crops and therefore ensure household food security. In Ngumburuni, wetlands or locally known as “*Njacha*” are popular for cultivation of rice and several variety of vegetables. Low soil fertility coupled with inability to afford buying fertilizers is probably the main factors which force farmers to practice this wasteful form of agriculture in Ngumburuni wetlands.

A study conducted by REMP (2003), determined that in Ngumburuni, most of the soils are sandy and they are obviously not really suitable for agriculture except around wetland patches where more fertile soils are obtained. The other reason for cultivation around wetland inside the reserve has been due to availability of high soil moisture content through out the year. However, despite these endowments, shifting cultivation is still practiced within Ngumburuni wetlands, probably because of strong weed infestation.

According to Vissoh *et al.* (2000) small scale farmers have poor means of combating weeds in their farm plots. Kaoneka (2000) observed that clearing the forest canopy promotes fast emergence of suppressed undergrowth plants and germination of light sensitive seeds. The above observation is likely to be a reason for shifting cultivation in Ngumburuni wetlands.

As a subsistence strategy, shifting cultivation has not been popular with many governments and international agencies. Matiru (2002) urges that shifting cultivation is regarded as a waste of land and human resources as well as being a major cause of soil erosion and deterioration. The cleared field is used for a year or two, then a farmer moves on to another patch of the forest.

The study conducted in Zambia by Chidumayo (1997) observed that shifting cultivation has been a serious environmental problem in miombo woodlands where by crops are grown in small ash gardens locally known as *Chitemene* made by burning pile of wood cleared from larger areas of forests. Like wise, Gadgil (1992) emphasized that shifting cultivation to a large extent, results into large-scale deforestation, soil and nutrient loss, and invasion by weeds and other species.

Observation during the field survey revealed that some farmers leave few trees in their cultivation areas for specific reasons such as: provision of shade, for several future uses such as obtaining fire-wood, support climbing crops, provision of fruits, hanging beehives, shade for resting, obtaining medicine and other several uses. Most of the trees found in shifting cultivation areas had relatively lower DBH basically because the larger size ones had been harvested.

Plate 4: Slash and burn practices inside Ngumburuni forest reserve

The diagram below gives the summary of the main trading networks of the forest products in Ngumburuni forest reserve.

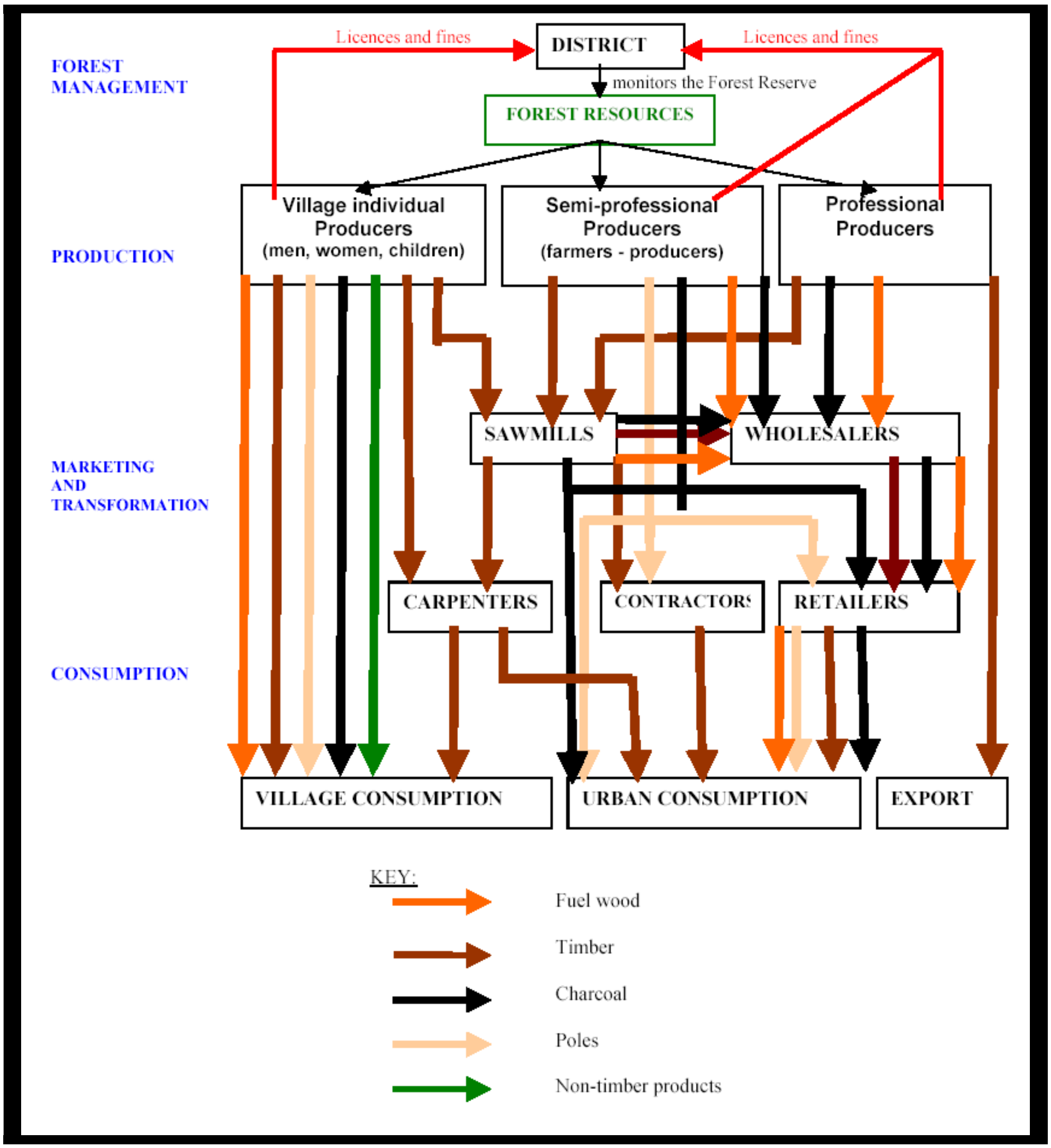

Figure 8: Main forest products trading network from Ngumburuni forest reserve

Source: REMP (2003)

5.3 Determining corrective measures required to improve the conservation of Tree biodiversity and wetland ecosystem in Ngumburuni forest reserve

The results on determination of corrective measures to improve the conservation of tree biodiversity and wetland ecosystems in Ngumburuni forest reserve are presented in Tables 13 and 14, and plates 5, 6, 7 and 8.

It is apparent, based upon the results of this study, that human activities in Ngumburuni forest reserve have had and are currently having adverse impact upon tree biodiversity, vegetation composition and other various aspects of biodiversity within the forest wetland ecosystems. Suggested conservation measures by the respondent indicated that wide variety of programmes and activities should be developed in order to promote conservation of Ngumburuni forest reserve wetlands ecosystems.

Although promotion of alternative income sources, access to small scale loans and law enforcement have been the prioritized conservation measures, their implementation should be simultaneous with other suggested measures, since they compliment each other. Adam and Hulme (2001), urged that, to attain successful conservation, a wide range of integrated conservation projects and development programmes should be emphasized.

Communities adjacent to Ngumburuni forest reserve already have non-timber activities but, presently, they are more a livelihood source at subsistence level rather than a real means for making money. Yet, with regard to protection of the forest, the development of a sustainable extraction of those non-timber products could contribute to the conservation. According to Mvungi (2001), involvement in non wood activities is a possible alternative to the other destructive exploitation methods. Personal observation during the fieldwork revealed existence of several non wood activities carried out by villagers around Ngumburuni forest reserve such as: exploitation of beekeeping, wild food, medicinal plants, ecotourism and hand craft works.

As revealed by key informants during the survey, most of villagers in Rufiji district are interested in beekeeping. Some of the villagers have already tried it or occasionally harvested wild honey. Three producers groups are supported by the District beekeeping development service (Ikwiriri) in the Ngumburuni neighborhood, in Mtunda and Muyuyu. But, generally, the people have no experience and they need training to implement it on a large scale. As responded by key informants, it was determined that villagers still face some challenges in beekeeping projects such as: lack of funds for the starting investments, low selling prices and frequent fires which burn hives and kill bees. If these obstacles will be minimized, beekeeping would enable villagers to raise substantial level of household income. According to FBD (2007) in some villages in Manyoni, district determined that beekeeping has significantly improved the socio-economic conditions and well-being of the beekeepers whereby the average income was increased from USD. 150 in June 2000 to USD. 691 by June 2003.

Wild fruits from tree species like *Vitex doniana, Manilkara sansibarensis , Syzygium guineense, Tamarindus indica and Suregada zanzibariensis* and several edible mushroom are plenty in Ngumburuni forest reserve. Effective exploitation of these resources could assist the adjacent communities to secure household food security and the surplus could be used to generate income through sales.

Plate 5: One of edible Mushroom species in Ngumburuni forest reserve

Source: REMP (2003)

In turkey, for example, widely diverse wild food plants are collected for personal and home consumption, and any surplus is sold on the street or in city market (FAO, 2000). Similarly, Härkonen, (1995) observed that, wild food contributes significantly in supplementing nutritional deficiencies common in Tanzania.

Apart from food plants, Ngumburuni forest reserve contains important populations of medicinal plants. Medicinal plants constitute one of the most important groups of wild plants in terms of their contribution to the economy and well-being of rural households (Shackleton and Shacklaton, 2004). Using medicinal plants is also the most important way of getting relief from various diseases. The observation made by URT (2001) indicated that about four billion people (about two thirds of the world population) depend on traditional medicine for their primary healthy care needs. In Tanzania about 10% of the flora has some kind of application in traditional therapeutics and about 80% of the world's rural population depend medicinal plants for the treatment of a variety of diseases (Hedberg *et al*., 1982).

Exploitation of medicinal plants for income generation is not well utilized in community around Ngumburuni. As responded by a traditional medicine seller at Ikwiriri, it is possible to generate up to Tsh. 80 000 per month. This amount is lower than what is obtained in other places in Tanzania. URT (2001) for instance, reported that in villages around Zaraninge forest reserve in Bagamoyo a saler of medicinal plant could generate up to Tsh 300 000 per month while those in villages around Mgori forest reserve in Singida, Tanzania get Tsh. 170 000 (Hamza, 2004).

Handcraft activities are other useful sources for income generation to local communities adjacent to Ngumburuni. The field survey determined that hand craft productions are still at small scales especially those conducted by the women such as pottery and weaving. The situation is a bit better for the carvings produced from *Dalbergia melanoxylone* whose market is promoted by tourists who pass through

Ikwiriri town on their way to and from the Selous game reserve. Other potential buyers of carvings from craftsmen near Ngumburuni are middle men who sell carvings at big curio shops in Dar es Salaam, Zanzibar and Arusha. With improvements in the infrastructural systems, the likelihood of increasing the number of tourists who visit the southern part of Tanzania is high and, therefore, the market of handcraft products could definitely improve.

Plate 6: A Researcher observing pottery work at Muyuyu village, Rufiji district.

Plate 7*:* Young men preparing carvings at Umwe north village, Rufiji district.
Source: Mpingo Project (2004)

It was noted that, the possibility of establishing ecotourism activities in and around Ngumburuni forest reserve is high, since it is well endowed with natural attractions such as Lake Umwe on the southern side of the reserve, wide diversity of plants and animal species, as well as closeness to Selous game reserve. Ecotourism enables poor rural people to diversify their livelihoods and creates economic incentives to protect natural resources (Nunes *et al*., 2004). It was further noted that, to initiate effective tourism around Ngumburuni forest reserve, tourist facilities such as rest-houses, campsites and social security systems should be established. Together with this, local people need to be trained and get motivated in organizing tourist activities. The study carried out in Nepal by Wells (1993) observed that ecotourism has been increasing in rural areas and hence become lucrative business to farmers. Similarly, in Coast Rica, Brandon (1992) observed that, over 90% of tourists visit local owned enterprises such as souvenir shops, hotels, butterfly farms, art galleries and small factories.

Protection of the forest is important in management of its resources (Adam and Hulme, 2001; Woodcock, 1995). This approach has already been implemented in Ngumburuni forest reserve, although more efforts are needed. As reported by the environment committee chairman at Umwe north village, there are forest patrol teams comprised of voluntary scouts from each village around the forest reserve, who have obtained training and provided with working gear such as tents, sleeping bags, touches, GPS and a gun under the control of a staff from the district game unit who forms as an additional member in each team. The efforts of guarding scouts in Ngumburuni forest reserve are supported by clearly formulated rules which indicate what activities are allowed and not allowed in the reserve.

As reported by the head of the forest scout unit, the established rules pertaining to Ngumburuni forest reserve have been classified into three categories which include;

(i) *Access rule*; this define who may use the forest. In particular, the communities will have to decide if outsiders will be allowed or not to enter the forest, and if yes, under which conditions and for which uses.

(ii) *Uses rules*, whereby the main goal is to set out the authorized, restricted and forbidden uses. In addition, the plan must specify the uses permitted only on licenses with fees, those permitted on the issue of domestic user permits and those freely allowed for community members.

(iii) *Reducing frequency of fire*, whereby fire should be restricted in areas of biodiversity importance such as secondary forest.

However, it has been noted that, thorough investigation should be dome before implementation of command and control approach, otherwise it may not succeed. According to Matiru (2002), the Forest department in Kenya between the period 1980s to 1990s used the command and control approach in all levels by using armed forest guards to police the forest boundaries and enforce management rules and procedures. The weakness of this approach was top down decision making the process and poor feedback mechanism from the bottom up except in writing monthly or quarterly reports.

Further to this, the revenue collected from the forest department was handled to central government and not ploughed back to improve forest in terms of tools provision and field staff motivation. As reported by Paulo (2003), forest decentralization approaches in Kenya overlook the lower management class and contribution of local people. This demoralization leads to serious forest destruction rather than expected high level of conservation success.

Effective community awareness is another important concern towards forest resources conservation, since the majority of villagers around Ngumburuni forest reserve have low level of education and poor access to extension services. According to David (2006), education and learning clearly have a significant role to play in livelihood, since they represent both an important ‘asset’ (knowledge, skills and capabilities) and learning can help people to improve their life, manage vulnerability and change. Critical areas which need effective awareness include; appropriate agricultural practices, understanding potentials and threats of forest resources, and wastage reduction during wood processing.

Shifting cultivation in Ngumburuni is no longer sustainable due to increase in human population. However, response from key informants and personal observation revealed that majority of villagers around Ngumburuni still practice this waste form of land management. The threats of shifting cultivation can only be overcome by the adoption of land use practices like agroforestry in their individual plots outside the reserve. Agroforestry provides different land use options, compared with traditional agricultural and forestry systems (Hannah and Milla, 2002). It makes use of the complementarities between trees and crops, so that the available resources can be more effectively exploited (Lulandala, 2005). It is a practice that respects the environment and has an obvious landscape benefits. The agroforestry plot remains productive for the farmer and generates continuous revenue, which is not the case when arable land is exclusively reforested (Sanchez, 1987). Agroforestry allows for the diversification of farm activities and makes better use of environmental resources (Nair and Graetz, 2004). Lulandala, (2005) emphasized that; appropriate agroforestry systems improve soil physical properties, maintain soil organic matter, and promote nutrient cycling. Successful implementation of agroforestry practices around

Ngumburuni forest reserve will reduce community dependence on some important household needs such as fuelwood, fruits and vegetables from the forest reserve.

Apart from dissemination of agroforestry education, other useful knowledge to be emphasized to villagers sorrounding Ngumburuni forest reserve could include tree planting. So far the exercise has been done by few primary schools and one community based organization at Umwe centre village. Furthermore, it has been observed that utilization of awareness education materials such as posters, leaflets, booklets and film shows is very low for the communities around Ngumburuni forest reserve. This is likely to be another important reason toward less awareness of conservation knowledge among community members. Carney (1998); Jules, P. and David, S. (2004), observed that, awareness education materials continue to brighten the community even where extension staff is absent.

Revision in forest policy on commercial timber harvesting is an important area which needs immediate attention. Several conflicts have been observed due to alteration of some rules which govern commercial utilization of forest products. It has been noted that, most forest governing authorities lack data regarding timber stocks, trade dynamics and proper knowledge on forest management plans (Milledge and Kaale, 2005).

Therefore, through participating local communities, zoning and harvesting plans should be introduced based on scientific inventory findings and socio economic situation of surrounding communities. Further to this, there should be more strictness on harvesting and trade of class I species (*Dalbergia melanoxylone*) and class II species (*Pterocarpus angolensis, Swartizia madagascarensis, Afzelia quanzensis, Millettia stuhlmannii, Milicia exelsa,* and *Newtonia spp*).

Improving market for cashew nut crop would be another important strategy towards reducing dependence on forest resources. Cashew nut is the major cashew crop in the Coast region, however, its market has been decreasing thus putting many villagers in extreme economic hardship. With increased production costs and taxes on cashew nut exports many farmers have not been able to maintain production of high quality cashew, resulting in the export price drop. This had had impact on the purchasing price offered by local exporters to farmers. Mitchelle *et al.,* (2003) observed that, in order to sell his harvest, farmers in Mtwara were ready to accept low prices (i.e Tsh. 175 per kilogram) instead of the Tsh. 540 set by government.

Knowledge in reduction of wastage during wood utilization is highly lacking among Ngumburuni surrounding communities. Only the large diameter parts of the trees are preferred and the rest are left for fire wood or left to decay in the field. The off cuts from fallen trees can be used to create small sized but valuable products such as souvenirs. Sales of these products would be other good sources of income to some villagers around the forest reserve. Rehabilitation of two dormant SIDO workshops at Muyuyu and Ikwiriri would help to provide training to interested individuals and therefore create employment opportunities for them. The success of this program will not only reduce wastage of wood products, but also reduce threats to few preferred species for souvenir production such as *Delbergia melanoxyone*, which is among highly threatened timber species.

CHAPTER SIX

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the results obtained and the subsequent discussion, the following main conclusion can be drawn:

(a) Wetland ecosystems in Ngumburuni forest reserve still contain significant forest resource base in terms of stocking, biodiversity, forest products and services that contribute to the livelihood of adjacent communities and available biodiversity.

(b) The Ngumburuni forest reserve vegetation cover and tree biodiversity have been changing with time. The changes have been more prominent during the period 1995-2004 especially on the northwestern side of the reserve due to high human population and closeness to Dar es salaam – Mtwara main road.

(c) The occurring changes in the wetland ecosystems within Ngumburuni forest reserve have been mainly influenced by human activities which involve several land management activities such as charcoaling, logging, shifting cultivation, population growth and frequent fire which affected a vast proportion of the forest ecosystem and biodiversity composition.

(d) Both internal and external forces have been determined to be underlying causes of wetland degradation in Ngumburuni forest reserve. In the first place, issues such as low income, poor extension services and low education level was determined. On the other hand, participation of Tanzania Government in the free trade and liberalization policy opened the door to multinational foreign companies to trade with the country in different scenarios. Among them included forest resources whereby, Ngumburuni forest reserve was highly inclusive.

(e) Felling of trees creates large gaps in the forest ecosystem that attract emergence of pioneer tree species hence loss of biodiversity. The keystone species are likely to be replaced by less resilient species which loose forest quality. Uncontrolled forest exploitation has negative impact on wetland ecosystem functioning, such as decrease in access to water, pasture to wildlife, breeding grounds as well as building poles and medicinal plants that are crucial to the livelihood of surrounding communities.

(f) To achieve sound management in the Ngumburuni forest wetland ecosystems, several measures were suggested by villagers and some were due to my own observations. However, the outcome of these efforts will not only assist conservation of wetlands areas, but also the rest of the forest reserve ecosystems.

5.2 Recommendations

(a) Ngumburuni forest reserve should be protected from resource degradation especially on the northwestern side, caused by several land management systems especially charcoaling, shifting cultivation and logging to avoid open large part of the forest that invites emergent trees species which are threat to biodiversity conservation and maintenance of gene pool.

(b) Further to this, there should be management actices that will promote regeneration of key species that are crucial for maintaining ecosystem functioning.

(c) Government authorities such as Forestry and Beekeeping Division, NGOs and CBO working in the area and other national strategies such as MKUKUTA should promote alternative income sources in conjunction with communities and investment opportunities. Also the use of energy efficient stoves and establishment of woodlots should be encouraged.

(d) Environmental awareness campaigns should be emphasized from schools to community levels regarding merits of conserving forest resources as well as impacts of associated disturbances. Simple learning materials such as posters, booklets and leaflets written in Kiswahili would assist wide dissemination of knowledge due to small number of extension staff in Rufiji district.

(e) Promotion of Joint Forest Management regime (JFM), where by local communities will be effectively integrated into the management of forest resources. This will be effected with support of CBOs, NGOs and the government

(f) Further studies are recommended especially on determining alternative means of household income generation instead of depending on forest products and cashew nuts which has loose export value.

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APPENDICES

Appendix I: Field inventory form

Date:………………………Recorder:…………………Village……..……………..…

Form No:………………... Strata……………………..Characteristics…...……….

………

Plot No:………………….. Location-Eastings…………….Northing:……...……….

……

Tree No.	Code	Botanical name	Local name	Ns	Dbh (cm)

Regenerations:

S/N	Code	Species Name	Frequency

Appendix II: Questionnaires for household survey

A: GENERAL INFORMATION

A1. Date of interview ……………………………………………..………

A2. Name of enumerator…………………………………………..………

A3. Name of respondent……………………….……………..….….……

A4. Name of Division……………..……………….……………..………

A5. Name of Village………………..……….……………………….…..…….

A6. Household identification number………….…………………………

PART ONE

B. BACKGROUND INFORMATION

B1. Sex of respondent

01 = male [ ]

02 = Female [ ]

B2. Age of respondent in years ………..

B3. Marital status of respondent

01 = Married [ ]

02 = Not married [ ]

03 = Widowed [ ]

04 = Divorced [ ]

B4. What is your current occupation ……………………………………..

B5. What is the total number of family member in the household? ....

B6. Household composition

Family member name	Relationship to Family head	Sex	Age	Education level
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				

PART 2:
MANAGEMENT OF WETLAND RESOURCES

C1. How are wetlands important to you?

(i) ……………………………………………………………..

(ii)…………………………………………………………….

(iii)……………………………………………………………

(iv)…………………………………………………………….

(v)……………………………………………………………..

(vi)…………………………………………………………….

C2. What are causes of wetland disturbances in the forest reserve?

(i) ………………………………………………………………..

(ii)……………………………………………………………….

(iii)………………………………………………………………

(iv)……………………………………………………………….

(v)………………………………………………………………..

(vi)……………………………………………………………….

C3. Why do you practice this type of land management system? (Shifting cultivation, agroforestry, fallowing)

(i) ………………………………………………………………..

(ii)……………………………………………………………….

(iii)………………………………………………………………

(iv)……………………………………………………………….

(v)………………………………………………………………..

(vi)……………………………………………………………….

C4. Where do you get the following resources?

(a) Firewood: ……………………, ……………………, …………………..

(b) Fruits: ……………………, ……………………..…, …………………..

(c) Water: …………………,………………………, …………………..

(d) Vegetables: ……………………, ……………………, …………………..

C4. Which ways do use to clear land for agriculture, why do you prefer it?

(i) ………………………………………………………………..

(ii)……………….……………………………………………….

(iii)……………..……………………………………………………

C5 Do you leave few trees while clearing the forest for agriculture, If **YES** why?

(i) …………………………………………………………………..

(ii)………………..……………………………………………….

(iii)……………..……………………………………………………

C6. What is the source of labour for your activities?

(i) …………………………………………………………………..

(ii)………………..……………………………………………….

(iii)……………..……………………………………………………

C7. With reasons, which tree species do you prefer for: fire wood, building your house, roofing, timber, charcoal production

For firewood uses

(i) …………………………………………………………………..

(ii)……………………………………………………………….

(iii)……………………………………………………………………

For building your house

(i) ……………………………………………………………..

(ii)…………………………………………………………….

(iii)……………………………………………………………

(iv)…………………………………………………………….

For charcoal production

(i) ……………………………………………………………..

(ii)…………………………………………………………….

(iii)……………………………………………………………

For timber

(i) ……………………………………………………………..

(ii)…………………………………………………………….

(iii)……………………………………………………………

C8. What are other uses for trees to your household?

(i) ……………………….………..……………………………………………

(ii)……………………..…………..……………………………………………

(iii)……………………………………………………………………………

C9. Do you get extension services, which one is more reliable to you? (Livestock, forestry, agriculture)

……………………………………………………………………………

……………………………………………………………………………

C10. Have you been involved in forestry conservation campaign? (When, by which organization)

(i) ………………………………………………………….……………………

(ii)…………………………………….………………………………

(iii)…………………………………..………………………………

C11. Have you planted any tree around you house? (Which species, how many, for what uses?

(i) ………………………………………………….……………………

(ii)…………………………………….………………………………

(iii)…………………………………..………………………………

(iv)……………………………………………………………………

C12. What other activities are you engaged for income generation?

(i) ………………………………………………….……………………

(ii)…………………………………….………………………………

(iii)…………………………………..………………………………

C13. Which ways do you think can be adopted to rescue forests resources from further destruction within wetland areas?

(i) ………………………………………………….……………………

(ii)…………………………………….………………………………

(iii)…………………………………..………………………………

Appendix III (a): Checklist for village natural resources committee and elders

1. General information

Name of the village……………………………………………….

Number of VNRC members…………… male……………..female……………..

Success and problem of forest patrol teams………………………………………..

2. **Current condition of wetlands in the forest**

   (a) The general trend of availability of useful resources (large size timber trees, medicinal plants, non wood forest product, sacred areas, clean water, fire wood)

   (b) Causes of degradation of wetland resources in the reserve and underlying causes

   (c) Extent of forest degradation as perceived by community

3. **Forest resources use**

   (a) Importance of forest wetlands resources to the community members (type of products and services accessed by villagers and their priority)

   (b) Condition and potential of wetland outside the reserve (in general land and individual plots)

4. **Way forward**

   Recommendation on sustainable conservation of forest wetland products and services

Appendix III (b): Checklist for DFO, PMs and DAO

1. Management objectives of Ngumburuni forest reserve
2. Staffing level and responsibilities relating to management of the forest reserve
3. Management problems and underlying causes

4. Land use practices around the wetland areas in the reserve and the reasons behind
5. Villagers main economic activities (both forest related and non forest related)
6. What has been done to conserve the wetlands and the forest as the whole in Ngumburuni (NGO involved, CBO developed, level of community participation)
7. What remained to be done in order to achieve sustainable forest resources management (problems from villagers, government, NGO etc)
8. Any suggestion to researchers

THANK YOU

Appendix IV: List of tree species found in Ngumburuni forest reserve wetlands

S/N	Species local name	Species botanical name	Code
1	Mbebeti	*Albizia sp.*	1
2	Mbeku	*Dombeya rotundifolia*	2
3	Mchekea	*Bridelia micrantha*	60

4	Mdaa	*Euclea divinorum*	3
5	Mdimu	*Suregada zanzibariensis*	4
6	Mfumbili	*lonchocarpus heterophyla*	7
7	Mfuru	*Vitex doniana*	5
8	Mgude	*Sterculia appendiculata*	54
9	Mguruka	*Bosca salicifolia*	55
10	Miaa/Milala	*Hyphanaene compressa*	6
11	Mkambala	*Acacis nigrescens*	8
12	Mkekijembe	*Dichrostachys cinerea*	9
13	Mkomafi	*Xylocarpus granatum*	10
14	Mkombanziko	*Crosspteryx febrifuga*	59
15	Mkongo	*Afzelia quanzesis*	11
16	Mkulo	*Spirostachys*	12
17	Mkumbi	*Trichilia dregeana*	13
18	Mkundekunde	*Senna sp.*	14
19	Mkuyu	*Ficus sp.*	15
20	Mkwaju	*Tamandalis indica*	16
21	Mkwanga	*Acacia tortilis*	17
22	Mlondondo	*Hymenaea verrucosa*	19
23	Mnangu	*Hymenaea verrucosa*	20
24	Mndundu	*Cordyla africana*	21
25	Mneke	*Pteleopsis myrtifolia*	22
26	Mngolo	*Sclerocarya birrea*	23
27	Mninga	*Pterocarpus angolensis*	24
28	Mnongoro	*Monanthotaxis buchananii*	25

Appendix IV Cont'.

29	Mnywamaji	*Strychnos panganesis*	26
30	Mpangapanga	*Millettia stuhlmannii*	27
31	Mpingipingi	*Ximenia caffra*	28
32	Mpingo	*Dalbergia melanoxyon*	29
33	Mpome	*Commiphora ugogensis*	30
34	Mpugupugu	*Markhamia lutea*	31
35	Mpuyo	*Bersama abyssinica*	32
36	Msegese	*Piliostigma thonningii*	33
37	Msekeseke	*Swartzia madagascariensis*	34
38	Msenjele	*Erythrina melanacantha*	64
39	Mshada	*Vangueria infausta*	46
40	Msinzi	*Bruguiera zymnorrhiza*	36
41	Msonda	*Acacia sieberiana*	37
42	Msufi	*Bombax rhodognaphalon*	38
43	Mtabwe	*Grewia trichocarpa*	39
44	Mtande	*Trichilia emetica*	45
45	Mtanga	*Albizia versicolor*	42
46	Mtaranda	*Markhamia obtusifolia*	41
47	Mtasi	*Baphia kirkii*	43
48	Mtesatesa	*Drypetes natalensis*	18

49	Mtete	*Hymenocardia ulmoides*	44
50	Mtondolo	*Brachystegia speciformis*	47
51	Mtonga	*Julbernardia globiflora*	48
52	Mtopetope	*Annona senegalensis*	49
53	Mtumba	*Lannea schweinfurthii*	50
54	Mtunda	*Manilkara sansibarensis*	51
55	Muhilo	*Vangueria infausta*	52
56	Muhoro	*Pseudolachnostylis maprouneifolia*	53

Appendix IV Cont'.

57	Muhungo	*Apodytes dimidiate*	40
58	Muuya	*Sterculia africana*	56
59	Mvinje	*Casuarinas livingistonei*	57
60	Mvule	*Milia excelsa*	58
61	Myegea	*Kigelia Africana*	61
62	Myembayemba	*Antidesma vernosum*	62
63	Mzambarua	*Syzygium guineense*	63

Appendix V: The current tree composition and species abundance of Ngumburuni forest reserve wetlands.

Species botanical name	Species local name	Closed stratum	Degraded stratum
Acacia sieberiana	msonda	2	3
Acacia tortilis	mkwanga		4
Acacis nigrescens	mkambala	6	5
Afzelia quanzesis	mkongo	4	
Albizia sp.	mbebeti		2
Albizia versicolor	mtanga	6	4
Annona senegalensis	mtopetope	5	4
Antidesma vernosum	myembayemba	6	5
Apodytes dimidiate	muhungo	4	
Baphia kirkii	mtasi	2	2
Bersama abyssinica	mpuyo	4	4
Bombax rhodognaphalon	msufi		2
Bosca salicifolia	mguruka	3	2
Brachystegia speciformis	mtondolo	5	
Bridelia micrantha	Mchekea	5	1
Bruguiera zymnorrhiza	msinzi		4
Casuarinas livingistonei	mvinje		1
Commiphora ugogensis	mpome		3
Cordyla africana	mndundu		1
Crosspteryx febrifuga	mkombanziko		1
Dalbergia melanoxyon	mpingo	4	4
Dichrostachys cinerea	mkekijembe	2	1
Dombeya rotundifolia	mbeku	4	
Drypetes natalensis	mtesatesa	4	1
Erythrina melanacantha	msenjele	2	
Euclea divinorum	mdaa	8	2

Appendix V Cont'.

Ficus sp.	mkuyu	2	
Grewia trichocarpa	mtabwe	6	2
Hymenaea verrucosa	mlondondo		4
Hymenaea verrucosa	mnangu		2
Hymenocardia ulmoides	mtete	3	3
Hyphanaene compressa	miaa/milala	17	12
Julbernardia globiflora	mtonga	2	4
kigelia Africana	myegea		2
Lannea schweinfurthii	mtumba	6	3
lonchocarpus heterophyla	mfumbili/mjejema	3	2
Manilkara sansibarensis	mtunda		6
Markhamia lutea	mpugupugu	3	2

Appendix V Cont'

Markhamia obtusifolia	mtaranda			
Milia excelsa	mvule	4		
Millettia stuhlmannii	mpangapanga	3		
Monanthotaxis buchananii	mnongoro	1		
Piliostigma thonningii	msegese	2		
Pseudolachnostylis maprouneifolia	muhoro	3	3	
Pteleopsis myrtifolia	mneke		5	
Pterocarpus angolensis	mninga	3		
Sclerocarya birrea	mngolo	2	7	
Senna sp.	mkundekunde	4	8	
Spirostachys	mkulo			3
Sterculia africana	muuya		7	
Sterculia appendiculata	mgude	4		
Strychnos panganesis	mnywamaji	2		
Suregada zanzibariensis	mdimu	2		
Swartzia madagascariensis	msekeseke	3		
Sysygium cuminii	nsenjele	7		
Syzygium guineense	mzambarua		4	
Tamandalis indica	mkwaju	5	5	
Trichilia dregeana	mkumbi	2		
Trichilia emetica	mtande	2	2	
Vangueria infausta	mshada	4		
Vangueria infausta	muhilo	4	5	
Vitex doniana	mfuru	8	5	
Ximenia caffra	mpingipingi		2	
Xylocarpus granatum	mkomafi		2	
Total		**45**	**76**	

Appendix VI (a) Diversity and dominance Indices for trees found in the closed stratum of Ngumburuni forest reserve

S/N	Species name	Local name	IVI	H'	(n/N)^2
1	*Acacia sieberiana*	msonda	2.203933541	0.024848	6.08E-05
2	*Acacis nigrescens*	mkambala	3.728054406	0.034562	0.000288
3	*Albizia versicolor*	mtanga	3.209960832	0.03672	0.000169
4	*Annona senegalensis*	mtopetope	2.376678887	0.03611	5.4E-05
5	*Antidesma vernosum*	myembayemba	3.260463951	0.029733	0.001945
6	*Baphia kirkii*	mtasi	5.359818173	0.073439	0.000338
7	*Bersama abyssinica*	mpuyo	2.203933541	0.024848	6.08E-05
8	*Bosca salicifolia*	mguruka	2.32708219	0.020602	1.35E-05
9	*Bridelia micrantha*	mfuru	5.655907667	0.064847	0.000817
10	*Dalbergia melanoxyon*	mpingo	10.780667	0.094159	0.000662
11	*Dichrostachys cinerea*	mkekijembe	3.728054406	0.034562	0.000288
12	*Drypetes natalensis*	mtesatesa	5.655907667	0.064847	0.000817
13	*Dombeya rotundifolia*	mbeku	4.890695927	0.0446	0.000729
14	*Euclea divinorum*	mdaa	3.931479044	0.03611	5.4E-05
15	*Erythrina melanacantha*	mpingipingi	3.849087567	0.042053	0.001459
16	*Ficus sp.*	mkuyu	4.860840844	0.04331	0.000976
17	*Grewia trichocarpa*	mtabwe	3.4196857	0.048431	0.000761
18	*Hymenocardia ulmoides*	mtete	5.59163847	0.073439	0.000338
19	*Hyphanaene compressa*	miaa	3.728054406	0.034562	0.000288
20	*Julbernardia globiflora*	mtonga	2.6719047	0.034562	0.000288
21	*Lannea schweinfurthii*	mtumba	4.691661323	0.049695	0.000122
22	*lonchocarpus heterophyla*	mfumbili/mjejema	3.260463951	0.029733	0.001945
23	*Markhamia lutea*	mpugupugu	3.4196857	0.048431	0.000761
24	*Milia excelsa*	mvule	3.209960832	0.03672	0.000169
25	*Millettia stuhlmannii*	mpangapanga	1.969589444	0.020602	1.35E-05
26	*Monanthotaxis buchananii*	mnongoro	2.696896625	0.031386	0.000221
27	*Piliostigma thonningii*	msegese	4.860840844	0.04331	0.000976
28	*Pseudolachnostylis maprouneifolia*	muhoro	2.671904 7	0.034562	0.000288
29	*Pterocarpus angolensis*	mneke	4.860840844	0.04331	0.001459
30	*Sclerocarya birrea*	mngolo	3.4196857	0.048431	0.000761
31	*Senna sp.*	mkundekunde	7.714222512	0.094159	0.000662
32	*Sterculia appendiculata*	Mgude	2.696896625	0.031386	0.000221
33	*Strychnos panganesis*	mnywamaji	7.229034653	0.084107	0.000486
34	*Suregada zanzibariensis*	mdimu	9.781391853	0.089199	0.000729
35	*Swartzia madagascariensis*	msekeseke	4.890695927	0.0446	0.001459
36	*Sysygium cuminii*	nsenjele	3.260463951	0.029733	0.001945
37	*Tamandalis indica*	mkwaju	2.6719047	0.034562	0.000288
38	*Trichilia dregeana*	mkumbi	2.696896625	0.031386	0.000221
39	*Trichilia emetica*	mkomafi	5.004614028	0.056375	0.002917
40	*Vangueria infausta*	mshada	5.004614028	0.056375	0.000547
41	*Vitex doniana*	muhilo	3.849087567	0.042053	0.000243
	Shannon Index			**1.919767**	
	Index of dominance				**0.092834**

Appendix VI (b) Diversity and dominance Indices for trees found in the disturbed stratum of Ngumburuni forest reserve

S/N	Local name	Botanical name	IVI	H'	(n/N)^2
1	*Acacia sieberiana*	msonda	13.894	0.128	0.0038122
2	*Acacia tortilis*	mkwanga	13.454	0.034	0.0001176
3	*Acacis nigrescens*	mkambala	12.648	0.154	0.0066297
4	*Afzelia quanzesis*	mkongo	12.202	0.059	0.0004704
5	*Albizia sp.*	mbebeti	11.393	0.134	0.00442225
6	*Annona senegalensis*	mtopetope	10.861	0.192	0.0133035
7	*Antidesma vernosum*	myembayemba	10.745	0.18	0.0107751
8	*Apodytes dimidiate*	muhungo	1.966	0.02	0.0000294
9	*Baphia kirkii*	mtasi	10.498	0.047	0.0002646
10	*Bersama abyssinica*	mpuyo	9.776	0.11	0.00252105
11	*Bombax rhodognaphalon*	msufi	9.207	0.079	0.00101675
12	*Bosca salicifolia*	mguruka	8.118	0.047	0.0002646
13	*Brachystegia speciformis*	mtondolo	8.07	0.095	0.0016562
14	*Bridelia micrantha*	mchekea	1.92	0.02	0.0000294
15	*Bruguiera zymnorrhiza*	msinzi	8.012	0.139	0.0048828
16	*Casuarinas livingistonei*	mvinje	7.91	0.143	0.0053704
17	*Commiphora ugogensis*	mpome	7.663	0.173	0.0095452
18	*Cordyla africana*	mndundu	7.154	0.117	0.0029449
19	*Crosspteryx febrifuga*	mkombanziko	6.902	0.02	0.0000294
20	*Dalbergia melanoxyon*	mpingo	6.701	0.027	0.0000661
21	*Dichrostachys cinerea*	mkekijembe	6.585	0.127	0.0037289
22	*Drypetes natalensis*	mtesatesa	1.769	0.011	0.0000073
23	*Euclea divinorum*	mdaa	6.468	0.02	0.0000294
24	*Grewia trichocarpa*	mtabwe	5.944	0.051	0.0003111
25	*Hymenaea africana*	mlondondo	5.784	0.055	0.0003871
26	*Hymenaea verrucosa*	mnangu	5.71	0.085	0.0012446
27	*Hymenocardia ulmoides*	mtete	5.56	0.076	0.0008918
28	*Hyphanaene compressa*	miaa	5.45	0.093	0.0015484
29	*Julbernardia globiflora*	mtonga	5.382	0.108	0.0023863
30	*Kigelia Africana*	myegea	5.259	0.043	0.00020335
31	*Lannea schweinfurthii*	mtumba	5.206	0.112	0.00265825
32	*Lonchocarpus heterophyla*	mjejema	4.815	0.108	0.0023863
33	*Manilkara sansibarensis*	mtunda	1.731	0.011	0.00000735

34	*Markhamia lutea*	mpugupugu	4.62	0.088	0.0013426

Appendix VI (b) Cont'.

35	*Pseudolachnostylis maprouneifolia*	mtaranda	4.254	0.108	0.0023863
36	*Pteleopsis myrtifolia*	mvule	4.2	0.07	0.00073745
37	*Sclerocarya birrea*	mngolo	4.021	0.027	0.00006615
38	*Senna sp.*	mkundekunde	5.524	0.04	0.00008575
39	*Sterculia africana*	muuya	5.472	0.047	0.00013965
40	*Syzygium guineense*	mzambarua	5.164	0.047	0.00013965
41	*Tamandalis indica*	mkwaju	5.03	0.056	0.00015435
42	*Trichilia emetica*	mkumbi	1.731	0.011	0.00000735
43	*Vangueria infausta*	mshada	4.218	0.076	0.00060515
44	*Vitex doniana*	mfuru	3.605	0.033	0.0000441
45	*Ximenia caffra*	mpingipingi	3.545	0.031	0.00003675
46	*Xylocarpus granatum*	mkomafi	2.088	0.02	0.0000294
	Shannon Index			**3.672**	
	Index of dominance				**0.02571655**

Appendix VII: Distribution pattern of regenerants in the two forest strata of Ngumburuni forest reserve, Rufiji district

Closed forest stratum					Degraded forest stratum				
Sp Code	Local name	Botanical name	% Rltv freq	Stocking	Sp code	Local name	Botanical name	f% Rltv freq	Stocking
5	Mfuru	*Vitex doniana*	33.8	2452	5	Mfuru	*Vitex doniana*	27.8	742
6	Miaa/Milala	*Hyphanaene compressa*	17.7	362	6	Miaa/Milala	*Hyphanaene compressa*	12.1	341
41	Mtaranda	*Markhamia obtusifolia*	12.5	315	41	Mtaranda	*Markhamia obtusifolia*	10.1	297
22	Mneke	*Pteleopsis myrtifolia*	4.9	212	42	Mtanga	*Albizia versicolor*	9.1	214
51	Mtunda	*Manilkara sansibarensis*	4.1	208	39	Mtabwe	*Grewia trichocarpa*	5.2	178
49	Mtopetope	*Annona senegalensis*	3.9	185	2	Mbeki	*Dombeya rotundifolia*	5.1	164
44	Mtete	*Hymenocardia ulmoides*	3.8	183	14	Mkundekunde	*Senna sp.*	5.1	164
29	Mpingo	*Dalbergia melanoxyon*	3.4	180	20	Mnangu	*Hymenaea verrucosa*	3.6	112
58	Mvule	*Milia excelsa*	2.4	111	54	Mgude	*Sterculia appendiculata*	3.4	110
3	Mdaa	*Euclea divinorum*	1.3	80	9	Mkekijembe	*Dichrostachys cinerea*	3.3	108
8	Mkambala	*Acacis nigrescens*	1.5	60	16	Mkwaju	*Tamandalis indica*	3.2	104
59	Mkombanziko	*Crosspteryx febrifuga*	1.3	57	25	Mnongoro	*Monanthotaxis buchananii*	2.6	88
12	Mkulo	*Spirostachys africana*	1.2	58	34	Msekeseke	*Swartzia madagascariensis*	2.2	83
13	Mkumbi	*Trichilia dregeana*	1.1	52	47	Mtondolo	*Julbernardia globiflora*	2.1	52
26	Mnywamaji	*Strychnos panganesis*	1.1	52	59	Mkombanziko	*Crosspteryx febrifuga*	2.1	52
27	Mpangapanga	*Millettia stuhlmannii*	0.9	43	13	Mkumbi	*Trichilia dregeana*	2.1	52

Appendix VII Cont'

Closed forest stratum					Degraded forest stratum				
Sp Code	Local name	Botanical name	% Rltv freq	Stocking	Sp Code	Local name	Botanical name	% Rltv freq	Stocking
36	Msinzi	*Bruguiera zymnorrhiza*	0.8	41	8	Mkambala	*Acacis nigrescens*	0.9	48
29	Mshada	*Vangueria infausta*	0.8	41					
65	Myombo	*Brachystegia bussei*	0.8	41					
17	Mkwanga	*Acacia tortilis*	0.7	39					
24	Mninga	*Pterocarpus angolensis*	0.6	36					
25	Mnongoro	*Monanthotaxis buchananii*	0.6	36					
34	Msekeseke	*Swartzia Madagascariensis spp*	0.4	32					
37	Msonda	*Acacia sieberiana*	0.2	28					
38	Msufi	*Bombax rhodognaphalon*	0.2	28					
47	Mtondolo	*Julbernardia globiflora*	0.1	23					
Total			**100**	**4955**				**100**	**2909**

Appendix VIII (a): Factors for vegetation cover change (raw data)

Factors for vegetation cover change	Villager's response (%)		
	Mkupuka	Umwe kaskz	Mangwi
Low education level	30	16	22
low household income	22	22	24
Large household size	11	18	21
Poor extension services	20	20	22
Main economic activities	17	24	11
Total	**100**	**100**	**100**

Appendix VIII (b): Factors for vegetation cover change (means in corresponding angles)

Factors for vegetation cover change	Villagers response (corresponding angles)			
	Mkupuka	Umwe kaskz	Mangwi	Means
Low education level	33.21	23.58	27.28	**28**
low household income	27.97	27.28	29.33	**28**
Large household size	19.37	25.1	27.28	**24**
Poor extension services	26.56	26.56	27.97	**27**
Main economic activities	24.35	29.33	19.37	**24**

Appendix VIII (c): Factors for vegetation cover change (analysis of variance)

ANOVA

Source of variation	SS	df	MS	F	F crit
Between Groups	49.7	4	12.4	0.93	3.5
Within Groups	133.7	10	13.4		
Total	**183.4**	**14**			

s.e.d = sqrt(2 * variance/n) = sqrt(2* 13.4/5) = **2.31**

Since *F* calc< *F*tab, there is no significant differences in factors of vegetation cover changes between sampled villages

Appendix IX (a): Suggested corrective measures for conservation of Ngumburuni forest reserve (raw data)

Corrective measures	Villager's response (%)		
	Mkupuka	Umwe kaskz	Mangwi
Initiate alternative sources of income	28	25	32
Access to small scale loans	17	18	17
Increase conservation awareness	22	19	20
Law enforcement	22	23	18
Improved public services (water, shops, hospitals)	11	15	13
Total	**100**	**100**	**100**

Appendix IX (b): Suggested corrective measures for conservation of Ngumburuni forest reserve (means in corresponding angles)

Corrective measures	Villager's response (corresponding angles)			
	Mkupuka	Umwe kaskz	Mangwi	Means
Initiate alternative sources of income	31.95	30	34.45	**32.13**
Access to small scale loans	24.35	25.1	24.35	**24.60**
increase conservation awareness	27.97	25.84	26.56	**26.79**
Law enforcement	27.97	28.66	25.1	**27.24**
improved public services (water, shops, hospitals)	19.37	22.79	21.13	**21.10**

Appendix IX (c): Suggested corrective measures for conservation of Ngumburuni Forest Reserve (analysis of variance)

Source of variation	SS	df	MS	F	F crit
Between Groups	195.3	4	48.8	19.0	3.5
Within Groups	25.6	10	2.6		
Total	**220.9**	**14**			

s.e.d = sqrt(2 * variance/n) = sqrt(2* 13.4/5) = 1.02

Since F calc> Ftab, there is significant differences in measures suggested for conservation of forest reserve

L.S.D = $_{t\ 0.05,10}$ * s.e.d = 2.2 * 1.02 = 2.2

Appendix X (a): Causes of vegetation cover change (raw data)

Causes	Villager's response (%)		
	Mkupuka	Umwe kaskz	Mangwi
Logging	23	26	24
Agriculture	23	25	22
Charcoaling	24	18	23
Frequent fire	11	13	16
Population growth	19	18	15

Appendix X (b): Causes of vegetation cover change (means in corresponding angles)

Causes	Villager's response (corresponding angles)			Mean
	Mkupuka	Umwe kaskz	Mangwi	
Logging	28.66	30.66	29.33	**30**
Agriculture	28.66	30	27.28	**28.6**
Charcoaling	29.33	25.1	28.66	**27.7**
Frequent fire	19.37	21.13	23.58	**21.4**
Population growth	25.84	25.1	22.79	**24.6**

Appendix X (c): Causes of Vegetation cover change (analysis of variance)

Source of variation	SS	df	MS	F	F crit
Between groups	136.1	4	34.02	11.29	3.47
Within groups	30.1	10	3.01		
Total	**166.2**	**14**			

s.e.d = sqrt(2 * variance/n) = sqrt(2* 3.01/5) = 1.2

Since F calc> Ftab, there is significant differences in causes for vegetation cover change between villages

L.S.D = $t_{0.05,10}$ * s.e.d = 2.2 * 1.2 = 2.64