## 1.0 INTRODUCTION

### The East Usambara Mountains

The forests of the East Usambaras, located between 4°48′132 – 5°13′ S and 38°32′–38°48′ E belong to the chain of the Eastern Arc Mountains. They are among the most important vegetation for biodiversity conservation in Africa, containing high rates of endemism in both plant and animal species. Myers *et al.* (2000) documented that these forests have the highest ratio of endemic flora and fauna per 100 $km^2$ of all biodiversity hotspots in the world.

They are also home to communities of poor people who need to utilize the forests' natural resources for survival. The East Usambara forests are largely located in Muheza district (90%) and the balance is in Korogwe district. It is estimated that about 120,000 people live in these areas, distributed across 61 villages.

The major threats to the forests in the East Usambaras are fire, spreading from surrounding farmlands, logging, gold mining and farmland encroachment particularly into the yet ungazetted forests. There is also a serious issue of invasive species outstandingly, of the tree *Maesopsis eminnii* and various shrubs, herbs and lianas.

In Muheza District the East Usambaras are embedded in one nature reserve (Amani), 11 forest reserves, one proposed forest reserve (Derema), four village forest reserves and two private forests. Outside these reserves, most of the forests have been cleared for farmland and the remaining forests are in private land.

Studies have indicated that if the forests become too fragmented and isolated, a number of the species only known to exist from these forests will become globally extinct. Forest loss will also disrupt the ecological services currently provided by the forests to the villages and towns in the vicinity of the East Usambaras.

The Derema Forest Corridor, located in Muheza District Tanga with about 940 ha of land, was once used for cardamom farming and other human activities, now is to be gazetted later this year as a National Forest Reserve. Adjacent to this corridor however, are five villages namely; Kisiwani, Kwemdimu, Msasa IBC, Kwezitu and Kambai with a total human population of 7,878 out of which 14.3% is dependent in one way or another, on this forest. In order to accomplish the gazettement mission, development of a management plan for this forest is essential and this is only made possible after conducting both biodiversity and socio-economic surveys of the forest.

## 2.0 OBJECTIVES

### 2.1 Main objective

The overall objective of this study is to collect all important bio-physical and socio-economic information for enhancement of formulation of management plan of the Derema Forest Corridor.

### 2.2 Specific Activities

From the above highlight of Derema Forest Corridor, the proposed specific activities to be conducted in the forest for the biodiversity survey include the following:

a) Carry out biological baseline surveys
b) Identify and provide information of biological values and importance of this forest
c) Provide a system for monitoring aspects of forest biodiversity
d) Assess levels of disturbance by the incidences of tree cutting, cardamom farms, planted exotics and other colonizing plant species
e) Collect opportunistic data (species list) on all other groups of vertebrates and invertebrates
f) Undertake socio-economic appraisal of the impact of resource use by the adjacent communities
g) Provide recommendations, after analyses on:
    i. Species richness microhabitat - through zoning and mapping
    ii. Flora and Fauna records and distribution
    iii. Current disturbance incidences (severity and incidences)
    iv. Conservation and management measures that Forest and Beekeeping Division and other stakeholders should follow to improve forest cover and maintain biodiversity of the forest including management potentials and options such as remaining an autonomous Forest Reserve, annexation to Amani Nature Reserve or Nilo Nature Reserve, application of JFM arrangements etc
    v. Indicate possible roles of the different stakeholders in the conservation and potential actual benefits
    vi. The forest status monitoring indicators to be tracked over time

## 3.0 DESCRIPTION OF THE FOREST

### 3.1 General description

#### 3.1.1 Description

Name: Derema Forest Corridor
Location: Muheza District, Tanga Region, Tanzania.
Area: 938.53 ha or 9.4 $km^2$
Status: Proposed National Forest Reserve
Map: Forest Division map JB 2569

#### 3.1.2 Location

Grid reference: 38°45′E - 38°47′E; 5 °00′S – 5°02′S
Derema Forest Corridor is connected to Amani Nature Reserve, the largest single block of forest in the East Usambara Mountains to the south (Fig. 3.1)

Elevation: Approximately 190 - 1,130 m above sea level (Fig. 3.2).

Vegetation: Submontane and lowland forests. The majority of Derema Forest Corridor can be classified as dense lowland forest.

Climate: The mean annual rainfall is 1,910 mm and the mean minimum and maximum Temperature is 16.3°C and 24.1°C, respectively.

Figure 3.1 The location of Derema Forest Corridor in relation to other East Usambara forests.

Figure 3.2 Topographical map of Derema Forest Corridor

## 4.0 VEGETATION

### 4.1 Introduction

A survey of the vegetation type and plant species diversity found in Derema Forest Corridor was conducted within the forest. Simple quantitative and repeatable methods were employed and the results can be compared with other forest surveys elsewhere. Human disturbance within the forest was also recorded.

### 4.2 Sampling and data collection

#### 4.2.1 Sampling units and sampling exercise

The sampling units were forest areas of the Derema Forest Corridor established after a preliminary survey with great assistance of the map of Amani Nature Reserve and Derema Forest Corridor and forest officers in the area. Systematic sampling techniques were employed on four transects located at a predetermined interval of 2 km, together covering a total distance of 8.3 km. The transects ran west–east (Figure 4.1), ensuring coverage of all effects of altitude and human on the vegetation composition, abundance and quality. A total number of 41 plots located 200 m apart along the transects were established on the entire forest area and data collected there from.

Figure 4.1 Location of vegetation transects and plots in Derema Forest Corridor

Due to the nature of this study, Whittaker plot design was employed, whose features are described below:

- 20 m x 50 m main plot within which are two 5 m x 10 m plots at two corners
- Ten 0.5 x 1 m plots along the main plot boundaries
- One 10 m x 20 m central plot

### 4.2.2 Data collection

In this design, only those species not found in small plots were counted in the main plot, the smallest plots were used for regenerants'counts and trees with DBH ≥ 4, 10 m x 5 m plots for trees with DBH ≥ 10 cm and 10 m x 20 m plots for DBH ≥ 20 cm. In all plots, human disturbances were assessed: counting stumps, effect of fire, tree injuries and health, fodder collection and presence of agricultural crops.

In each plot laid, names of all plants encountered were recorded using scientific names aided by a botanist from Tanzania Forestry Research Institute (TAFORI). For each plant species encountered, information on its different uses was availed by local ethno-botanists. From these techniques, such information as identity of plant species, uses, status, distribution and abundance, level of disturbance, exotics and other colonizing plant species could be gathered for further analyses. Also intensive desk studies were executed for collection of secondary data with reference to Lovett (1989; 1993) and Ruffo *et al.* (1989).

## 4.3 Data analysis

Species diversity is the most dominant method for ecological and conservation techniques (Kent and Coker, 1992). This was determined employing species diversity indices and species area relationships.

### 4.3.1 Species diversity indices

As recommended by Krebs (1989), Shannon index of diversity or Shannon-Wiener index of diversity was used as it is not affected by sample size and puts more emphasis on rare species.

### 4.3.2 Species area relationships

The curves presented species diversity in a graphical form in which cumulative number of species was plotted against area.

### 4.3.3 Description of the species

Each species encountered was described according to its life form and where possible, ecological type, habitat and endemic status. The following are keys to the abbreviations used:

Ecological type (based on Iversen, 1991)

F Forest dependent species: This is defined as primary forest only. It does not include forest edge or secondary forest;

f Forest dwelling but not forest dependent: Species occurring in primary forest as defined above as well as other vegetation types. Thus these are not forest-dependent species; and

O Non-forest species: These are species that do not occur in primary or secondary forest or forest edge.

Habitat (based on Hamilton, 1989)

L Lowland: Species occurring at altitudes of <850 m;

S Submontane: Species occurring at altitudes of >850 m.

Endemic status (based on Iversen, 1991)

E Endemic: Occurring only in the Usambara mountains;

N Near endemic: Species with limited ranges in the Eastern Arc mountains and/or the East African lowland forests;

W Widespread distribution.

EU Range limited to the East Usambaras;

WU Range limited to the West Usambaras

## 4.4 RESULTS AND DISCUSSION

### 4.4.1 General

Results on survey of vegetation of Derema Forest Corridor are summarized in Appendix II. The study identified 1,435 plant species distributed within 153 families. There is a very significant discrepancy with results obtained in Kambai Forest Reserve by Cunneyworth (1996), Manga Forest Reserve by Doggart *et al.* (1999) and Mtai Forest reserve by Doggart (1999). In these similar studies, the identified plant species were 162, 329 and 271 respectively.

This can be due to the fact that in Kambai, only trees and shrubs were counted. In the survey of Derema, all plant species of all life forms including trees, shrubs, herbs, lianas, epiphytes and orchids, also the opportunistic species not found in the established plots were considered.

As recommended by Kershaw (1973), the curve presented species diversity in a graphical form in which cumulative number of species was plotted against number of plots covered. As the size of the sample was increased, the number of species increased very noticeably. The minimal number of plots required for this study was the area at which the curve became horizontal, for this case it was 41 plots. This shows how Derema Forest Corridor is endowed with an enormous number of plant species with more or less an even distribution compared to Kambai, Manga and Mtai Forests in which 51, 46 and 110 plots had to be laid.

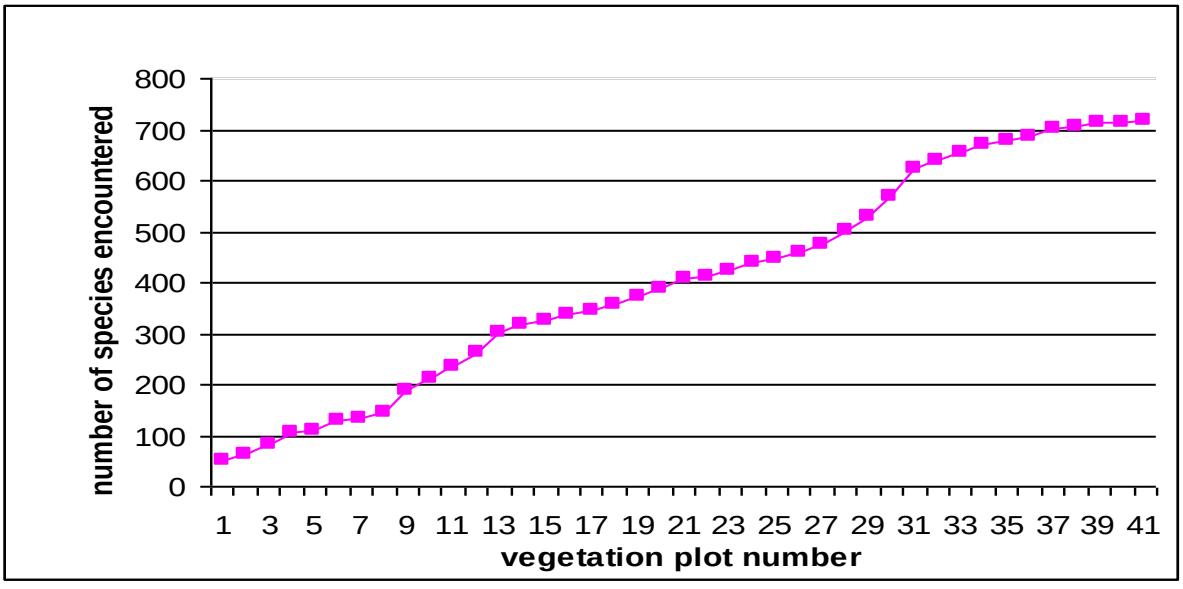


Figure 4.2 Species accumulation rates of plant species by vegetation plot in Derema

### 4.4.2 Life form

The life forms of these species are as summarized below with their respective numbers and percentages.

Table 4.1 Summary of plant species life form and distribution in Derema Forest Corridor

| Species' life form | Number of species encountered | Percentage composition of life form to the forest |
|---|---|---|
| Trees | 524 | 36.5 |
| Shrubs | 325 | 22.6 |
| Herbs | 395 | 27.5 |
| Lianas | 4 | 0.3 |
| Climbers | 173 | 12.1 |
| Palms | 8 | 0.6 |
| Epiphytes | 3 | 0.2 |
| Orchids | 3 | 0.2 |

From the results in Table 4.1 above, it is evident that the largest composition of the forest is from trees, followed by shrubs and herbs. Also, climbers are numerous, indicating the difficulty one is expected to encounter when penetrating the forest.

### 4.4.3 Species richness and diversity

Species richness and diversity are important characteristics of Derema Forest Corridor that determine its potential for biodiversity conservation. A Shannon-Wiener index of species diversity of 4.32 was obtained for Derema, indicating high biodiversity conservation potential of the forest.

### 4.4.4 Ecological type

Results in Table 4.2 below indicate that the majority (16.4%) of the plant species of Derema Forest Corridor is forest non-dependent species and 9.1% is forest dependent species. These results are in agreement with similar studies by Cunneyworth (1996), Doggart *et al.* (1999) and Doggart (1999) for Kambai, Manga and Mtai Forests, respectively.

Table 4.2 Summary of ecological types for plant species of Derema Forest Corridor

| Ecological type | Number of species | % of total species |
|---|---|---|
| F - Forest Dependent Species | 130 | 9.1 |
| f - Forest Non-Dependent Species | 235 | 16.4 |
| O - Non-Forest Species | 98 | 6.8 |
| Unknown | 971 | 67.7 |
| Total | 1,435 | 100.0 |

### 4.4.5 Habitat

Table 4.3 Summary of the habitat for the plant species of Derema Forest Corridor

| Habitat | Number of species | % of total species |
|---|---|---|
| L – Lowland Forest Species | 104 | 36.2 |
| S – Submontane Forest Species | 11 | 3.8 |
| L & S | 172 | 59.9 |
| Total | 287 | 100.0 |

Most of the species of Derema Forest Corridor (36.2%) are lowland and only 11 (3.8%) are entirely sub-montane. However, about 60% are found in both habitats.

In the sub-montane habitat, two species *Morinda asteroscepa* and *Oxyanthus speciosus* are found in forest gaps whereas in the both lowland and sub-montane, the forest gap species are *Trema orientalis*, *Cussonia zimmermannii* and *Markhamia lutea* .

### 4.4.6 Endemic status

The status of the species can also be summarized by Figure 4.3 as: 30 (2%) have been introduced (alien), almost 80 (6%) are nearly endemic with limited ranges in the Eastern Arc Mountains and /or the East African lowlands between Somalia and Mozambique and 12 (1%) are endemic. Figure 4.4 shows that, of the endemic species, 4 (5%) species are endemic to the East Usambaras namely; *Saintpaulia grotei*, *Psychotria triclada, Cola usambarensis* and *Rinorea scheffeleri* in which the former is also endangered. Eight species (10%) namely; *Saintpaulia magungensis, Chassalia albiflora, Englerodendron usambarense, Greenwayyodendron suaveolens, Rinorea angustifolia, Rytigynia longicaudata, Sericanthe odoratissima* and *Uvariodendron oligocarpum* are endemic in both East and West Usambaras.

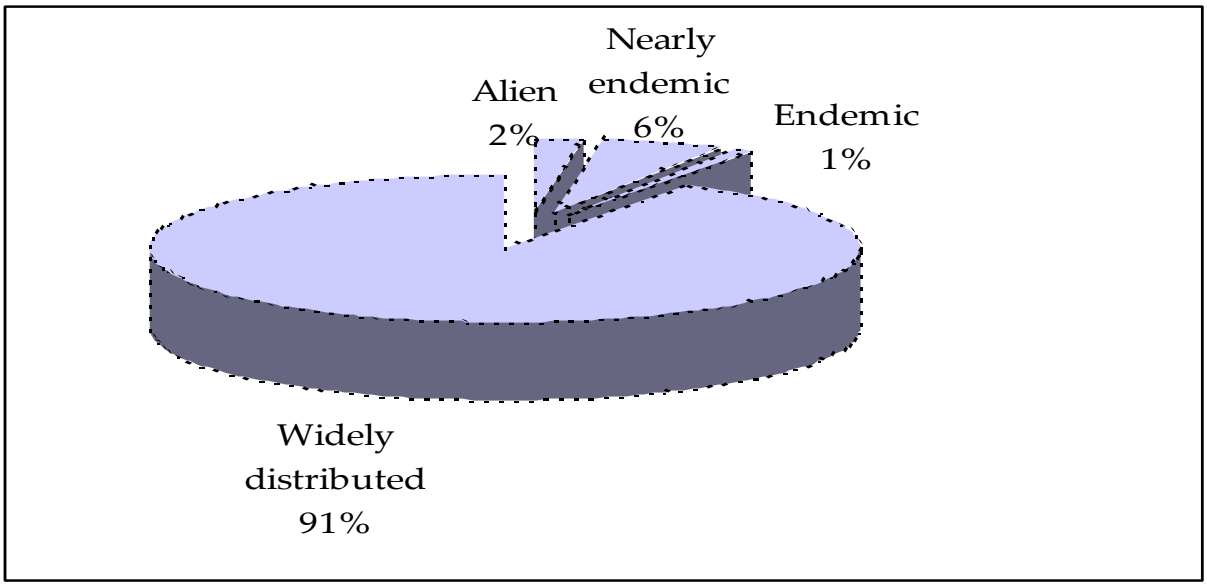


Figure 4.3 Summary of endemic status for plant species of Derema Forest Corridor

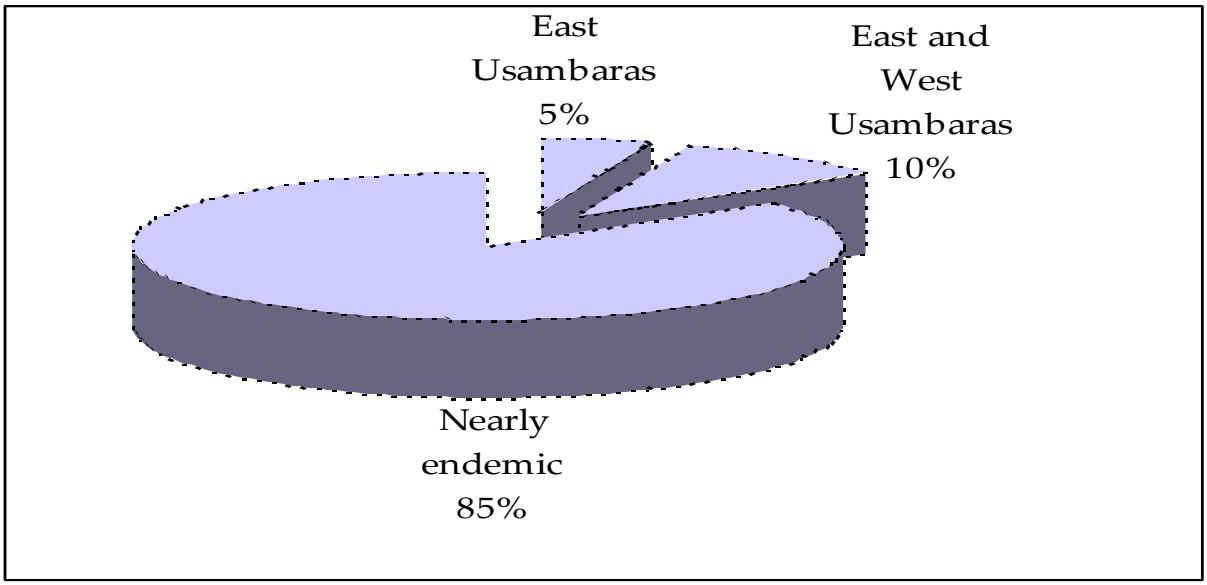


Figure 4.4 Proportions of endemic plant species of Derema Forest Corridor

It should be noted here that, out of all the endemic species, three are shrubs (*Psychotria triclada, Chassalia albiflora* and *Englerodendron usambarense*), two are herbs (*Saintpaulia grotei* and *S. magungensis*) and seven are trees (*Greenwayyodendron suaveolens, Rinorea angustifolia, R. scheffeleri, Rytigynia longicaudata, Sericanthe odoratissima, Uvariodendron oligocarpum* and *Cola usambarensis*). And that all are forest dwelling species in which two (17%) namely; *Saintpaulia magungensis* and *Saintpaulia grotei* are non-forest dependent and the remaining 10 (83%) are forest dependent.

These observations confirm why previous researchers have globally identified the East Usambara forests as an area of high endemism within the hotspot. The forests have also been listed as a national priority for conservation investment based on the present threat and biodiversity value.

### 4.4.7 Introduced species

The introduced species are a result of local naturalization taking place as a result of human encroachment and the Amani Botanical Garden. They include the agricultural species of *Musa* spp., *Piper nigrum, Citrus aurantium, C. sinensis, Mangifera indica, Manihot esculenta, Artocarpus heterophyllus, A. integrifollia, Capsicum frutescens* and *Cocos nucifera.*

Other agricultural crops are *Manihot glaziovii, Psidium guajava, Syzygium aromaticum, Syzygium cuminnii, Telfairea pedata* and *Elettaria cardamomum.* The other species are *Tectona grandis*, *Opuntia cochenilifera, Hyptis suaveolens* and *Olyra latifolia*. Some of the introduced species are also invasive, colonizing the forest area. They include *Maesopsis eminnii, Cedrella odorata, Lantana camara, Clidemia hirta, Psidium cattleianum, Landolphia owariensis, Elaeis guineense, Arenga pinnata* and *Bamboo vulgaris.*

*Maesopsis eminii,* a fast growing, gregarious pioneer tree species, was initially introduced to the area in 1913 (Binggeli, 1989) and large-scale spread started in the 1970s, following industrial logging and the species' subsequent planting to restock the logged sites, and its use as a nurse tree for *Cephalosphaera usambarensis.* The establishment of *M. eminii* plantations was discontinued in 1981 and commercial harvesting banned in 1986 (Hall, 1995). According to Binggeli (1989), *M. eminii* would have the potential to invade up to 50% of the natural forest area in the East Usambaras within the next 200 years.

In the study on *Maesopsis eminii* in the East Usambaras, Viisteensaari *et al.* (2000) concluded that no active, risky eradication of *Maesopsis* is needed in the conservation area, but a priority management task should be to avoid canopy gaps.

### 4.4.8 Vegetation type and distribution

A survey of the Derema Forest Corridor identified five types of vegetation in the entire forest area. These are Forest, Open or disturbed forest, Bush or thicket, grassland and woodland, as depicted in Figure 4.5 below.

Figure 4.5 Major vegetation type of Derema Forest Corridor

### 4.4.9 Forest disturbance

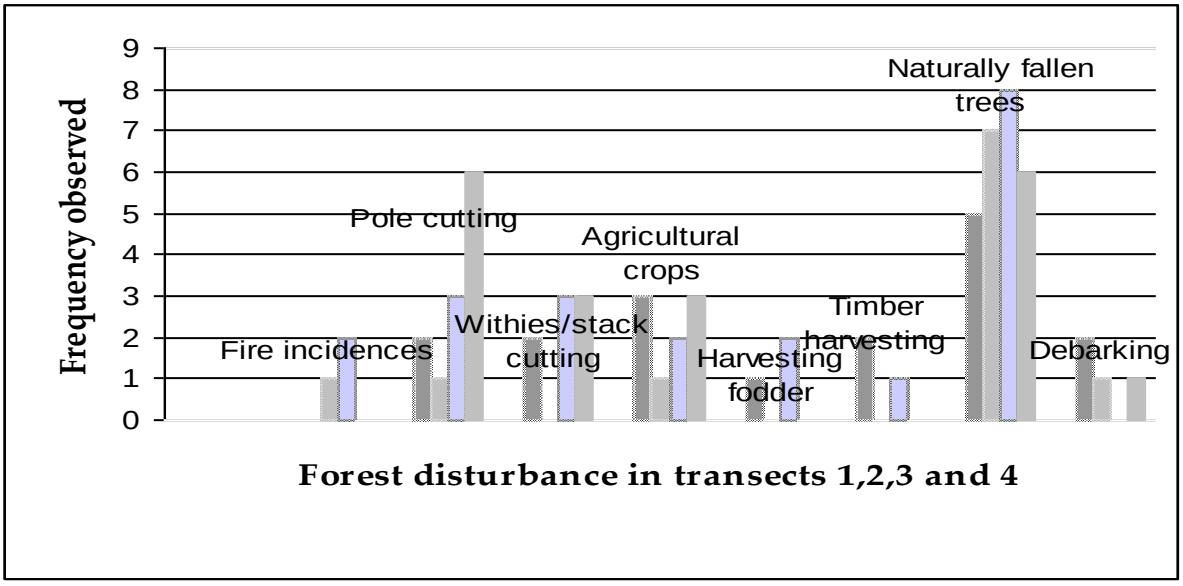


Figure 4.6 Forest disturbance and frequency in Derema Forest Corridor

Eight types of forest disturbance were identified and quantified in the forest. These were fire incidences indicated by such signs as ash and chars, pole cutting, withies and stack cutting, previous farming activities and harvesting fodder. Others were timber harvesting, natural tree falls and tree debarking for medicine.

Plate 4.1 Agricultural forest disturbance

Plate 4.2 Forest disturbance for fodder

The natural tree falls are not influenced by human beings therefore; only seven types of disturbances are discussed. Pole cutting was the major forest disturbance observed with 28.6% followed by previous agricultural activities (21.4%), cutting withies and stacks (19%), debarking (9.5%) and fodder, timber and fire (7.1% each).

In the areas previously used for agricultural activities, there were such crop remnants as banana, cardamom, cloves, cassava etc. with significant number of trees remaining scattered among cultivations. The preferred species for pole include *Mesogyne insignis, Alchornea hirtella, Allanblackia stuhlmanii* and *Sorindea madagascariensis.* Debarking of trees for medicine is mainly on *Athocleista grandiflora* which is claimed to treat asthma, worms and hernia. The other tree species with medicinal properties include *Myrica salicifolia, Rauvolfia caffra, Albizia gummifera, Rhus natalensis, Ficus thonningii* and *Vangueria escalenta.*

Indicators of previous and current illegal timber harvesting included old stumps, emergent coppices, human trails and abandoned sawing pits. The important timber species include *Milicia excelsa*, *Khaya anthotheca, Cephalosphaera usambarensis*, *Newtonia buchananii*and *Ocotea usambarensis.*

As noted elsewhere (Doggart *et al.,* 1999), accessibility was the main determinant of the rate and distribution of the human disturbance on the Derema forest. The highest rate was in the areas adjacent to the human communities in the villages. Previous timber and pole extraction and use of the forest for cultivation have opened the forest canopy and could explain current day high density of poles and the extension of the invasive *Maesopsis eminnii* and *Lantana camara* in these areas.

## 4.5 CONCLUSION AND RECOMMENDATIONS

Despite its existence without protection, it is evident that Derema Forest Corridor with 1,435 identified plant species is rich in plant species diversity, with Shannon-Wiener Index of 4.32 and a more or less even distribution compared to the adjacent Kambai Forest Reserve and Manga and Mtai Forest Reserves. Most of the species of Derema Forest Corridor are both lowland and sub-montane and the sole lowland species outnumber the sub-montane. The presence of numerous climbers makes the forest difficult to penetrate.

Like the forests of Amani Nature Reserve, Derema has the alien species constituting 2%, the nearly endemic species 6% and the endemic species 1% of the identified species. All of the endemic species are forest dwelling and 83% of them are forest dependent.

Some of the introduced species are also invasive, posing threats to biodiversity of the area. These include *Maesopsis eminii* which has long been in debate on how to control its spread in the whole area of East Usambara forests.

There are also five types of vegetation in the entire forest area, namely; forest, open or disturbed forest, bush or thicket, grassland and woodland. These vegetation types are mostly influenced by human activities in the forest. The major forest disturbance caused by human beings in Derema Forest Corridor is pole cutting, followed by previous agricultural activities, cutting withies and stacks, debarking, fodder, timber extraction and fire.

From the above observations and conclusions, the following could therefore be put forward as recommendations:

- The significance of Derema Forest Corridor in terms of biodiversity, high endemism and the services (source of water for River Zigi, eco-torism, etc.) need to be safeguarded by assigning the area a national priority for conservation since it is still a forest in a general land. This need comes from the fact that all of the endemic species are forest dwelling and mostly forest dependent. Establishment of the legal status of Derema Forest Corridor should be done first then the forest annexed to Amani Nature Reserve. This is because, there is a continuity of similar biodiversity in the two forests and they are juxtapositioned within the same political district of Muheza, their management will therefore, be much more facilitated.

- In order to exonerate the threat of *Maesopsis eminii* spread, no active and risky eradication is needed in the conservation area, but a priority management task should be to avoid canopy gaps. This can be successfully subdued through forest tree gap planting and in-situ conservation of the existing resources.

- On-farm tree management should be encouraged and practiced in the area. This can be implemented through retaining of the existing indigenous during farm clearing.

- Awareness creation and advocacy programs on tree planting mainly on planting fast growing plant species should be carried out. This shall include a participatory evaluation of suitable species to cater for the communities' need for poles, withies, stacks, fodder, timber and medicinal needs.

- There should be specific village tree planting days which shall encourage tree planting by all households on their farms. There should also be a minimum number of trees that each household should plant during that particular day every year. All these should be arrived at employing participatory approaches.

- Strengthening capacity in the enforcement of by-laws on all issues pertaining tree planting, management and utilization and use of fire in the area.

- Clear forest boundaries and fire lines should be made, consolidated and regularly maintained.

- Enough biodiversity liaison officers need to be availed in the area.

- Provision of alternative income generating activities i.e. (i.e. bee keeping, butterfly keeping, promote cultivation of high value cash and food crops, fish farming, poultry keeping both exotic and local chicken, brick making, mushroom cultivation, livestock keeping). These will reduce the total dependence on the forest.

- More studies are required to establish the facts for the other species whose ecological, habitat and endemic status were not indicated.