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Effect of Anthropogenic Activities in Dry Miombo Woodlands on Wood Stock and Tree Diversity: A Case of Chenene Forest Reserve, Bahi, Tanzania

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ABSTRACT: This study assessed Woodstock, species richness, tree diversity and Importance Value Index (IVI) of Chenene Forest Reserve (CFR). Forest inventory carried out in 120 systematically selected sample plots. The forest was post stratified into disturbed and undisturbed strata. The information recorded includes: diameter at breast height, species name, Geographical Positioning System (GPS) readings, and frequency of the species. Indicators of human activities such as charcoal kilns, pitsawing, burnt area and grazing signs. Analysis of the inventory data was done using Microsoft Excel. The inventory carried out in 2011 revealed that average number of stems per hectare (N), basal areas per hectare G (m^2ha^{-1}), and volume per hectare V (m^3ha^{-1}) as 352 ± 35.20 (SE), 6.84 ± 0.68 (SE) and 44.68 ± 4.47 (SE) respectively. The parameters between disturbed and undisturbed strata in this study revealed low parameters in disturbed stratum as compared to undisturbed strata were 567± 87.37 stems ha^{-1}, Basal area 11.21± 1.10m^2ha^{-1} and volume 71.21± 7.00 m^3ha^{-1} in undisturbed forest stratum and 246± 15.00 stems $^{ha-1}$, Basal area 3.25±0.20 m^2ha^{-1} and volume 17.92 ± 1.00 m^3ha^{-1}. The study identified 95 species and the Shannon- Index of 4.17. The study concludes that CFR is potential for having high tree diversity and is fairly stocked to provide products and services to the surrounding communities. The study recommends starting Joint Forest Management (JFM), Preparation of management plans and good governance in the management of CFR.

KEYWORDS: *Anthropogenic*; Woodstock; Tree Diversity; Miombo Woodland.

1 INTRODUCTION

Tanzania's forests and woodlands cover about 33.4 million hectares (ha) of the total land area which is about 38% of the total land area of 88.6 million ha (FAO, 2010). These forests and woodlands support the livelihoods of 87% of the poor populations who live in rural areas (CIFOR, 2004). Of the total forest area, about 13 million hectares cover reserved land in which there are 621 forest reserves and village land forest reserves of varying size from 3.0 to 580,000 ha (MNRT, 2005). Forest reserves are managed for protection, production or both and they may be under the jurisdiction of central government, local government, community and individual (URT, 1998).

Miombo Woodland is the most extensive vegetation type in Africa, covering an estimated 2.7 million km^2 in regions receiving greater than 700 mm mean annual rainfall on nutrient poor soils (Campbell, 1996). Miombo Woodlands is distinguished from other African savanna, woodland and forest formation by the dominance of tree species in the family Fabaceae sub-family Caesalpinioideae, particularly in the genera *Brachystegia, Julbernadia and Isorbelinia* (Frost, 1996). These genera are seldom found outside Miombo. Although this dominance by Caesalpinionideae is characteristic their contribution to numbers and Woodstock varies extensively within and between communities (Frost, 1996). What factors favour this dominance is an interesting but as yet largely unanswered question, though the wide spread occurrence of ectomycorrhizae in their root may enable them to exploit porous, infertile soils more efficiently than groups lacking ectomycorrhizae (Högberg and Nylund, 1981). The Woodstock and species composition structure of Miombo Woodlands appear superficially to be relatively uniform over large regions, suggesting a broad similarity in key environmental conditions. Woody plants comprise 95 – 98% of above ground biomass of undisturbed stands; grasses and herbs make up the remainder (Chidumayo, 1993). The woodlands typically comprise an upper canopy of umbrella shaped trees; a scattered layer, often

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absent, of sub-canopy tree; a discontinuous understorey of shrubs and saplings; and a patchy layer of grasses (Campbell, 1966). The uniformity in appearance is due in part to the remarkably similar physiognomy of the dominant canopy trees, no doubt a reflection of their origins in the Caesalpinioideae. Differences in Woodstock and species composition and diversity are more apparent at lock scale. The origin of these differences is under: geomorphic evolution of the landscape (Cole, 1986); edaphic factors, principally soil moisture and soil nutrients (Campbell et al. (1988) and past and present land use and other anthropogenic disturbances (Chidumayo, 1987), have all been implicated. According to Chidumayo (1989) anthropogenic activities play a big role in the dynamics of Miombo Woodlands. The Woodstock and species composition and diversity have been affected in many ways by human beings, and it is believed no part of it remains absent of human influence (WWF – SARPO, 2001). Knowledge of the extent to which Woodstock and tree diversity have been affected is inadequate. This study assessed the Woodstock and tree diversity in Chenene Forest Reserve (CFR). CFR is a central Government owned forest located in Dodoma region Tanzania. Its management was devolved to Bahi District Council in 1992. It is against this background that the area is selected for this study since it is a good representative of forest which its management was devolved to local government in central part of Tanzania and as such it is worth assessing Woodstock and tree diversity under this management regime.

2 MATERIAL AND METHOD

2.1 THE STUDY AREA

Chenene Forest Reserve (CFR) is located in Bahi District, Dodoma Region at latitude 4^{o} to 8^{o}S and longitude 35^{o} to 37^{o}E. Bahi District is one of the six districts of Dodoma Region. Other districts are Kondoa, Chamwino, Dodoma Municipality, Mpwapwa and Kongwa. The headquarters of the district is located in Bahi ward which is 50 km away from Dodoma Mucipality and located close to the highway linking Singida and Dodoma regions. Bahi district extends between latitude 4^{0} and 8^{0} South and between longitude 35^{0} and 37^{0} East. On the east, the district shares its boarder with Chamwino and Dodoma Municipal; Kondoa district on the north, Iringa region on the Southwest, and Manyoni District on the West. Their populations and households are in **Table 1.** The location of CFR is indicated in **(Fig. 3).**

Table 1: Population and households' distribution of villages adjacent to CFR, Bahi, Tanzania

Village	Population (2002)	Population (2008)	No. of households (2011)
Mayamaya	3 203	8 812	1 159
Chenene	2 342	6 362	720
Mkondai	1 310	5 240	1 529
Babayu	3 520	8 750	1 580

Source: URT, (2009); Village registers, (2011).

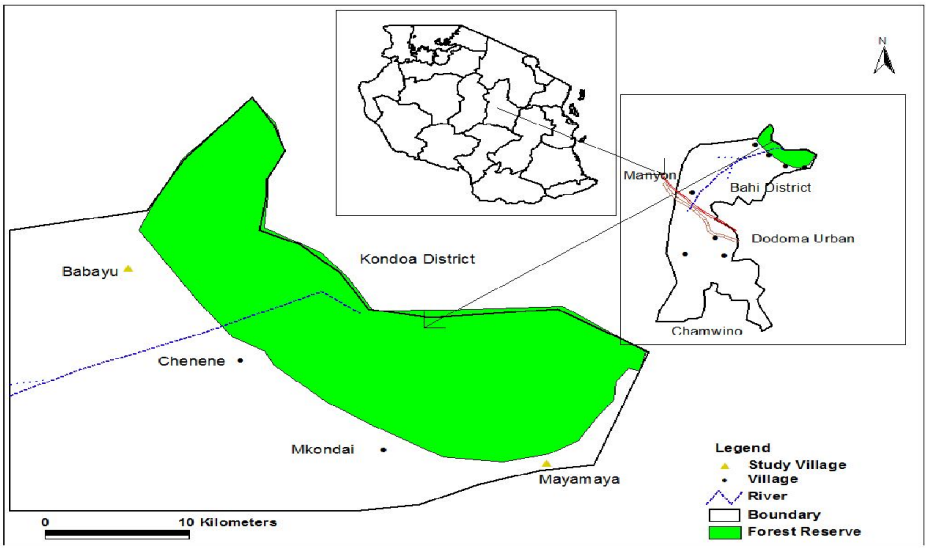

Fig. 1: Location of Chenene Forest Resrve

2.2 DATA COLLECTION

Forest inventory was conducted to determine Woodstock and tree diversity, their distribution and estimate the available stock in the forest reserve. Forest inventory is defined as the procedure for obtaining information on quantity and quality of forest resources and other characteristics of the land on which trees are growing (Malimbwi, 1997). The actual inventory was preceded by a reconnaissance survey which involved layout of transects and plots on the map of forest reserve.

To cover the whole forest reserve area and variations between vegetation cover, systematic sampling design was adopted in this study. Systematic sampling enabled an even distribution of the samples throughout the forest reserve and hence increases the chance of including all vegetation types in the area (Phillip, 1994).

The study adopted sampling intensity of 0.1% which is equivalent to 120 plots. The sample plots were stratified into disturbed and undisturbed strata as shown in Table 2.

Table 2: Distribution of sample plots in the study area

Forest strata	No. of plots	Plot size (ha)	Plot area (ha)
Disturbed forest stratum	60	0.07	4.2
Undisturbed forest stratum	60	0.07	4.2
Total	**120**	**0.07**	**8.4**

Circular shaped plots were adopted because they are easy to use, they reduce edge effects in samples and counting errors during inventory of border trees are minimized. The effects are less on the circle plots than in square and rectangular plots (Krebs, 1989). The sample plot was divided into three areas of 5m, 10m and 15m radius.

The information that was recorded from each sample plot include: diameter at breast height (dbh), tree species name, Geographical System Positioning (GPS) readings, indicators of human activities such as pitsawing, fire signs, charcoal kilns and grazing signs.

2.3 DATA ANALYSIS

For the miombo woodland forest, the total tree volume was calculated using allometric equation developed by Malimbwi *et al.,* (2005). The equation was:

$V= 0.000011972D^{3.191672}$

From the collected data, it was possible to compute other forest stand parameters such as: density, i.e. the number of stems per hectare (N) and Basal area per hectare (G). These parameters are very important in forest management as they provide useful information on forest stocking levels. Tree diversity was determined using the Shannon Wiener index. The knowledge of tree diversity is useful for establishing the influence of human activities and the state of succession and stability in the environment (Misra, 1989). The species diversity increases with the number of species in the community (Krebs, 1989).

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

Where:

H'=Shannon-Wiener Index

P_i =is the proportion of total sample belonging to the ith species ($p_i = n_i / N$)

ni = the number of individuals of each species.

Forest stock and tree diversity were compared using undisturbed and disturbed strata to reflect the past tree stocking and tree diversity.

Importance Value Index (IVI) was computed as the average of relative basal area, density and frequency. The IVI for a species is a composite of the three ecological parameters i.e. density, frequency and basal area which measure different features and characteristics of a species in its habitat. Ecologically, density, basal area and frequency of a species measure the distribution of a species within the population while basal areas measure the area occupied by the stems of the trees.

3 RESULTS AND DISCUSSION

3.1 FOREST INVENTORY

The inventory carried out in 2011 revealed that average number of stems per hectare (N), basal areas per hectare G (m^2ha^{-1}), and volume per hectare V (m^3ha^{-1}) as 352 ± 35.20 (SE), 6.84 ± 0.68 (SE) and 44.68 ± 4.47 (SE) respectively. The parameters between disturbed and undisturbed strata in this study revealed low parameters in disturbed stratum as compared to undisturbed stratum (Table 3).

Table 3: Parameters between disturbed and undisturbed forest strata in CFR, Bahi, Tanzania

Stand Parameters	Forest strata		t- stat	P- value
	Undisturbed	Disturbed		
N (stems/ha)	567 ± 87.37	246 ± 15.60	4.099	< 0.0001***
G (Basal area/ha)	11.21 ± 1.10	3.25 ± 0.20	5.949	< 0.0001***
V (Volume/ha)	71.21 ± 7.00	17.92 ± 1.00	4.187	0.006***
Shannon's Index	4.17± 0.41	4.00 ± 0.40	4.136	< 0.0001***

The variation might be attributed by excessive human activities in CFR since the forest was not managed under Joint Forest Management (JFM). The forest management was devolved to local government authority but the type of devolution did not involve the local people in the management of forest. Iddi (2002) highlighted a gap between policy and practice as a result of poor understanding of the responsibilities and benefits of the communities. The author pointed out that this is exacerbated by the dilemma of finding suitable focus for decision making, therefore, if societal needs, resource potential and institutions guiding resource use are not harmonized, the potential exists for negative outcomes on both ecological (resources) and societal aspects emanating from unresolved conflicts.

3.1.1 SPATIAL COMPARISON ON STOCKING, BASAL AREA AND VOLUME IN CFR

STOCKING DISTRIBUTION

The distribution by diameter classes for the disturbed and undisturbed forest strata generally indicated 'J' shape DBH distribution (Fig. 2). This was an indication of active regeneration as it is expected for natural forest (Phillip, 1994).

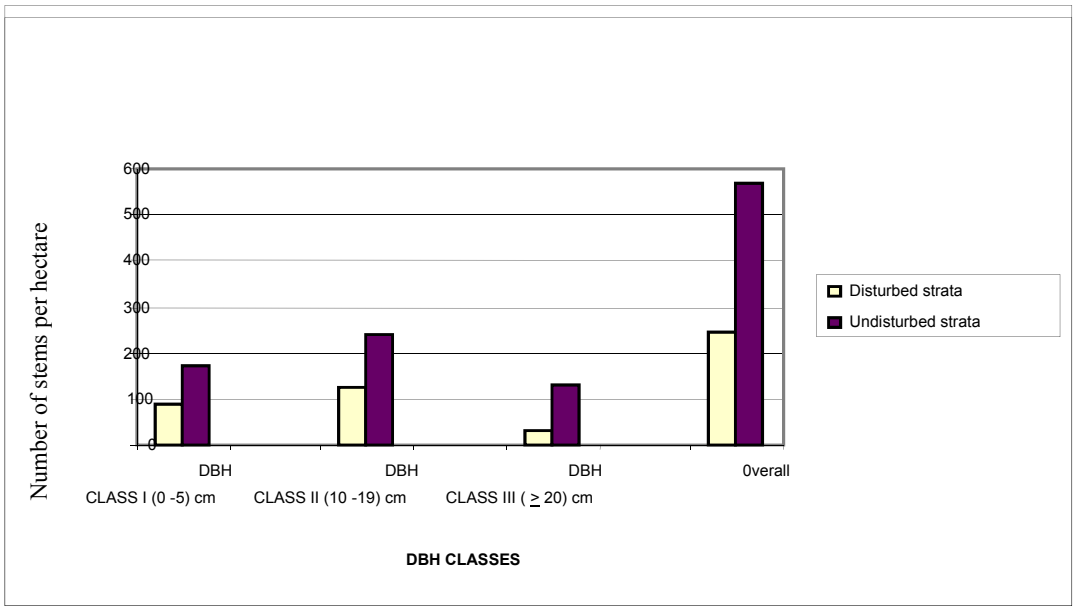

Figure 2: Number of stems ha-1 distribution by diameter classes for disturbed and undisturbed strata for CFR 2011, Bahi, Tanzania.

The average number of stems per hectare for all diameter classes was 567 for undisturbed forest strata and for disturbed forest strata were 246. There was significant difference ($p<0.0001$) in number of stems per hectare between undisturbed and disturbed forest strata (Table 3). However, the disturbed forest strata had more number of stems per hectare for DBH classes I and II as compared to undisturbed forest strata (Figure 2). This indicates that human activities have negative impact on large diameter classes leaving large number of small diameters in disturbed strata.

Generally, in both undisturbed and disturbed forest strata, more number of trees was found in small diameter classes I and II indicating abundance of young trees which is a characteristic of natural forests (Phillip, 1994). It is also a manifestation of the ecosystem resilience. Such distribution is a common characteristic of natural forest with intimate mixture of trees of all age classes. This provide an indication that the stands were developing and regeneration in the forest reserve was taking place as well as the population structure was stable (Isango, 2007; Chingonikaya, 2010). The tree density reported in this study is within the range as reported by different authors studied in miombo woodlands (Isango, 2007; Chingonikaya, 2010).

BASAL AREA DISTRIBUTION

The average basal area per hectare for all diameter classes was 11.21 m^2ha^{-1} for undisturbed forest strata, where as for disturbed strata was 3.25 m^2ha^{-1}. This difference was significant ($p<0.0001$) (Table 3).

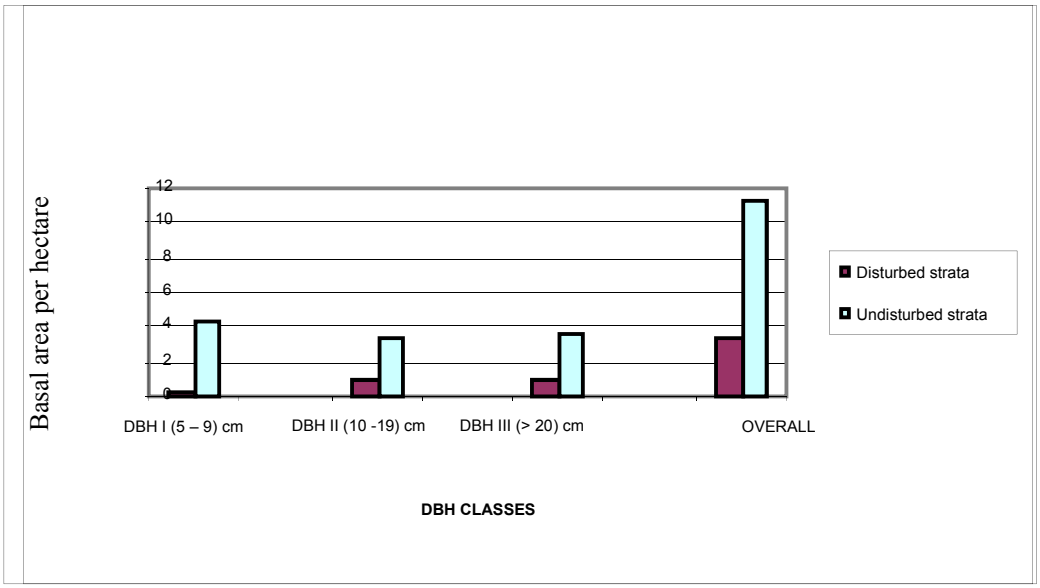

Figure 3: Distribution of basal area per hectare (G) by diameter classes for undisturbed and disturbed strata of year 2011 in CFR, Bahi, Tanzania.

Comparatively undisturbed forest had more average basal area than disturbed forest (Table 3) The reason might be that human activities had caused more removal of some diameter classes especially classes III (>20 cm) in disturbed forest stratum (Figure 3) this might be attributed by chopping down trees during pit sawing, charcoal making, poles for construction and fuelwood.

The basal area reported in this study is within the range as reported by different authors studied in other miombo woodlands. For example Chingonikaya (2010) studied in Mgori Forest Reserve observed that the basal area had a mean of 9.65 to 18.50 m^2ha^{-1} while Isango (2004) reports a range of 10 to 14 m^2ha^{-1}.

3.1.2 VOLUME DISTRIBUTION

The average volume distribution for all diameter classes in the undisturbed forest strata were 71.21 m^3ha^{-1} while the distribution for disturbed forest strata were 17.72 $m3ha^{-1}$. This difference was significant ($p<0.0001$). Furthermore, the undisturbed forest strata had more volume per hectare than disturbed forest strata (Table 3) However, the difference of more than 53.29 m^3ha^{-1} between means of (undisturbed) and disturbed forest was considerable large and cannot simply be ignored. The reason might be that human activities had caused more removal of some diameter classes especially classes II and III in disturbed forest stratum (10 – 20cm and > 20 cm) DBH (Figure 4). This may be due to pit sawing, charcoal burning, and poles for construction and fuelwood.

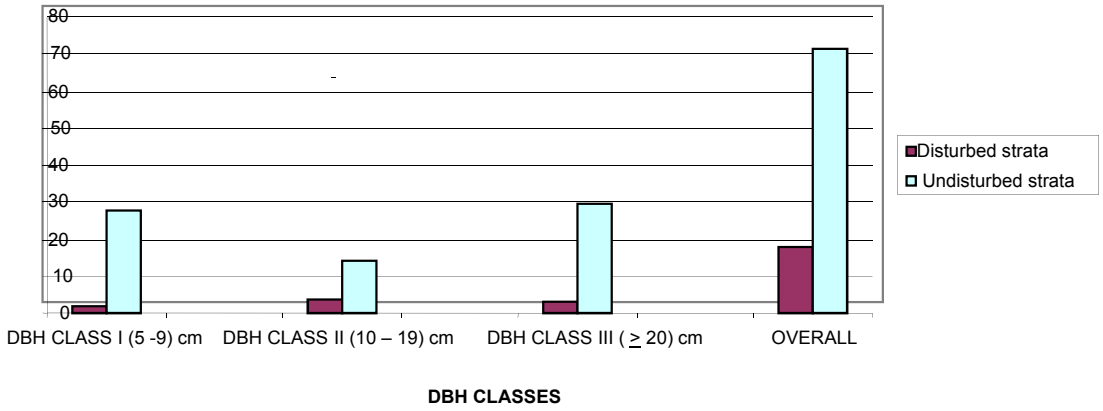

Figure 4: Volume per hectare (V) distribution by diameter classes for undisturbed and disturbed strata of year 2011 in CFR, Bahi, Tanzania

Large volume was recorded in large diameter classes for undisturbed forest strata (Figure 4) as had been with basal area. Generally, volume trend was similar to that of basal area whereby small and medium diameter classes had small volume in both strata while large diameter class in undisturbed forest strata had large volume due to their fewer numbers (Figure 4).

3.1.3 SPECIES COMPOSITION AND RICHNESS

Table 4 shows the general characteristics of CFR tree resources. A total of 95 tree species were identified. The species richness (95) of trees observed in this study compares well with miombo woodland forests occurring in other areas. Luoga (2000) enumerated 79 species in Ktulangalo Forest Reserve while Backeus (2006) found 86 species around Ihombwa village. Njana (2008) and Mafupa (2006) found 82 and 46 species in Urumwa Forest Reserve and Igombe River Forest Reserve respectively. The higher the number of species richness in the study area was contributed to the presence of Bubu riverine forest that contributes to growth of many species.

Table 4: Characteristics of tree resources in CFR

Parameters	Value
1. Richness (number of species)	95
2. Shannon's Index	4.17

Krebs (1989) suggests that value of the index usually lies between 1.5 to 3.5, Shannon diversity increases with increase in number of species, in this study, the index is high (4.17) as compared to those found in Kitulangalo miombo forest, Tanzania by Nduwamungu (1996) which were 3.79, 3.56 and 3.26 for all diameter classes respectively. Zahabu (2001) reported Shannon – Index of 3.79 and 3.13 respectively in miombo woodland of Kitulangalo Forest Reserve, Morogoro, Tanzania.

3.1.4 IMPORTANCE VALUE INDEX (IVI)

The Importance Value Index (IVI) provides knowledge on important species of a plant community. Based on IVI *Brachystegia boemii* was the most dominant species. Followed by *Brachystegia speciformis, Vitex doniana, Albizia versicolor, Brachystegia globiflora* and *Acacia tortilis.* Others were *Combretum molle; Pterocarpus angolensis, Acacia nilotica and Xeroderris stulmanii* (Figure 5) show the distribution of important tree species in the woodland.

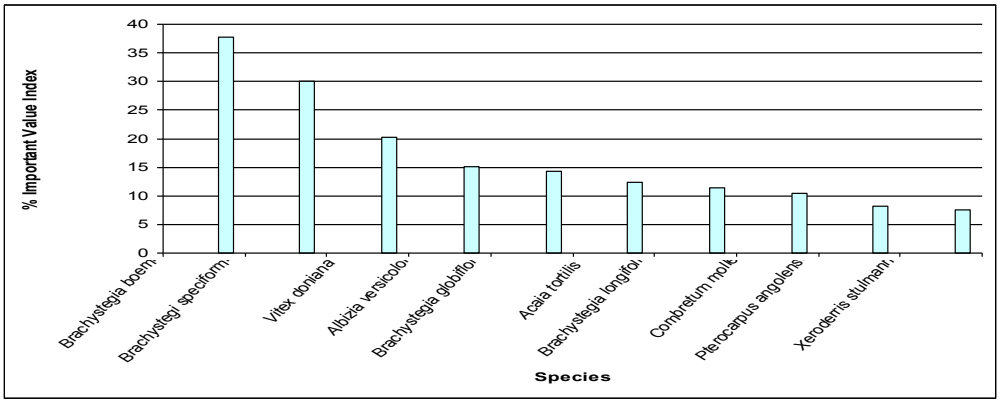

Figure 5: Species richness according to IVI in CFR, Bahi, Tanzania.

The results disclose that, the most important species in the scale of Shannon Wierner Index of Diversity. The IVI rank species in a way to give an indication on which species come out as important element of the miombo trees (Munishi *et al.,* 2008).

4 CONCLUSION

The study revealed that CFR has a reasonably good woodstock and tree species composition and richness. The Woodstock in undisturbed (intact) strata forest were high (71.21 m^3/ha) as compared to disturbed forest strata (17.92 m^3/ha). Species noted to be dominant include: *Brachystegia boemii, Brachystegia speciformis, Vitex doniana, Brachystegia longifolia, Combretum molle, Pterocarpus angolensis, Acacia nilotic and Xeroderris stulmanii.*

However, species richness for some timber tree species such as *Pterocarpus angolensis, Dalbegia melanoxylon, Albizia versicolor and Brachystegia boemii* were found in undisturbed forest strata due to over exploitation. The harvesting involves charcoal making, poles cutting (milunda), pitsawing and fuelwood. This indicates a sign of human activities which can lead to unsustainable supply of forest products and services and hence poor provision of livelihoods to the surrounding communities.

5 RECOMMENDATIONS

The study recommends preparation of management plans and promotion of good governance in management of CFR. Fuelwood, poles harvesting (milunda), charcoal making and pit sawing could have a contribution to deforestation in disturbed forest stratum. Similarly, state forests that cover large area of forests have experienced significant deforestation due to human pressure, lack of enforcement and weakness of institutions to tackle the deforestation problem.

Policy implications entail forest management and institutional interventions against inappropriate use: illegal logging, charcoal making, forest fires and overgrazing human activities. Simultaneously, poverty issues need to be tackled by providing more suitable ways of living to rural people that currently rely heavily on forests. Forest reserve areas should be associated with in depth analysis of socio-economic situation of villages that are close to them and potentially rely heavily on forests for grazing and other forest resources.

Finally, the study demonstrates the importance of CFR as dry miombo woodland which could be otherwise neglected.

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