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ASSESSMENT OF POPULATION STRUCTURE, COMPOSITION AND DIVERSITY OF *Dalbergia Melanoxylon* IN ITS DOMINATED ZONE OF NACHINGWEA DISTRICT, TANZANIA

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ABSTRACT

Forest management requires up-to-date information on the structure, composition and diversity of populations of plant species. The study was conducted in 2019 on the population status, composition and diversity of *Dalbergia melanoxylon* to enable sustainable conservation of the species. The community forests of Lionja B and Lipuyu were used to establish 15 plots and 30 plots in Lionja Forest Reserve in Tanzania.The parameters determined include height, stem per hectare, basal area per hectare, density per hectare, tree diameter class and total number of individuals of all species. Most important species were determined using species importance value (IVI) indices. The diversity of plant species was determined using Shannon-Wiener diversity index and compared using ANOVA. The number of stems, basal area and density per hectare was found to be 4.3, 27.2 m^2 and 483kg/m^3 respectively in Lionja Forest Reserve and 1.9, 7.6m^2 and 350.4kg/m^3 in Lionja B community forest. The diversity of plant species of all forms was significantly higher in the forest reserve compared to community forests ($P < 0.001$). Seventy-one (71) plants have been registered in Lionja Forest Reserve, 51 in Lionja B and 46 in Lipuyu. Plant density in the Lionja Forest Reserve was significantly higher than in community forests. The study found that overexploitation is highly disruptive to forests and, therefore, the study recommends protection, reforestation and restriction of forest resource use due to the importance of the species in the Tanzanian economy.

Keywords: *Dalbergia melanoxylon, population structure, species richness, Lionja forest reserve.*

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INTRODUCTION

Plant biodiversity is the variation of plant species in a specific area that influences healthy ecosystems (Luoga, 2000). Plant biodiversity also involves variation in life forms and variation in biomass in the ecosystem where, through regeneration, the success of one or more species depends on the presence of other species (Mafupa, 2006). Tropical forests are rich in resources such as food, wood products, shade, and people and influence the availability of rainfall in the given environment (FAO, 2010).

In Tanzania, *Dalbergia melanoxylon* was recorded as abundant in the 1930s (Grant 1934), most sources indicate that the species is now dispersed in the occurrence. In the 1960s, it was recorded as rare due to intensive exploitation. The places most heavily under harvest pressure are those that are easily accessible, close to the

main tourist markets for Makonde art and those close to sawmills in the Dar es Salaam, Lindi and Mtwara regions (Irene and Steve, 1994). The tree population has continued to decline due to overexploitation and inadequate firefighting (Read 1993).

Overexploitation of forests for various human needs has led to the loss of millions of hectares in Tanzania in recent years. Loss affects ecological systems and influences severe climate change (FAO, 2010). The forests of southern Tanzania, in particular the Lionja Forest Reserve in Nachingwea District and the Nambawala Forest Reserve in Kilwa District, are of global importance in terms of population structure and plant species diversity, including *Dalbergia melanoxylon*, a species that has become extinct in Africa with the exception of the coastal regions of Tanzania and Mozambique (Malimbwi, 2005).

About 30 years ago, a study on the state and diversity of populations in Tanzania was conducted to establish policies on conservation and protection strategies, but the extent of conservation reforestation or deforestation by overexploitation requires further information collection, hence this study was conducted in 2019 (Malimbwi *et al.*, 2000). The importance of forests in southern Tanzania necessitated this research in the Lionja Forest Reserve, Nachingwea District. The objectives of the study were to investigate population status, composition structure and diversity in areas dominated by *Dalbergia melanoxylon* in southern Tanzania, particularly the Lionja Forest Reserve, Nachingwea, Lindi region and the surrounding community forests of Lionja B and Lipuyu.

MATERIALS AND METHODS

Study area

Lionja forest reserve is located in Nachingwea district, Lindi region, Southern of Tanzania. It is one of the Miombo woodland forests, found between longitudes 38°20'-38°30'E and latitudes 10º12'-10°20'N. This forest reserve is surrounded by Lionja B and Lipuyu villages community forests in Nachingwea District. Lionja forest reserve is considered by the biologists in Lindi Region as one of the unexplored forests (Shechambo 2004). Lionja Forest Reserve is located at an elevation of 340 meters above sea level.

Sampling technique

The study used a sampling intensity of 0.1% in which 30 plots were taken from forest reserves and 15 plots were taken from community forests (Cunningham, 2001). Due to the dispersal of *Dalbergia melanoxylon* around the Lionja Forest Reserve, a purposive sampling technique was used to collect data. A radius of 20 m for each plot and a distance of 100 m from each transect in both directions were used. All plant species with > DBH4 cm were made to within 0.1 cm and each disaggregated height was made to within 0.1 m (Cunningham 2001). Microsoft Excel was used to create 5 DBH classes where DBH 0-10 cm treated as class 1, DBH 10.1-20 cm treated as class 2, DBH 20.1-30 cm as class 3, DBH 30.1-4-cm as class 4 and DBH ≥ 45 cm as class 5 (Malimbwi *et al*., 2002). The number of stems/plots and base areas/plots and their conversion to per hectare were parameters determined in the study. Other items recorded include species name, genus name, and number of individuals/plot.

Number of stems/hectare

A formula used to calculate number of stems/hectare was N=n/A ……..[1]

where N=number of stems/plot, n=total number of trees in each DBH class and A= total area of the sampled plot. DBH was measured from the ground surface to 130 cm height using measuring tape.

Basal area/hectare

A formula used to calculate basal area/plot was gi $=\pi \times D2 / 4$ ……..[2]

Basal area/hectare (BAH) was calculated as $G=\sum gi / A$ ……..[3]

Where: G=basal area/hectare (m2/ha), gi =basal area of tree (m2), n=number of plots surveyed, D=diameter at breast height (DBH), A=Total area of sampled plots (ha) $\pi=3.14$

Data analysis

ANOVA was used to compare Data on density, basal area/hectare. Number of stems/hectare of

different habitants. Simpson diversity indices was used to compute species diversity (H'=ΣPi*In Pi)
where H' is the index of diversity, Pi is the species value importance in which the diversity index was computed as C= ΣPi2 ……..[4]
where C is the index number (Munishi *et al.*, 2008).
As the number of species in the community increase, the diversity index increases (Krebs, 1989). However, the differences in diversity between Lionja Forest Reserve and the Community forests were compared using ANOVA while the species composition were analyzed using Importance Value Index in which density, frequency and basal area are measured.

The following was used to calculate the Importance Value Index:
IVI = RA + RD + RF ……..[5]

Where IVI: is Importance Value Index; RF: is relative frequency; RD: is relative density; and RD: is relative dominance in area. The density of a species reflects the abundance of a species in a given community. The dominance is defined as the area occupied by the basal area of a species per plot (0.1ha). The relative dominance was obtained by dividing the total basal area for a given species by the total basal area of all species per plot. Relative frequency, density, and dominance of the species was calculated as:

RF= AF/ TF ×100 ……..[6]

Where RF: is relative frequency of species; AF: is absolute frequency of the species; and TF: is the sum of absolute frequencies of all species.

RD= AD/ TD ×100 ……..[7]

Where RD: is relative density of species; AD: is absolute density of species (per ha); and TD: is total density of trees (per ha).

RA = A/ TA ×100 ……..[8]

RESULTS

DBH distribution classes and number of stems/ hectare

Diameter at breast height which is one of the most common dendrometric measurements was recorded in the Lionja Forest Reserve and Lionja B community forest using a tree caliper.The stems or individual tree assessed were then distributed in five diameter classes of 0-10 cm, 10-20 cm, 20-30 cm, 30-40 cm and over 40 cm. The study findings revealed that, *Dalbergia melanoxylon* stems/hectare was 10 with 0 – 10cm DBH in Lionja forest reserve, more than 5 stems/ha with 10 – 20 cm DBH in Lionja community forest. *Dalbergia melanoxylon* population in Lionja Forest Reserve was normally distributed. There were an appreciable number of seedlings of less than 10 cm DBH and larger mature trees estimated at less than 4 trees per ha being over 40 cm DBH.

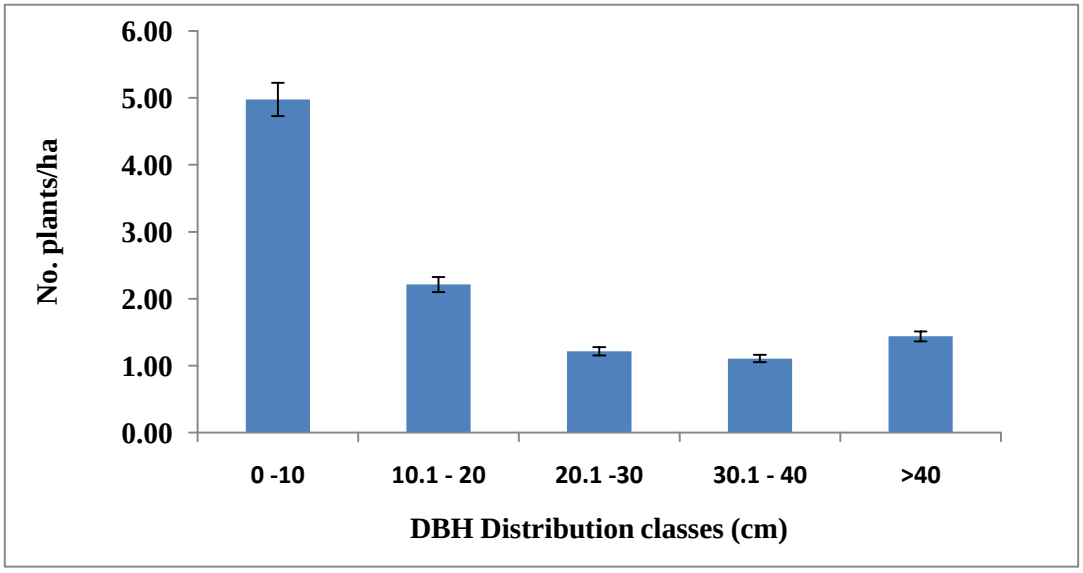

Figure 1: Distribution of Number of Stems/ha in DBH Classes for *D. melanoxylon* in in Lionja Forest Reserve, Nachingwea District

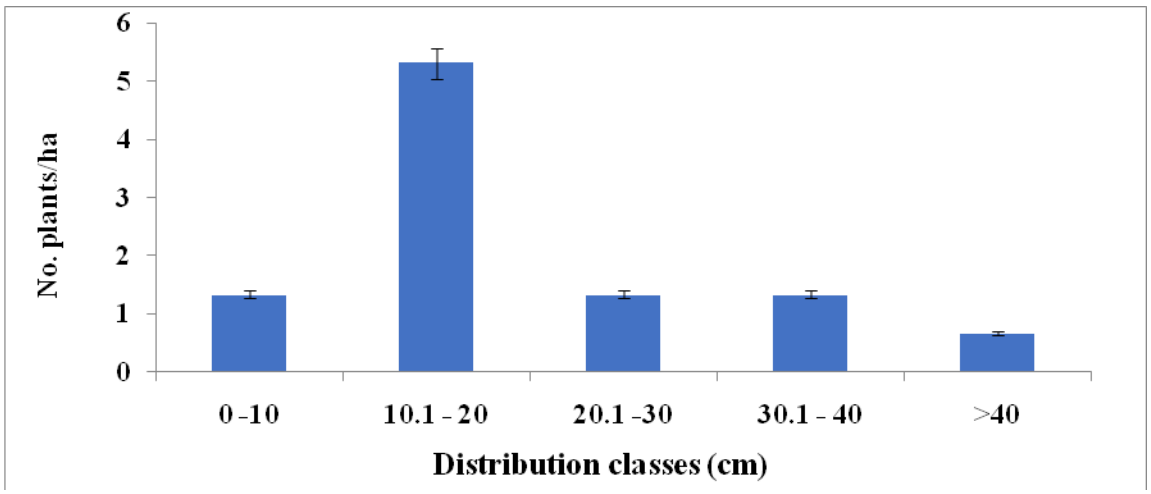

Figure 2: *Dalbergia melanoxylon* stems/hectare in Lionja B Community forest in Nachingwea District.

Basal area

Basal area increased with increasing DBH in Lionja Forest Reserve. Basal area/ hectare average was over 90 m^2 per ha in large trees with DBH of over 40 cm (Figures 3) while in Lionja B many individual trees belonged to the DBH distribution of over 10cm with basal area of over 8.0-10.0 m^2.

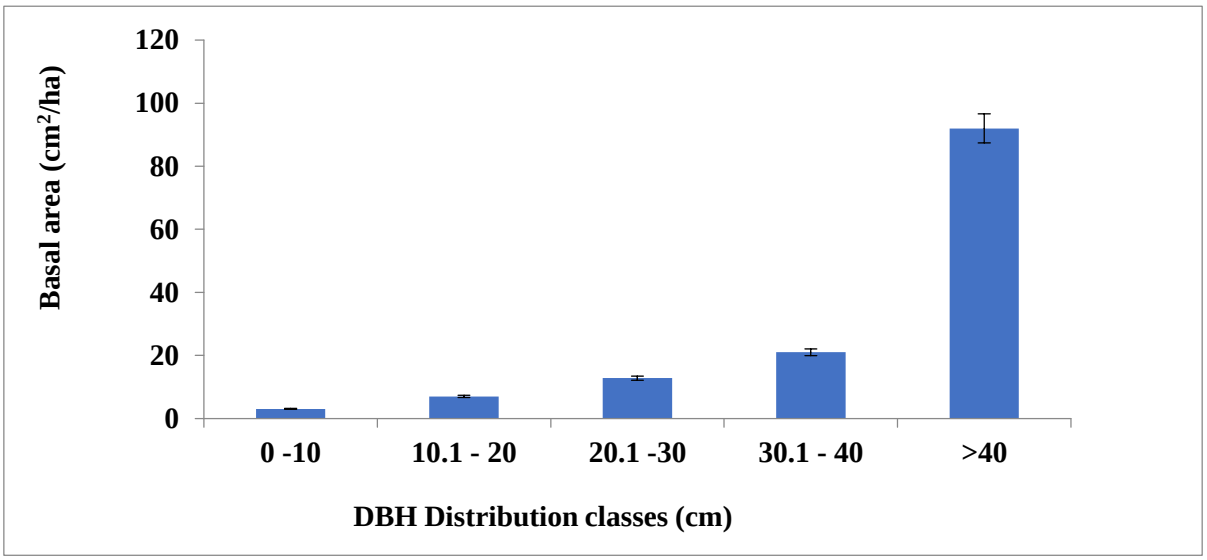

Figure 3: *Dalbergia melanoxylon* basal area/hectare distribution classes in Lionja Forest Reserve in Nachingwea District

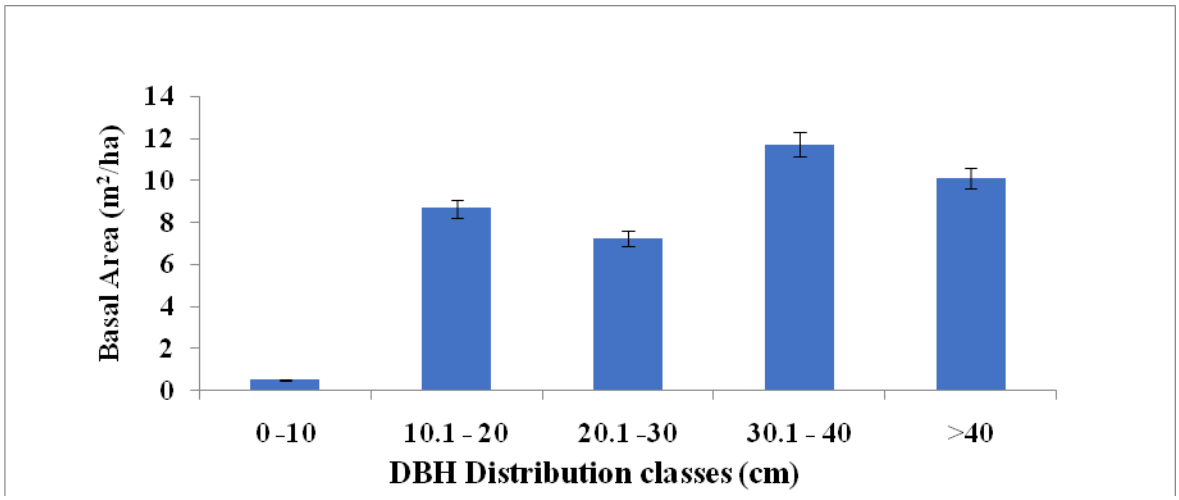

Figure 4: *Dalbergia melanoxylon* basal area/hectare distribution in DBH classes in Lionja B Community Forest in Nachingwea District

Density

The observed densities for forests in Nachingwea showed that plants with low DBH also were lighter in the range of 50-60 kg/m3 while larger trees with over 40cm DBH had heavier densities of over 450 kg/m^3. Within the same DBH class, there was not much differences in densities between reserve forest and community forests. This was observed in the young tree DBH classes of less than 10 cm and those with DBH of over 40 cm. Lipuyu forest did not have representative *D. melanoxylon*

stand with measurable DBH (less than 10 cm and over 40 cm) to assess.

Community forest and Reserved forest plant densities in Nachingwea District

In the studied ecological zone of *Dalbergia melanoxylon* in Miombo woodland, plant diversity in Lionja Forest Reserve was more diverse than in nearby community forests of Lionja B and Lipuyu with SWI (Shannon-Wiener diversity index) which ranged from 1.57 to 2.7 (with a mean ± standard error of 2.301 ± 0.297) as shown in table 1. In Lionja B community forest, SWI ranged from 0.85 to 1.898, with a mean of 1.37 ± 0.36. While in Lipuyu community forest, SWI ranged from 0.97 to 2.01, with a mean of 1.49±0.31. One-way ANOVA revealed significant differences in the diversity between Lionja Forest Reserve and the two community forests ($P < 0.001$). It was found no significant difference between the two community forests ($P > 0.05$).

Lionja Forest Reserve highest value of evenness was (0.46) while in Lipuyu community forest was (0.30) and Lionja B community forest was (0.28). ANOVA indicated significance evenness between Lionja Forest Reserve and the two community forests ($P < 0.001$). This significant was also applied to plant species richness where it was highest in Lionja Forest Reserve (18.7) followed by Lionja B community forest (8.25) and Lipuyu community forest (7.80).

Table 1: Richness, evenness and plant density of selected forests in Nachingwea District

Parameter	Forest			Statistical Test		
	LFR	**LB**	**LP**	**F-Value**	**Significance value**	**Final statement**
Plant diversity	2.30	1.37	1.49	10.33	<0.001	Significant
Plant evenness	0.46	0.28	0.30	33.7	<0.001	Significant
Richness	18.7	8.25	7.80	59.62	<0.001	Significant
Simpson	6.24	3.75	4.69	6.25	<0.01	Significant

LFR = Lionja Forest Reserve, **LB** = Lionja B community forest, **LP** = Lipuyu community forest

Plant species composition in Lionja Forest Reserve and the nearby community forests of Lionja B and Lipuyu

Different plant species amounting to 112 were recorded when Lionja Forest Reserve and nearby community forest of Lionja B and Lipuyu in Nachingwea district were surveyed. A total of 71 plant species (tree and shrubs) were identified in Lionja forest reserve, 51 plant species were identified in Lionja B community forest and 46 plant species were recorded in Lipuyu community forest.

A total of 35 tree species, 18 shrubs species, 12 herbaceous species and 4 species of grasses were recorded during the survey in Lionja Forest Reserve in Nachingwea. The IVI which provides knowledge on important species of a plant community was computed for these forests. Based on IVI, *Pterocarpus angolensis* was most dominate species in Lionja Forest Reserve followed by, *Dalbergia Melanoxylon, Diplorynchus condylocarpon, Combretum adenogonum, Markhamia zanzibarica, Julbernadia globiflora, Pteleopsis myrtifolia, Bauhinia petersiana, Commiphora Africana* and *Holarrhena pubescens.* Figure 1 indicated how tree and shrub in the Lionja Forest Reserve are distributed.

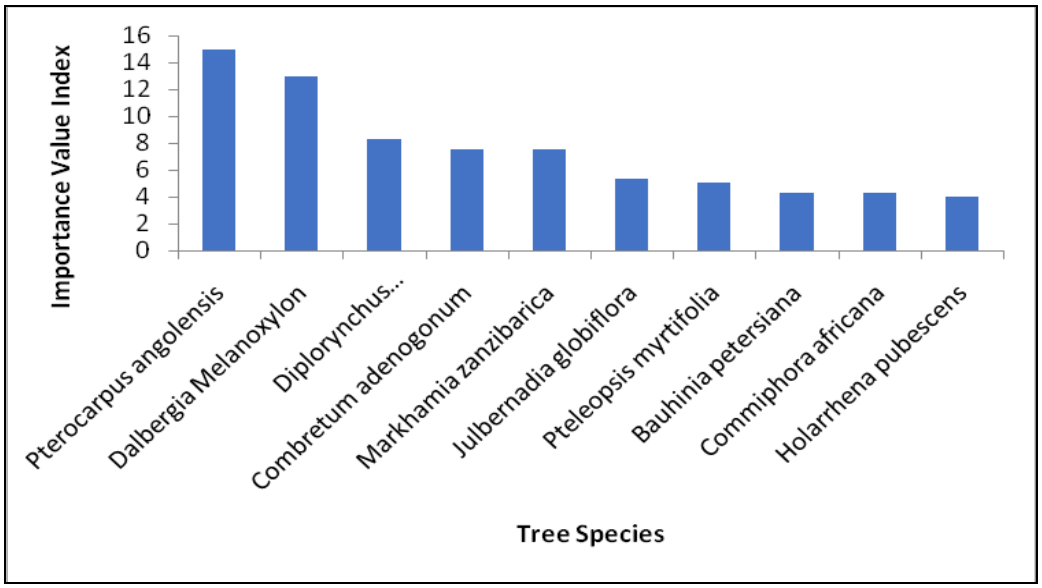

Figure 5: Importance Value Index **(**IVI)/richness recorded plant species in Lionja Forest Reserve, Nachingwea District

DISCUSSION

Dalbergia melanoxylon in this study was observed in scattered clusters in all sampled areas. An investigation conducted by Opulukwa *et al.* (2002) had shown that *Dalbergia melanoxylon* constituted 4% of the 103 species recorded in the region and most of these were found clustered in the region**.** In the Lionja B community forest, the number of plants/ha formed a fairly normal distribution, with the largest number of individual plants per ha being five (5) in the 10-20 cm DBH distribution classes, but the other distribution classes were well represented. A closer look by Opulukwa *et al.* (2002) had revealed that the number of stems/hectare was 20, as also observed by Malimbwi *et al.* (2000) in southern Tanzania but also as Hawkins *et al.* (1996) reported the same 20 stems/ha in Mikumi National Park. It is evident that *Dalbergia melanoxylon* has declined enormously over the past 20 years since the last inventory in the same area by Malimbwi *et al.* (2000). The third sampling site, Lipuyu, did not have *Dalbergia melanoxylon* worthy of evaluation as most were seedlings less than 4 cm DBH. Most of Lipuyu's community forest was cultivated by smallholder farmers.

D. *melanoxylon* has been shown to grow slowly and increase in diameter by only 1-1.4 cm per year, particularly during seedling age (Washa and Nyomora, 2012). *Dalbergia melanoxylon* with DBH above 40 cm have been found rare in the Lionja Forest Reserve and the Lionja B Community Forest. This is clearly an indication that overexploitation of *D. melanoxylon* in these forests. The study observed more abundant natural regrowth of seedlings in the Lionja Forest Reserve and the Lionja B Community Forest. This could be due to wildlife and crop disturbances that result in injured root suckers of *D. melanoxylon.*

Differences in conservation management strategies have resulted in different species composition in different forests. The results are consistent with other studies that have concluded that highly protected areas have higher diversity, uniformity and species density than less protected areas (Dhaou *et al*, 2010). This is based on the assumption that habitat protection reduces plant resource extraction that promotes greater plant species richness than in unprotected areas (Bruner *et al*., 2011).

All community forests in this study had Shannon-Wiener index values below 2, indicating low plant species diversity. These results indicate that the community forests in this study are less protected than the forest

reserve. Okland (1990) noted that less protected areas are vulnerable to human disturbance. For example, the Nachingwea Community Forest, Lionja B and Lipuyu Forest have been heavily disturbed by crop cultivation. Since the study was conducted in an ecological zone of *Dalbergia melanoxylon*, which is one of the most valuable timber tree species, there was a lot of illegal harvesting in forest reserves than in the community forest as this led to a reduction in plant diversity and composition.

The Lionja Forest Reserve had more than 71 species of plants, which compares well to the number of species that were counted in the nearby Lionja B Community Forest and Lipuyu Community Forests. This high number of species may indicate a reduction in the level of disturbance of human activities, which are likely to increase vegetation growth and reproduction, as suggested by Hitimana (2009). It could also indicate that the forest has an ideal habitat for floral growth and reproduction. However, it is also possible to attribute the high number of species to its protected status. of the forest mainly because a comparison of the number of species in this forest with less protected forests such as community forests.

These results reveal that the most important species in the Lionja Forest Reserve have high diversity at the Shannon Weiner Diversity Index level. The IVI classifies species to give an indication of which species appear to be important components of miombo forest trees (Munishi *et al.* 2008). Grasses and herbaceous species such as *Heteropogon contortus*, *Panicum maximum* and *Digitaria sp* strongly dominated the forest as it is more of an open grassland habitat and the research was conducted during the rainy season. In addition, grasses and grasses have shorter life cycles than tree species, so during the rainy season will grow faster.

Apart from the great plant diversity in the Lionja Forest Reserve, valuable timber tree species were harvested illegally as it was very rare to encounter mature stems in the forest during the forest inventory carried out. The most dominant tree species were *Pterocarpus angolensis* and *Dalbergia melanoxylon*.

CONCLUSION AND RECOMMENDATION

Conclusively, the number of stems, basal area and density per hectare was found to be 4.3, 27.2 m^2 and 483kg/m^3 respectively in Lionja Forest Reserve and 1.9, 7.6m^2 and 350.4kg/m^3 in Lionja B community forest. On the other hand, Lipuyu community forest, did not have *Dalbergia melanoxylon* worth assessing since most were seedlings of less than 4 cm DBH. Most part of Lipuyu community forest was under cultivation by the small scale farmers. Significantly higher plant species diversity, richness and evenness were found in Lionja forest reserve compared to the nearby community forest of Lionja B and Lipuyu. For a plant species composition, a total of 71 plant species were recorded in Lionja forest reserve, 51 plant species in Lionja B community forest and 46 plant species in Lipuyu community forest. Grasses and shrubs highly dominated the forests under this study since the study was conducted during the rainy season. However, species richness for some timber species and non timber forest products such as *Pterocarpus angolensis* and *Dalbergia melanoxylon* were very poor due to over harvesting for the market and livelihood support. The impacts of anthropogenic disturbances were highly observed and expected to increase further with the growing population and enhanced accessibility. Strict law enforcement on exploitation of forest should be encouraged. On the other hand, restoration of the ecosystem through reforestation in most degraded areas of the forest should also be given immediate attention by forest management authorities.

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