Green Economy in Biosphere Reserves

TECHNICAL REPORT

BIODIVERSITY SURVEY IN EAST USAMBARA BIOSPHERE RESERVE TANGA REGION, TANZANIA

by

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EXECUTIVE SUMMARY

The biodiversity survey for the East Usambara Biosphere Reserve was conducted in order to update the environmental and biodiversity status of the EUBR including flora and fauna. The specific objectives included in the survey were to carry out assessment and inventory exercise so that environmental and biodiversity status of the EUBR including flora and fauna list is obtained in terms of abundance and endemic status, to determine biodiversity indices of flora and fauna and assess disturbance for update environmental status of the East Usambara Biosphere Reserve. The survey covered Amani Nature Reserve, Nilo Nature Reserve, Bombo East I, Manga, Mgambo, Mtai and Kwamngumi forest reserves. A systematic sampling design was used to lay transects during data collection. Transect was established and the distance between transect was 700m. Distance from plot to plot was 300m apart. For the sake of covering representative sample of forested blocks in the East Usambara Biosphere Reserve stratification approach was adopted. A total of 210 plots were established. Sampling intensity of 0.25% was adopted from the Frontier Tanzania Biodiversity survey 2002. Circular and concentric sample plots of 0.07065ha each were established. The GPS recorder and the plot layout map were used to allocate the plots in the field. Once the centre of a plot was located, three concentric circles were marked i.e. nested subplots of radii 3m, 6m and 15m. The Microsoft Excel spreadsheet software and PC-Ord computer software and R - softwares were used to analyse the inventory data. The result indicates that Amani Nature Reseve had 157 tree species richness higher than any other forest reserve where survey was taken and Bombo East I being the least with 19 tree species richness. However, the results for Fauna species indicted that Nilo Nature Reserve had higher species richness than any other forest reserve. Endemic species of the EUBR was presented. The biodiversity indices of flora at Amani Nature Reserve showed highest value of Shannon wiener index (4.012 — 4.208 while Bombo East I showed a below standard value of Shannon wiener index (1.121— 1.894). The Shannon wiener value for fauna was 4 – 4.255 in Nilo Nature Resrve and 3.143 — 3.523 in Bombo East I. Human and environmental disturbances, relative frequencies of flora and fauna and basal area, volume per ha for trees for each forest reserve were also presented. There is still potential of high species richness within the studied core areas. The surveyed core areas still experiences human pressure that there is a need of regulate local communities their daily home stead livelihoods diversification so that these high biodiversity resources could be released from this dependence.

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ABBREVIATION AND ACRONYM

AFIMP	Amani Forest Inventory and Manageement Planning Project
ANR	Amani Nature Reserve
EU	East Usambara
WU	West Usambara
EUBR	East Usambara Biosphere Reserve
EUCAMP	East Usambara Conservation Area Management Programme
EUCFP	East Usambara Catchment Forest Project
GERBR	Green Economy in Biosphere Reserve
GPS	Geographical Position System
MAB	Man and Biosphere
NNR	Nilo Nature Reserve
TAFORI	Tanzania Forest Research Institute
TPRA	Tropical Pestiside Research Athourity
UNESCO	United Nations Educational Scientific and Cultural Organization
URT	United Republic of Tanzania

CHAPTER ONE: INTRODUCTION

1.1 Background

The East Usambara Mountains are the rain forests that secure water supply for the surrounding local community and Tanga city population of more than 273,332 people (URT, 2012). Water for industrial use in Tanga city originates from these rain forests. Local people in the mountains depend on the forests for many of their daily livelihoods needs. Together with this importance to the country, the East Usambara Mountains are known worldwide for the diversity of flora and fauna, and for the exceptionally high degree of endemic plants and animals found in the forests.

In 1975 the Government of Tanzania under the Ministry of Natural Resources and Tourism - Forest and Beekeeping Division set aside potential forest areas for water catchment value together with high biodiversity value, East Usambara rain forests being one among these areas.

Historically, the East Usambara Mountains has undergone transformation of heavy mechanised logging to feed plywood industry in Tanga. The mechanised logging was discarded by Forest Inventory results (Hamilton and Bensted-Smith, *eds* 1989) that indicated a tragedy of commons if it continues. To restore forest reserve that resulted due to harvesting using heavy machine which lead to the destruction of biodiversity, made an establishment of East Usambara Catchment Forest Project (EUCFP) in 1991 and later became East Usambara Conservation Area Management Programme (EUCAMP) that run up 2002. One of the objectives of the project was to place the East Usambara unique value of ethenobotany, high biodiversity and endemism into a safe custody i.e. establishment of Amani Nature Reserve in 1997. That was not enough since Amani is only 8380 ha a broader approach was thought to nominate East Usambara as one among the Man and Biosphere Reserve programme. Therefore, in November 2000, the East Usambara Mountain forest area was designated as a UNESCO *Man and the Biosphere (MAB) Reserve*, with an area of about 83,600 hectares. One of EUCAMPs' activities is to determine the baseline information of the diversity of flora and fauna of the East Usambara Mountains using Frontier Tanzania an activity that produced individual biodiversity reports for every core and buffer zone area of the biosphere reserve.

Since these biodiversity baseline data are now old as far as 2002 (about 12 years old); and these core forest blocks have been experiencing different management regimes including Joint Forest Management, it's worth to conduct a (monitoring) follow up survey of flora and fauna. More over in line with inception of Green Economy in Biosphere Reserves (GEBR): A Means to Poverty Reduction, Biodiversity

Conservation and Sustainable Development in Sub-Saharan Africa project - East Usambara Biosphere Reserve (EUBR), the base line data for biodiversity is very crucial. This is a kind of stock taking of biodiversity indices prior the start of the project that will have an effect to the biodiversity.

1.2 Objective of the Study

1.2.1 General Objective

The overall objective of this study was to conduct a biodiversity survey for the EUBR in order to update the environmental and biodiversity status of the EUBR including flora and fauna in the core and buffer zone areas.

1.2.2 Specific Objectives

The specific objectives of the study were to:

1. carry out assessment and inventory exercise so that environmental and biodiversity status of the EUBR including flora and fauna list is obtained in terms of abundance and endemic status
2. determine biodiversity indices of flora and fauna.
3. assess disturbance for update environmental status of the East Usambara Biosphere Reserve

1.3 Limitation of the study

1. Limited financial resources – this forced the researcher to sample only 50 percent of the 762 plots intended.

2). Nature of the terrain – It was expected for the crew to cover 8 plots per day but due to steep slope the crew managed in average 5 plots per day. Therefore, due this fact the crew fails to cover 381 plots as intended and managed only 220 plots which are equal to 57.7%. Also out of 220 plots covered 10 plots were inaccessible. These inaccessible plots were found in: Manga (1 plot), Mtai (2 plots), Nilo (6 plots) and Amani (5 plots).

3). Adverse weather conditions caused by Rainfall – Data were collected during rainy season; therefore in some instances the crew were forced to go very late in the field. Also when the crews were in field and it was raining, they were forced to remain standing until the rain stoped.

4). GPS sometimes lost satellite reading due to thick forest with tall trees that form canopy closure

These problems were overcomed through incorporation of data from opportunist observation.

CHAPTER TWO: LITERATURE REVIEW

2.1 An overview of biodiversity aspects

Biodiversity surveys were initiated in the East Usambara Mountains in 1995 to provide baseline information on the biological values of the forests for management planning and monitoring, and to train field staff in the use of biological inventory techniques (Johansson, 1998). Understanding assemblages of fauna and flora and how their numbers and compositions change over time and space has long been a fundamental interest of terrestrial ecologists and has increasingly become recognized as an important component of fisheries science and management. Organisms that occur in a particular place may be classified as a community or an assemblage, and the meaning of these terms varies among ecologists (Morin, 1999). Individual fauna and flora species vary widely in their morphology, physiology, and tolerance and response to their surroundings. The abundance, importance, or dominance of each species can be expressed numerically so that different communities can be compared on the basis of species similarities and differences (Dalling *et al*. 1998). Species composition is also used to determine forest condition and trend, which are valuable tools to judge the impact of previous management and guide future decisions. Mwasumbi *et al* (1994) have shown that heavy human disturbances (especially extensive timber logging, agricultural clearance) of coastal forests reduce their biodiversity values as plant-diversity and the habitats of rare plant species are lost. Species composition is another measure of diversity in a forest. Species composition is the assemblage of plant species that characterize the vegetation (Isango, 2007). It is one of the major components of biologically spatial structure (Ingram *et al*., 2005). The most common measure of composition is richness (the number of different species) and abundance (the number of individuals per species found in specified area). Species richness can be documented by calculating its relative density (RD), while the distribution of species is shown by relative frequency (RF). The abundance is calculated as relative dominance (RDo) whereas the importance value index (IVI) is the sum of relative density (RD), relative frequency (RF) and relative dominance (RDo) of species (Evariste *et al*., 2010). The IVI of a species in the community gives idea of its relative importance in community (Banerjee and Srivastava, 2010).

2.2 Factors influencing distribution of organisms

The information from the past, recent or historical, may provide qualitative or quantitative descriptions of pre disturbance conditions. A number of physical factors can limit the ecological success of fauna and flora populations, example water quantity, water quality and physical habitat structure, which in turn set the framework in which biotic interactions occur, such as growth, reproduction, trophic dynamics, and

competition (Karr *et al*. 1986; Fausch *et al*. 1988; Rabeni and Jacobson 1999). These physical factors may also be quantified by a suite of more proximate measures (e.g., nutrient concentrations, depth profiles, and physical cover) and are further influenced by more broad-scale processes over watersheds and riparian zones. The analysis of most of the ecological data indicated that species with similar ecological requirements showed a common response to habitat degraded by siltation. The dominant species can be quantified by calculating a statistic known as 'importance value" (Smith and Smith, 2001). Importance values can be calculated after the size and number of individual trees of the various species is measured. This index is used to determine the overall importance of each species in the community structure. In calculating this index, the percentage values of the relative frequency, relative density and relative dominance are summed up together and this value is designated as the Importance Value Index or IVI of the species (Curtis, 1959). Biodiversity provides a range of services, including aesthetic, cultural and recreational values as well as goods that have direct use values (FAO, 2006). Apart from that, it enhances many other ecosystem services including carbon storage, water supply and soil fertility (Shahbaz and Suleri, 2009; Munishi *et al*., 2011). Ecosystem services concept is of significant importance for our understanding of the role of nature for maintaining human livelihoods (Papageorgiou *et al*., 2005). Therefore, there is a need for effective valuation of biodiversity for ecosystem services (FAO, 2006; Mertz *et al*., 2007; Howard *et al*., 2000).

2.3 Stand structure

According to Mbwambo *et al*. (2008), stand structure include species composition, diameter distribution and their spatial distribution. Also, Husch *et al*. (2002) defined stand structure based on stand parameter which are basal area, volume and numbers of trees. Furthermore, Huang *et al*. (2003) added that the components of the forest structure include stand diversity, diameter size and size distribution attributes. The structural attributes of forest stand are important in understanding and managing forests ecosystems because they have direct value as a source of products (e.g. wood) or in providing services (e.g. sequestration and storage of carbon) (Franklin *et al.,* 2002). Plant composition is the contribution of each plant species to the vegetation, generally expressed as a percent, so that all species components add up to 100% (Stubbelefield, 1994). In some forest types, the number of tree species may increase with age, but in others, the old-growth stage may be relatively simple, with low species diversity. Species composition may change with time due to variations in moisture levels associated with seasonal rainfall fluctuations (Munishi, 2001). Locally, unpredictable disturbance, environmental contrast within and among tree fall gaps that favor trees with different regeneration requirements may also influence species composition. Further, random conditions affecting reproductive or mortality rates can also maintain species diversity through competition for resources (Clarke & Robertson 2000).

2.4 Species diversity

Diversity is the structural and functional variety of plants and animals at genetic, species, population, community and ecosystem levels (McElhinny, 2005). Harrison *et al*. (2007) indicated two components of species diversity: the spread of individuals between species within the community (evenness) and species richness which is the actual number of different species in a community rather than the number of individuals contained therein. Huang *et al*. (2003) highlighted that species diversity in tropical forests varies greatly from place to place mainly due to variation in biogeography, habitat and disturbance causing differences in species composition at all scales. This can be argued since in Neotropics the maximum richness is found up to 300 tree species per hectare while in Asia, the highest richness is 225 ha^{-1} (Huang *et al.,* 2003). The author pointed out further that even though it is reported a maximum of 60 species per hectare in Africa it is because of lack of data that has restricted most discussion of rarity in the tropics to local scarcity but other studies have reported more than this amount.

Vayreda *et al*. (2012) highlighted that forest with high species diversity may promote a more efficient use of resources and higher rate of carbon sequestration compared with sites of a lower number of species or poor structural diversity. As a result these stands can maintain a higher living carbon stock. According to Krebs (1989), Shannon Wiener index increases with the number of species in the community but does not exceed 5.0 while Simpson Dominance index decreases. For instance Munishi *et al*. (2004) working in Urugulu mountain forest reported a Shannon-Wiener diversity index value (*H*' = 3.31), Kijazi (2007) reported H' = 3.379 in Mlesa Village Management Area at Amani Nature Reserve, Dugilo (2009) working in montane stratum of Selela Village land forest reserve reported a (*H*' = 1.298), while Erenso *et al*. (2014) working in Boda dry montane forest in Ethiopia reported (*H*' = 1.79).

2.4.1 Biodiversity indices

Both Shannon and Simpson diversities increase as richness increases, for a given pattern of evenness, and increase as evenness increases, for a given richness, but they do not always rank communities in the same order. Simpson diversity is less sensitive to richness and more sensitive to evenness than Shannon diversity, which, in turn, is more sensitive to evenness than is a simple count of species (richness, S). In practice, which measure of diversity to use depends on what one wishes to focus on (pure richness or a combination of richness and evenness), the relative abundance pattern of the data, comparability to previous studies, and the interpretability of the results.

Low species diversity suggests:

- relatively few successful species in the habitat
- the environment is quite stressful with relatively few ecological niches and only a few organisms are really well adapted to that environment
- food webs which are relatively simple
- change in the environment would probably have quite serious effects

High species diversity suggests:

- a greater number of successful species and a more stable ecosystem
- more ecological niches are available and the environment is less likely to be hostile
- complex food webs
- environmental change is less likely to be damaging to the ecosystem as a whole

Dominance of some species or families is a defining characteristic and a unifying feature of a particular ecological region (Byers, 2001). The observed *D'* values in this study falls within the ranges of other forests with similar vegetation. A high *H'* value in state forest is the effect of forestland tenure regime; since the forest has been under state tenure regime with relatively strict management regime where harvesting was not allowed.

Diversity increases with increases in the number of species (richness) and equitability of distributions among species (evenness). Species diversity relates to the number of the different species and the number of individuals of each species within any one community.

2.4.1.1 Species Richness

Species richness represents the number of species found in a distinct area. It is the simplest and oldest assemblage structural index. It computed simply by counting the number of species represented in an assemblage. Unfortunately, species richness is not very informative because it shows only the number of species present, and does not evaluate the relative abundance of those species. In other words, it gives the same weight to both rare and common species. This limitation is especially important when detecting rare species is a priority. In general, the larger the sample or the greater the number of samples collected, the greater the number of expected species. Consequently, it may be misleading to compare species richness among samples or sites that are based on incomplete counts with varying sample sizes,

area sampled, or effort expended. Such systems are critical as a benchmark for comparison to detect and understand effects of human activities on ecosystems and to serve as a goal for ecological restoration.

2.4.1.2 Evenness

Evenness estimates the population sizes of each species that are present in the area. So, the community where one or two species dominate and several are of minor importance is considered less even than a community where several species all share equal abundance. As species richness and evenness increase, the overall diversity of the community consequently increases.

2.4.1.3 Simpson's index

Simpson's Diversity index is one such measure of diversity that takes into consideration both richness and evenness and focuses on dominance. Simpson's diversity index is the general term for three related indices: *Simpson's Index (D), Simpson's Index of Diversity (1-D),* and *Simpson's Reciprocal.* The value of Simpson's index ranges from 0 to 1. Thus, the bigger the value of D, the lower the diversity of the community Simpson's index gives more weight to the species that are most abundant and the number of rare species does not significantly affect the value of the index (Simpson, 1949). Diversity studies indicates that a Shannon-Wiener diversity Index (*H*) normaly varies between 1.5 and 4.5 and rarely exceed 5 (Krebs, 1989; Kent and Coker, 1992), but a threshold value of 2 has been mentioned to be minimum value above which an ecosystem can be regarded as medium to highly diverse (Munishi, 2001). This maximum value varies depending on the type of the biological community sampled and the sampling approach used (e.g., minimum diameter and size of sample units) (Mwakalukwa *et al.,* 2014). It had been stated that, disturbance may either increase species richness and may maintain species diversity (Gautam and Watanabe, 2005) and, the periodic or recruitment disturbances at the intermediate levels perpetuate both pioneer and primary species as a result species with different life history strategies are able to co-exist and consequently high levels of species richness and diversity is maintained (Luoga, 2000).

Some times human disturbances can be hard to quantify because signs of cutting can quickly decay as 95% of dead tropical forest wood can decay within 22 years (Marshall *et al.,* 2012). However, in the present study area, stumps indicated tree cutting started since many years ago and continues to present. According to Hitimana *et al.* (2004) the variations in stocking levels of the forests cannot be attributed to tree cutting alone but also to other random factors such as site quality and /or historical events that are not well understood.

2.4.1.4 Important value index (IVI)

Relative density

Relative density is the study of numerical strength of a species in relation to the total number of individuals of all the species. Also is a measure of the density of one species in relation to the total density of all species. Thus, a comprehensive measure of species diversity should include components of both species richness and the relative abundances of the species that are present.

Relative frequency

The degree of dispersion of individual species in an area in relation to the number of all the species occurred.

Relative dominance

Dominance of a species is determined by the value of the basal cover. It is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

2.5 Stocking and Basal area

Stocking include number of stems or basal area per unit area normally a hectare, and reflects the spatial distribution of tree individuals within the forest and the distribution of different species in relation to one another (Krebs, 1989). Hitimana *et al*. (2004) explained that in mixed uneven-aged tropical forests generally represent all age classes a typical reversed "J" shaped curve. Diameter distribution is ecologically more informative when accompanied with data on spatial distribution of individual (Krebs, 1989), and is commonly used to assess the disturbance effect within forests and detect trends in regeneration pattern (Hitimana *et al.,* 2004). The variation in stem density in undisturbed natural forest has been reported to be less than in the disturbed forest (Huang *et al.,* 2003). Studies done in other montane signifies variations for instance Mialla (2002) reported a stocking of 1822 $\pm$ 9.4 stems ha^{-1} and basal area of 69.3m^2ha^{-1} while Dugilo (2009) reported a stocking of 310 $\pm$ 145 stems $ha^{-1}$with a basal area of 6.56 $\pm$ 1.74 m^2ha^{-1}. Kijazi (2007) reported a stocking of 3043 $\pm$ 360 (SE) and basal area of 42.096 $\pm$ 4.973 (SE) m^2 ha^{-1} in Mlesa Village Management area at Amani Nature Reserve. The probable reason was that, there were few individual trees with larger diameter classes since most of larger diameter trees have been harvested for timber.

High basal area ha^{-1} in the state forestland tenure suggests that; state forestland tenure regime is dominated by more mature forest than the village forest reserves due to long term protection. Stand basal area is the sum per hectare of cross sectional areas of all trees estimated at breast height

(Malimbwi, 1997). The basal area is a good predictor for biomass and carbon since it integrates the effect of both the number and size of trees (Srivastara *et al.,* 2011; Murali *et al.,* 2005; Navar *et al.,* 2002). The low basal area in forests under village/communal forestland tenure regime is an indication of over exploitation of these forests.

2.6 Stand volume

The assessment of stand volume is important indicator in evaluation of the forest ecosystem productivity especially the current increased consumption of bio-energy obtained from forests. Its estimation is important for decision making and sustainable management of forest resources (Adeknle *et al.,* 2013). For instance Mialla (2002) reported a mean volume of 626.2 ± 5.4 m^3 ha^{-1}, Kijazi (2007) reported a mean volume of 530.337 ±87.883 m^3ha^{-1} in Mlesa Village Management area at Amani Nature Reserve and Dugilo (2009) reported a mean volume of 40.03 ± 11.21 m^3ha^{-1}. The state forests were affected by illegal logging of large diameter trees as witnessed during the inventory. The result on mean basal area and mean volume ha^{-1} removals between these state forests did not show statistical significant difference whereas there was statistical significant difference in mean number of stems ha^{-1} removals between forests. Removal results in this study are comparable to other studies with for example Luoga *et al.* (2002) observed a mean of 55.00 ± 8.96 stems ha^{-1} in Kitulangalo Forest reserve whereas the general land in Kitulangalo had a mean removal of 182.00 ± 24.19 stems ha^{-1}. The general land forest experienced high removal since it was an open access regime. On the other hand, Mbwambo *et al.*, (2012) observed that the lowest number of stems (42 ± 39 stems ha^{-1}), basal area (0.6 ± 0.3 m^2ha^{-1}) and volume (2.8 ± 1.7 m^3ha^{-1}) harvested were recorded in Mgori VFR compared to Shagayu FR (state) with 52 ± 42 stems ha^{-1} harvested. The low harvestable rate in Mgori VFR is attributed by improvement in conservation strategies of village forest areas.

Stand volume and its assessment

The assessment of stand volume is important indicator in evaluation of the forest ecosystem productivity especially the current increased consumption of bio-energy obtained from forests. Its estimation is importand for decision making and sustainable management of forest resources (Adeknle *et al.,* 2013). Forest volume dictates the allocation of forest products such as poles and timber while estimation of wood volume enables calculation of the monetory value of commodities and services that forests provide to society (Adeknle *et al.,* 2013).

2.7 Carbon stocks

Several studies on climate change have indicated that forest ecosystems play an important role in carbon cycle and storage (Munishi and Shear, 2004; Marshall *et al.,* 2011; Phiri, 2013). Above ground biomass measurement at local, regional and global levels is critical for estimating global carbon storage and assessing ecosystem response to climate change mitigation and is a way of overcoming anthropogenic disturbances (Zhao *et al.,* 2012). Accurate estimation of forest biomass is required for greenhouse gas inventories and terrestrial carbon accounting.

Carbon stocks, importance and assessment

Several studies on climate change have indicated that forest ecosystems play an important role in carbon cycle and storage (Munishi and Shear, 2004; Marshall *et al.,* 2011; Phiri, 2013). Forests are the major reservoirs of terrestrial biodiversity and contain about 50% of the global terrestrial biomass and carbon stocks (IPCC, 2007), and they store about 80% and 40% of all above and belowground biomass carbon, respectively (Smalca, 2007). This implies that the principal element for the estimation of forest's carbon stock is the estimation of forest biomass. Aboveground biomass measurement at local, regional and global levels is critical for estimating global carbon storage and assessing ecosystem response to climate change mitigation and is a way of overcoming anthropogenic disturbances (Zhao *et al.,* 2012). The forest carbon pools are considered internationally by UNFCCC because is one of the carbon reseivours which through their ability to sequester a considerable atmospheric CO_2 can mitigate the effects of GHGs that cause global warming and climate change problems, and is mainly the largest carbon pool which is directly affected by forest degradation (Vashum and Jayakumar, 2012).

2.8 Forest disturbances

Forest disturbances can be in a large or small scale. Disturbances at smaller scales tend not to affect landscapes; nonetheless, these disturbances may be important as a result of their combined effects over space and time (Frolking et al., 2009: Noone et al., 2012). Large-scale disturbances are those that affect entire landscapes and ecological systems and cause deforestation (Ismail and Kamarudin, 2011). Forest degradation cause significant impacts on ecosystem function, biodiversity, changes in forest micro-climate and livelihoods although some degree of disturbance can increase biodiversity (Mitchell and Schaab 2008).

Variation in species composition in forets of either similar of different conditions is obvious and has been experienced. For instance, studies in montane forests done by Mialla (2002) reported a total of 42 trees and shrubs species in Monduli catchment forest reserve. Dugilo (2009) reported a total of 24 and 18

trees and shrubs species at Selela village land forest reserve but it is not known exactly the species composition for the dry montane of LFR.

Assigning biodiversity values to specific sites has been widely used to describe community composition and structure or to prioritize conservation policy decisions and the biodiversity value depending not only on the habitat studied and the species examined, but also on the measurement used (McDolnald *et al.,* 2010). The author added that, most methods used for measuring species diversity are those which combine aspects of species richness, diversity and evenness. However, most studies use Shannon Wiener and Simpson diversity indices (McDolnald *et al.,* 2010). McElhinny (2005) pointed out that these quantities are the measure of structural diversity and are indicative of biological diversity and the most measures of diversity of a system with one attribute or element has a diversity of zero.

CHAPTER THREE: METHODOLOGY

3.0 METHODOLOGY

3.1 Description of the study area

3.1.1 Location

Geographically the East Usambara Biosphere Reserve is found in Tanga Region, Tanzania, East Africa. It lies between $4^{0}48^{1}$ to $5^{0}13^{1}$ and $38^{0}\ 32^{1}$ to $38^{0}\ 48^{1}$ with area coverage of 1300 km^{2}. Administratively EUBR falls under the jurisdiction of three districts authorities in Tanga region namely; Korogwe, Muheza and Mkinga. Nationally the core protected forest blocks are under the Northern Zone of Tanzania Forest Services, Ministry of Natural Resources and Tourism.

The East Usambara Biosphere Rererve was zoned into core areas, buffer zone and transition zone. The core area of the biosphere reserve which is the sites of extensive biodiversity research and training includes the Amani Nature Reserve and Nilo nature reserve. It is characterized by high concentrations of endemic flora (including many medicinal plants) and is the home of threatened and endangered bird species. The other remaining part of the core area includes 14 protected forest reserves namely Semdoe, Derema corridor, Kambai, Manga, Mlinga, Kwamarimba, Segoma, Kwamngumi, Mlungui, Bamba Ridge, Mtai, Mgambo, Bombo East I and II. The buffer zone include the commercial forest plantations like Longuza Teak Project, patches of natural forest where local communities turned to Village forest reserve (like Mpanga, Kizingata, Kizee, Handei and Mfundia) and some tree crop in their farms. As a matter of purposive sampling, this inventory was concentrate in 7 forest areas (Table 1).

Table 1: Forests which were involved in inventory

S/n	Name	Ha	Ha sampled	Plots planned	Plots covered	Percent of Plots covered
1	Amani Nature Reserve	8380	4190	148	73	49.3
2	Nilo Nature Reserve	6025	3012	106	45	42.5
3	Mtai Forest Reserve	3182	1591	56	39	69.6
4	Manga Forest Reserve	1635	817.5	28	19	67.9
5	Mgambo Forest Reserve	1506	673	23	16	69.6
6	Kwamngumi Forest R	1137	568	20	18	90.0
7	Bombo East I	1109	224	8	6	75.0

3.1.2 Livelihoods

Seventy two local communities (villages), 14 Tea and Sisal estates camps are found in the transitional zone depending on buffer zone forests for provision of timber. This high biodiversity value of the forest

offers the following products and services to the villagers: firewood, medicinal plants, water, soil erosion protection, game meat, wild honey, wild vegetables and fruits, and fresh air. Adjacent local communities are permitted to collect dead wood from the forest for fuelwood twice a week. Crops cultivated include; cocoyams, banana, maize, beans, sweet and irish potatoes, cow peas and rice. Cash crops include sugarcane, tea, and spices such as clove, cardamom, black paper, and cinnamon. Other sources of livelihoods of some of households include fishfarming, vegetable gardening, diary goats and cows kept at zero grazing.

3.2 Data collection

3.2.1 Primary data

Two types of data were collected namely forest stand parameters (Trees, Saplings, Herbs, Climbers and Shrubs) (Appendix 1) and fauna parameters, that means flora and fauna inventory data. The flora inventory data were collected from a forest plots as representative of the stand together with opportunistic collection. Forest plots are key link between the social, institutional and forest resource data collected (Ostrom, 1999). Fauna data was captured along the same transect where plots were established. Plots was used as points (point counts) and the presence of signs, tracks, voice and observation was used for fauna assessment and identification, perpendicular distance from the observed object was taken for abundance computation. Opportunistic sampling and the use of local people experience was also employed to capture other fauna information that was not captured during the survey.

3.2.2 Secondary data

Secondary data were obtained from books, journals, websites, data base and unpublished reports.

3.3 Sampling design

A systematic sampling design was used. Transect was established and the distance between transect was 700m. Distance from plot to plot was 300m apart. For the sake of covering representative sample of forested blocks in the East Usambara Biosphere Reserve stratification approach was adopted. A total of 381plots were established.

3.3.1 Sampling intensity, size and shape of the plots

Sampling intensity of 0.25% was adopted from the Frontier Tanzania Biodiversity field work of 1991 through 2002. Circular and concentric sample plots of 0.07065ha each were established. The choice of circular plot was motivated by the fact that it has the advantage of reducing edge effect (Nduwamungu, 1996). The GPS recorder and the plot layout map were used to allocate the plots in the field. Once the centre of a plot was located, three concentric circles were marked (i.e. nested subplots of radii 3m, 6m and 15m). In 3-metre radius subplot, data that was collected included all herbaceous ground cover and seedlings with diameter of less than 2cm. The species identification was done using Lovett, 2006, Schulman, 1998, Hamilton and Bensted-Smith (*eds*) (1989), Frontier Tanzania Biodiversity survey reports, NAFORMA field guide with the help of a local and qualified botanists.

3.4 Data analysis

3.4.1 Inventory data

The Microsoft Excel spreadsheet, PC-Ord computer and R - softwares were used to analyse the inventory data. The parameters which were computed includes stand structure parameters that included a species list, number of stems per hectare (N), basal area per hectare (G-m^2/ha), and volume per hectare (V-m^3/ha). The Volume per hectare not for harvesting purposes but can be later calibrated into other parameters like Carbon stock standing for other needs. Also basal area and volume skewness can suggest anthropogenic impacted to the biodiversity. Species diversity indices were computed. Since there was no existing model of diameter volume-relationship for Core areas within the EUBR, height of sampled trees was measured using optical instruments then the form factor of 0.5 was used for volume calculation. The form factor of 0.5 was used as an average for natural forest form factor that range between 0.4 and 0.6 (Phillip, 1983). Before the computation of stand parameters, a checklist of tree and shrub species was prepared and single tree volumes calculation was obtained through the following formula:

$V = ghf$……..……..(1)

Where;

V = volume estimation (m^3/ha)

g = basal area of the tree (m^2/ha)

h = height of the tree (m)

f = form factor (0.5); and

Basal area of the tree was obtained through the following formula;

$g_i = \prod d^2/4$, ……..……..…..(2)

g_i = basal area for ith tree inm^2

$\prod$ = pie (≈ 3.14)

d = diameter measured at breast height

Tables and histograms were used to summarise the inventory data.

3.4.2 Analysis of biodiversity indices

Biological communities vary in the number of species they contain and knowledge of this number was important in understanding the structure of the community. The number of species in a community is referred to as ***species richness***. According to Malimbwi (1997) an emerging criterion of describing mixed uneven aged forest is the diversity index, high desirable property for a forest community. The knowledge of the species diversity is particular useful when one wishes to study the influence of biotic disturbance or the state if succession, or stability of the forest community. Diversity indices are the measure of species diversity about richness in a forest community. The indices provide more information about community composition rather than species richness; also take relative abundances of different species into account (Magurran, 1988). Biodiversity indices calculated included Shannon Wiener Index (H'), Index of dominance (ID) and Eveness.

3.4.2.1 Shannon-wiener index of diversity (H')

Shannon-wiener index of diversity (H') was used to determine flora and fauna species diversity. The Shannon-wiener index is the most widely used index of diversity, which combines species richness and evenness and also not affected by sample size. Krebs (1989), explained Shannon-Wiener Index of diversity as a measure of information content of a sample and since information content is a measure of uncertainty, the large the value of H', the greater the uncertainty. The index increases with the number of

species in the community but in practice, for biological communities H' does not exceed 5.0. The Shannon-wiener function was calculated using the following formula (Kent and Coker, 1992):

$$H' = -\sum_{i=1}^{s} (P_i \log a\ P_i) \quad \text{.....(4)}$$

Where;

H' = the Shannon-wiener index of diversity,

$\sum$ = the summation symbols,

s = the number of species,

P_i = the proportion of individuals or the abundance of the species in the sample,

$\log_a$ = the logarithm to base a (any base of a logarithm may be taken).

3.4.2.2 Index of dominance (ID)

The index of dominance is a measure of the distribution of individuals among the species in a community. This index of dominance is also called Simpson's Index of diversity and is equal to the probability of picking two organisms at random that are of different species (Krebs, 1989). The greater the value of dominance index, the lower is the species diversity in the community and vice versa. It was calculated as described by Misra (1989):

$$ID = \sum (ni/N)^2 \quad \text{.....(5)}$$

Where;

ID = the index of dominance

ni = the number of individuals of species i in the sample

N = the total number of individuals (all species) in the sample

$\sum$ = the summation symbol

3.4.2.3 Index of Evennes

Species evenness refers to how close in numbers each species in an environment are. Mathematically it is defined as a diversity index, a measure of biodiversity which quantifies how equal the community is numerically (*http://en.wikipedia.org/wiki/Species_evenness of 04/08/2014*).

The evenness of a community can be represented b;

$$J' = \frac{H'}{H'_{\max}}$$

Where H' is the number derived from the Shannon diversity index and $H'_{\max}$ is the maximum value of H', equal to:

$$H'_{\max} = -\sum_{i=1}^{S} \frac{1}{S} \ln \frac{1}{S} = \ln S.$$

J' is constrained between 0 and 1. The less variation in communities between the species, the higher **J'** is. **S** is the total number of species.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 RESULTS AND DISCUSSION

4.1 Stand structure of the forests core area

4.1.1 Tree Species composition

The results for species list in the core areas assessed were summarized in Figure 1 below. Detailed list of the species were presented in Appendix 1-7. Amani Nature reserve revealed high value of number of species richness recoreded followed by Mtai FR and Nilo NR. Mgambo, Manga and Kwamngumi FR revealed more or less the same number of species recorded; while Bombo East I FR revealed smallest number of species recorded.

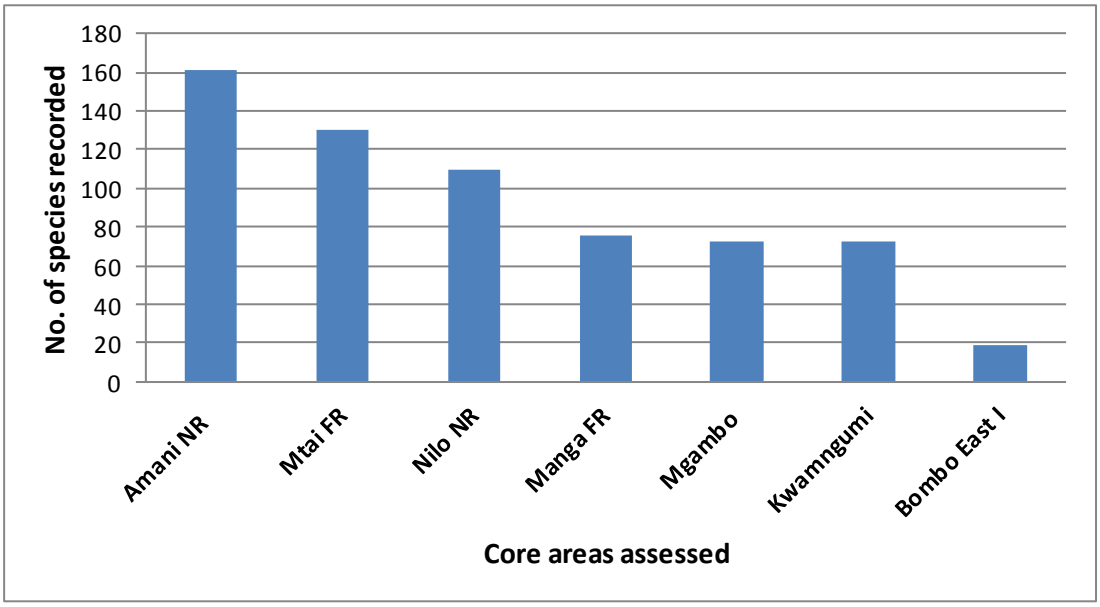

Figure 1: Species richness in assessed core forests

The number of species in a community is referred to as ***species richnes*** (*http://faculty.clintoncc.suny.edu/faculty/michael.gregory/files/bio%20206/206%20laboratory/species%20diversity/species_diversity.htm 04/08/2014*). The higher the number of species recorded for example in Amani NR suggests that there is high flora specie richness campared to other forested blocks, followed by Mtai FR and Nilo NR.

4.1.1.1 Relative density of the forest reserve (trees)

The Relative density of the forest reserve (trees) in the study sites are presented in Figure 2-8.

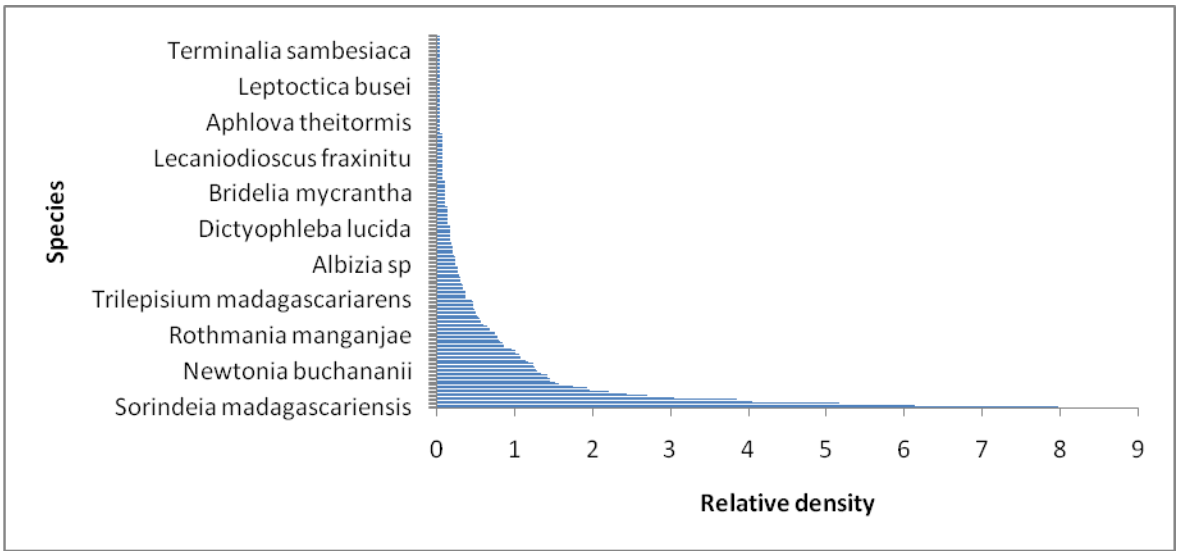

Figure 2: Relative density for Amani Nature Reserve

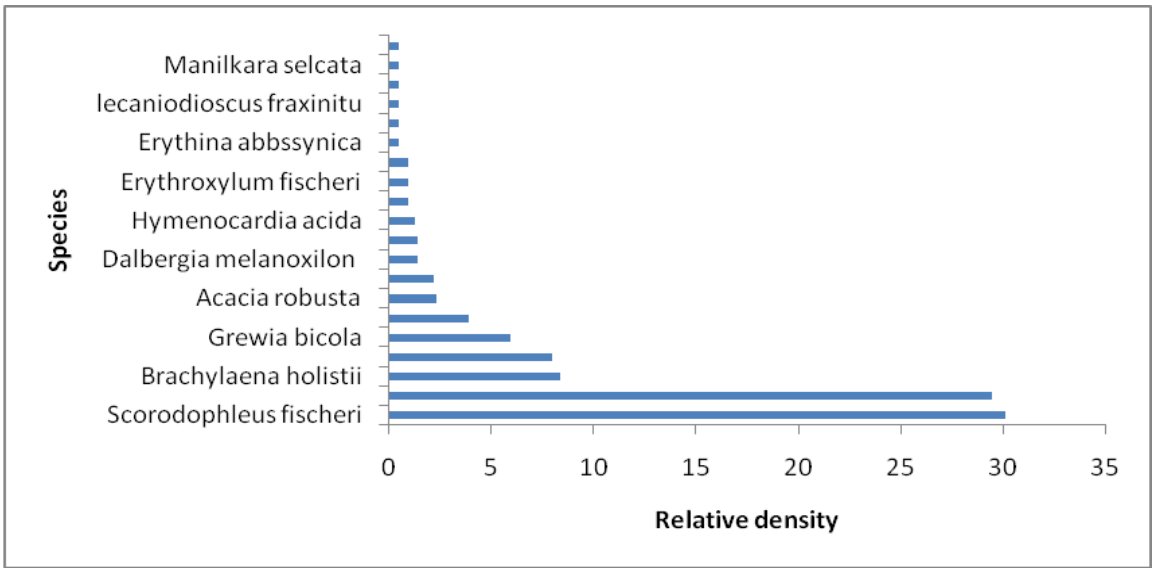

Figure 3: Relative density for Bombo East I

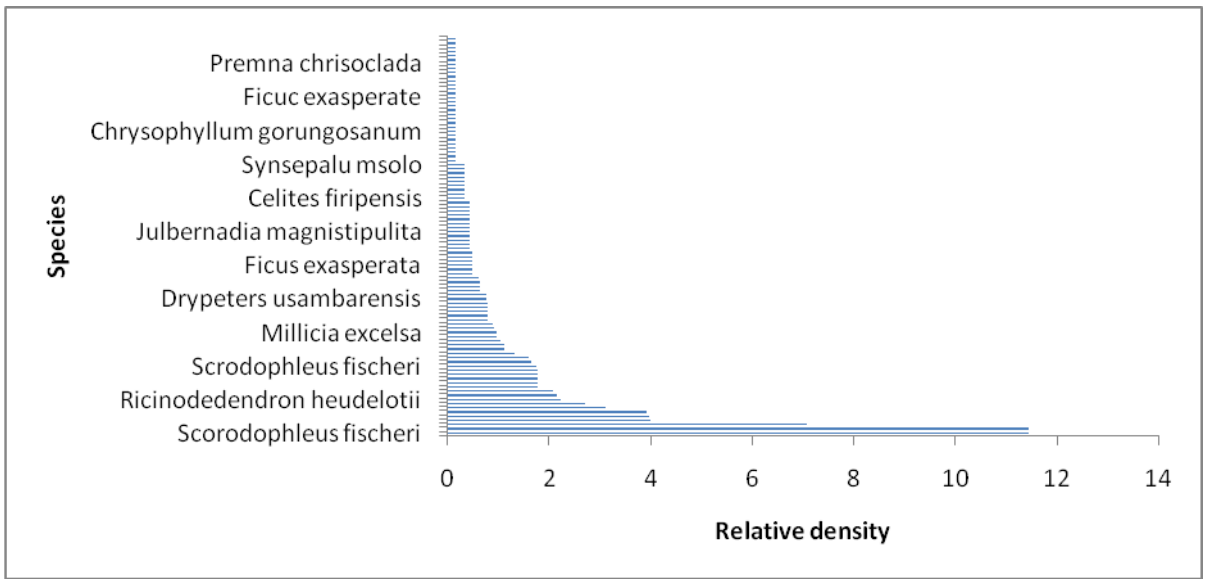

Figure 4: Relative density for Kwamngumi Forest Reserve

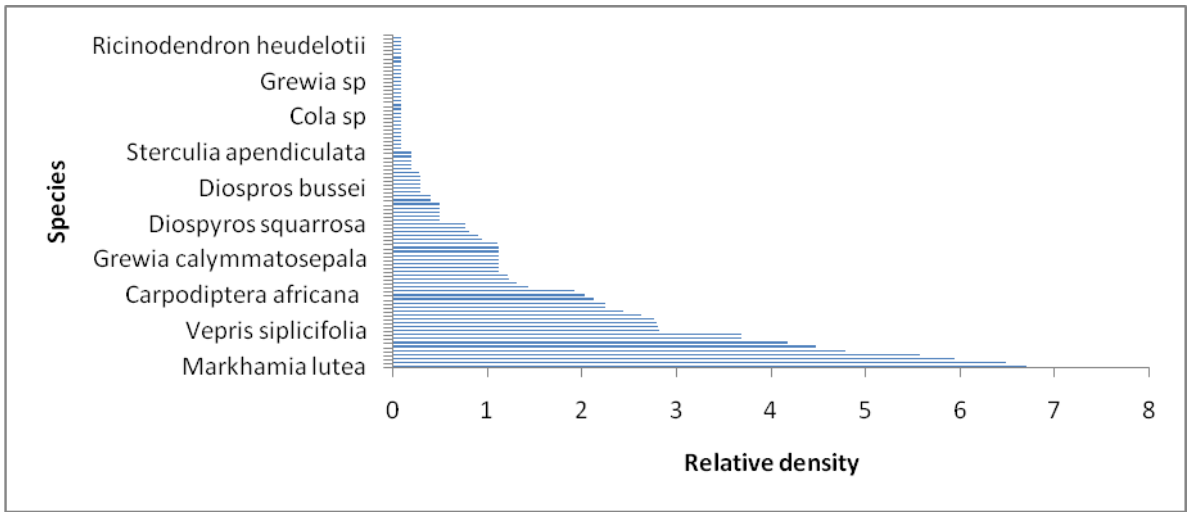

Figure 5: Relative density for Manga Forest Reserve

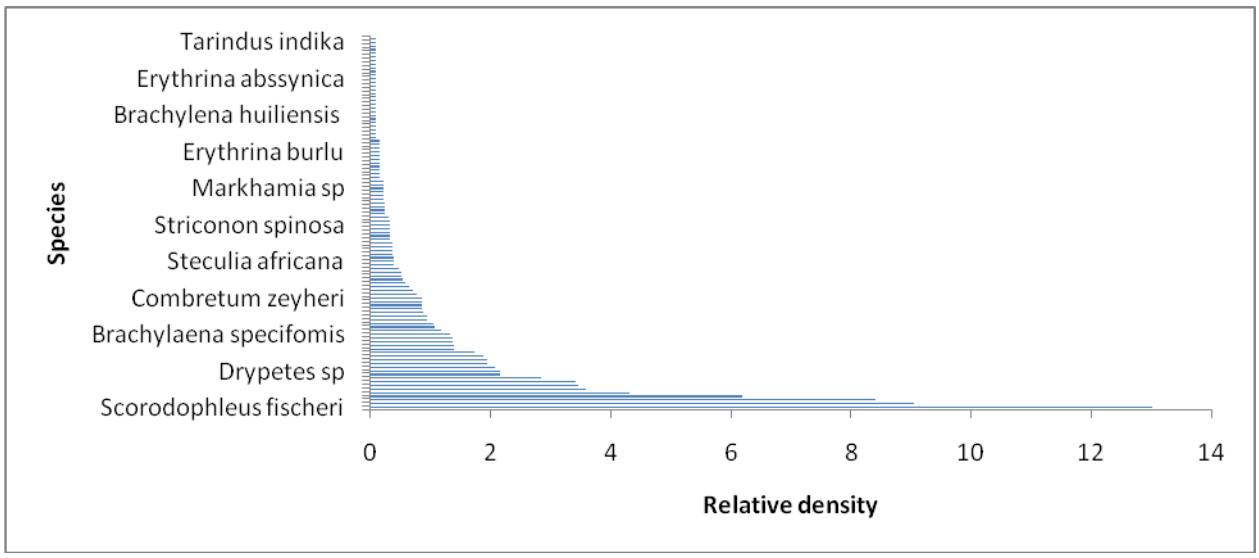

Figure 6: Relative density for Mgambo Forest Reserve

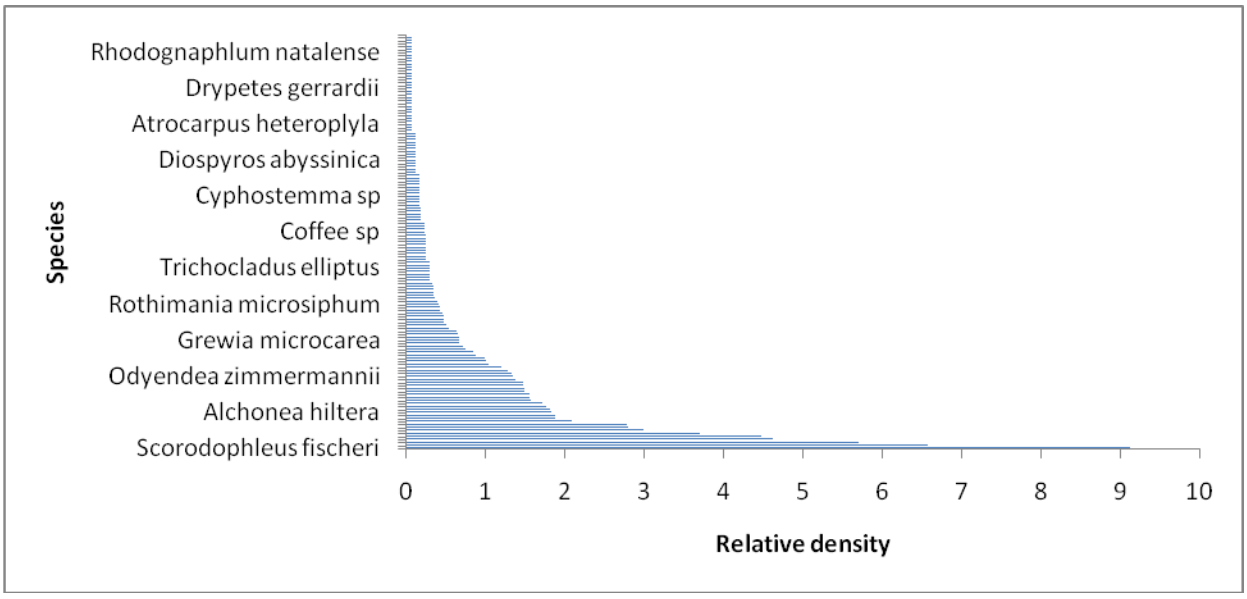

Figure 7: Relative density for Mtai Forest Reserve

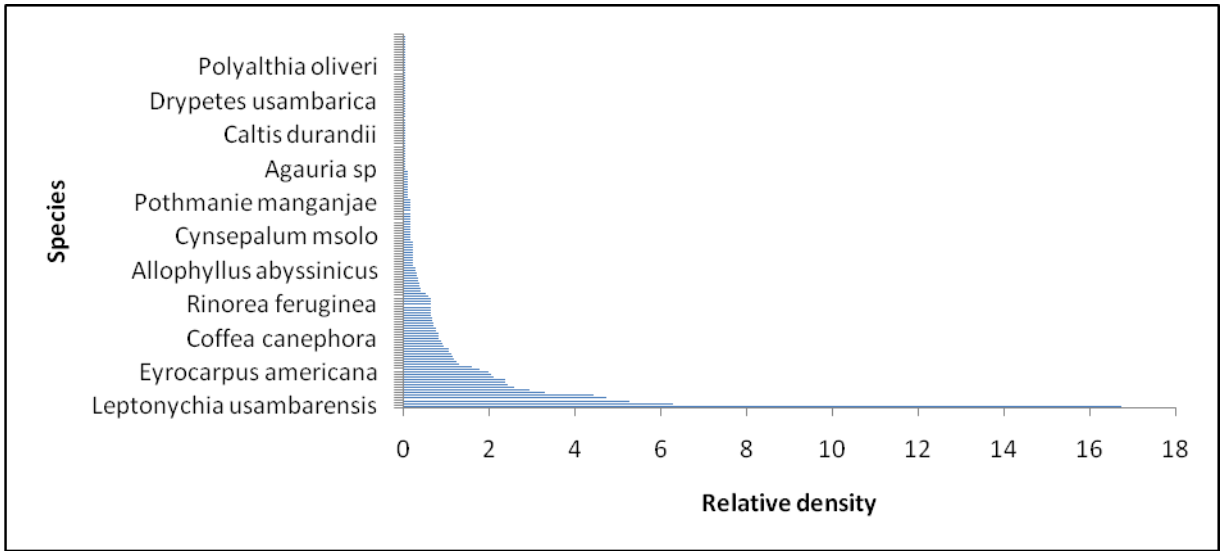

Figure 8: Relative density for Nilo Nature Reserve

The variations in relative density in the study sites (the highest relative density and the lowest relative density) are presented in Table 2.

Table 2: Variations in relative density

Forest	Species with the highest relative density	Species with the lowest relative density
Amani	1. Sorindeia madagascariensis (7.97%)	1. Vitex amaniensis (0.03%)
	2. Cephalosphaera usambarensis (6.13%)	2. Voacanga thouarsii (0.03%)
	3. Maesopsis eminii (5.16%)	3. Zanthoxylum giletii (0.03%)
Bombo East I	1. Scorodophloeus fischeri (30.12%)	1. Manilkara selcata (0.45%)
	2. Dombeya rotundifolia (29.4%)	2. Polyathia oliveri (0.45%)
	3. Brachylaena holistii (8.32%)	3. Sclerocary birrea (0.45%)
Kwamngumi	1. Scorodophloeus fischeri (11.46%)	1. Tebenaemontana heudelotii (0.16%)
	2. Combretum apiculata (11.44%)	2. Trilepisium madagascariarens (0.16%)
	3. Tabernaemontana venticosa (7.07%)	3. Zanlhoxylum usambarensis (0.16%)
Manga	1. Markhamia lutea (6.70%)	1. Terminalia sp (0.10%)
	2. Lindackeria stipulate (6.48%)	2. Trichilia ematica (0.10%)
	3. Teclea simplicifolia (5.94%)	3. Zanthoxylum giletii (0.10%)
Mgambo	1. Scorodophloeus fischeri (13%)	1. Tarindus indika (0.08%)
	2. Lindacarya sterculata (9.03%)	2. Terminalia spinosa (0.08%)
	3. Combretum sp (8.39%)	3. Vepris trichocarpa (0.08%)
Mtai	1. Scorodophleus fischeri (9.11%)	1. Sterculia apendiculata (0.060%)
	2. Sorindeia madagascariensis (6.56%)	2. Synsepaturm msolo (0.060%)
	3. Mesogyne msignis (5.69%)	3. Tectona grandis (0.060%)
Nilo	1. Leptonychia usambarensis (16.75%)	1. Trilepisium madagascariarens (0.06%)
	2. Rhinorhea fergnea (6.29%)	2. Vepris amaniensis 0.06%)
	3. Cephalosphaera usambarensis (5.29%)	3. Zanlhoxylum usambarensis (0.06%)

4.1.1.2 Relative dominance of trees

Relative dominance of the forests reserves is presented in Figure 9-15.

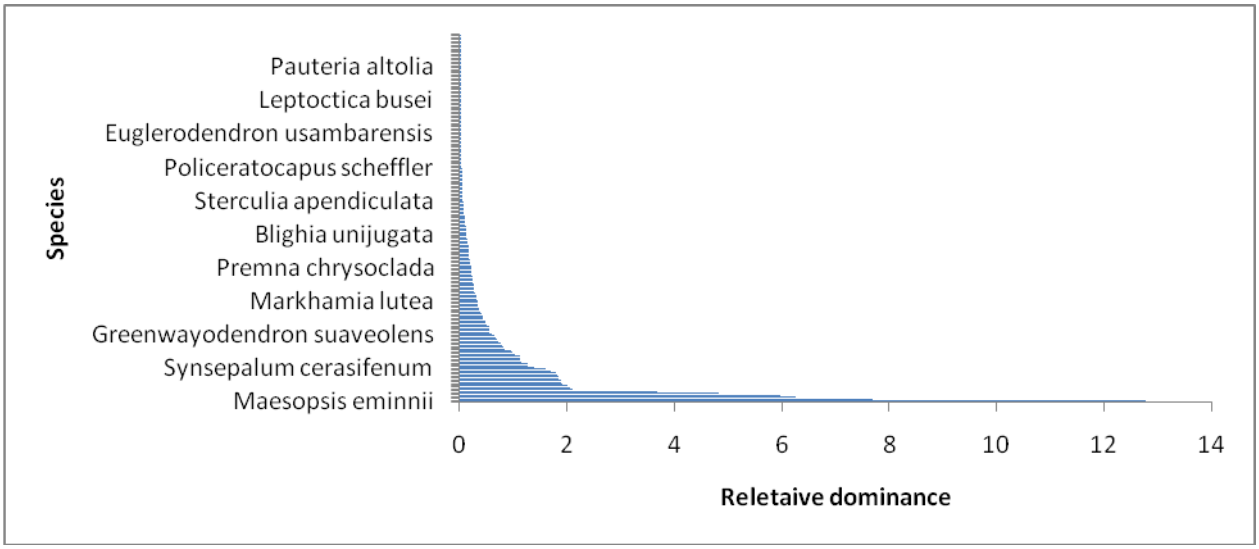

Figure 9: Relative dominance for Amani Nature Reserve

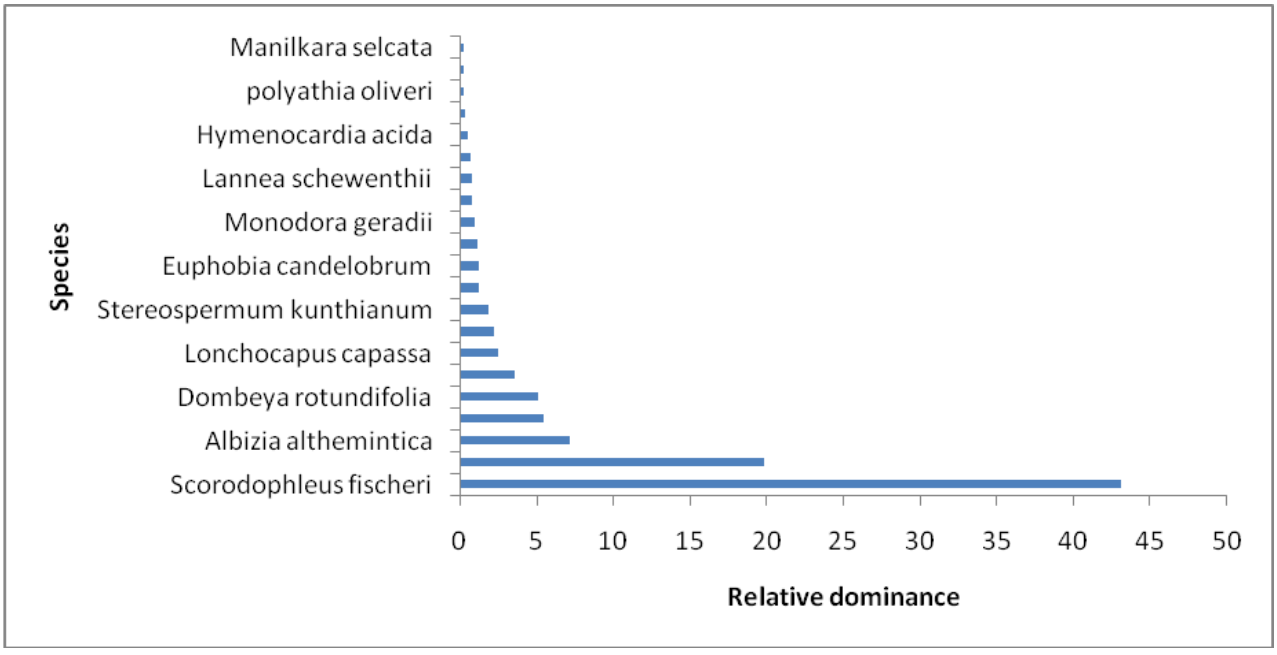

Figure 10: Relative dominance for Bombo East 1

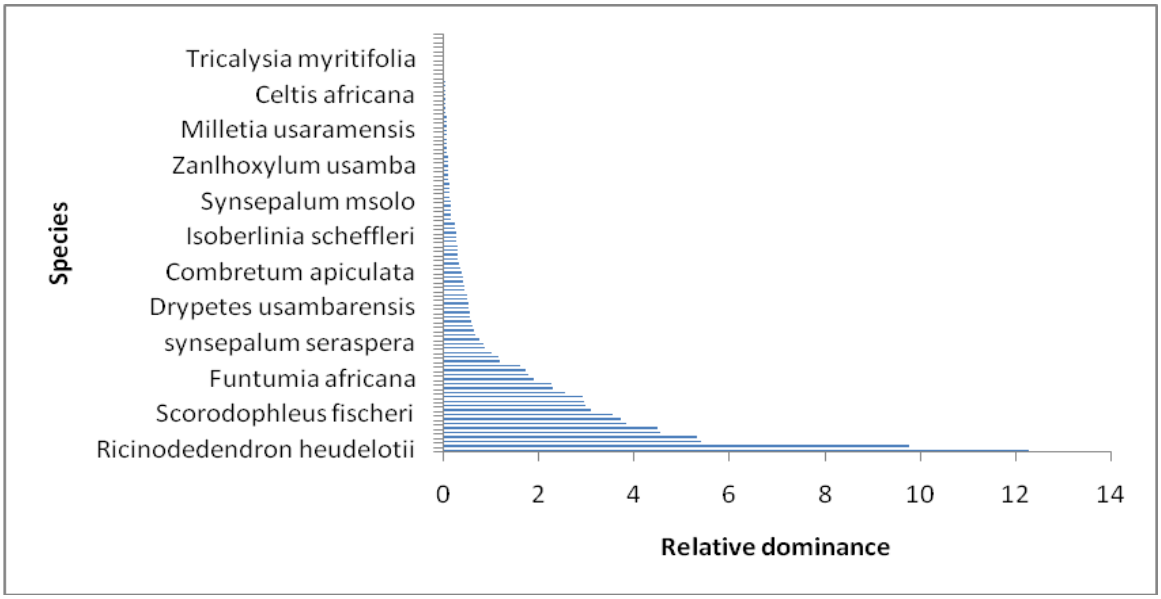

Figure 11: Relative dominance for Kwamngumi Forest Reserve

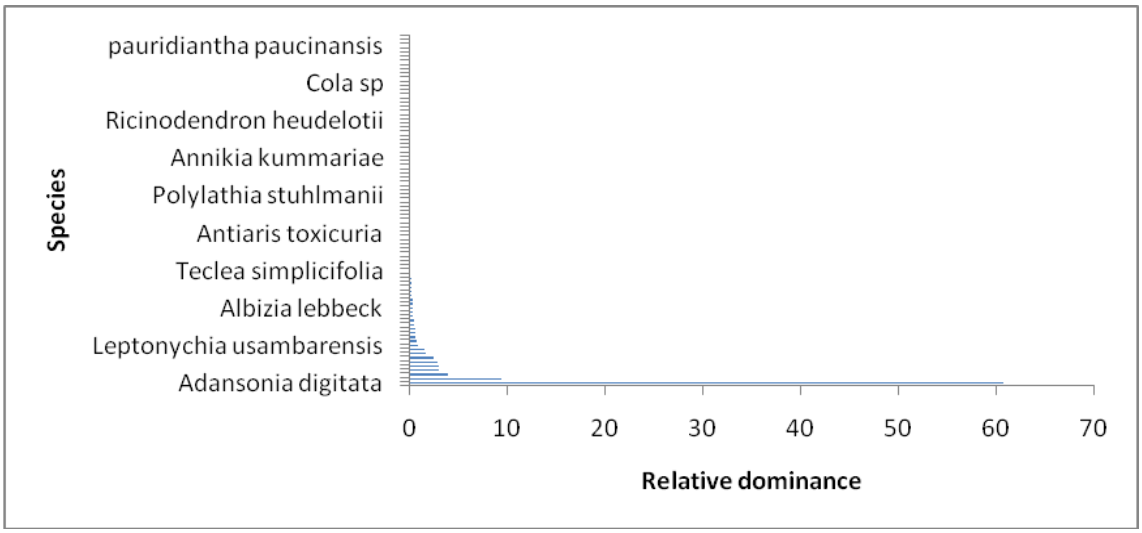

Figure 12: Relative dominance for Manga Forest Reserve

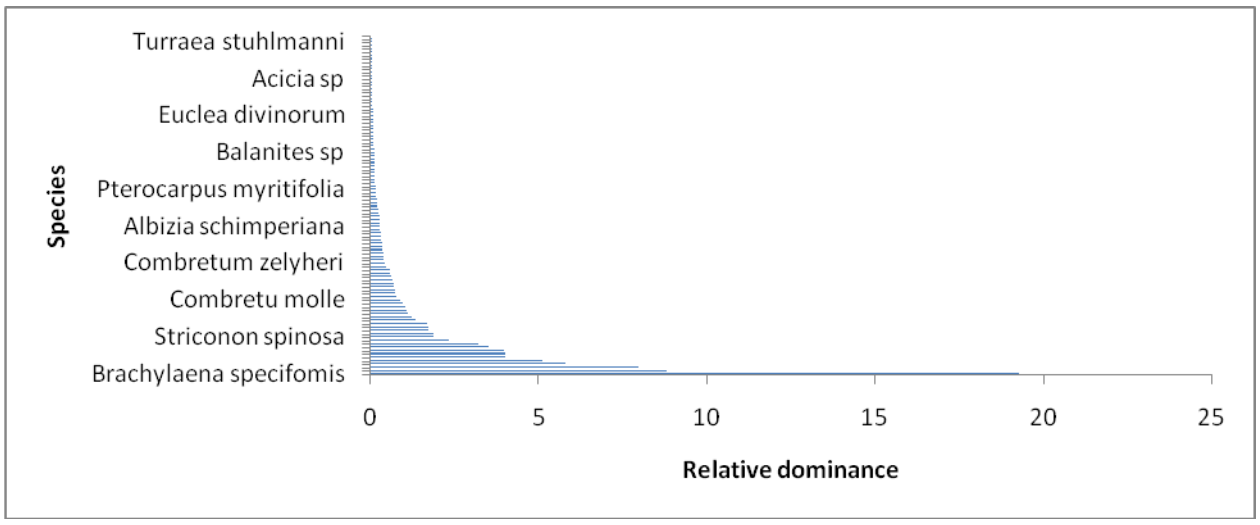

Figure 13: Relative dominance for Mgambo Forest Reserve

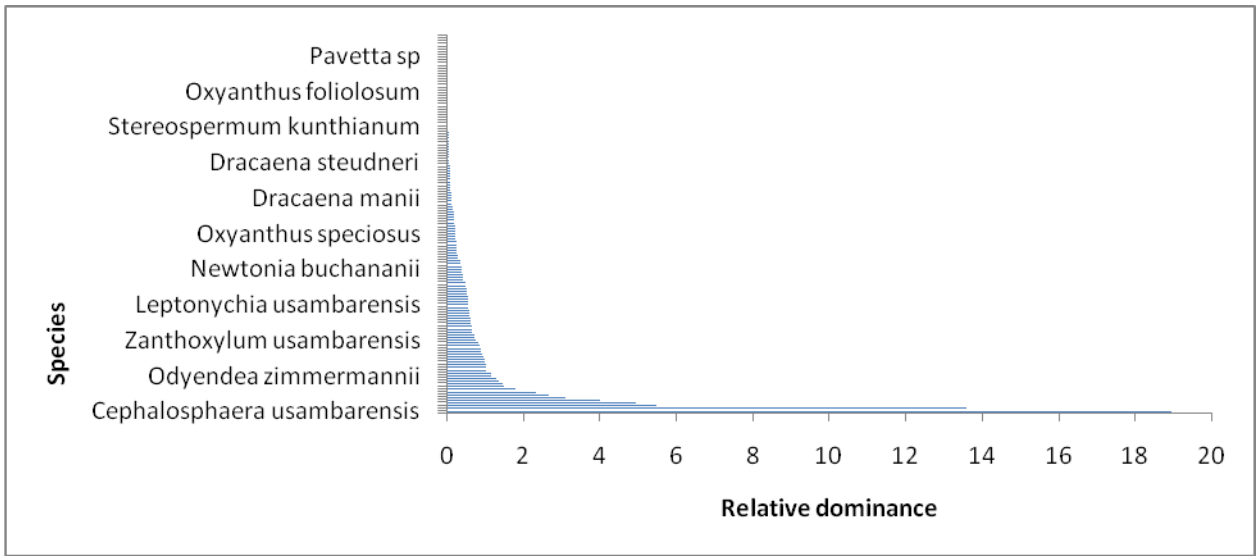

Figure 14: Relative dominance for Mtai Forest Reserve

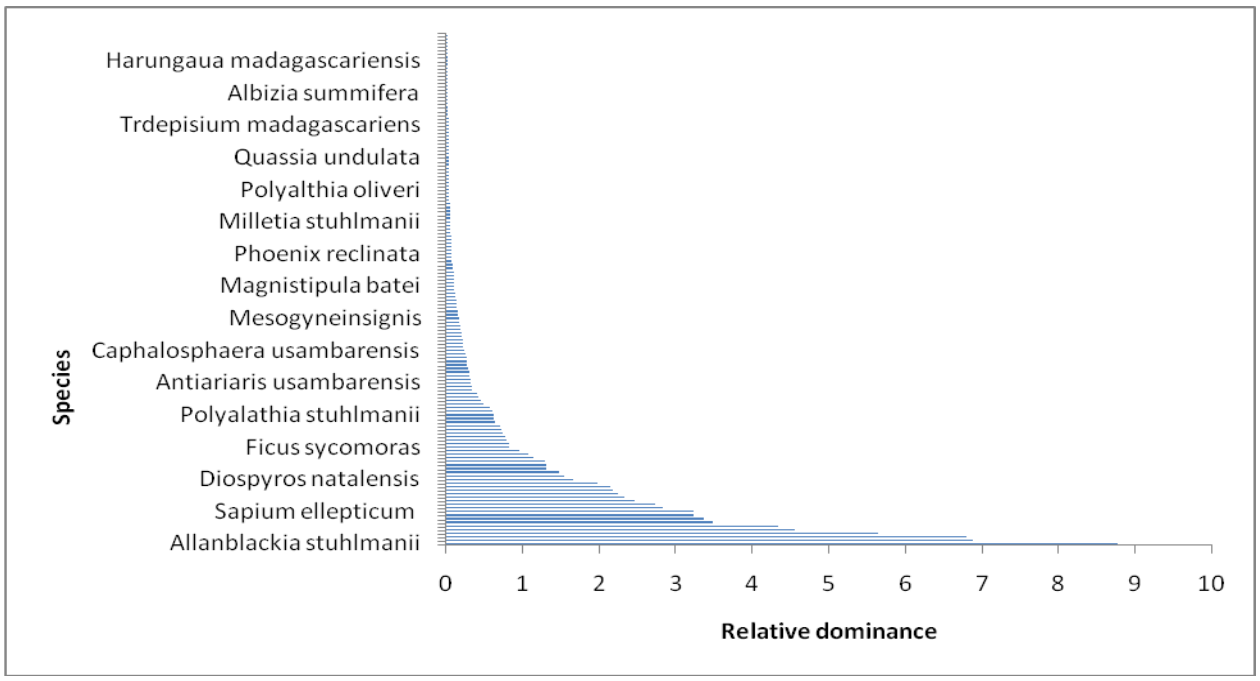

Figure 15: Relative dominance for Nilo Nature Reserve

The variations in relative dominance in the study sites (the highest relative dominance and the lowest relative dominance) are presented in Table 3.

Table 3: Variations in relative dominance in study area

Forest	Highest Relative dominance	Lowest relative dominance
Amani	1. Maesopsis eminii (12.76%)	1. Bauhinia kalantha (0.0022%)
	2. Acacia polyacantha (7.67%)	2. Celtis africana (0.004%)
	3. Newtonia buchananii (6.24%)	3. Draecaena steuderi (0.0049%)
Bombo E1	1. Scorodophloeus fischeri (43.07%)	1. Erythina abbssynica (0.22%)
	2. Brachylaena holistii (19.85%)	2. Manilkara sulcata (0.27%)
	3. Albizia althemintica (7.15%)	3. Lecaniodioscus fraxinitu (0.30%)
Kwamngumi	1. Ricinodedendron heudelotii (12.28%)	1. Sorindeia madagascariensis (0.018%)
	2. Isoberlinie scheffleri (9.78%)	2. Uvariodendron oligocarpum (0.023%)
	3. Scorodophloeus fischeri (5.41%)	3. Sericanthe orioratissima (0.023%)
Manga	1. Albizia petersiana (9.52%)	1. Diospyros abbysinica (0.0018%)
	2. Tamarindus indica (3.94%)	2. Afrosersalisia cerasifera (0.0028%)
	3. Manilkara sulcata (3.11%)	3. Dombeya cincinaata (0.003%)
Mgambo	1. Brachylaena specifomis (19.27%)	1. Croton dichogamus (0.008)
	2. Sterculia africana (8.79%)	2. Croton shefflera (0.010)
	3. Brachylaena holisti (7.97%)	3. Turraea stuhlmanni (0.012)
Mtai	1. Cephalosphaera usambarensis (18.92%)	1. Keetia sp (0.005)
	2. Allanblackia stuhlmanii (13.59%)	2. Grewia microcarea (0.0071%)
	3. Scorodophloeus fischeri (5.50%)	3. Phyllanthus sp (0.008%)
Nilo	1. Allanblackia stuhlmanii (8.76%)	1. Chitranthus oblongnevis (0.007%)
	2. Newtonia buchananii (6.87%)	2. Crelodendrum sp (0.008%)
	3. Ricinodedendron heudelotii (6.79%)	3. Englerophytum natalensis (0.009%)

4.1.1.3 Volume, Basal area and Stems per ha

The results on the basal area, volume per ha and stem per ha for trees are summarised and presented in Table 4. For the sake of clearly showing the variations among the forests Figures 16 and 17 are also presented.

Table 4: Summary of forest structure parameters

S/No	Forest name	Volume (m^3/ha)	Basal area (m^2/ha)	2SE Volume	2SE BA	Stems/ha	2SE Stems/ha
1	Amani Nature Reserve	204.21	12.69	55.83	2.66	510	95
2	Bombo East I	17.39	3.33	11.33	1.27	390	132
3	Kwamgumi	106.96	9.52	40.98	2.82	394	118
4	Manga A (babao tree)	716.44	72.81	1151.15	102.73	550	179
5	Manga B (No babao tree)	155.20	24.11	73.15	12.48	550	179
6	Mgambo	109.00	19.78	93.11	12.26	979	521
7	Mtai	242.77	14.77	161.85	7.77	484	98
8	Nilo Nature Reserve	141.98	10.27	40.20	1.78	444	177

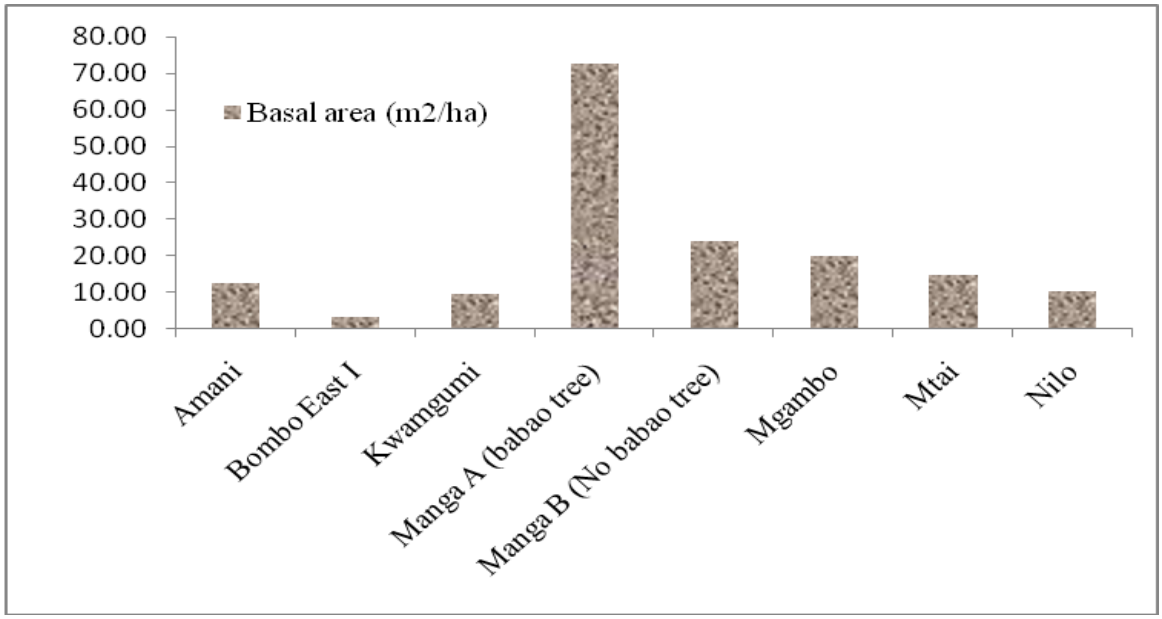

Figure 16: Variation of basal area in the studied forests

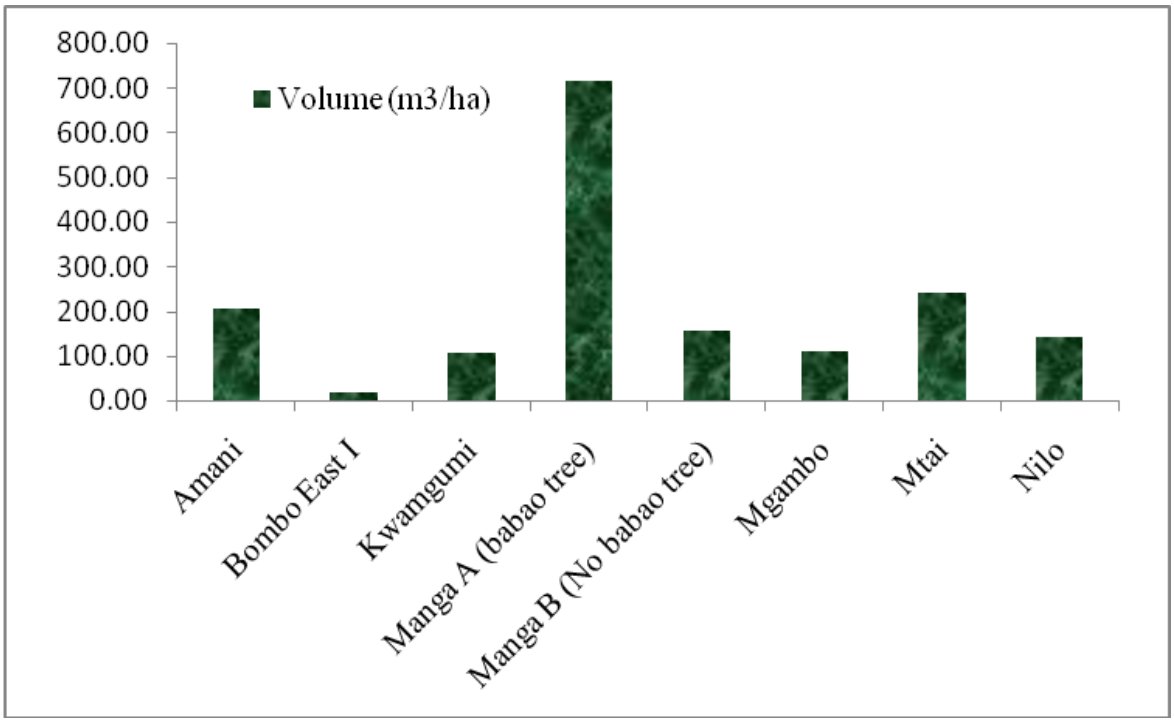

Figure 17: Variation of volume in the studied forests

Similar effect of baobab tree in volume was also noticeable in basal area per ha. The basal area per ha indicate the management between seven forest reserve were different. The poor management was shown by Bombo East I and followed by Kwamngumi forest reserve. Reported basal area includes 52 ± 24 m^2/ha in Usambara by Munishi *et al.* (2001); 42 ± 26 m^2/ha and Kijazi (2007) reported 42.096 ± 4.973 at Mlesa Village Management Area – Amani Nature Reesrve.

4.1.1.4 Biomass

The computed biomass for the surveyed forests is presented in Fig. 18. For example, analyses showed that the stock of carbon for intact natural forests in South-Eastern Australia was about 640 ± 383 t/ha of total carbon (biomass plus soil), with 360 ± 277 t/ha of biomass carbon (living plus dead biomass) (Mackey *et al,* 2008), while in Tanzania, carbon stock in tree biomass including roots was 517 ± 17 t/ha in Usambara, and 384 ± 10 t/ha in Uluguru mountains.

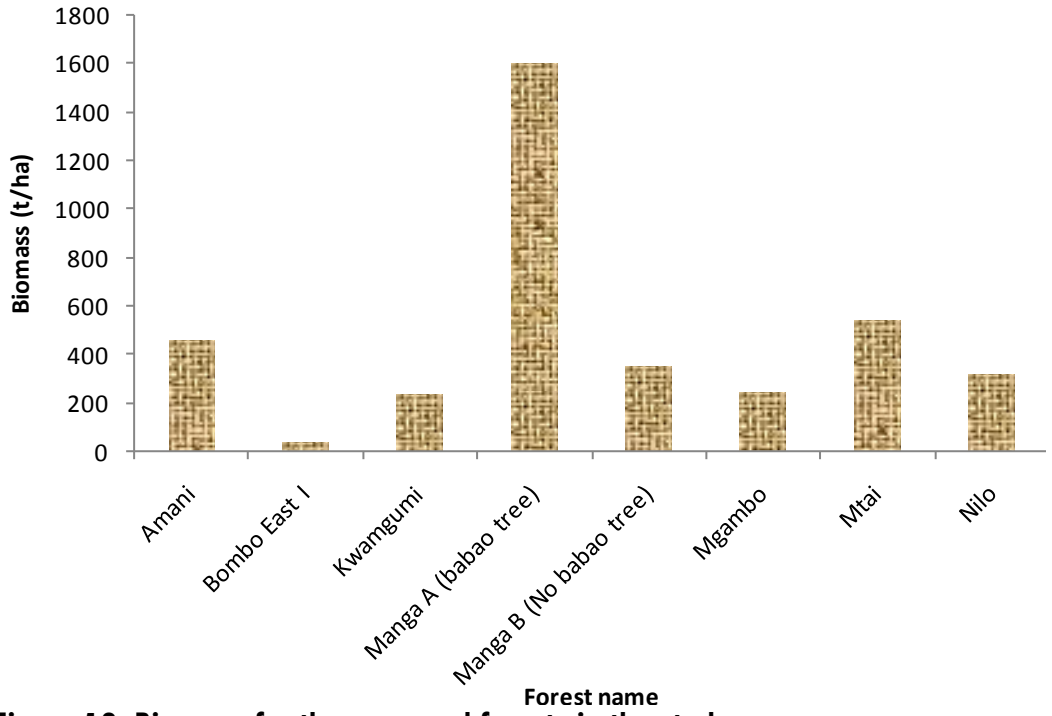

Figure 18: Biomass for the surveyed forests in the study area

The organic carbon density was 420 ± 100 t/ha in West Usambara and 290 ± 53 t/ha in Uluguru mountains. Other biomass amount reported elsewhere in the world include 435 – 530 t/ha in Sri Lanka by Brown (1997); 395 t/ha, 427 t/ha Usambara; 648 ± 16 t/ha; 569.4 t/ha in Mrumbai forest reserve in India; 509 t/ha Yamakura *et al*. (1986); 324 t/ha Natural forest; 468 t/ha; 260 t/ha in Africa; 215 tropical Asia; 500 – 600 t/ha in Appalachain mountain (Whittaker, 1996); 223 t/ha; 120 – 358 t/ha. 446 t/ha.

4.1.1.5 Relative frequency of saplings in forest reserves

The results on the relative frequency for sapling are presented in Figure 19 – 25. The saplings indicated rate of regeneration of different species in the forest and abundance. Bombo East I showed very low rate of sapling implies that the rate of regeration is very low. This was a result of impact of human disturbance.

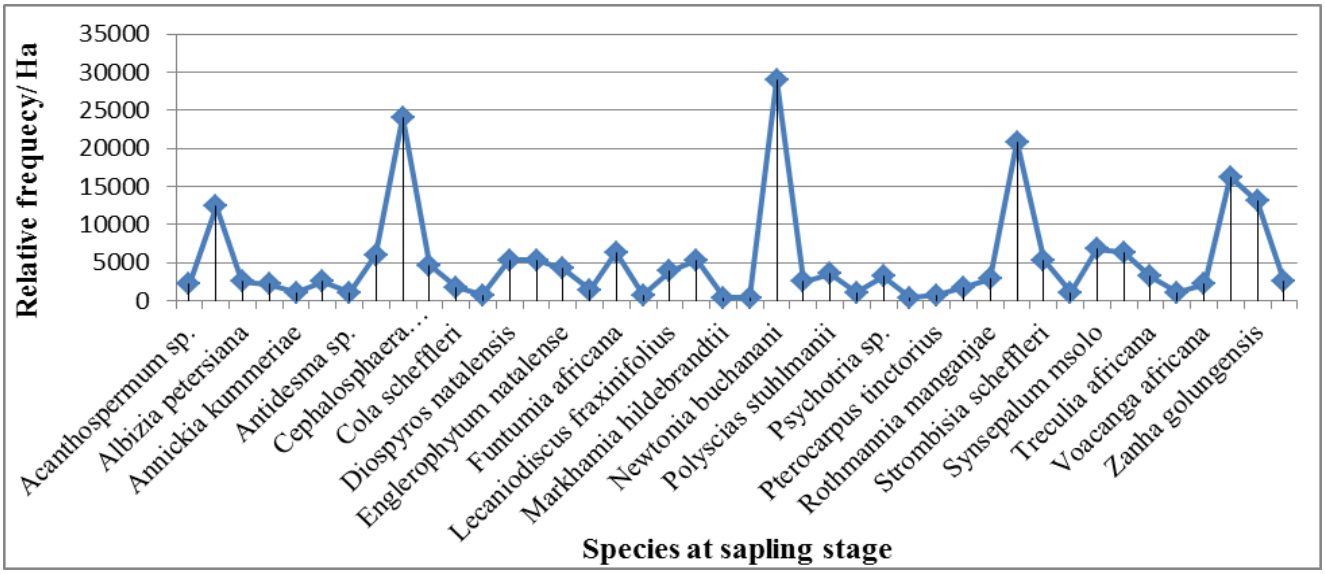

Figure 19: Relative frequency of saplings - Nilo Nature Reserve

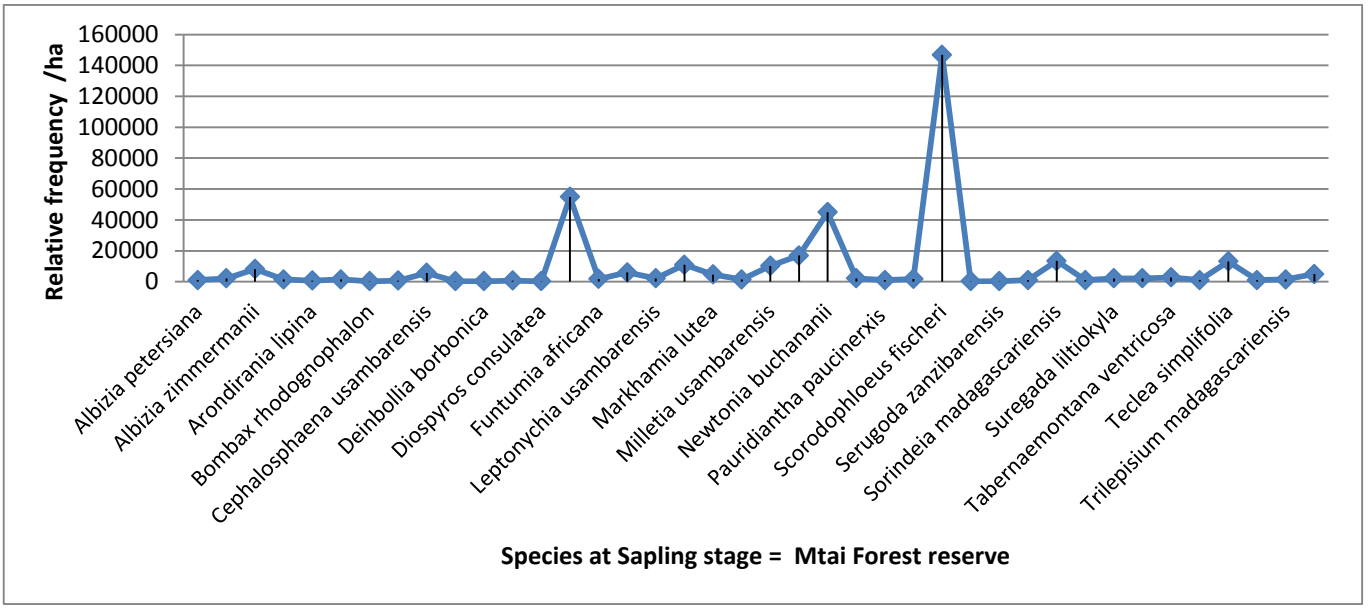

Figure 20: Relative frequency of saplings - Mtai Forest reserve

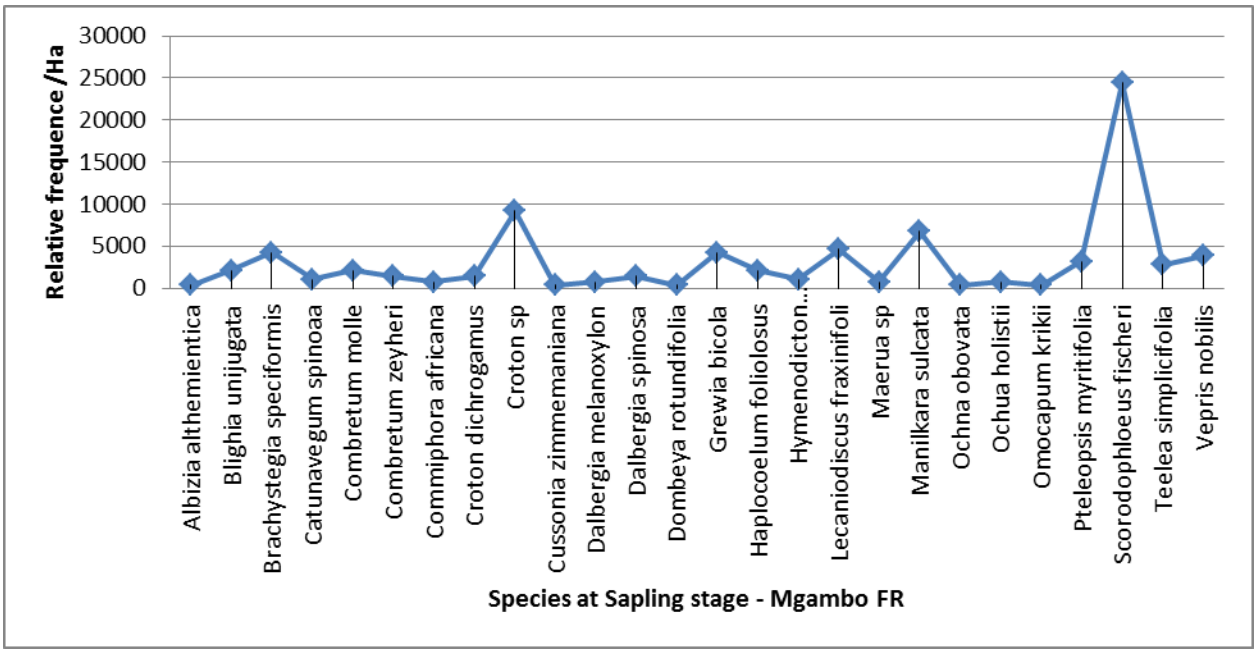

Figure 21: Relative frequency of saplings - Mgambo Forest

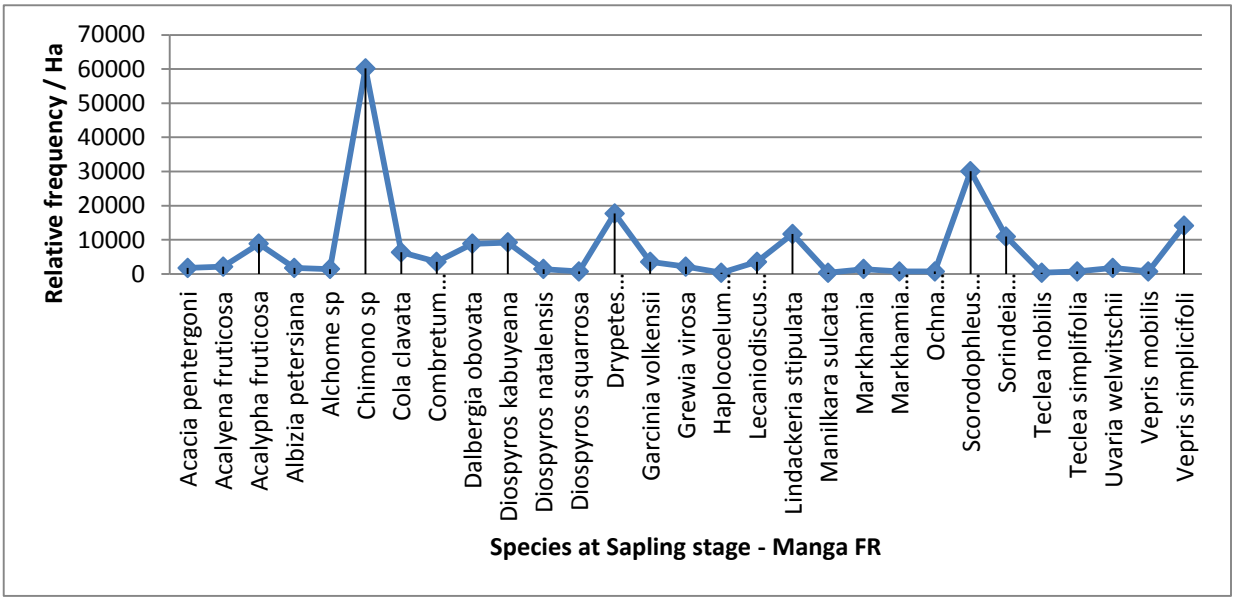

Figure 22: Relative frequency of saplings – Manga Forest reserve

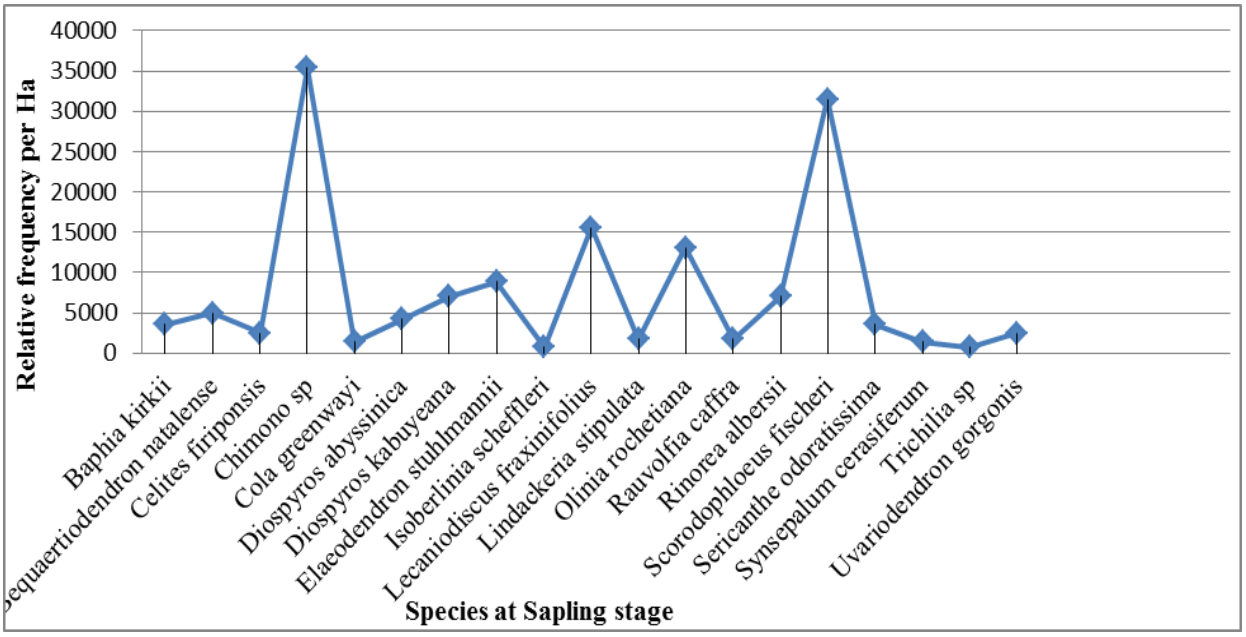

Figure 23: Relative frequency of saplings - Kwamngumi Forest

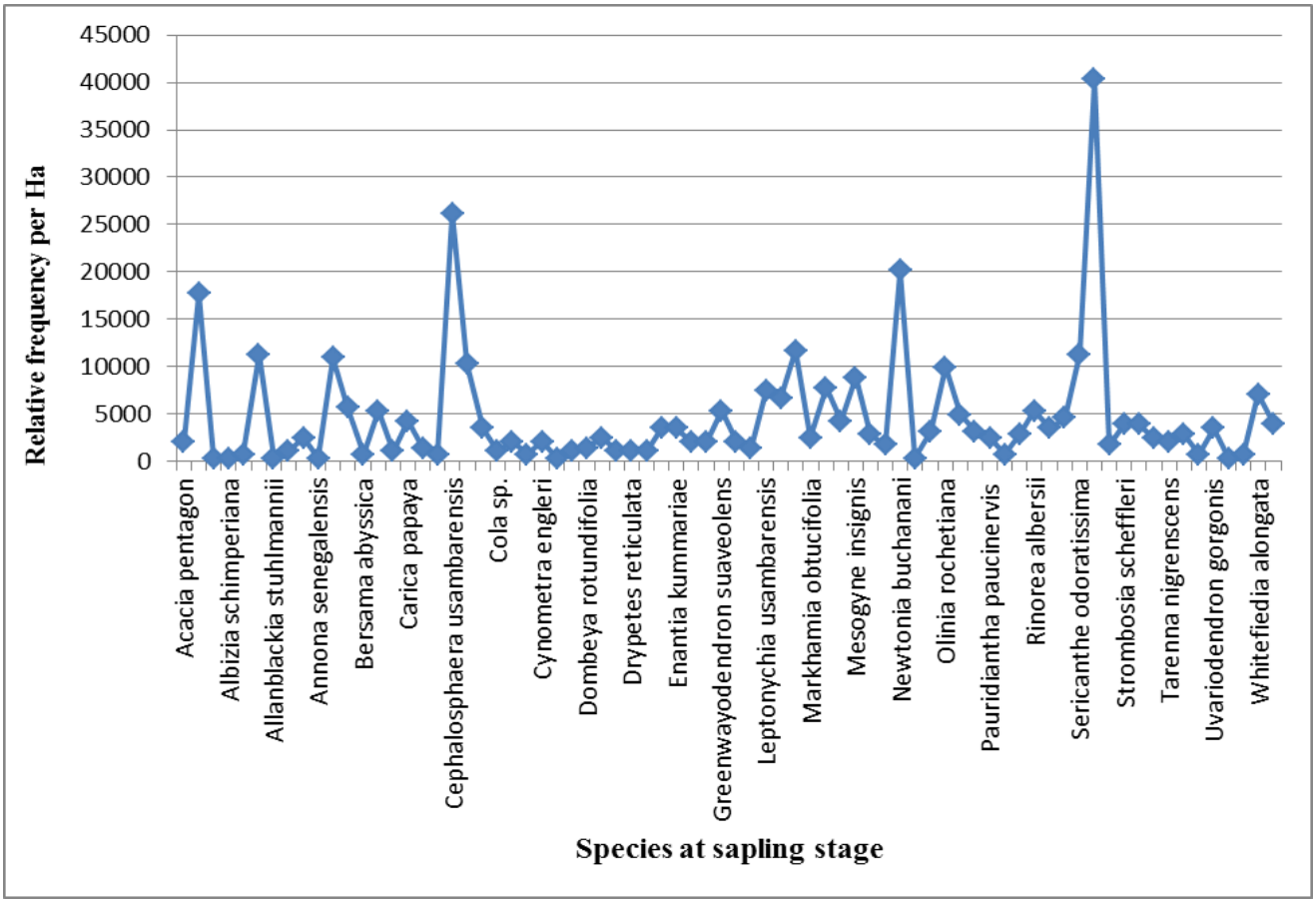

Figure 24: Relative frequency of saplings - Amani Forest Nature Reserve

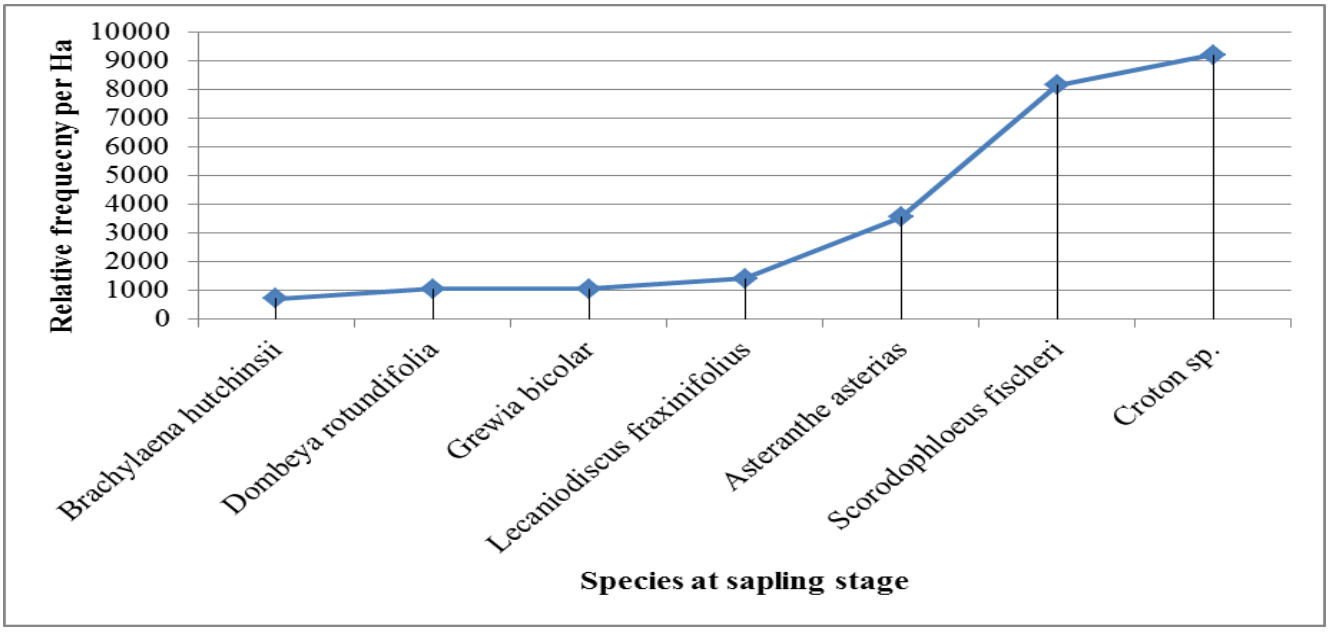

Figure 25: Relative frequency of saplings - Bombo East 1

4.1.1.6 Endemic flora species

Table 5 shows that, 10 species endemic to the Usambara were recorded, 4 species endemic to the East and West Usambara were recorded, while 7 species endemic to the East Usambara were recorded in this survey. Similar results were recorded by Beharrell, *at el*, 2002 that 13 species were recorded as endemic to the Usambara. Four species endemic to the East and West Usambaras were recorded: *Uvariodendron oligocarpum, Uvariodendron pycnophyllum, Englerodendron usambarense* and *Rinorea angustifolia albersi*. The author added that nine species were recorded as endemic to the East Usambaras: *Magnistipula butayei, Cynometra brachyrrahchis, Cynometra longipedicellata, Cynometra* sp. A, *Zenkerella grotei, Rytigynia xanthotricha, Placodiscus amaniensis, Cola scheffleri* and *Cola usambarense*. The plausible reason of the species not recorded in this survey could be not all core areas within the East Usambara Biosphere reserve were surveyed.

Table 5: Endemic flora species

Botanical names	vernicula names	Amani	Nilo	Kwamngumi	Mtai	Manga	Mgambo	Bombo E I	ENDEMIC STATUS
Allanblackia stuhlmannii	Msambu	√	√						N
Alsodeiopsis schumannii	Mkaangambeyu	√							N
Angylocalyx braunii	Mhande		√	√					N
Annickia kummeriae	Ng'waka		√			√			N
Beilschmiedia kweo	Mfimbo	√	√		√				N
Cola usambarensis	Muungu	√							E(EU)
Cola clavata	Mkavi		√	√	√	√			E(EU)
Cola greenwayi	Kola		√	√					E(EU)
Cynometra brachyrrachis	Mkwe	√							E(EU)
Cynometra engleri	Mkwe	√	√		√	√			E(EU)
Cynometra sp.	E (EU)			√					E(EU)
Drypetes usambarica	Kihambia	√			√				N
Englerodendron usambarense	Msase	√							EU & UW
Garcinia volkensii	Mfilafila	√							N
Greenwayodendron suaveolens	Ng'waati	√							N
Isoberlinia scheffleri	Mbarika	√							N
Placodisaus amaniensis		√	√						E(EU)
Rytigynia schumannii	Mtuavuaha			√					N
Rytigynia sp			√			√			N
Sterculia appendiculata	Mgude	√							N
Uvariodendron gorgonis			√	√					EU & UW
Uvariodendron oligocarpum	Mkenene	√		√					EU & UW
Zanthoxylum usambarense	Mhombo		√	√					N

Source: Field data survey 2014

4.1.2 Fauna species composition

4.1.2.1 Relative frequency for Fauna in forest reserves

The results on the relative frequency for fauna were presented in Figure 26-32. The results presented in

Figure 26 were found with high frequency included Fischer turaco, Rock hyrax, monkey, long billed tailor bird, Hornbills, blue monkey and barbet. Other fauna were found with low frequency included, bats, eathworms and some birds. Mtai FR birds showed high relative frequency compared to other fauna, for example Figure 27 revaled abundance of Crowned hornbill, Arrow marked babble, Fork tailed drongo, Collored sunbird, Black bacced puff back, Green wood hoopoe, Hartlaus turaco and Helmeted guinea.

Others included the group of mammals like Blue monkey and bush pig. The other fauna revealed with very low frequency but of different species indicating high diversty of fauna

Fig 28 indicates fauna in Mgambo FR has high relative frequency included Red-capped robin chat, Peregrin falcon, crowned hornbill, Wild pig, Tropical boubou, and Common bulbul. Dikdik and blue monkey were caught with medium frequency while others fauna species showed low relative frequency. To other side of view, Tropical boubou, Blue monkeys, Wild pig, and Common bulbul revealed high relative frequency in Manga FR (Figure 29) compared to White browed coucal, Laughing dove, Colobus monkey and collared sunbird which revealed medium frequency while others revealed very low relative frequency. At Kwamngumi FR (Figure 30) birds revealed highest relative frequency for example Black backed puff back, Tropical boubou, Variable sunbirds, Common bulbul and Grey backed camaroptera. Others were mammals like Blue monkey and Bushpigs. At Bombo East I (Figure 31) showed that birds had highest relative frequency for example; Trumpeter hornbill followed by Arrow marked babble and Tropical boubou compared to other fauna. Amani NR (Figure 32) revealed highest abundance of birds like Silver cheecked hornbill, Hornbill, Fischer's turaco, Red winged starling, Green barbet. Other fauna revealed high frequency were Blue monkeys, while the less abundance ones are the Black and white collubus monkey.

These results complied with that of Borghesioa *et el*., 2008 recorded birds in the East Usambara Mountains and observed in undisturbed forest the highest diversity of ground-foraging birds species like Fischer's Turaco *Tauraco fishcer,* Sharpe's Akalat *Sheppardia harpei* and Usambara Thrush *Turdus* [*olivaceus*] *roehli*. The author also observed richness in Dove, ellowbill, Mombasa Woodpecker, Hornbills and Pigeon, Long billed tailor bird. East Usambara Mountains hast has been recognized globally as important Biodiversity Hotspot by Conservation International, an Endemic Bird Area by BirdLife International, a Centre of Plant Diversity by WWF and IUCN, and a Globally Important Ecoregion by WWF (Burgess et al. 2007).

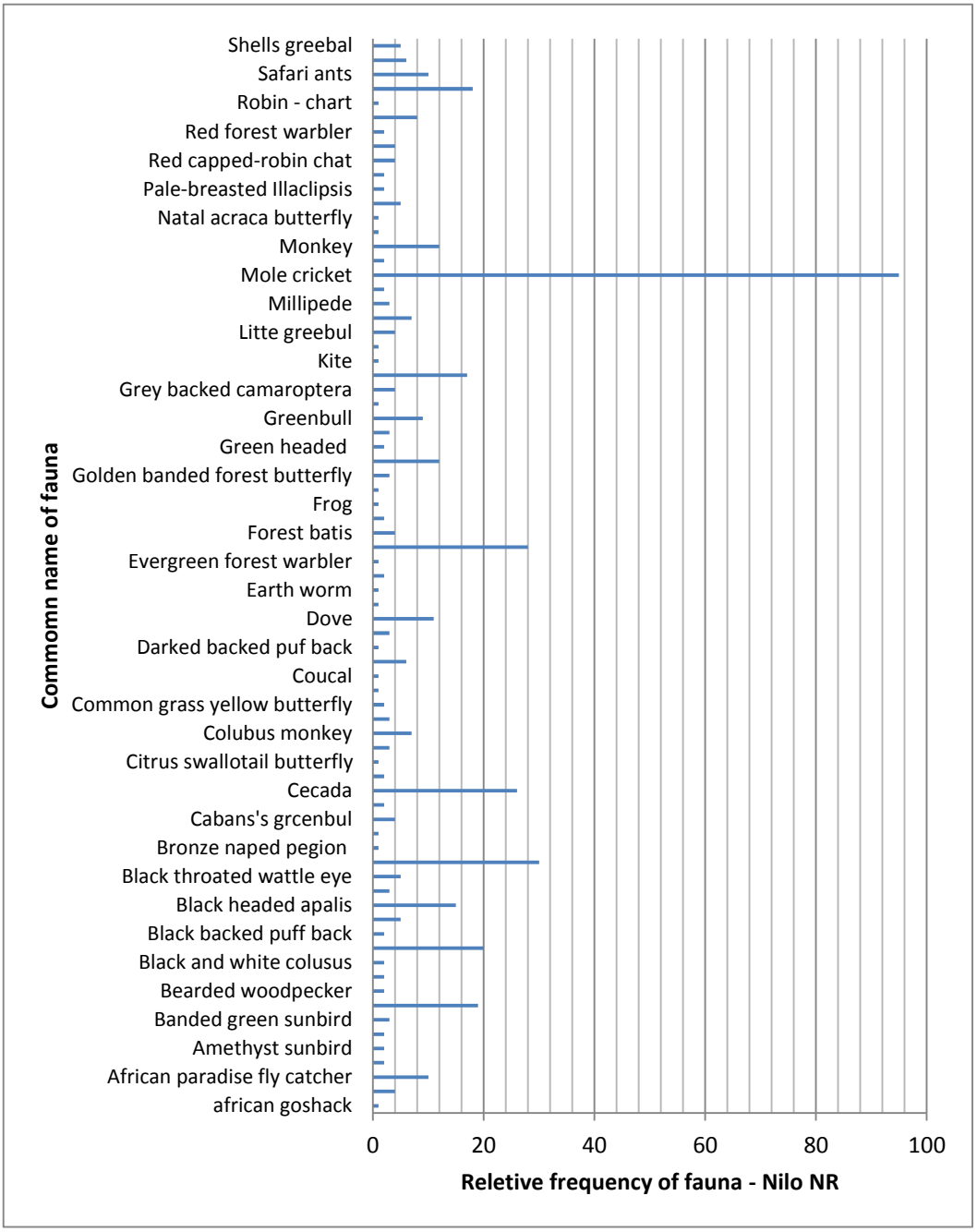

Figure 26: Relative frequency for Fauna - Nilo Forest

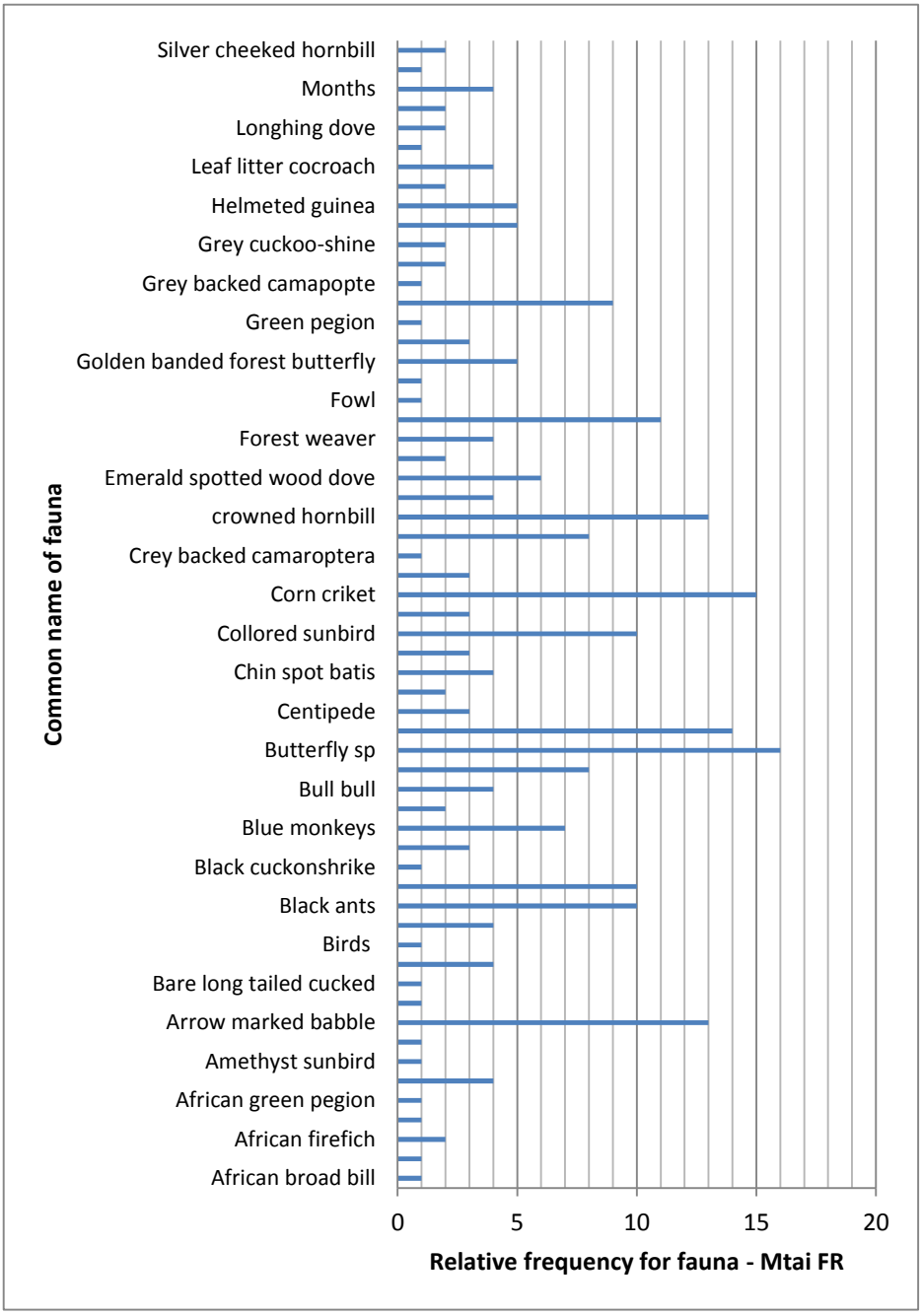

Figure 27: Relative frequency for Fauna - Mtai Forest

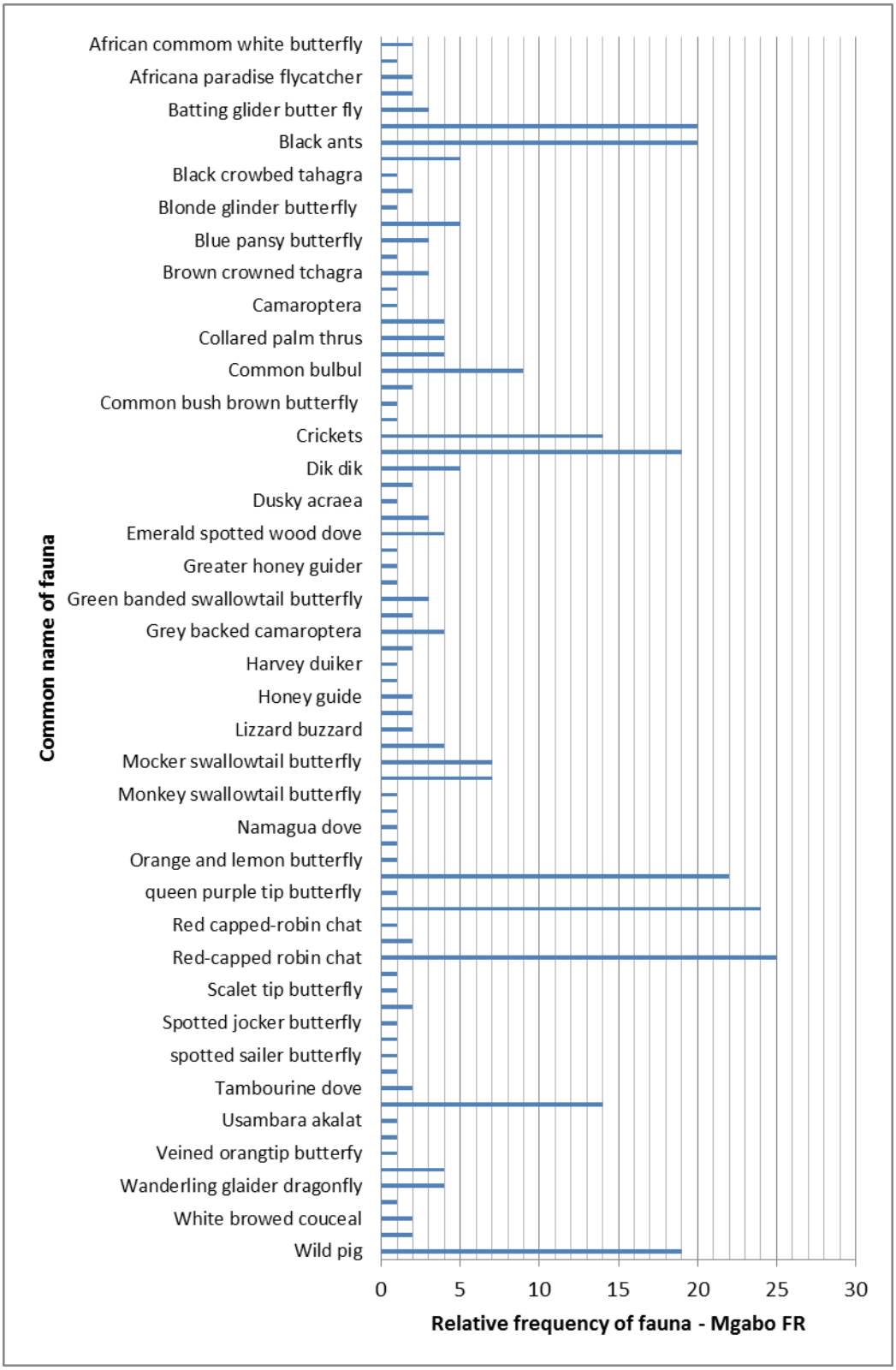

Figure 28: Relative frequency for Fauna - Mgambo Forest

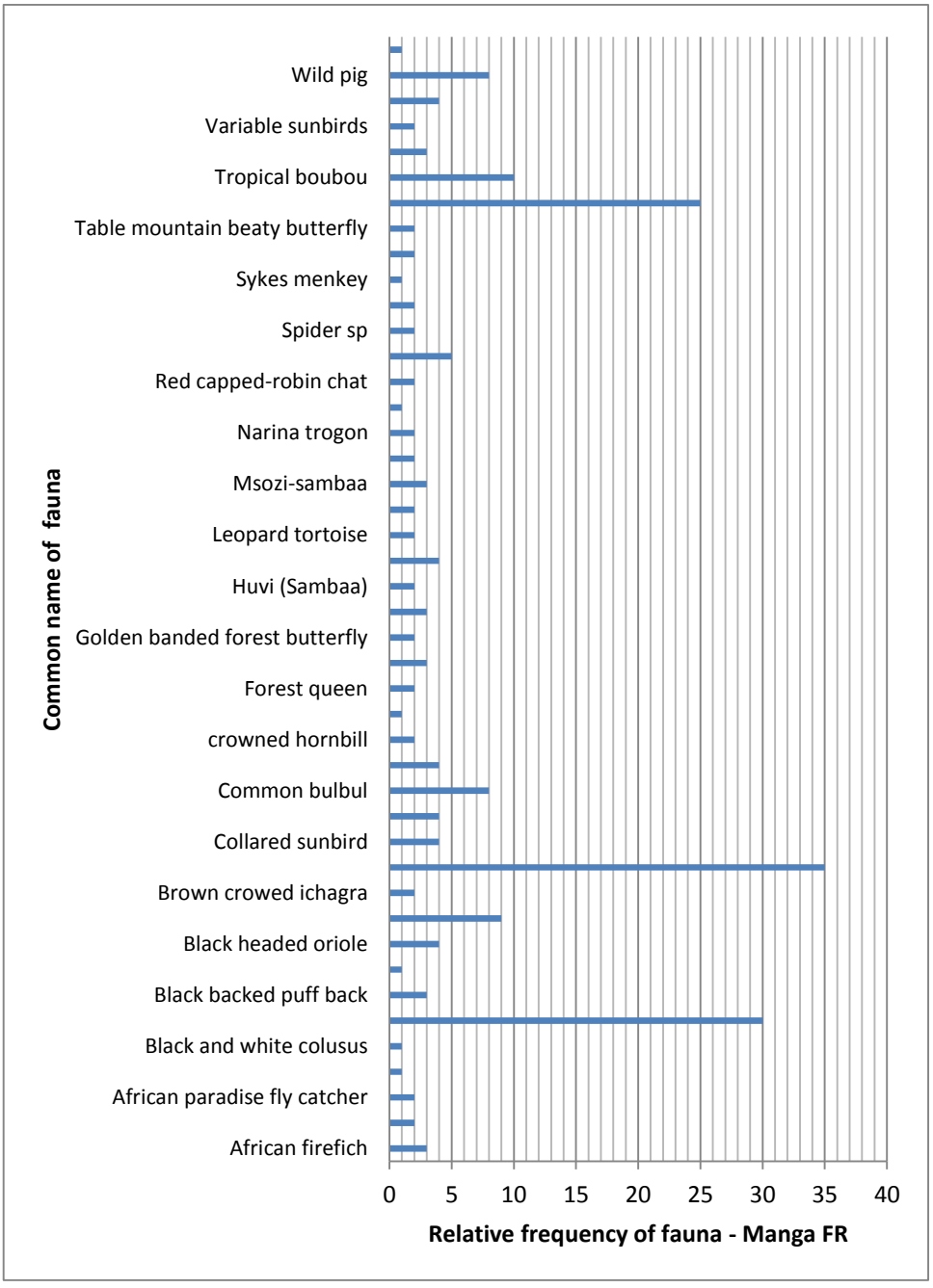

Figure 29: Relative frequency for Fauna - Manga Forest

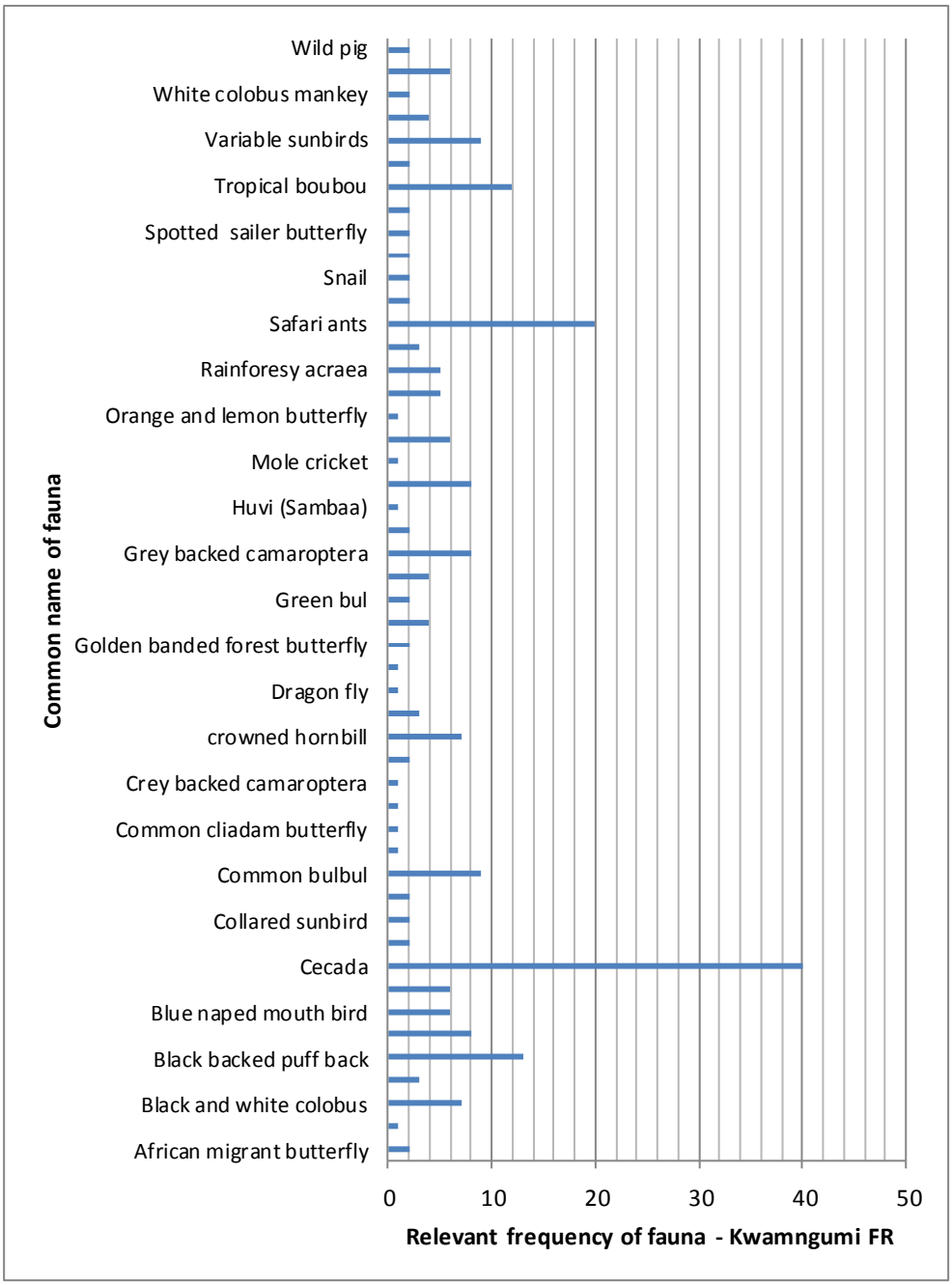

Figure 30: Relative frequency for Fauna - Kwamngumi Forest

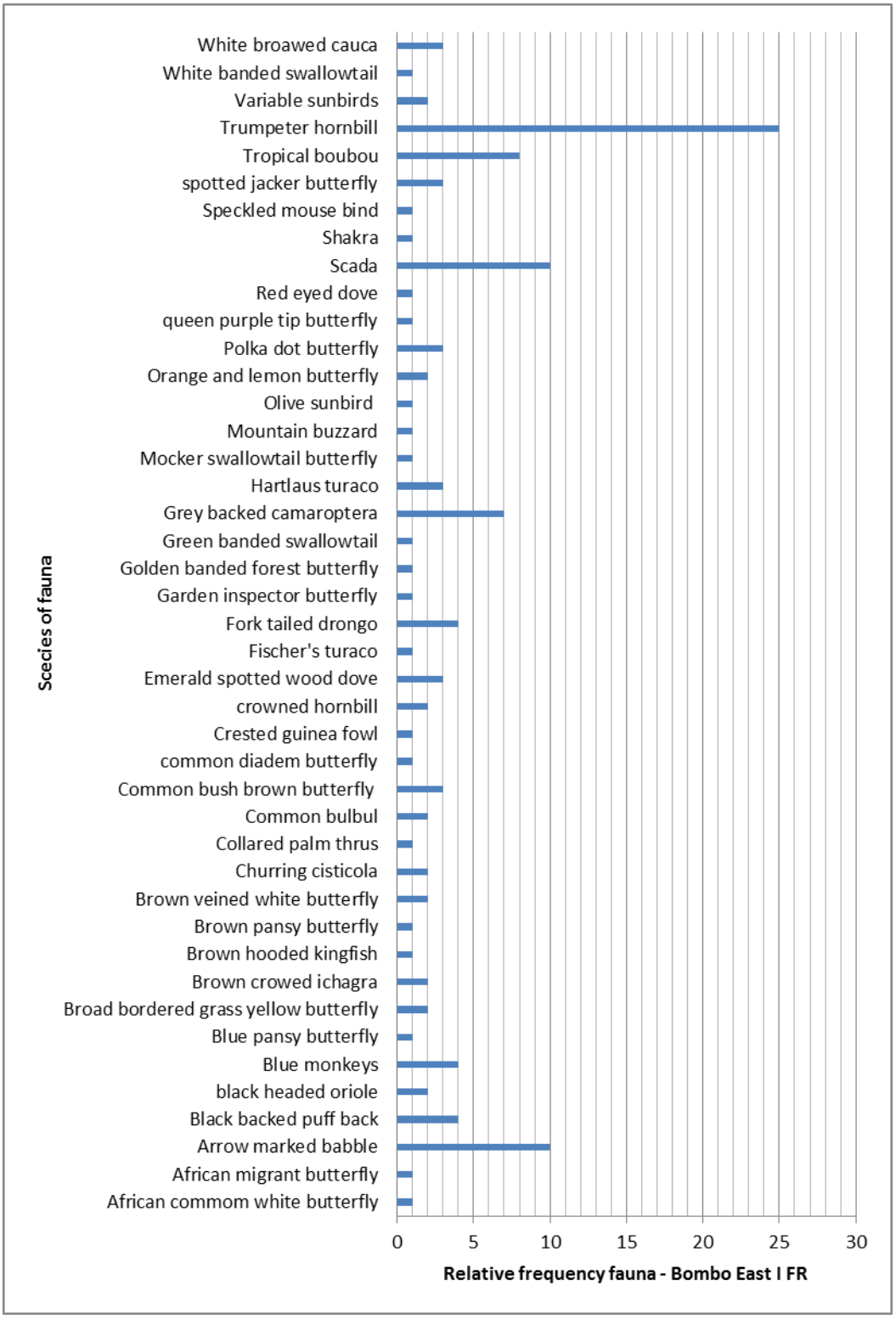

Figure 31: Relative frequency for Fauna - Bombo East 1 Forest Reserve

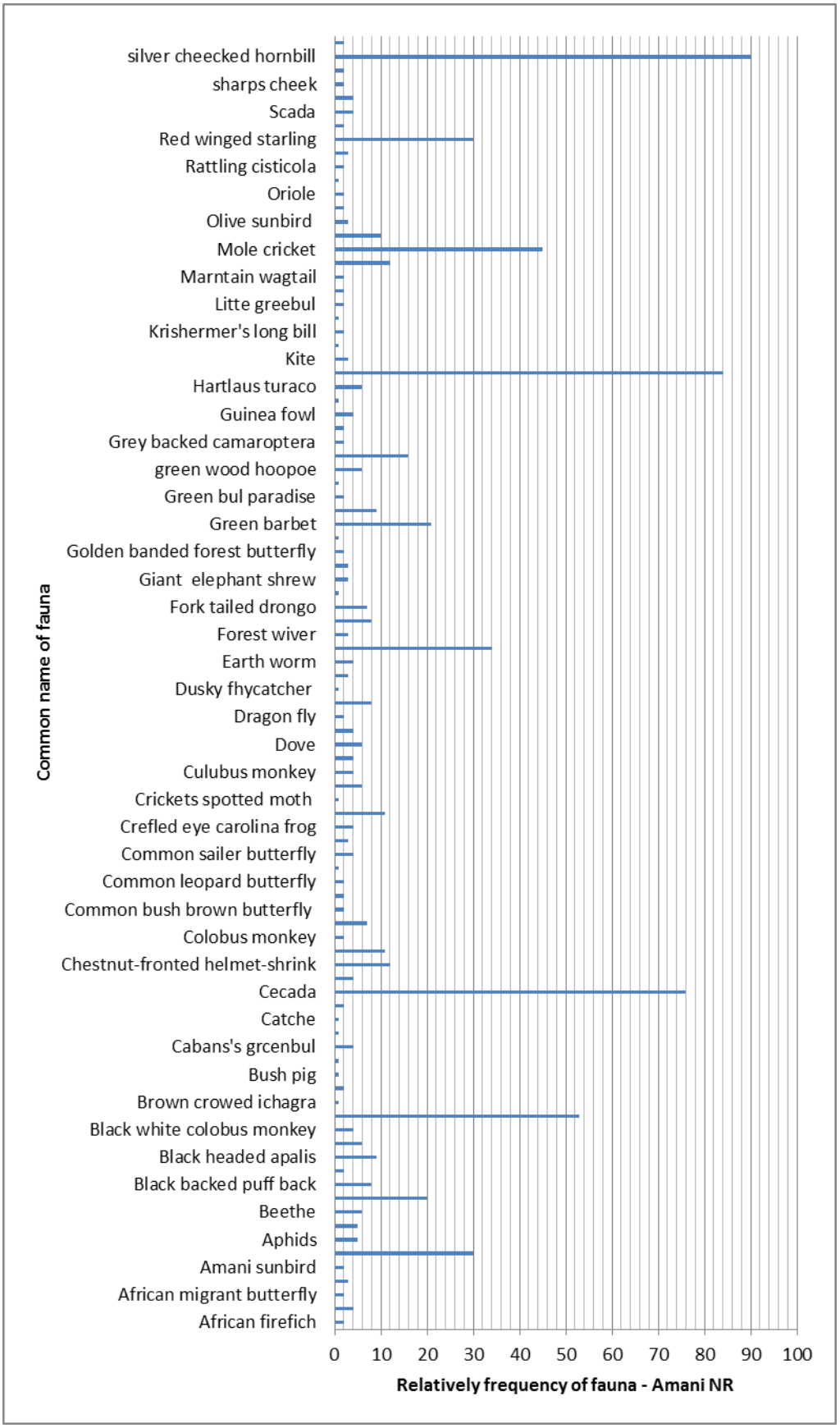

Figure 32: Relative frequency for Fauna - Amani Forest Nature Reserve

4.1.3 Opportunist observation

4.1.3.1 Flora

The flora species not recorded in plots but found in the opportunist observation included; Saintpaulia (African violet) plants that are found in the East Usambara biosphere reserve. Nine species of Saintpaulia were observed within Amani NR, Nilo NR; like the *Saintpaulia confuse, S.difficilis, S. grotei, S.intermedia, S. magungensis variety magungensis, S. magungensis variety minima, S.pendula variety pendula, S.pendula variety kizarae* and *S. tongwensis*. The Similar results were also reported by Watkins, *et el*. (2001).

4.1.3.2 Fauna

The fauna species that were seen in opportunist observation but not recorded in the systematic transects plots include Chameleon species; most of the reptiles includes snakes. Some birds also were observed. For example a guided night walk in Amani NR, one can observe *Chameleo deremensis* (3 horned), *Chameleo chameleon* (I soft hored), *Chameleon tempeli,* Bradypodion fischeri and *Rhampholeon brevicaudatus*. Snake like *Thelotornis usambarericus, Philothamnus macrops*, *Philothamnus punctatus, Bradypolion spinosus* and Leaf litter snake. Also endemic insect like the Amani flatwing dragnon fly was observed. However, Plate 1 - 11 also show opotunistic information which were taken during data collection. All the information signifies availability of Olive sunbird, Paradise flycatcher, Sharpes akalat , White tailed crested flycatcher, African broad bill, Amani sunbird, Lemon dove, Greenbull and Northern olive birds species found in Usambara Biossphere Reserves.

Plate 1: Olive sunbird eggs, Photo by Mkongewa

Plate 2: Paradise flycatcher nest, Photo by Mkongewa

Plate 3: Sharpes akalat stage,
Photo by Mkongewa

Plate 4: White tailed crested flycatcher nest ambang
Photo by Mkongewa

Plate 5: African broadbill net
Photo by Mkongewa

Plate 6: Chicks of Amani sunbird and net
Photo by Mkongewa

Plate 7: Eggs of Sharpes akalat
Photo by Mkngewa

Plate 8: Lemon dove incubating ambanfulu
Photo by Mkongewa

Plate 9: Little green net
Photo by Mkengewa

Plate 10: Nestling shelley's greenbull
Photo by Mkengewa

Plate 11: Northern olive thrush eggs and nest
Photo by Mkengewa

4.1.4 Results of Biodiversity indices of flora and fauna

4.1.4.1 Shannon-wiener index of diversity (H'), Index of dominance (ID) and Evenness of flora

The Shannon-Weiner index was developed from information theory and is based on measuring uncertainty. The degree of uncertainty of predicting the species of a random sample is related to the

diversity of a community. If a community is dominated by one species (low diversity), the uncertainty of

prediction is low; a randomly-sampled species is most likely going to be the dominant species. However, if diversity is high, uncertainty is high.The results of Shannon-wiener index of diversity (H'), Index of dominance (ID) and Evenness of flora of seven forest reserve assessed were presented in Table 6.

Table 6: Diversity indices of the flora

Name of Forest	Diversity Indices		
	Shannon-wienner (H')	**Dominance**	**Evenness**
Nilo NR	3.069 — 3.447	0.0399 — 0.06715	0.06385 — 0.0672
Mtai FR	3.025 — 3.427	0.04025 — 0.0716	0.6477 — 0.8089
Mgambo FR	2.688 — 3.179	0.047 — 0.08983	0.7383 — 0.9028
Manga FR	2.52 — 3.062	0.05623 — 0.1145	0.6541 — 0.8493
Kwamngumi FR	2.399 — 2.573	0.1036 — 0.1369	0.5794 — 0.6895
Amani NR	4.012 — 4.208	0.01797 — 0.02779	0.7245 — 0.8420
Bombo East 1 FR	1.121 — 1.894	0.157 — 0.3884	0.7299 — 0.9568

4.1.4.2 Shannon-wiener index of diversity (H'), Index of dominance (ID) and Evenness of fauna

The results Shannon-wiener index of diversity (H'), Index of dominance (ID) and Evenness of fauna was presented in table 7.

Table 7: Diversity indices of the fauna

Name of Forest	Diversity Indices		
	Shannon	**Dominance**	**Evenness**
Nilo	4 – 4.255	0.01854 – 0.02657	0.6537 – 0.752
Mtai	3.953 – 4.201	0.01881 – 0.02719	0.6856 – 0.7903
Mgambo	3.624 – 3.931	0.02421 – 0.03629	0.6952 – 0.8095
Manga	3.171 – 3.515	0.03475 – 0.05536	0.7217 – 0.8564
Kwamngumi	3.2988 – 3.622	0.0325 – 0.05083	0.6857 – 0.8181
Bombo East 1	3.143 – 3.523	0.03432 – 0.05614	0.7406 – 0.8720
Amani	3.83 – 4.087	0.02373 – 0.03433	0.5772 – 0.6818

Amani Nature reserve revealed higher value of H' of flora of 4.012 – 4.208 compared to other forest core areas assessed. Nilo Nature Reserve revealed H' of flora of 3.069 – 3.447 followed by Mtai forest reserve that revealed H' of flora of 3.025 – 3.427 while; Mgambo forest reserve and Manga forest reserves revealed 2.688 – 3.179 and 2.399 – 2.573 respectively. The least H' of flora of 1.121 – 1.804 of flora was revealed in Bombo East I forest reserve. Futher more, the results from this study compare well with those obtained from other studies with similar conditions. Malimbwi and Mgasha

(2002) in their study also obtaines H' values in Mkindo Forest Reserve as 3.162 and 3.202 in woodland and lowland parts respectively, while in Palaulanga Forest Rerserve the value were 3.169 in lowland and 3.48 in miombo wood land. Also Munishi *et al.* (2004) reported diversity index value of 3.31 in the Uluguru Mountains while Kijazi (2007) recorded H' of 3.379 within the utilization zone for Mlesa village at Amani NR and H' 3.271 was observed by IFRI 2001 in Amani Nature Reserve

The plausible reasons of H' being highhest in Amani could be explained by the fact that the flora is recovering from human disturbance possed by illegal alluvial gold mining. Furthermore the findings in Table 6 suggests that Bombo East I is very poor in term of flora richness and this may be due to high tree cutting observed of *Brachylaena huillensis* for calving making. These results is supported by the results of low value of richness obtained in figure 1 above and impact of human disturbances in Bombo East I presented in Figure 38 which revealed high cutting of trees, medium fire damage, trapping, grazing and uncontrolled foot paths. Human disturbance have negatve impact to biodiversity richness. Pole cutting was reported by Hamilton and Bensted-Smith (1989) to have a major influence on the forest that can alter the balance of species.

Table 7 showed that H' of fauna was the highest at Nilo Nature Reserve of 4 – 4.255 compared to the rest of core areas surveyed. Mtai Forest reserve and Amani Nature reserve showed a H' of fauna of 3.953 – 4.201 and 3.83 – 4.087 respectively. However, the H' of all forests that were surveyed indicated high diverse of fauna. This included the Bombo East I that have lowest H' of flora but have H' of fauna of 3.143 – 3.523. The plausible reason of Bombo East I revealed high H' could be influenced by the reserve bordering the Bombo East II an animal corridor to Mkomazi National Park. These results suggests that Bombo East I need to be well managed and protected to save this diverse fauna that contributes to the fauna richness of East Usambara Biosphere Reserve.

Mbwambo *et al.*, 2004 urged that the greater the value of Shannon-wiener index the higher the species diversity. Krebs (1989), explained Shannon-Wiener Index of diversity as a measure of information content of a sample and since information content is a measure of uncertainty, the large the value of H', the greater the uncertainty. Krebs (1989), added that Shannon Wiener index increases with the number of species in the community but does not exceed 5.0. Munishi (2001), urged that the H' value that is greater than 2.0 have been assigned as medium to high species diversity, with a maximum value of 5.

Index of Dominance and Evenness

The Index of dominance (ID) observed in this inventory is presented in Table 6 and 7 above both for flora and fauna. The results in Table 6 revealed the index of dominance for flora of 0.157 - 0.3884 for Bombo East I; 0.1036 — 0.1369 for Kwamngumi FR; 0.05623 - 0.1145 for Manga; 0.047 - 0.08983 for Mgambo; 0.04025 - 0.0716 for Mtai; 0.0399 - 0.06715 for Nilo NR and 0.01797 - 0.02779 for Amani NR.

The results in Table 7 revealed Index of Dominance for fauna of 0.03475 – 0.05536 for Manga FR; 0.03432 – 0.05614 for Bombo East I; 0.0325 – 0.05083 for Kwangumi FR; 0.02421 – 0.03629 for Mgambo; 0.02373 – 0.03433 for Amani NR; 0.01881 – 0.02719 for 0.01881 – 0.02719 for Mtai FR and 0.01854 – 0.02657 for Nilo NR. These results imply that the probability of picking randomly two individuals belonging to the same species was higher for core area with higher ID and the probability becomes lower as the ID was becoming less. Therefore these results suggest that there was relatively more heterogeneity in vegetation in core forest with low ID like Amani Nature Reserve and thus can be interpreated as showed high richness in species of flora.

The Index of Dominance for flora obtained in this study was more or less similar with that obtained in submontane forest in other studies. For example Kijazi (2007) observed ID of 0.051 within the utilization zone for Mlesa village at Amani NR, while; Munishi *et al*. (2004) obtained Index of Dominance value of 0.05 and 0.04 for Kisimagonja in West Usambara and Uluguru respectively.

The relevant abundance of rare and common species is called evenness. The results in Table 6 and 7 revealed the evenness of each core forest areas assessed. Communities dominated by one or a few species have a low evenness while those that have a more even distribution of species have high evenness. Species diversity includes both species richness and evenness. Communities with large number of species that are evenly distributed are most diverse and communities with few species that are dominated by one species are the least diverse. Table 6 showed the evenness of flora species within the studied forest core areas. Nilo NR seems to have less evenness of flora of (0.06385 - 0.06715) as compared to the rest of the forests. Table 7 showed higher value of evenness (0.6537 – 0.752) of fauna on the same core area – Nilo NR. These results implied that the species of fauna in Nilo NR were all abundant. The value of a diversity index increases both when the number of types increases and when

evenness increases. For a given number of types, the value of a diversity index is maximized when all types are equally abundant (*http://faculty.clintoncc.suny.edu/faculty/michael.gregory/files/bio%20206/206%20laboratory/species%20diversity/species_diversity.htm* 04/08/2014).

4.1.5 Human impact on core area and environmental status of the East Usambara Biospher reserve

Results from human impacts observed during the assessment were summarized in the table 8 below. These results suggest that most of the core areas assessed experiences high human disturbance that influences the change in biodiversity.

Table 8: Summary of human impact on environment observed during the inventory

Core area	Fire damage	Logging /cutting	Trapping	Cultivation	Foot path	Clearing	Buildings	Grazing
Nilo		√			√			
Mtai	√		√		√			
Mgambo	√	√		√	√	√	√	√
Manga			√			√		√
Kwamngumi	√	√						
Bombo East I	√	√	√		√			√
Amani	√	√		√	√	√		

Detailed of generally observation found within plots on human impact was presented in Figures 33 - 39 below. Figure 33 indicated that there were high frequency of tree cuttings and footpath found within Nilo Nature Reserve although the impact was medium and low respectively. However, other human impacts due to fire damage, trappings, cultivation, forest clearing, buildings, mining, charcoal production and grazing were not observed within Nilo Nature reserve. These results imply that majority of the community surrounding the reserve are aware of the importance of the conservation. Despite of majority being aware of the conservation but some people still depends on the forest products e.g poles and timber for buildings and firewood see Table 8. Therefore the management has to solicit this by showing other alternatives e.g through awareness creation among the community surrounding the forest and by establishing other sources of income generating activities.

Figure 34 revealed medium impact on fire damage, trapping and foot paths in Mtai Forest reserve. Mgambo FR experiences impact on fire, high impact on grazing and foot path, medium impact on cutting, building, clearing and cultivation (Figure 35). In Manga FR traping, grazing and clearing (Figure 36)

showed high impact on environment. Kwamngumi FR (Figure 37) showed fire damage and tree cutting poses negative impact to the environment though at a medium level, while Amani NR (Figure 39) revealed high fire damage, tree cutting, cultivation, and clearing. According to observation clearing was caused by electricity power transmission line. Bombo East I (Figure 38) revealed high impact on environment caused by fire damage, grazing, trapping and foot paths.

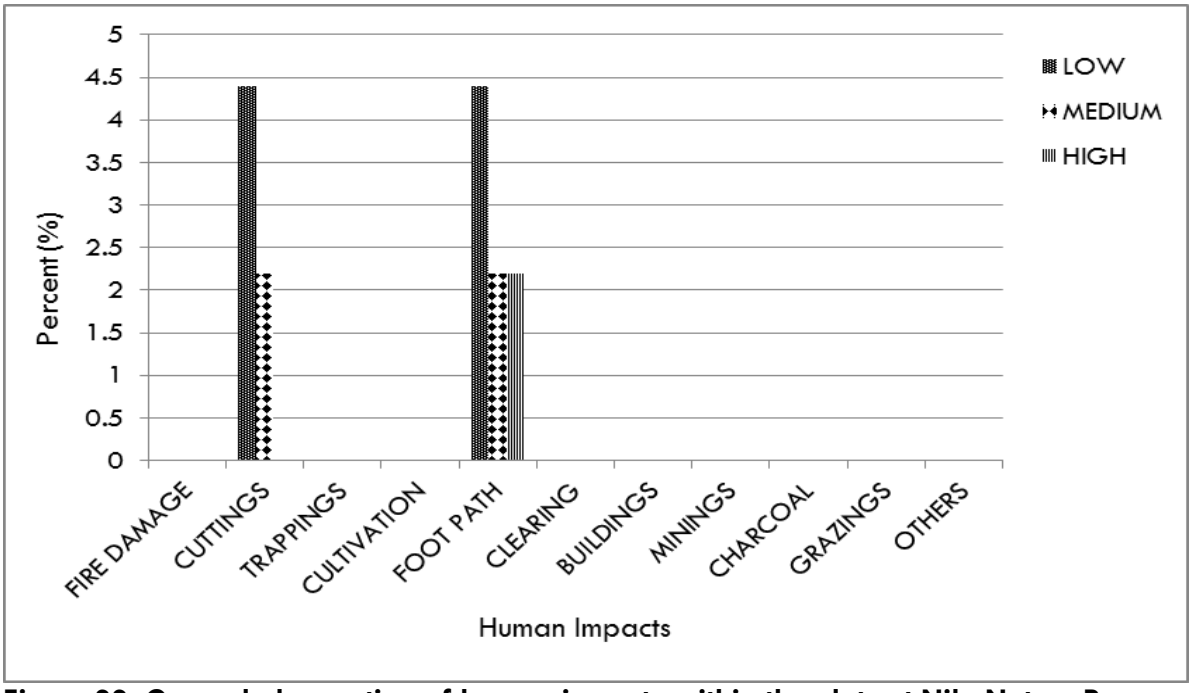

Figure 33: General observation of human impacts within the plots at Nilo Nature Reserve

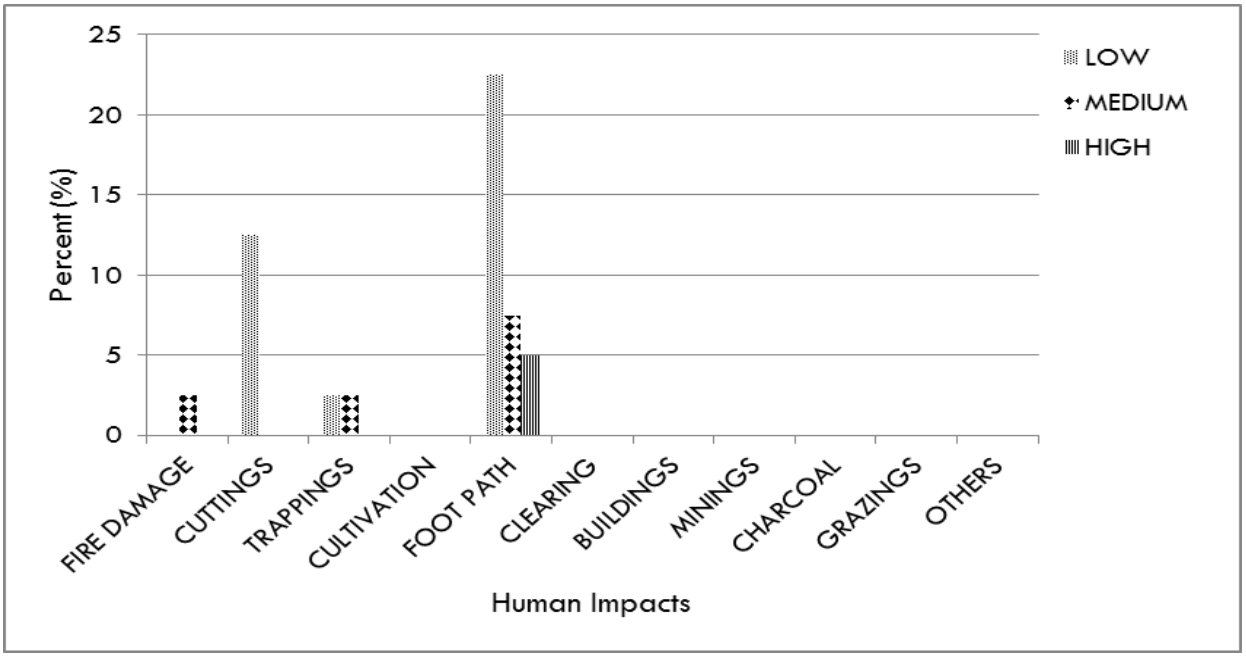

Figure 34: General observation of human impacts within the plots at Mtai Forest Reserve

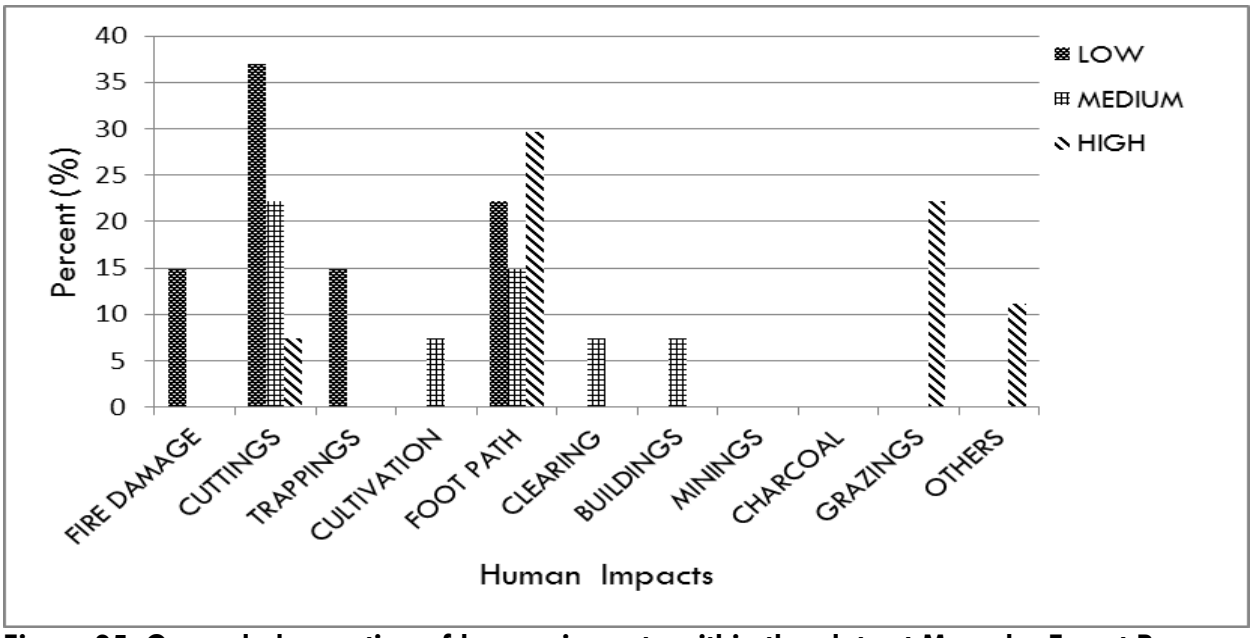

Figure 35: General observation of human impacts within the plots at Mgambo Forest Reserve

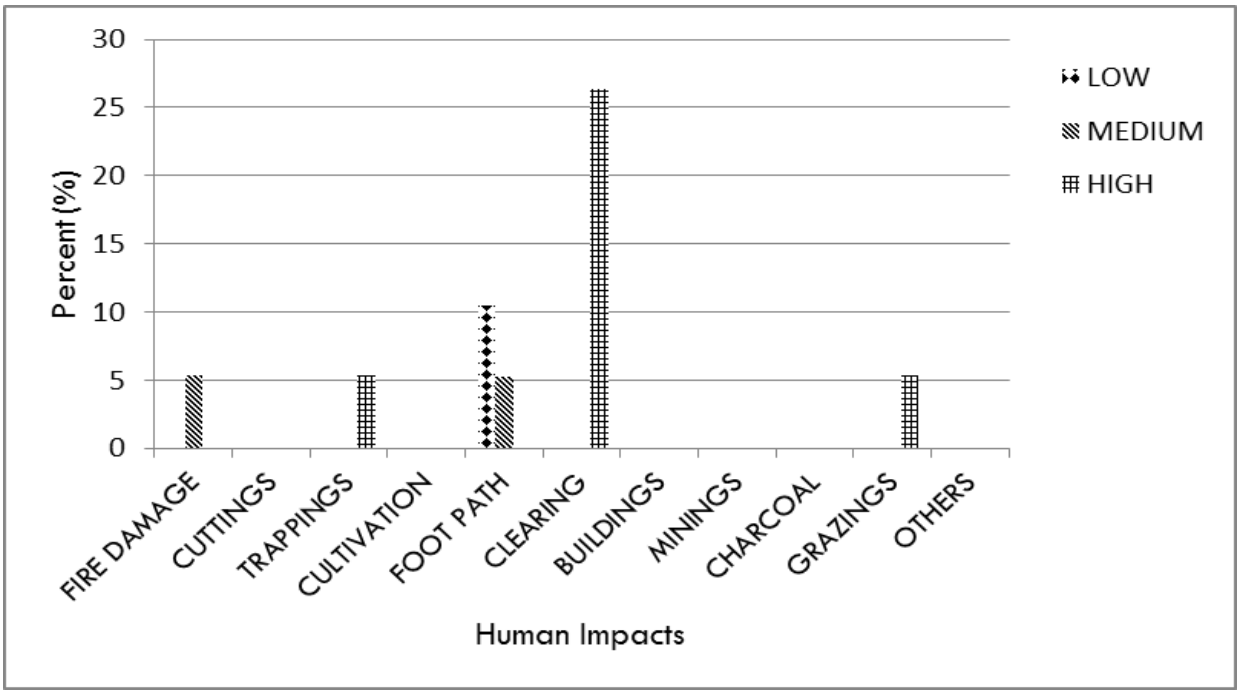

Figure 36: General observation of human impacts within the plots at Manga Forest Reserve

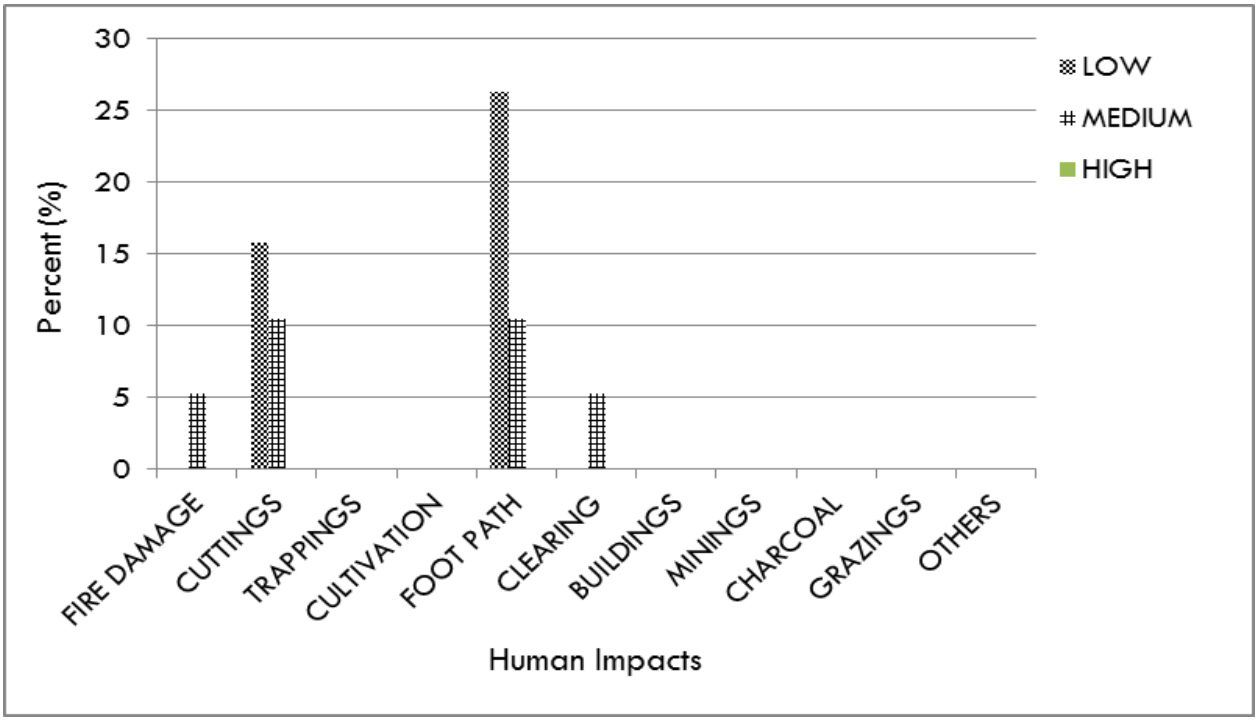

Figure 37: General observation of human impacts within the plots at Kwangumi ForestReserve

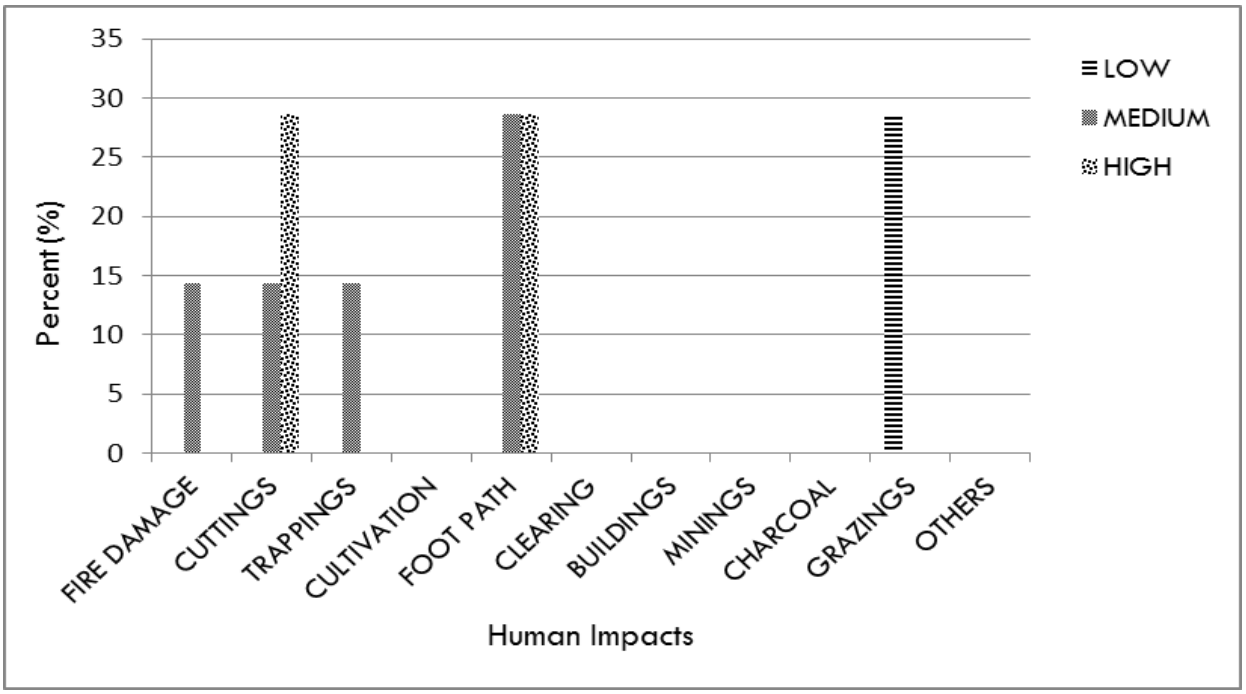

Figure 38: General observation of human impacts within the plots at Bombo East I

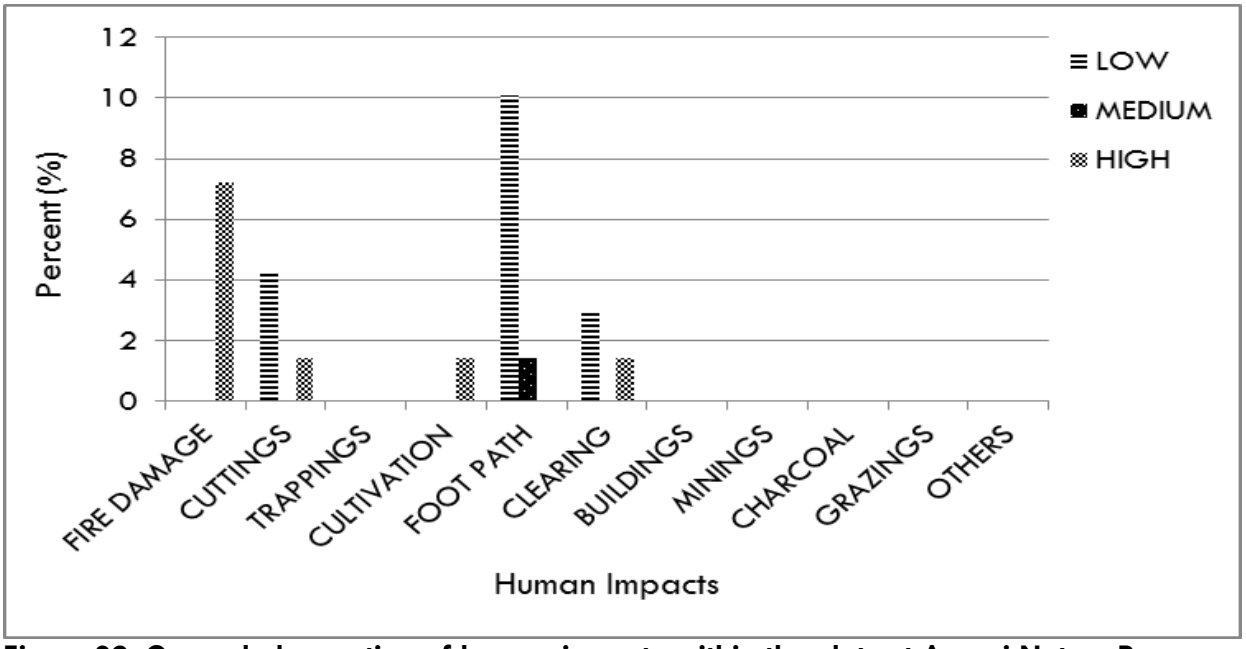

Figure 39: General observation of human impacts within the plots at Amani Nature Reserve

These results presented in Figure 33 – 39 reveal local communities depend on the core forest resources for their livelihoods. This was mostly observed in in all core forests assessd. Based on these results, majority of the communities surrounding the reserve, need continuous awareness raising campaign on importance of the conservation of biodiversity and the ecosystem as a whole. In addition it seems this

situation can be checked by provision of alternatives by establishing or intensifying other sources of household livelihoods diversitication activities that incooperate Income generating activities.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the study findings, it is reasonable to conclude that here is still potential of high species richness within the studied core ares. The list of recorded flora and fauna species were the vivid information potraying this fact. Bird species are abundant fauna in the area. The biodiveristy indices revealed highest richness of the core forest area a situation that calls for deliberate efforts to protect these unique resources.

The surveyed core forests still experiences human pressure that there is a need of taking care of their daily home stead livelihoods diversification so that these high biodiversity resources could be released from this dependence. In addition awareness rising in conservation method could encourage the local community to participate in conservation. Fire as a bad servant should be advocated to local communities surrounding these core areas.

5.2 Recommendations

The results from this study suggests a follow up study or rather a monitoring phase in a longer duration to capture detailed information of the flora and fauna changes together with change in human dependence of this valuable richest biodiversity resources of the East Usambara Biosphere Reserve.

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APPENDICES

Appendix 1: List of plant species of Amani Nature Reserve

S/N	Botanical names	vernacular names	Habitat	Uses
1	*Acacia polyacantha*	Mgunga	Lowland	Shade, buildings, firewood
2	*Afrosersalicia cerasifera*	Muohoyo	Lowland & Submontane	Firewood, medicinal
3	*Albizia glaberrima*	Mshai-mamba	Lowland & Submontane	Timber, poles
4	*Albizia gummifera*	Mshai	Lowland & Submontane	Timber
5	*Albizia petersiana*	Mshai	Lowland & Submontane	Timber
6	*Albizia sp.*	Mzungu	Lowland & Submontane	Timber
7	*Albizia versicolor*	Mkingu	Lowland & Submontane	Timber
8	*Alchornea cordifolia*	Alkonea	Lowland & Submontane	Medicinal
9	*Alchornea hirtella*	Zasa	Lowland & Submontane	Medicinal
10	*Allanblackia stuhlmannii*	Msambu	Submontane	Edible oil
11	*Allophylus abyssinicus*	Mtitu	Submontane	Timber
12	*Allophylus stachyanthus*	Mbangwe	Lowland	Poles, buildings, firewood
13	*Alsodeiopsis schumannii*	Mkaangambeyu	Submontane	Medicinal
14	*Aningeria adolfi-friedericii*	Kuti	Submontane	Poles, buildings, firewood
15	*Anisophyllea obutusifolia*	Msaamti	Lowland	Firewood
16	*Anisophyllea sp.*	Msaa	Submontane	Medicinal
17	*Annickia kummeriae*	Ng'waka	Lowland	firewood
18	*Annona senegalensis*	Mtopetope pori	Lowland	Edible fruits, medicinal
19	*Anthocleista grandiflora*	Mpumu	Lowland	Medicinal
20	*Antiaris toxicaria*	Mkuzu	Lowland & Submontane	Timber
21	*Antiaris usambarensis*	Mkomba	Lowland & Submontane	Timber
22	*Antidesma venosum*	Mkhufu	Lowland & Submontane	Medicinal, poles
23	*Aoranthe penduliflora*	Samanka	Lowland & Submontane	Medicinal
24	*Aphloia theiformis*	Mpumu	Lowland & Submontane	Timber
25	*Araucaria angustifolia*		Lowland & Submontane	Ornamental
26	*Aulacocalyx diervilleoides*	Msiwa	Lowland & Submontane	Medicinal
27	*Barringtonia racemosa*	Mkuvukuvu	Lowland	Timber
28	*Bauhinia kalantha*		Lowland	Climber
29	*Bawsonia lucida*	Kigwande		Firewood
30	*Beilschmiedia kweo*	Mfimbo	Lowland & Submontane	Timber
31	*Blighia unijugata*	Mzinda nguwe	Lowland & Submontane	Timber
32	*Bombax rhodognaphalon*	Msufi mwitu	Lowland	Timber
33	*Bosqueia phoberas*	Mzugu	Lowland	Firewood, medicinal
34	*Bridelia micrantha*	Ng'wiza	Lowland & Submontane	Poles, buildings, firewood
35	*Cedrella odorata*	Msedrella	Lowland	Timber
36	*Celtis africana*	Kimungwe	Lowland & Submontane	Timber
37	*Celtis gomphophylla*	Mjambegha	Lowland & Submontane	Firewood

38	*Celtis sp.*	Msaji	Lowland & Submontane	Timber
39	*Cephalosphaera usambarensis*	Mtambaa	Submontane	Timber
40	*Chrysophyllum gorungosanum*	Kuti	Submontane	Timber
41	*Cinnamomum camphora*	Kemfa	Submontane	Timber
42	*Cocconia grandis*	Ingoingoi	Submontane	Climber
43	*Codia africana*	Mfufu	Submontane	Timber
44	*Coffe sp.*	Mbuni pori	Submontane	Firewood
45	*Cola usambarensis*	Muungu	Submontane	Medicinal
46	*Combretum molle*	Mnama	Lowland & Submontane	Poles, buildings, firewood
47	*Cussonia zimmermannii*	Mtindi	Lowland & Submontane	Medicinal
48	*Cylicomorpha parviflora*	Mtonto	Lowland & Submontane	Medicinal
49	*Cynometra brachyrrachis*	Mkwe	Lowaland	Medicinal
50	*Cynometra engleri*	Mkwe	Lowaland	Medicinal
51	*Dictyophleba lucida*	Nkhambaa	Lowland	Climber
52	*Diospyros natalensis*	Kihambia	Lowland	Medicinal,firewood
53	*Dombeya rotundifolia*	Mluati	Lowland	Poles, buildings, firewood
54	*Dracaena steudneri*		Lowland & Submontane	Ornamental
55	*Drypetes gerrardii*	Kihambia	Lowland & Submontane	Medicinal
56	*Drypetes sp.*		Lowland & Submontane	Medicinal
57	*Drypetes usambarica*	Kihambia	Submontane	Medicinal
58	*Elaeis guineense*	Muwese	Lowland	Seed
59	*Enantia kummeriae*	zono	Submontane	Timber
60	*Englerodendron usambarense*	Msase	Lowland & Submontane	edible fruits, firewood
61	*Erythrophleum guineense*	Mkarati	Lowland & Submontane	Medicinal, firewood
62	*Fernandoa magnifica*	Mlualua	Lowland	Medicinal, firewood
63	*Ficus exasperata*	Msasa	Lowland	Catchment, fruit, shade
64	*Ficus holstii*	Msoso	Lowland	Medicinal
65	*Ficus sycomorus*	Mkuyu	Lowland	Catchment, fruit, shade
66	*Funtumia africana*	Kiimboti	Lowland & Submontane	Poles, buildings, firewood
67	*Garcinia volkensii*	Mfilafila	Lowland	Medicinal, firewood
68	*Greenwayodendron suaveolens*	Ng'waati	Submontane	Poles, buildings, firewood
69	*Grewia platyclada*	Mkole	Lowland & Submontane	edible fruits, firewood
70	*Gyrocarpos amerincanus*	Mbawa	Lowland	Medicinal
71	*Harrisonia abyssinica*		Lowland	Medicinal, firewood
72	*Harungana madagascariensis*	Mkuntu	Submontane	Medicinal, firewood
73	*Isoberlinia scheffleri*	Mbarika	Lowland & Submontane	Timber
74	*Khaya anthotheca*	Tondoo	Lowalnd	Timber
75	*Landolphia lucida*	soso		Climber
76	*Lannea amaniensis*	Mumbu	Lowland & Submontane	edible fruits, firewood
77	*Lannea schimperi*	Mbuluzigi	Lowland & Submontane	edible fruits, firewood
78	*Lannea sp.*	Muumbu	Lowland & Submontane	edible fruits, firewood
79	*Lecaniodiscus fraxinifolius*	Mbwewe	Lowland & Submontane	Medicinal, firewood

80	*Leptactina benguelensis*		Lowland & Submontane	Medicinal, firewood
81	*Leptonychia usambarensis*	Zonozono	Lowland & Submontane	Medicinal, firewood
82	*Leucaena leucocephala*	Mpopote	Lowland	forder
83	*Lonchocarpus capassa*	Mfumbii	Lowland & Submontane	Medicinal, firewood
84	*Macaranga capensis*	Mkumba	Submontane	Timber
85	*Maesopsis eminii*	Mhesi	Lowland & Submontane	Timber
86	*Manilkara densiflora*	Mgambo	Lowland	edible fruits, firewood
87	*Maranthes goetzeniana*	Ng'anga	Lowland	Medicinal, firewood
88	*Markhamia lutea*	Mtaanda	Lowland	Medicinal, firewood
89	*Markhamia obtusifolia*	Mmiuyu	Lowland	Poles, buildings, firewood
90	*Maytenus acuminata*	Mlimbalimba	Submontane	Tool handles, firewood
91	*Melia azedarach*	Mpopote	Lowland	Timber, shade
92	*Maespsis eminii*	Mhesi	Submontane	Poles, buildings, firewood
93	*Mesogyne insignis*	Mkuhe	Submontane	Poles, buildings, firewood
94	*Milicia excelsa*	Mvule	Lowland	Timber
95	*Millettia stuhlmannii*	Mhafa	Lowland	Timber
96	*Millettia usambarensis*	Mhafa	Lowland & Submontane	Timber, shade
97	*Multidentia crassa*	Muohoyo	Lowland	edible fruits, firewood
98	*Myrianthus holstii*	Mkonde	Lowland & Submontane	edible fruits, firewood
99	*Newtonia buchananii*	Mnyasa	Submontane	Timber
100	*Nuxia congesta*	Mgandu	Lowland & Submontane	medicinal
101	*Ocotea usambarensis*	Kemfa	Lowland & Submontane	Timber
102	*Odyendea zimmermannii*	Mbanku	Submontane	Poles, buildings, firewood
103	*Olinia rochetiana*	Mwambe	Lowland & Submontane	Medicinal
104	*Oxyanthus speciosus*	Mbini mwitu	Submontane	Medicinal
105	*Parinari excelsa*	Mbula	Lowland & Submontane	edible fruits, firewood
106	*Parkia filicoidea*	Mnyese	Lowland & Submontane	edible fruits, firewood
107	*Pauridiantha paucinervis*	Kahawa pori	Lowland	Medicinal
108	*Phaenix reclinata*	Msaa	Lowland	Weaving, Ornamental
109	*Placodisaus amaniensis*		Lowland	Poles, buildings, firewood
110	*Polyceratocarpus scheffleri*	Ngwati	Submontane	Timber
111	*Polycias fulva*	Mkogho	Lowland & Submontane	Timber
112	*Polyscia stuhlmannii*	Mzonozono	Lowland & Submontane	Timber, medicinal
113	*Pouteria adolfi-friedericii*	MKuti	Lowland	Medicinal, firewood
114	*Pouteria alnifolia*	Mkuhutu	Lowland	Medicinal
115	*Pouteria cerasifara*	Muohoyo		Fruits,food
116	*Pouteria sp.*		Lowland	Medicinal, firewood
117	*Premna chrysoclada*	Mhaha	Lowland	Medicinal, poles
118	*Prunus africana*	Mkomahoyo	Submontane	medicinal
119	*Psychotria sp.*		Lowland	Medicinal, poles
120	*Pterocarpus tinctorius*	Mningamaji	Lowland	Timber
121	*Rauvolfia caffra*	Ng'weeti	Lowland & Submontane	Timber, medicinal

122	*Rawsonia lucida*	Kigwande	Lowland & Submontane	Medicinal, firewood
123	*Ricinodendron heudelotii*	Tondoro	Lowland & Submontane	Timber, medicinal
124	*Rothmania manganjae*	Kitovutovu	Lowland & Submontane	Medicinal, firewood
125	*Rytigynia schumannii*	Mtuwavua	Lowland & Submontane	Medicinal, firewood
126	*Sapium ellipticum*	Mkongoo	Lowland	Medicinal, firewood
127	*Schefflera myinantha*	Mkongoo	Lowland	Medicinal, firewood
128	*Schrysophylum pruprechrum*	Kuti	Lowland & Submontane	Medicinal, firewood
129	*Sericanthe odoratissima*	Kahawa pori	Lowland & Submontane	Medicinal, firewood
130	*Shefflerodendron usambarense*	Msase	Submontane	Medicinal, firewood
131	*Sorindeia madagascariensis*	Mkwingwina	Lowland	edible fruits, firewood
132	*Sorindeia obtusifolia*	Mpilipili	Lowland	edible fruits, firewood
133	*Sterculia appendiculata*	Mgude	Lowland	Timber
134	*Stereospermum kunthianum*	Mhande	Lowland & Submontane	Medicinal, firewood
135	*Strombosia scheffleri*	Msangana	Submontane	Medicinal, firewood
136	*Strychnos spinosa*	Mkonga	Lowland	edible fruits, firewood
137	*Synsepalum cerasiferum*	Muohoyo	Lowland	Medicinal, firewood
138	*Synsepalum msolo*	Msambia	Lowland	Medicinal, firewood
139	*Tabernaemontana ventricosa*	Muambe	Lowland	Medicinal, firewood
140	*Tarenna nigrescens*	Mshasha	Lowland	Medicinal, firewood
141	*Tarenna sp.*	Mshagachole	Lowland	Medicinal, firewood
142	*Terminalia ivorensis*	Mteminalia	Lowland	Timber, shade
143	*Terminalia sambesiaca*	Mhugweluala	lowland	Timber, shade
144	*Trema orientalis*	Mshinga	Lowland & Submontane	Shade, firewood
145	*Tricalysia myritifolia*	Saani	Lowland	Poles, buildings, firewood
146	*Trilepisium madagascariensis*	Mzughu	Lowland	medicinal
147	*Uvariodendron oligocarpum*	Mkenene	Lowland	Medicinal, firewood
148	*Vangueria infausta*	Mdayampofu	Lowland	edible fruits, firewood
149	*Vangueria madagascariensis*	Mvilu	Lowland	edible fruits, firewood
150	*Vepris simplicifolia*	Mndizi	Lowland	Medicinal, firewood
151	*Vitex amaniensis*	Mfulu	Lowland & Submontane	Fruits, Timber
152	*Vitex keniensis*	Mfulu	Lowland	edible fruits, firewood
153	*Voacanga africana*	Mbwewe	Lowland	Medicinal, firewood
154	*Voacanga thouarsii*	Mbwewe	Lowland	Medicinal, firewood
155	*Whilefuldi elongata*	Mboonyati	Lowland	Timber, firewood
156	*Zanha golungensis*	Mkwanga	Lowland	Medicinal, firewood
157	*Ziziphus mauritiana*		Lowland	edible fruits, firewood

Appendix 2: List of plant species of Nilo Nature Reserve

S/N	Botanical names	vernicula names	Habitat	Uses
1	*Acacia polyacantha*	Mgunga	Lowland	Firewood, shade
2	*Afrosersalcia cerasifera*	Muohoyo	Lowland & Submontane	Firewood, shade
3	*Agauria sp.*	Mwandai	Lowland & Submontane	Poles, buildings, firewood
4	*Albizia glaberiana*	Mshai	Lowland & Submontane	Timber
5	*Allanblackia stuhlmannii*	Msambu	Submontane	Cooking oil
6	*Allophylus abyssinicus*	Mbangwe	Submontane	Timber
7	*Ampelocissus africana*		Lowland	Climber
8	*Angylocalyx braunii*	Mhande	Lowland	Medicinal
9	*Aningeria adolfi-friedericii*	Kuti	Submontane	Poles, buildings, firewood
10	*Annickia kummeriae*	Ng'waka	Lowland	Firewood
11	*Anthocleista grandiflora*	Mpumu	Lowland & Submontane	medicinal
12	*Antiaris toxicaria*	Mkuza	Lowland & Submontane	Timber
13	*Antiaris usambarensis*	Mkomba	Lowland & Submontane	Timber
14	*Antidesma membranaceum*	Mpunguu	Lowland & Submontane	Medicinal, poles
15	*Antidesma sp.*	Muwindi	Lowland & Submontane	Poles, buildings, firewood
16	*Aoranthe penduliflora*	Sa-maka	Lowland	Poles, buildings, firewood
17	*Beilschmiedia kweo*	Mfimbo	Lowland & Submontane	Timber
18	*Bequaertiodendron natalense*	Mdunyuyu	Lowland	medicinal
19	*Bersama abyssinica*	Mbamba	Lowland	Medicinal, Firewood
20	*Blighia unijugata*	Mzinda-nguusa	Lowland & Submontane	Timber, shade
21	*Bombax rhodognaphalon*	Msufi mwitu	Lowland	Timber
22	*Bosqueia phoberos*	Mfialisa	Lowland	Medicinal, Firewood
23	*Celtis Africana*	Kimungwe	Lowland & Submontane	Timber
24	*Celtis durandii*	Mjambega	Lowland	Firewood
25	*Celtis gomphophylla*	Mjambega	Lowland & Submontane	Firewood
26	*Celtis philippensis*	Kimungwe	Lowland & Submontane	Firewood
27	*Cephalosphaera usambarensis*	Mtambaa	Submontane	Timber
28	*Chitranthus oblongnevis*	Mzengamandi	Lowland & Submontane	Traps animals
29	*Clerodendrum sp.*	Msoo wa kiko	Lowland	Poles, buildings, firewood
30	*Coffea camphora*	Mkahawa	Submontane	fruit,food,medicinal
31	*Cola clavata*	Mkavi	Submontane	Medicinal
32	*Cola greenwayi*	Kola	Submontane	Medicinal
33	*Combretum schumannii*	Mpera mwitu	Lowland	Firewood
34	*Commiphora africana*	Mtuntwi	Lowland	Firewood
35	*Cordia africana*	Mfufu	Lowland & Submontane	Medicinal, Firewood
36	*Cremaspora triflora*	Msiwa	Submontane	Medicinal, Firewood
37	*Croton sylvaticus*	Mkogho	Lowland	Medicinal, Firewood
38	*Cussonia arborea*	Ntindi	Lowland & Submontane	Medicinal

39	*Cynometra engleri*	Mkanga	Lowland	Timber
40	*Diospyros natalensis*	Kihambie	Lowland	medicinal
41	*Diospyros sp.*	Mdiemzize	Lowland	Poles, buildings, firewood
42	*Dombeya rotundifolia*	Mwati	Lowland	Medicinal, poles
43	*Drypetes sp.*		Lowland	Medicinal, Firewood
44	*Drypetes usambarica*	Kihambie	Submontane	Poles, buildings, firewood
45	*Enantia kummariae*	Zonozono	Submontane	Medicinal
46	*Englerophytum natalense*	Mduyuyu	Lowland & Submontane	Fruits,food
47	*Entandrophragma excelsum*	Mzonozono	Submontane	Medicinal, firewood
48	*Erythrophleum african*	Mamba	Lowland & Submontane	Medicinal
49	*Eucalyptus grandis*	Mkaritusi	Lowland & Submontane	Timber
50	*Eucalyptus maidenii*	Mkaritusi	Lowland & Submontane	Timber
51	*Ficus exasperata*	Msasa	Lowland & Submontane	Catchment, shade
52	*Ficus lutea*	Mkuyu	Lowland	Catchment, shade
53	*Ficus sur*	Mkuyu	Lowland	Catchment, shade
54	*Ficus sycomorus*	Mkuyu	Lowland	Shade, fruits
55	*Ficus vallis-choudae*	Mkuyu	Lowland	Catchment
56	*Funtumia africana*	Mkimboti	Lowland	Medicinal, firewood
57	*Grandidiera boivinii*	Mbangu	Lowland	Medicinal, firewood
58	*Grewia bicolar*	Mkole	Lowland	Medicinal, firewood
59	*Harungana madagascariensis*	Mkuntu	Submontane	Medicinal, firewood
60	*Isoberlinia scheffleri*	Mbarika	Lowland & Submontane	Timber
61	*Lamprothamnus zanguebaricus*	Mtei	Lowland & Submontane	Medicinal
62	*Lecaniodiscus fraxinifolius*	Mbwewe	Lowland & Submontane	Medicinal, Firewood
63	*Leptonychia usambarensis*	Zonozono	Lowland & Submontane	timber
64	*Macaranga capensis*	Mkumba	Submontane	Timber
65	*Maesa lanceolata*	Mdami	Lowland	Medicinal
66	*Maesopsis eminnii*	Mhesi	Lowland	Timber
67	*Magnistipula batayei*	Mlawia	Lowland	Medicinal, Firewood
68	*Mesogyne insignis*	Mkuhe	Submontane	Medicinal
69	*Milicia excelsa*	Mvule	Lowland & Submontane	Timber
70	*Millettia stuhlmanii*	Mhafa	Lowland	Timber
71	*Mimusops sp.*	Mtombwe	Lowland	Medicinal, Firewood
72	*Mosa lanceolata*	Mteketeke	Lowland & Submontane	Food
73	*Myrianthus holstii*	Mkonde	Lowland & Submontane	Edible fruits, firewood
74	*Neoboutonia sp.*	Mhondoghogho	Submontane	firewood
75	*Newtonia buchananii*	Mnyasa	Submontane	Timber
76	*Odyendea zimmermannii*	Mbanku	Submontane	Medicinal, poles
77	*Oxyanthus speciosus*	mbuni pori	Submontane	Medicinal, poles
78	*Phoenix reclinata*	Mkindu	Lowland	Weaving, poles
79	*Polyalthia oliveri*	Mzonozono	Lowland	Ornamental
80	*Polyalthia stuhlmannii*	Mzonono	Lowland	Poles, buildings, firewood

81	*polyathia oliveri*	Mzonozono	Lowland	Timber
82	*Polyscias fulva*	Kongo	Lowland	Timber
83	*Pterocarpus tinctorius*	Mkula	Lowland	Timber
84	*Quassia undulata*	Baukhu	Lowland	Medicinal, Firewood
85	*Ricinodendron heudelotii*	Mtondoo	Lowland & Submontane	Medicinal, Firewood
86	*Rinorea ferruginea*	Kibandu	Submontane	Poles, buildings, firewood
87	*Rothmannia manganjae*	Kitovutovu	Lowland & Submontane	Medicinal, Firewood
88	*Rytigynia sp.*	Kisumutu	Lowland & Submontane	Medicinal, Firewood
89	*Sapium ellipticum*	Mkongoo	Lowland	Medicinal, Firewood
90	*Schefflera myinantha*	Mkongoo	Lowland	Medicinal, Firewood
91	*Sorindeia madagascariensis*	Mkwingama	Lowland	edible fruits, firewood
92	*Strombosia scheffleri*	Msangana	Lowland	Poles, buildings, firewood
93	*Strombosia sp.*	Mwaka	Lowland	Poles, buildings, firewood
94	*Synsepalum cerasiferum*	Msambia	Lowland	Medicinal, Firewood
95	*Synsepalum msolo*	Msambia	Lowland	Medicinal, Firewood
96	*Syzygium sp.*	Mshiwa	Lowland	edible fruits, firewood
97	*Tabernaemontana venticosa*	Muambe	Lowland	Medicinal, Firewood
98	*Tarena sp.*	Mshagasha	Lowland	Medicinal, Firewood
99	*Tarenna nigrescens*	Mshangashande	Lowland	Medicinal, Firewood
100	*Tecomaria nyassae*	Muuwauwa	Submontane	Poles, buildings, firewood
101	*Terminalia sp.*	Mbukwe, Mkenge	Lowland & Submontane	Timber
102	*Tricalysia myrtifolia*	Saani	Lowland	Medicinal
103	*Trichilia dregeana*	Mgoimazi	Lowland	Timber,firewood, shade
104	*Trilepisium madagascariensis*	Mzunghu	Lowland & Submontane	Medicinal
105	*Vangueria infausta*	Mkwakwa	Lowland	edible fruits, firewood
106	*Vepris amaniensis*	Mndizi	Lowland	Medicinal, Firewood
107	*Voacanga africana*	Mbwewe	Lowland	Medicinal
108	*Zanha golungensis*	Mnkwanga	Lowland & Submontane	Medicinal, Firewood
109	*Zanthoxylum usambarense*	Mhombo	Submontane	Medicinal, Firewood

Appendix 3: List of plant species of Bombo East I

S/N	Botanical names	vernicula names	Habitat	Uses
1	*Acacia robusta*	Mtansi	Lowland	Poles, buildings, firewood
2	*Albizia anthelmintica*	Mfuleta	Lowland & Submontane	medicinal
3	*Brachylaena huillensis*	Mkarambati	Lowland	Calving
4	*Catunaregam spinosa*	Mkwakwa	Lowland	edible fruits, firewood
5	*Dalbergia melanoxylon*	Mpingo	Lowland	Calving
6	*Dombeya rotundifolia*	Mkiika	Lowland & Submontane	Poles, buildings, firewood
7	*Erythrina abssynica*	Mpopoma	Submontane	Medicinal, firewood
8	*Euphorbia candelabrum*	Ganga	Lowland	Trapping birds, medicinal

9	*Grewia bicolar*	Mkole	Lowland & Submontane	edible fruits, firewood
10	*Hymenocardia acida*		Lowland	Medicinal, firewood
11	*Lannea schweinfurthii*	Muumba	Lowland	edible fruits, firewood
12	*Lecaniodiscus fraxinifolius*	Mbwewe	Lowland & Submontane	Medicinal
13	*Manilkara sulcata*	Mcheji	Lowland	edible fruits, firewood
14	*Monodora grandidieri*	Mkuakua	Lowland & Submontane	Medicinal, firewood
15	*polyalthia oliveri*	Mhozohozo	Lowland	Ornamental
16	*Sclerocary birrea*	Mng'ong'o	Lowland	edible fruits, firewood
17	*Scorodophloeus fischeri*	Mhande	Lowland	Medicinal, firewood
18	*Stereospermum kunthianum*		Lowland & Submontane	Medicinal, firewood
19		Kipasasu		Poles, buildings, firewood

Appendix 4: List of plant species of Kwamngumi Forest Reserve

S/N	Botanical names	vernicula names	Habitat	Uses
1	*Albizia gummifera*	Mshai	Lowland & Submontane	Timber, Firewood
2	*Antiaris toxicaria*	Mkuza	Lowland & Submontane	Timber, Firewood
3	*Aoranthe penduliflora*	Sa-manka	Lowland & Submontane	Timber,firewood,medicinal
4	*Baphiopsis stuhlmannii*	Mforogo	Lowland	Buildings, Medicinal
5	*Barringtonia racemosa*	Mkuvukuvu	Lowland	Poles, buildings, firewood
6	*Bequaertiodendron natalense*	Mduyuyu	Lowland & Submontane	Buildings, Medicinal
7	*Blighia unijugata*	Mzinda-nguusa	Lowland	Timber
8	*Brachylena huillensis*	Mkarambati	Lowland	Calving, Buildings
9	*Bridelia micrantha*	mshasha	Lowland & Submontane	Medicinal
10	*Celtis africana*	Kimungwe	Lowland	Timber
11	*Celtis gerrardii*	Kimungwe	Lowland & Submontane	Firewood
12	*Celtis philipensis*	Kimungwe	Lowland & Submontane	Firewood
13	*Celtis sp.*	Kimungwe	Lowland & Submontane	Firewood
14	*Chrysophyllum gorungosanum*	JXI	Submontane	Timber
15	*Chrysophylum zimmermanii*	JX	Lowland & Submontane	Poles, buildings, firewood
16	*Chytranthus obliquinervis*		Lowland	Timber
17	*Cola clavata*	Mkavi	Submontane	medicinal
18	*Cola greenwayi*	kola	Submontane	medicinal
19	*Combretum apiculatum*	Mbukwe	Lowland & Submontane	Ropes - tree back
20	*Combretum schumannii*	Mwankaa	Lowland	Poles, buildings, firewood
21	*Cynometra sp.*	mkweleanyani	Lowland	Medicinal
22	*Diospyros abyssinica*	Mkea kilindi	Lowland	Medicinal, firewood
23	*Diospyros kabuyeana*	Mkea kilindi	Submontane	Poles, buildings, firewood
24	*Diospyros natalensiS*	Mkeakilindi	Lowland	Poles, buildings, firewood
25	*Dracaena laxissima*	Msale	Lowland	Ornamental
26	*Drypetes gerrardii*	kihambia	Lowland & Submontane	Poles, buildings, firewood

27	*Drypetes sp.*	kihambia	Lowland & Submontane	Poles, buildings, firewood
28	*Drypetes usambarica*	kihambia	Submontane	Poles, buildings, firewood
29	*Elaeodendron stuhlmanii*	Mtayaya	Lowland	Timber
30	*Fagoropsis angolensis*	Mkunguni	Lowland & Submontane	Timber
31	*Ficus exasperata*	Msasa	Lowland	Shade, cathment
32	*Ficus sycomorus*	Mkuyu	Lowland & Submontane	fruit,foo,medicinal
33	*Funtumia africana*	kiimboti	Lowland & Submontane	Poles, buildings, firewood
34	*Grewia goetzeana*	mkole	Lowland	Poles, buildings, firewood
35	*Grewia tenax*	Mkole	Lowland	edible fruits, firewood
36	*Haplocoelum inoploeum*	Mhale	Lowland	Medicinal, firewood
37	*Hymenocardia acida*	JVII	Lowland	Medicinal, firewood
38	*Isoberlinia scheffleri*	Mbarika	Lowland & Submontane	Timber
39	*Julbernadia magnistipulata*	Mhangala	Lowland & Submontane	Timber, Firewood
40	*Lannea amaniensia*	muumbu	Lowland & Submontane	edible fruits, firewood
41	*Lecaniodiscus fraxinifolius*	Mbwewe	Lowland & Submontane	Medicinal, firewood
42	*Leptonychia usambarensis*	Mtengu	Lowland & Submontane	Firewood
43	*Lindacarya sterculata*	Kigeukhai	Lowland & Submontane	Poles, buildings, firewood
44	*Manilkara sulcata*	mshezi	Lowland & Submontane	edible fruits, firewood
45	*Mesogyne insignis*	Mkuhe	Submontane	Poles, buildings, firewood
46	*Milicia excelsa*	Mvule	Lowland	Timber
47	*Milletia usambarensis*	Mfulu	Lowland	Timber
48	*Mimusops kummel*	Mghambo	Lowland	Medicinal, firewood
49	*Nesogordonia holtzii*	khaviganyika	Lowland & Submontane	Timber
50	*Olinia rochetiana*	Mwambe	Lowland	Medicinal, firewood
51	*Podocarpus falcatus*	Mse	Submontane	Timber
52	*Premna chrisoclada*	Mhaha	Lowland	Medicinal, firewood
53	*Prunus africana*	Mkomahoyo	Submontane	medicinal
54	*Rauvolfia caffra*	Ng'weti	Lowland & Submontane	Timber
55	*Ricinodendron heudelotii*	Tondoo	Lowland & Submontane	Medicinal, firewood
56	*Rinorea ferruginea*	Mdiga	Submontane	Timber
57	*Rytigynia schumannii*	Mtuavuaha	Lowland	Medicinal, firewood
58	*Scorodophloeus fischeri*	Mhande	Lowland	Medicinal, firewood
59	*Sericanthe odoratissima*	Kahawa mwitu	Lowland & Submontane	medicinal
60	*Sorindeia madagascariensis*	mkwingama	Lowland	edible fruits, firewood
61	*synsepalum cerasiferum*	Msambia	Lowland	Medicinal, firewood
62	*Synsepalum msolo*	Msambia	Lowland	Medicinal, firewood
63	*Tabernaemontana ventricosa*	Mbwewe	Lowland & Submontane	Medicinal, firewood
64	*Teclea simplicifolia*	Mndizi	Submontane	Buildings, Medicinal
65	*Terminalia sambesiaca*	Mhugweluala	Lowland	Timber
66	*Tricalysia myrtifolia*	Saani	Lowland	Medicinal, firewood
67	*Tricalysia sp.*			firewood
68	*Trilepisium madagascariensis*	Mzunghu	Lowland & Submontane	Medicinal, firewood

69	*Uvariodendron gorgonis*	Mkenene	Lowland	medicinal
70	*Uvariodendron oligocarpum*	Mkenene	Submontane	Medicinal, firewood
71	*Vepris nobilis*	Mndizi	Lowland	Medicinal, firewood
72	*Zanthoxylum usambarense*	Mhombo	Submontane	Medicinal, firewood

Appendix 5: List of plant species Manga Forest Reserve

S/N	Botanical names	vernicula names	Habital	Uses
1	*Acacia brevispica*	Mgunga mshewe	Lowland & submontane	Firewood
2	*Acacia sp.*	Mngunga	Lowland & submontane	Medicinal
3	*Acacia tortilis*	Mgunga	Lowland	Firewood
4	*Adansonia digitata*	Mbuyu	Lowland	Edible fruits, ropes
5	*Afrosersalicia cerasifera*	Mnyoohoyo	Lowland & submontane	Firewood
6	*Albizia anthelmintica*	Mfuleta	Lowland & submontane	Medicinal, firewood
7	*Albizia glaberrima*	Mshai	Lowland	Timber
8	*Albizia gummifera*	Mshai	Lowland & submontane	Timber
9	*Albizia lebbeck*	Mshai	Lowland & submontane	Agroforestry
10	*Albizia petersiana*	Mshai	Lowland & submontane	Timber
11	*Albizia sp.*	Myombeyombe	Lowland & submontane	Timber, Firewood
12	*Alchornea sp.*	Zasa	Lowland & submontane	Medicinal, firewood
13	*Annickia kummeriae*	Ng'waka	Lowland	Firewood
14	*Antiaris toxicaria*	Mkuzu	Lowland & submontane	Timber
15	*Balanites aegyptiaca*	Mkonga	Lowland	Edible fruits, handles
16	*Carpodiptera africana*	Mlanga	Lowland & submontane	Poles, buildings, firewood
17	*Coffea sp.*	mbuni pori	Submonatane	Firewood
18	*Cola clavata*	Mkavi	Submonatane	medicinal
19	*Cola sp.*	Mkavi	Submonatane	medicinal
20	*Combretum schumannii*	Mpera mwitu	Lowland	Firewood
21	*Cordia monoica*	Mgomosi	Lowland	Medicinal, firewood
22	*Croton gynopsis*	Mwegomozi	Lowland	Buildings, Medicinal
23	*Croton sylvaticus*	Mhamachuma	Lowland	Buildings, Medicinal
24	*Cussonia arborea*	Mtindi	Lowland & submontane	medicinal
25	*Cynometra engleri*	Mkwe	Lowland	Poles, buildings, firewood
26	*Deinbollia borbonica*	Mbwakabwaka	Lowland	fruit,medicinal
27	*Dialium holtzii*	Mhetee	Lowland	Medicinal
28	*Diospryros abyssinica*	Mtitu	Lowland	Medicinal, firewood
29	*Diospyros kabuyeana*	Mkea kilindi	Submonatane	Poles, buildings, firewood
30	*Diospyros mespiliformis*	Mhena	Lowland & submontane	Medicinal, firewood
31	*Diospyros natalensis*	Kihambie	Lowland	Medicinal, firewood
32	*Dombeya cincinnata*	Mkiika	Lowland	Medicinal, firewood
33	*Drypetes gerrardii*	Mnofi	Lowland & submontane	Medicinal

34	*Drypetes usambarica*	Kihambie	Submonatane	Poles, buildings, firewood
35	*Fernandoa magnifica*	Muava	Lowland & submontane	medicinal
36	*Grewia bicolor*	Mkole	Lowland & submontane	edible fruits, firewood
37	*Grewia calymmatosepala*	Mkole ng'ombe	Lowland	edible fruits, firewood
38	*Grewia goetzeana*	Mkole ng'ombe	Lowland	edible fruits, firewood
39	*Grewia sp.*	Mkole ng'ombe	Lowland	edible fruits, firewood
40	*Haplocoelum inoploeum*	Mhale	Lowland & submontane	Medicinal, firewood
41	*Khaya sp.*	Tondolo		Timber
42	*Lannea schweinfurthii*	Muumbu	Lowland	edible fruits, firewood
43	*Lecaniodiscus fraxinifolius*	Mbwewe	Lowland & submontane	Medicinal, firewood
44	*Leptonychia usambarensis*	Zonozono	Lowland & submontane	Poles, buildings, firewood
45	*Lindacarya sp.*	Mzinda-nguusa	Lowland	Poles, buildings, firewood
46	*Lindacarya steculata*	Mzinda-nguusa	Lowland	Firewood
47	*Lonchocarpus sp.*	Mkande	Lowland	Medicinal, firewood
48	*Manilkara sulcata*	Msewezi	Lowland	edible fruits, firewood
49	*Markhamia lutea*	Mtalawanda	Lowland	Medicinal, firewood
50	*Markhamia puberula*	Mtalawanda	Lowland	Medicinal, firewood
51	*Maytenus heterophylla*	Mramba	Lowland	Poles, buildings, firewood
52	*Millettia stuhlmannii*	Mhafa	Lowland	Timber
53	*Nesogordonia holtzii*	Khaviyanyika	Lowland & submontane	Timber
54	*Pauridiantha paucinervis*	Kahawa mwitu	Lowland	medicinal
55	*Polyalthia stuhlmannii*	Zonozono	Lowland	Medicinal
56	*Prunus africana*	Mkomahoya	Submonatane	Poles, buildings, firewood
57	*Pterocarpus mildbraedii*	Mningamaji	Lowland	Timber
58	*Rhodognaphalon schumannianum*	Msufi mwitu	Lowland	Timber
59	*Ricinodendron heudelotii*	Tondoa	Lowland & submontane	Poles, buildings, firewood
60	*Rothmannia macrosiphon*	Mukepuka	Lowland & submontane	Dye, medicinal
61	*Rytigynia amaniensis*	Mshonganya	Lowland & submontane	medicinal
62	*Scorodophloeus fischeri*	Mhande	Lowland	Medicinal, firewood
63	*Sorindeia madagascariensis*	Mkungwina	Lowland	fruit,food,medicinal
64	*Sterculia appendiculata*	Mparata nyani	Lowland	Timber
65	*Suregada zanzibarensis*	Mdimmbago	Lowland	Buildings, Medicinal
66	*Tamarindus indica*	Mkwaju	Lowland	edible fruits, firewood
67	*Teclea simplicifolia*	Mndizi	Submonatane	Medicinal, firewood
68	*Terminalia sambesiaca*	Mkulungu	Lowland	Timber, buildings, firewood
69	*Terminalia sp.*	Mkenge	Lowland	Timber, buildings, firewood
70	*Trichilia emetica*	Mgoimaji	Lowland	Timber, buildings, firewood
71	*Vepris simplicifolia*	Kolongolo	Lowland	Medicinal, firewood
72	*Zanthoxylum gillettii*	Mhombo	Lowland	Medicinal, firewood

Appendix 6: List of plant species Mgambo Forest Reserve

S/N	Botanical names	vernicula names	Habitat	Uses
1	*Acacia mellifera*	Msasa	Lowland & submontane	Poles, buildings, firewood
2	*Acacia robusta*	Mgunga	Lowland	Poles, buildings, firewood
3	*Acacia sp.*	Kikwata	Lowland	Poles, buildings, firewood
4	*Acacia tortilis*	Mgunga	Lowland	firewood,medicinal, shade
5	*Afzelia quanzensis*	Mbamba kofi	Lowland	Timber
6	*Albizia anthelmintica*	Mflueta	Lowland & submontane	Medicinal, Firewood
7	*Albizia petersiana*	mshai	Lowland & submontane	Timber,firewood
8	*Albizia schimperiana*	Mshai mawe	Lowland & submontane	Timber,firewood
9	*Balanites eagyptiaca*	Mkonga	Lowland	edible fruits, firewood
10	*Balanites sp.*	Mkonga	Lowland	edible fruits, firewood
11	*Balanites wilsonior*	Mkonga	Lowland	edible fruits, firewood
12	*Bombax rhodognaphalon*	Mwale	Lowland	Timber
13	*Boscia parviflora*		Lowland	edible fruits, firewood
14	*Brachylaena huillensis*	Mkarambati	Lowland	Calving, Buildings
15	*Brachystegia spiciformis*	Mtondolo	Lowland & submontane	Timber
16	*Combretum molle*	Mgondogondo	Lowland & submontane	Poles, buildings, firewood
17	*Combretum sp.*	Mgoegoe	Lowland	Poles, buildings, firewood
18	*Combretum zeyheri*	Mgondogondo	Lowland	Buildings, Medicinal
19	*Commiphora africana*	Mbambaaa	Lowland	Firewood, medicinal
20	*Commiphora sp.*	Mbambaaa	Lowland	Firewood, medicinal
21	*Commiphora zanzibarica*	Mbambaaa	Submontane	Firewood
22	*Commiphora zimmermannii*	Mbambaaa	Lowland	firewood
23	*Cordia monoica*	Mpera mwitu	Lowland	Firewood, medicinal
24	*Croton dichogamus*	mlagapala	Lowland	Firewood, medicinal
25	*Croton scheffleri*	Mhangusawana	Lowland & submontane	Firewood, medicinal
26	*Cussonia zimmermannii*	Mtindi	Lowland & submontane	medicinal
27	*Dalbergia melanoxylon*	Mpingo	Lowland	Calving, Buildings
28	*Diospyros abyssinica*	Mkeakilindi	Lowland	Firewood, medicinal
29	*Diospyros consulatae*	mzombazomba	Lowland & submontane	firewood,medicinal
30	*Diospyros sp.*	mzombazomba	Lowland & submontane	firewood,medicinal
31	*Diospyros squarrosa*	Mtambaa mchwa	Lowland & submontane	firewood,medicinal
32	*Dombeya rotundifolia*	Mluati	Lowland & submontane	firewood,medicinal
33	*Drypetes gerrardii*	Mnofi	Lowland & submontane	firewood,medicinal
34	*Drypetes sp.*	Kihambia	Lowland & submontane	firewood,medicinal
35	*Erythrina abyssica*	Muungu	Lowland & submontane	firewood,medicinal
36	*Euclea divinorum*	Mnama	Lowland & submontane	Medicinal, dye
37	*Grewia bicola*	Mkole	Lowland & submontane	edible fruits, firewood
38	*Grewia goetzeana*	Mkole	Lowland	Fruit, f ood
39	*Grewia similis*	Mkowe	Lowland	edible fruits, firewood

40	*Haplocoelum inoploeum*	Mhale	Lowland & submontane	Poles, buildings, firewood
41	*Haplocoelum sp.*	kijungasanzu	Lowland	Firewood, medicinal
42	*Keetia sp.*		Lowland	firewood,medicinal
43	*Lannea humilis*		Lowland	Root medicinal
44	*Lannea schweinfurthii*	Muumbu	Lowland	Firewood, medicinal
45	*Lecaniodiscus fraxinifolius*	Mbwewe	Lowland & submontane	Firewood, medicinal
46	*Lindacarya sterculata*	mnyanga	Lowland	Firewood, medicinal
47	*Maerua sp.*	mdudujika	Lowland	Firewood, medicinal
48	*Manilkara sulcata*	Msewezi	Lowland	edible fruits, firewood
49	*Markhamia sp.*	Mbokwe	Lowland	Firewood, medicinal
50	*Markhamia zanzibarica*	Mtalawanda	Lowland & submontane	Timber
51	*Mystroxylon aethiopicum*	Mlimbolimbo	Lowland	Medicinal, Firewood
52	*Phoenix sp.*	Mnazi pori	Lowland	edible fruits, firewood
53	*Phyllanthus sp.*	Manju	Lowland	Firewood, medicinal
54	*Pteleopsis myritifolia*	Mleakwezi	Lowland	Timber
55	*Sclerocarya birrea*	Mng'ongo	Lowland	edible fruits, firewood
56	*Scorodophloeus fischeri*	Mhande	Lowland	Poles, buildings, firewood
57	*Sorindeia madagascariensis*	Mkingwina	Lowland	edible fruits, firewood
58	*Sterculia africana*	Muoza	Lowland	Poles, buildings, firewood
59	*Strychnos spinosa*	Mkwankwa	Lowland	edible fruits, firewood
60	*Tamarindus indica*	mkwaju	Lowland	edible fruits, firewood
61	*Teclea nobilis*	Kilongolo	Lowland & submontane	Poles, buildings, firewood
62	*Teclea trichocarpa*	Kilongolo	Lowland	Poles, buildings, firewood
63	*Terminalia brownii*	mkonga	Lowland	Timber
64	*Terminalia spinosa*		Lowland	Poles, buildings, firewood
65	*Turraea stuhlmannil*	Mkilika	Lowland	Firewood, medicinal
66	*Uvaria sp.*	Mngwene	Lowland	Climber
67	*Vepris nobilis*	Kolongolo	Lowland	Firewood, medicinal
68	*Vepris simplicifolia*	Mndizi	Lowland	Medicinal, Firewood
69	*Xylopia sp.*	mdaa	Lowland	root,food
70	*Xylotheca tettensis*	Mbokwe	Lowland	Poles, buildings, firewood
71	*Ziziphus mucronata*	Lango	Lowland	edible fruits, firewood

Appendix 7: List of plant species of Mtai Forest Reserve

N/n	Botanical names	vernicula names	Habitat	Uses
1	*Afrosersalicia cerasifera*	Muohoyo	Lowland & Submontane	Firewood
2	*Alangium chinense*	Mkondogogo	Sumontane	Dram manufacturing
3	*Albizia glabrescens*	Mshai-mamba	Lowland & Submontane	Timber
4	*Albizia gummifera*	Mshai	Lowland & Submontane	Timber
5	*Albizia petersiana*	Mshai mwamba	Lowland & Submontane	Timber
6	*Albizia schimperiana*	Mshai	Lowland & Submontane	Timber
7	*Albizia sp.*	Mshai	Lowland & Submontane	Timber
8	*Albizia zimmermanii*	Mkenge	Lowland & Submontane	Timber
9	*Alchornea hirtella*	Zasa	Lowland & Submontane	medicinal
10	*Allanblackia stuhlmanii*	Msambu	Sumontane	Cooking oil
11	*Allophylus abyssinicus*	Mbangwe	Sumontane	Timber
12	*Angylocalyx braunii*	Mhande pori	Lowland	Firewood, Poles, Buildings
13	*Annickia kumeriae*	Ng'waka	Lowland	Firewood, Poles, Buildings
14	*Annona senegalensis*	Mtopetope	Lowland	edible fruits, firewood
15	*Anthocleista grandiflora*	Mpumu	Lowland & Submontane	Medicinal
16	*Antiaris toxicaria*	Mkuzu	Lowland & Submontane	Medicinal
17	*Antidesma membranaceum*	Mpunguu	Lowland & Submontane	medicinal
18	*Aoranthe penduliflora*	Samanka	Lowland & Submontane	Poles, buildings, firewood
19	*Artocarpus heteroplyllus*	Mfensesi	Lowland	edible fruits, firewood
20	*Beilschmiedia kweo*	Mfimbo	Lowland & Submontane	Timber
21	*Bequaertiodendron natalense*	Mnduyu	Lowland & Submontane	Medicinal, Firewood
22	*Blighia urijugata*	Mzindanguruwe	Lowland & Submontane	Timber, shade
23	*Bombax rhodognaphalon*	Msufi mwitu	Lowland	Timber
24	*Bombax sp.*	Msufi mwitu	Lowland	Timber
25	*Breonadia salicina*	Mdoghoe	Lowland & Submontane	Timber
26	*Bridelia micrantha*	Mwiza	Lowland & Submontane	Medicinal, Firewood
27	*Cedrella odorata*	Mvuje	Lowland	Timber
28	*Celtis africana*	Mgomoko	Lowland & Submontane	Timber
29	*Celtis durandii*	Mjambega	Lowland & Submontane	Firewood
30	*Celtis gomphophylla*	Mjambega	Lowland & Submontane	firewood
31	*Celtis zenkeri*	kimungwe	Lowland & Submontane	Timber
32	*Cephalosphaera usambarensis*	Mtambaa	Sumontane	Timber
33	*Chrysophyllum perpulchrum*	Mkutii	Lowland & Submontane	Timber
34	*Chytranthus obliquinevis*		Lowland	Timber
35	*Coffea sp.*	mbuni pori	Sumontane	Poles, buildings, firewood
36	*Cola clavata*	Mkavi	Sumontane	Medicinal, Firewood
37	*Combretum schumannii*	Mpera mwitu	Lowland	Firewood
38	*Commiphora eminii*	Mbombwe	Lowland	Firewood
39	*Croton pseudopulchellus*	Puishi	Lowland	Medicinal, Firewood

40	*Cryptocarya liebentiana*	Msagisagi	Lowland	Medicinal, Firewood
41	*Cussonia arborea*	Mtindi	Lowland & Submontane	Medicinal, Firewood
42	*Cussonia zimmermanii*	Mtindi	Lowland & Submontane	Medicinal, Firewood
43	*Cynometra engleri*	Mkwe	Lowland	Poles, buildings, firewood
44	*Cyphostemma sp.*	Mtondoo	Lowland	Poles, buildings, firewood
45	*Deinbollia borbonica*	Mkunguina	Lowland	Medicinal, Firewood
46	*Dichrostachys cinerea*	Kwakwagembe	Lowland	Poles, buildings, firewood
47	*Diospyros abyssinica*	Mkea kilindi	Lowland	Poles, buildings, firewood
48	*Diospyros kabuyaena*	Mkea kilindi	Sumontane	Poles, buildings, firewood
49	*Diospyros sp.*		Lowland	Dram manufacturing
50	*Diplorhynchus mossambicensis*	Mtobwe	Lowland	Medicinal, Firewood
51	*Dombeya cincinnata*	kwenga	Lowland	Ropes
52	*Dombeya rotundifolia*	Muati	Lowland	Poles, buildings, firewood
53	*Dracaena laxissima*	Mnonga	Lowland & Submontane	Onarmental
54	*Dracaena sp.*	Kangaga		Onarmental
55	*Dracaena steudneri*	Kangaga	Lowland & Submontane	Onarmental
56	*Drypetes gerrardii*	Mnofi	Lowland & Submontane	Medicinal
57	*Drypetes sp.*	Mnofi	Lowland & Submontane	Medicinal
58	*Drypetes usambarica*	Kihambie	Sumontane	Poles, buildings, firewood
59	*Ekebargia capensis*	mnyakwa	Sumontane	Timber
60	*Erythroxylum fischeri*	Muhande jivu	Sumontane	Timber
61	*Ficus exasperata*	Msasa	Lowland	catchment, shade
62	*Ficus sycomorus*	Mkuyu	Lowland & Submontane	catchment, shade
63	*Funtumia africana*	kimboti	Lowland & Submontane	Medicinal, Firewood
64	*Grewia goetzeana*	Mkoe	Lowland	edible fruits, firewood
65	*Grewia microcarpus*	Koleng'ombe	Lowland & Submontane	edible fruits, firewood
66	*Grewia sp.*	Mkole ngombe	Lowland & Submontane	edible fruits, firewood
67	*Haplocoelum foliolosum*	Mhale	Sumontane	Poles, buildings, firewood
68	*Isoberlinia scheffleri*	Mbarika	Lowland & Submontane	Timber
69	*Keetia sp.*		Lowland & Submontane	Poles, buildings, firewood
70	*Lecaniodiscus fraxinifolius*	Mbwewe	Lowland & Submontane	Medicinal, Firewood
71	*Leptonychia usambarensis*	Zono zono	Lowland & Submontane	Medicinal
72	*Lindacarya sterculata*		Lowland & Submontane	Firewood
73	*Macaranga capensis*	Mkumba	Sumontane	Timber
74	*Macaranga kilimandscharica*	Mkumba	Sumontane	Timber
75	*Maesopsis eminii*	Mhesi	Lowland & Submontane	Timber
76	*Magnistipula butayei*	Mlawia	Lowland	Medicinal, Firewood
77	*Mangifera indica*	Muembe	Lowland	edible fruits, firewood
78	*Markhamia lutea*	Mtalawanda	Lowland	Poles, hoe handle
79	*Mascarenhasia arborescens*	Msufimbago	Lowland	Medicinal
80	*Mesogyne insignis*	Mkuhe	Sumontane	Poles, buildings, firewood
81	*Milicia excelsa*	Mvule	Lowland	Timber

82	*Milletia usaramensis*	Muhafa	Lowland & Submontane	Timber, shade
83	*Millettia lasiantha*	Mhafa	Lowland	Timber
84	*Millettia sacleuxii*	Mshira	Lowland	Timber
85	*Millettia stuhlmanii*	Mhafa	Lowland	Timber
86	*Mimusops kummel*	Mghambo	Lowland	Poles, buildings, firewood
87	*Mimusops multinervis*	Mgambo	Lowland	Poles, buildings, firewood
88	*Myrianthus arboreus*	Mkonde	Lowland & Submontane	edible fruits, firewood
89	*Myrianthus holstii*	Mkonde	Lowland & Submontane	Medicinal, Firewood
90	*Myrianthus sp.*	Mkonde	Lowland & Submontane	Medicinal, Firewood
91	*Neoboutonia macrocalyx*	Mhodogogo	Sumontane	Firewood
92	*Newtonia buchanani*	Mnyasa	Sumontane	Timber
93	*Newtonia paucijuga*	Mtenwe	Lowland	Timber
94	*Odyendea zimmermannii*	Mbanku	Sumontane	Poles, buildings, firewood
95	*Ovaria sp.*			
96	*Oxyanthus speciosus*	mbuni pori	Sumontane	Medicinal, Firewood
97	*Oxystigma msoo*	Soso	Lowland	Trapping birds, Timber
98	*Pandanus engleri*	Kangaga	Lowland & Submontane	Medicinal, onarmental
99	*Parinari excelsa*	Muwa	Lowland & Submontane	edible fruits, firewood
100	*Pavetta sp.*	Armasei	Lowland	Medicinal
101	*Phyllanthus sp.*	Mfupa	Lowland	Medicinal
102	*Polyalthia sp.*	Mzonozono	Lowland	Timber
103	*Pteleopsis myrtifolia*	Mkowe	Lowland	Timber, Firewood
104	*Pterocarpus mildbraedii*	Mkula	Lowland	Timber
105	*Rhodognaphalo schumannianum*	mnyakwa	Lowland	Fertilizers in farm
106	*Ricinodendron heundelotii*	Mtindie	Lowland & Submontane	Medicinal
107	*Rinorea sp.*	Mdiga	Lowland	Medicinal
108	*Rothmannia macrosiphon*	Mkwingwina	Lowland & Submontane	Medicinal, dye
109	*Scorodophloeus fischeri*	Mhande	Lowland	Firewood, medicinal
110	*Shefflerodendron usambarense*	Msase	Submontane	Medicinal
111	*Sorindeia madagascariensis*	Mkwingwina	Lowland	edible fruits, firewood
112	*Sterculia appendiculata*	Mfune	Lowland	Timber
113	*Stereospermum kunthianum*	Mhande shekizo	Lowland & Submontane	Poles, buildings, firewood
114	*Suregada lithoxyla*	Mdim pori	Lowland	Firewood
115	*Suregada zanzibarensis*	Kidimidimu	Lowland	Medicinal
116	*Synsepalum msolo*	Msambia	Lowland	Medicinal, Firewood
117	*Synsepalum sp.*	Msambia	Lowland	Medicinal, Firewood
118	*Syzygium sp.*	Mshishwi	Lowland	Medicinal, Firewood
119	*Tabernaemontana ventricosa*	Muambe	Lowland & Submontane	Medicinal, Firewood
120	*Teclea simplicifolia*	Mndizi	Submontane	Poles, buildings, firewood
121	*Tectona grandis*	Mtiki	Lowland	Timber
122	*Terminalia sambesiaca*	Mhugweluala	Lowland	Medicinal, Timber
123	*Treculia africana*	Mfenesi pori	Lowland & Submontane	edible fruits, firewood

124	*Trichilia emetica*	Mngoi maji	Lowland	Timber
125	*Trichocladus ellipticus*	Mkombeti	Lowland & Submontane	Medicinal, Firewood
126	*Trilepisium madagascariensis*	Mzughu	Lowland & Submontane	Medicinal, fruits
127	*Vepris simplicifolia*	Kolongolo	Lowland	Medicinal
128	*Zanthoxylum usambarense*	Mhombo	Submontane	medicinal
129	*Ziziphus mauritiana*	Mkola	Lowland	edible fruits, firewood

Appendix 8: List of participant conducted biodiversity survey in East Usambara Mountains

S/N	Names	Title	Institution
1	Samwel M. Matura	Forester	Sokoine University of Agriculture - Morogoro
2	Hamidu A. Seki	Wildlife	Sokoine University of Agriculture - Morogoro
3	Victor S. Kaaya	Wildlife	TPRA - Arusha
4	Said M. Shormary	Botanist	TAFORI – Mafinga, Iringa
5	Gabriel Laiza	Botanist	TPRA - Arusha
6	Said A. Saidi	Driver	District Executive Director – Mkinga, Tanga
7	Said S. Hamadi	Driver	Amani Nature Reserve – Muheza, Tanga
8	Emanuel Komba	Forester	Nilo Nature Reserve – Korogwe, Tanga
9	Michael I. Kicholo	Botanist	District Forest Manager- Lushoto, Tanga
10	Salimu Juma	Forester	Nilo Nature Reserve – Korogwe, Tanga
11	Abraham Tomas	Wildlife	TPRA - Arusha
12	Iddy W. Beya	Botanist	Sokoine University of Agriculture, Morogoro
13	Erasto K. Msingwa	Wildlife	District Executive Director – Mkinga, Tanga
14	Mwarabu Jumbe	Forester	District Executive Director – Mkinga, Tanga
15	Iddy Rajabu	Botanist	TAFORI – Lushoto, Tanga
16	Hussen K. Chowa	Forester	Amani Nature Reserve – Muheza, Tanga
17	Yohana M. Daffa	Forester	District Forest Manager- Mkinga, Tanga
18	Emanuel C. Kato	Planner	District Executive Director – Mkinga, Tanga
19	Godfrey Msumary	Forester	Amani Nature Reserve – Muheza, Tanga

Appendix 9: Data collection forms for Flora and Fauna

EUBR INVENTORY DATA PLOT COLLECTION FORM
PLOT FORM

Forest name……..……..…….. PLOT NUMBER……..…..……
Area of the Forest Altitude……
…… Coordinates: easting……
District……. Northing ……..……
Recorder……..……. Canopy cover (%) ……..……
Date……..…… Slope……

1.0 SAPLINGS

S/N	Botanical names	Vernacular name	Frequency	Uses

2.0 TREE FORM

S/N	Botanical names	Vernacular name	DBH (cm)	Height (m)	Uses

3.0 SHRUBS/HERBSFORM

S/N	Botanical names	Vernacular name	Freq	Life form	Use

4.0 Disturbance Assessment Form

S/n	Species name	Common name	Life form	State of species	Uses

State of species: Codes:(1=New cut; 2=Old cut), Life form: Tree, herbs, shrubs, climbers, poles.

5.0 Human impact assessment in the plot

S/N	**Impact**	**Observations**
1	Fire damage	
2	logging/cutting	
3	Trapping	
4	Cultivation	

5	Foot path	
6	clearing	
7	Buildings	
8	Mining	
9	Charcoal	
10	Grazing	
11	Others	

Codes: N – Nill; L-low; M-medium; H-high

Data_Leaflet for the Fauna Survey									
SN	**Transect_#**	**UTM_Start**	**UTM_Finish**	**Habitat**	**Common_Name**	**Type**	**Group size**	**Status**	**Remarks**

General observation in the Forest……..…… …
……..……
……
……

Appendix 10: Forested core areas assessd against surrounding villages

Core Forest	Villages surrounding the Core area
Amani Nature Reserve	Kisiwani, Shebomeza, Mlesa, Mikwinini, Ubiri, Sakale, Mbomole, Magoda, Mashewa, Shembekeza, Kimbo, Potwe-ndondondo, Potwe-mpirani, Shamba-kapori, Mnyuzi, Kwamzindawa, Mkwakwani, Gereza, Kwagunda and Magunga-cheke
Nilo Nature Reserve	Kizara, Kilangangua, Kwemkole, Bombo-majimoto, Magunga Mzia, Folofolo-kiuzai, Kwenkeyu, Kijango, Kitivo, Makumba, Kazita, Zirai, Kwelumbizi, Kizerui, Kuze, Kwamtili, and Bosha-kwemntindi
Manga Forest Reserve	Misozwe, Kwatango, Segoma
Kwamngumi Fores Reserve	Kwamtili, Segoma, Kambai,
Mtai Forest Reserve	Muzi, Matemboni, Maramba , Maramba B, Hemsambia, Vuga, Kwekuyu and Kidundui
Mgambo Forest Reserve	Bwiti, Mgambo, Daluni, Kisiwani, Daluni kibaoni
Bombo East I Forest Resrve	Mtoni-bombo, Bombo-majimoto