WOODY VEGETATION STOCKING, COMPOSITION AND DIVERSITY IN MIOMBO WOODLANDS IN TANZANIA: A CASE STUDY OF MGORI FOREST RESERVE IN SINGIDA DISTRICT

Chingonikaya[1]*, E. E., Munishi[2], P.K.T. and. Luoga[3], E.J.

[1]Development Studies Institute, *Corresponding author ; [2]Department of Forest Biology;
[3]Department of Forest Mensuration and Management, Sokoine University of Agriculture, Morogoro, Tanzania

ABSTRACT

Participatory forest management (PFM) model is aimed at improving both forest resources conservation and livelihoods of local communities. In Tanzania, PFM is widely spread in forest reserves bearing the names of joint forest management, co forest management and community based forest management. However, despite the wide spread, less so far has been done to assess its contribution to conservation of the forest resources and livelihoods of local communities. The study, however, majored on assessment of forest resources by describing woody stocking, and species composition and diversity at Mgori Forest Reserve, in Tanzania. Mgori forest reserve (MFR) is one of the reserves in Tanzania, which are under the model. MFR is within miombo woodlands of Tanzania allocated along the western side of the country. Inventory data were collected from four village forest reserves, which are part of MFR. A total of 136 plots of the size 20 x 50 m (0.1ha) were laid in different clusters. The study enumerated a total number of 79 tree/shrub species. DBH distribution followed an inverse 'J' shape. Stem density in the study ranged between 494 and 885 N ha^{-1}, while basal area and woody volume distribution followed a 'J' shape. The basal area varied from 9.65 to 18.50 m^2 ha^{-1}, while the woody volume was averaged to 65.99 m^3 ha^{-1} with a range of 54.49 to 104.47 m3 ha-1. The most dominant tree species in the study were Brachistigia spiciformis and Jubernadia globifolia. Important value index of tree species ranged between 4.29 and 10.00, while Shannon Weiner index was between 2.54 and 3.04. Index of dominance in this study was between 0.03 and 0.11, while species diversity index ranged from 38.46 to 89.36 and species richness and evenness ranged between 9.65 and 21.04 and 1.55 and 1.81 respectively. The study concludes that woody stocking parameters as well as tree/shrub species composition and diversity indices are normal and similar to any other reserved forests in miombo woodlands.

Key words: miombo woodland, stem density, basal area, woody volume, species composition, diversity, participatory forest management, village forest reserves

INTRODUCTION

Mgori Forest Reserve, before being into the community-based forest management (CBFM) in 1996 had been targeted and gazetted to be one of the central government forest reserves since 1984. Management of the Mgori Forest Reserve by then was under the state ownership with forest officers and guards having the responsibility to its management. Despite the forest being under the government authority, overexploitation was rampant. This led the local communities under the respective village governments to make claim for managing and owning the reserve. The government in collaboration with Swedish International Development Agency (SIDA) handed the forest to local communities in 1996 (Wily 1996).

Mgori Forest Reserve is within the belt of miombo woodlands, which is rich of woody miombo species and their socio-economic important values. Miombo woodland is one of the most widespread vegetation in tropical Africa. It extends southwards from Tanzania, through Zambia, Mozambique into Zimbabwe and westwards to Angola and Democratic Republic of Congo (White 1983). Tanzania has about 33.5 million hectares of forests and woodlands. Out of which, over 60% accounts for woodlands (URT 1998), while Mgori forest reserve alone accounts for 0.3%. This indicates that in Tanzania miombo woodlands form the largest ecosystem (Rodgers, 1996).

Mgori Forest Reserve is among the good representative models of CBFM in Tanzania, however, much has not been done on socio-economic and ecological studies that provide information on its successfulness (Malimbwi and Mwansasu 1996; Wily 2001; 2002; Isango 2004).

This study considered that it is important to analysed ecological values in terms of woody vegetation stocking and composition. FAO (2003) asserts that these items are basic values in assessment of wealth of any forest.

The important interest for this study is scientific exploration and quantification of biodiversity. Learning on how many forms of life inhabit planet is a legitimate scientific quest (Wilson 1988). Describing distribution of tree stems, basal area and volume per hectares and diameter classes and biological diversity in a discrete unit of landscape calls for importance of its conservation (Janzen 1993). Information on vegetation leads to solve ecological problems, monitor management practices or provides the basis for prediction of possible future changes. Within plant communities, the presence or absence of a particular species is of a primary importance (Kent and Coker 1992), since species diversity is a very useful parameter for forest communities, particularly when one wishes to study the influence of biotic disturbances, the state of succession or stability of a forest community.

MATERIALS AND METHODS

Description of study area

Mgori Forest Reserve is in Mgori Division in Singida District in Singida Region, Tanzania (Figure 1). Five villages namely Unyampanda, Pohama, Mughuunga, Nduwamughanga and Ngimu surround the reserve. The reserve is dived into respective five village forest reserves (VFRs). Naming of the VFRs has been done purposely to enable management of the forest to be done by respective villages. The reserve lies between longitudes 35º 05' and 35º 22' East and latitudes 4º 45' and 4º 58' South. The forest has an area of about 45,000 ha. The forest is one of the three blocks of Singida Rural District. It is situated approximately 50 km east of Singida town. Mgori Division borders Kondoa and Hanang Districts to the eastern and northern parts respectively. Miombo types of vegetation dominate in the area. The vegetation type lies entirely within the Somalia-Maasai Regional Centre of Endemism (White 1983). The vegetation cover is mainly composed of *Jubernardia globiflora, Brachystegia speciformis, Combretum zeyheri, Lannea schimperi, Commiphora mossambicensis, Pretocarpus angolensis, Combretum molle* and *Lonchocarpus bussei*.

Forest inventory data

The inventory was carried out in four village forest reserves namely Ngimu, pohama, Unyampanda and Mughuunga. Although size of plots depends on the size of the study forest, a recommendable size of the plots is said to be at least 0.1 ha (Aldred and Alemdag 1988). Using sampling intensity (SI) of 0.05%, sample size was computed as:

$$Ha = FRA * SI$$

Where Ha = sample size in hectare at sampling intensity of 0.05%

FRA = Forest reserve area in hectare

SI = Sampling intensity, which is 0.05%

N = VFRA * SI/0.1ha

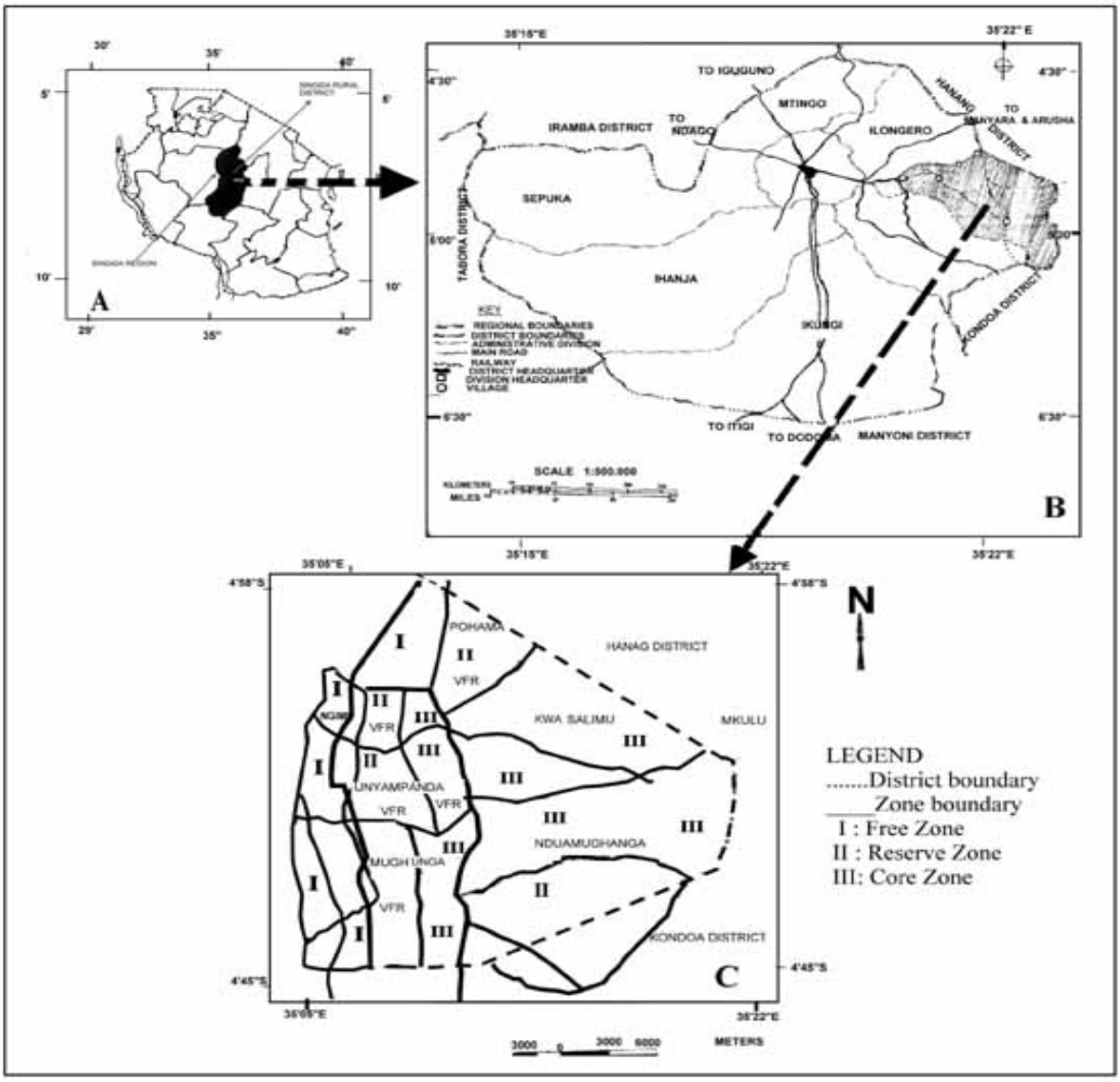

Figure 1: Map of A: Tanzania showing the location of Singida Region B: Singida Rural District showing the location of Mgori Division C: The study area (Mgori Division) showing the location of study villages and forest reserve zones (I-III)

Modified from GoT (1998)

Figure 1 Map of Tanzania (A) showing the location of Singida District in SingidaRegion (B) and Mgori Division (C) showing the location of study villages and forest reserve zones (I-III).

In the four selected village forest reserves, a clustering method was adopted for taking plots. The clusters were randomly selected as shown in the sketch (Figure 1). In each cluster, six 0.1 ha sized, 20 x 50 m plots were obtained at a distance of 200 m within and between transects.

Table 1 Sampling and sample size

VFR	Area coverage (ha)	Sampling intensity (%)	Required sample (ha)	Number of plots
Ngimu	1,966	0.05	0.98	10
Pohama	10,856	0.05	5.43	54
Unyampanda	7,250	0.05	3.63	36
Mughuunga	7,270	0.05	3.64	36
Total	27342	0.05	13.68	136

From each plot, at least 2 cm diameter at breast height (DBH) of every tree/shrub found in the plot was taken. Tree/shrub species was recorded for determination of species composition and diversity. The height of the most abundant tree/shrub species was taken from the smallest, medium and the largest ones. The height measurement during the pilot survey was normalized at one decimal place (0.1 m), while the DBH measurement was at one decimal place (0.1 cm). The tree/shrub height was measured using Sunto Hypsometer. The DBH of the tree/shrub was measured using diameter tape and measuring caliper.

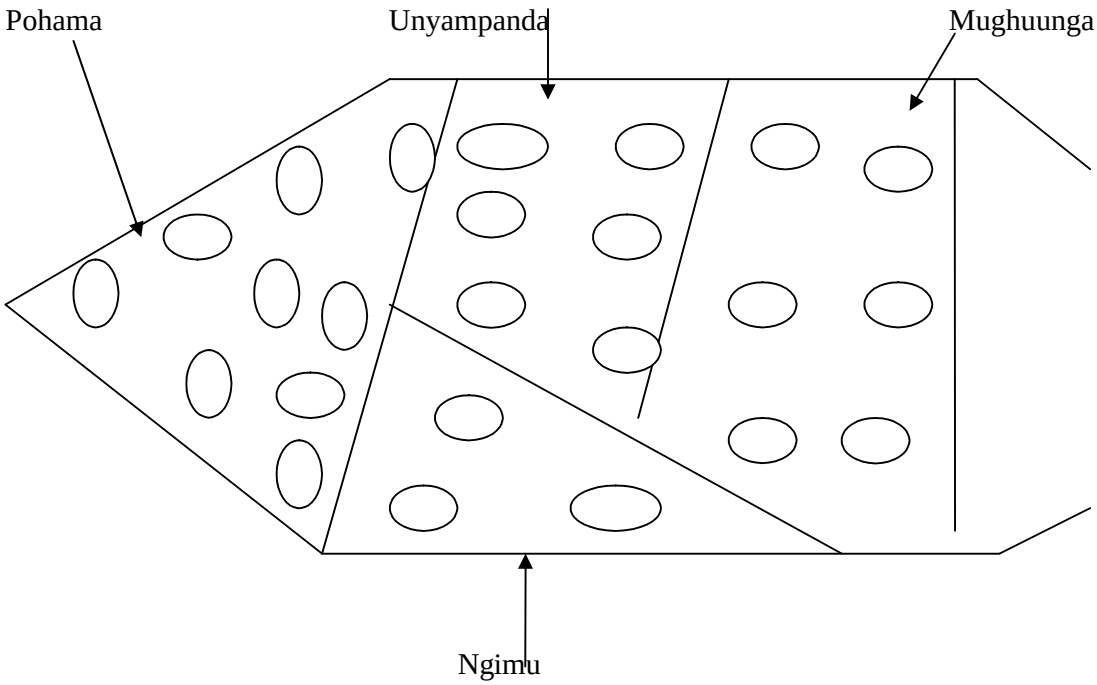

Figure 2: Sketch map showing selected clusters for inventory at Mgori forest reserve in Singida District, Tanzania

For tree/shrub species composition and diversity, in each plot, information on species name, number of stems per plot area and frequencies was collected. Identification of species names was done with the assistance of the plant species identifier. Identification of the plant species was also assisted by field assistants who were involved during the inventory. The field assistants had experience since during the establishment of monitoring plots after the inception of PFM in 1996. Vernacular names of species, which were not easily identified while in the field, were recorded.

Data analysis

Computer software namely Microsoft excels was used for analysing the data for stocking, species diversity and composition.

Stocking

(i) Density - number of stems (N) per hectare (Ha) that is N/Ha.

(ii) Basal area per hectare (G)

$G = 3.14 \times D^2/4$

Where: D is diameter at breast height (DBH)

(iii) Volume per hectare (V)

Volume was computed through adopting the formula which was developed by Malimbwi (1994).

$lnV = -10.145 + 2.69D$

Where: *ln* is natural logarithm

Species diversity and composition

Relative frequency (RF), relative density (RD), relative dominance (RDo), important value index (IVI), Shannon Weiner diversity index (H'), index of dominance (C), species diversity index (SDI), species richness (SR) and species evenness (E) were calculated for determination of composition and abundances of species in the forest.

*(i) Important Value Index (IVI***)**

According to Kent and Coker (1992), the IVI is computed as:

IVI = RF + RD + RDo

Where:

RF = (Frequency of one species)/(sum of all frequencies) x 100

RD = (Number of individuals of a species)/(total number of individuals of all species) x 100

RDo = (Combined G of a single species)/ (total G of all species) x 100

(ii) Shannon Weiner diversity index

According to Kent and Coker (1992), Shannon Weiner diversity index is calculated as:

$H' = -\sum p_i \ln p_i$

Where: H' = Shannon Weiner diversity index

pi = The proportion of individual or the abundance of the ith species expressed as a proportion of total cover

ln = Natural logarithm

(iii) Index of dominance

According to Kent and Coker (1992), Index of dominance is calculated as

$C = \sum(ni/N)2$

Where: C = Index of Dominance

ni = Number of species in the sample

N = Total number of individual species in the sample

(iv) Species diversity index (SDI)

According to Kohl *et al.* (1996), species diversity index is computed as:

$SDI = -\sum \log10(pi)/\log10(1/S)$

Where:

S = the number of species at that site (VFR)

Pi = ni/N

ni = total number of individuals in the ith species

N = total number of individual of all species

(v) Species richness

SR = (S-1)/(log10N)

Where: S and N are as for section (iv)

(vi) Species evenness (E)

E = H'/H'max

Where: H'max = log10 (S)

RESULTS AND DISCUSSION

Stocking Stem density

Stem distribution in this study ranged between 494 and 885 N ha^{-1} for Pohama and Ngimu village forest reserves, respectively (Table 2). The diameter class distribution is presented in Figure 3.

According to Margale (1958) in Odum (1971) in Isango (2007), species richness is calculated as:

Table 2 Distribution of stems per hectare at Mgori Forest Reserve in Singida District, Tanzania

VFR	dbh ≤ 5 cm	5 cm < dbh ≤ 10 cm	10 cm < dbh ≤ 20 cm	dbh > 20 cm	Total
Ngimu	225[3]	256	222	150	885
	(94)[7]	(84)	(95)	(52)	(262)
Pohama	64	158	194	79	494
	(38)	(67)	(72)	(40)	(113)
Unyampanda	118	168	164	45	496
	(56)	(85)	(51)	(29)	(135)
Mughuunga	81	155	216	68	521
	(39)	(54)	(78)	(43)	(166)
Average	122	184	199	86	599
	(72)	(48)	(26)	(45)	(195)

[3]Mean value [7]Standard deviation of the mean

The tree/shrub density reported in this study is within the range as reported by different authors studied in miombo woodlands of Tanzania (Malimbwi and Mwansasu 1994; Isango 2004; Backeus *et al.* 2006). It is pointed out that the tree density ranges from 71 to 1041 stems per hectare. The diameter class distribution of miombo woodland stands confirm to De iocourt's q factors procedure with stems frequencies decreasing with increase in dbh (inverse J-distribution). Such distribution is a common characteristic of natural forest with intimate mixture of trees of all age classes. This provides an indication that the stands are developing and regeneration in the forest reserves is existing as well as the population structure is stable (Nduwamungu 1997; Njana 1997; Isango 2007). The diameter class distribution reported in this study is similar to other studies such as Malimbwi and Mwansusu (1994), Isango (2004) and Isango (2007).

Basal area

The basal area in this study varied from 9.65 to 18.50 m^2 ha^{-1} for Pohama and Ngimu village forest reserves, respectively (Table 3). The distribution of basal area based on diameter class was almost followed a J-shaped trend, in which the basal area increases with increase in diameter classes (Figure 4).

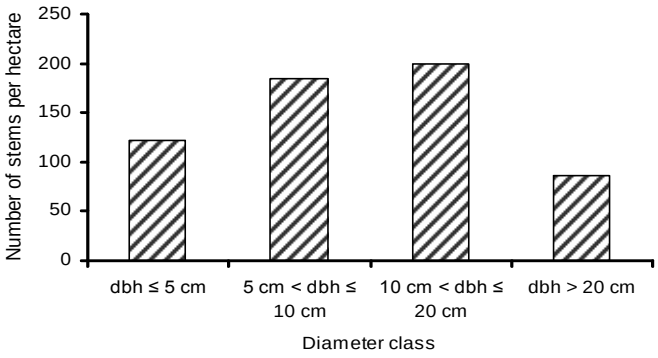

Figure 3: Diameter class distribution of stems at Mgori forest reserve in Singida District, Tanzania

Table 3 Basal area distribution of tree/shrub species at Mgori Forest Reserve in Singida District, Tanzania

VFR	dbh ≤ 5 cm	5 cm < dbh ≤ 10 cm	10 cm < dbh ≤ 20 cm	dbh > 20 cm	Total
Ngimu	0.32[5] (0.14)[7]	1.54 (0.47)	4.86 (2.39)	11.78 (4.70)	18.50 (5.31)
Pohama	0.09 (0.05)	0.92 (0.92)	4.12 (1.70)	4.52 (2.93)	9.65 (3.88)
Unyampanda	0.13 (0.08)	0.74 (0.0.33)	4.16 (1.92)	7.29 (2.67)	12.32 (5.19)
Mughuunga	0.15 (0.19)	0.89 (0.37)	6.89 (5.91)	4.22 (3.06)	12.16 (6.77)
Overall	0.13 (0.13)	0.91 (0.42)	4.92 (3.61)	5.72 (3.69)	11.68 (5.24)

[3]Mean value [7]Standard deviation of the mean

The basal area reported in this study is within the range as reported by different authors who studied in miombo woodlands (Strang 1974; Malibwi and Mwansasu 1994; Bystrom *et al.* 1987; Nduwamugu 1996; Malimbwi and Mugasha 2000; Isango 2004; Isango 2007). For example, Malimbwi and Mwansasu (1994) studied in the same forest reserve, observed that the basal area had a mean of 9.10 m^2ha^{-1}, while Isango (2004) reports a range of 10 to 14 m^2ha^{-1}.

Wood volume

Wood volume in this study is presented in Table 4 while its distribution based on diameter class is presented in Figure 5. The study revealed that the mean wood volume for MFR was 65.99 m^3 ha^{-1} with a range of 54.49 to 104.47 m^3 ha^{-1} for Pohama and Ngimu respectively.

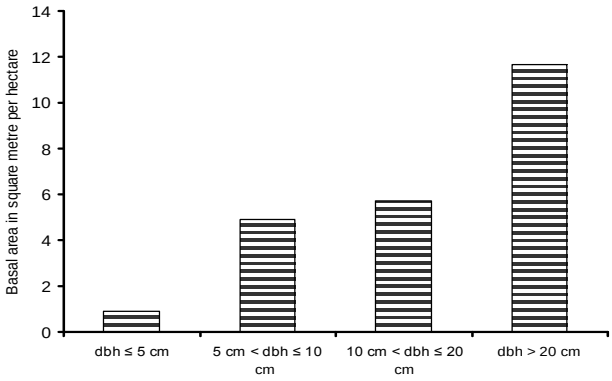

Figure 4: Basal area distribution at Mgori Forest Reserve in Singida District, Tanzania

Table 4 Volume distribution in m3 per hectare at Mgori Forest Reserve in Singida District, Tanzania

VFR	dbh ≤ 5 cm	5 cm < dbh ≤ 10 cm	10 cm < dbh ≤ 20 cm	dbh > 20 cm	Total
Ngimu	1.79[3] (0.78)[7]	8.70 (2.68)	27.45 (13.48)	66.54 (26.56)	104.47 (30.02)
Pohama	0.51 (0.30)	5.22 (2.20)	23.25 (9.58)	25.50 (16.53)	54.49 (19.15)
Unyampanda	0.75 (0.45)	4.18 (1.87)	23.49 (10.83)	41.19 (15.07)	69.61 (21.93)
Mughuunga	0.83 (0.05)	5.05 (2.07)	38.94 (33.37)	23.86 (17.28)	68.67 (38.26)
Average	0.76 (0.72)	5.14 (2.36)	27.79 (20.38)	32.30 (20.82)	65.99 (29.58)

[3]Mean value [7]Standard deviation of the mean

The distribution of wood volume showed a J-shaped structure. The observation is similar to other observations made by different studies such as Temu (1980), Kielland-Lund (1990), Nduwamungu (1996), Isango (2004) and Isango (2007). This reveals that volume increases according to the diameter classes of tree species and miombo woodlands have similar characteristics. From the review of different studies, it is noted that wood volume for miombo woodlands in Tanzania ranges from 39 to 120 m^3 ha^{-1}. Nduwamungu (1996), studying at Kitulangalo SUA Training Forest Reserve observed a mean volume of 71 m^3 ha^{-1}, while Malimbwi and Mugasha (2000) observed a maximum volume of 110 m^3 ha^{-1} in Miombo woodlands of Rufiji. In miombo woodlands in Iringa, Isango (2007) observed a volume value of 65.7 m^3 ha^{-1}.

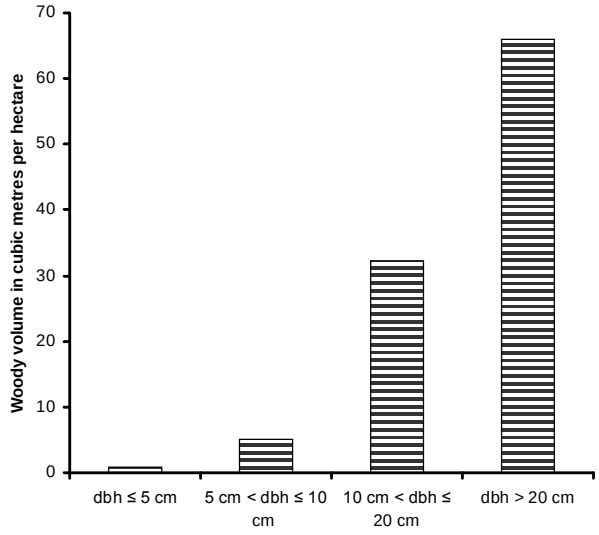

Figure 5: Distribution of wood volume in m^3 ha-1 at Mgori forest reserve in Singida district, Tanzania

Table 5 : Tree/shrub species and biodiversity indices at Mgori Forest Reserve in Singida District, Tanzania

VFR	Number of species	IVI	H'	C	SDI	SR	E
Ngimu	30	10.00	2.54	0.03	38.46	9.65	1.81
Pohama	67	4.48	3.04	0.04	81.90	19.31	1.74
Unyampanda	64	4.62	2.97	0.11	80.57	19.79	1.06
Mughuunga	70	4.29	2.92	0.11	89.36	21.04	1.58
Overall	79	5.85	2.87	0.07	72.57	17.45	1.55

Tree/shrub biodiversity and composition

Measures of plant diversity are many. However, this study selected few of them. Kohli *et al.* (1996) point out that the value of the indices indicates stability of community structure and its value to biodiversity.

Tree/shrub species

A total number of 30, 67, 64 and 70 tree/shrub species were enumerated at Ngimu, Pohama, Unyampanda and Mughuunga village forest reserves, respectively. Overall enumerated total number of tree/shrub species at MFR was 79 (Table 5). Various studies indicate different variations of number of tree/shrub species in miombo woodlands in Tanzania (Mbwambo 2000; Nduwamungu 2002; Malimbwi *et al.* 1998; Luoga 2000; Isango 2004; Backeus 2006; Isango 2007). For example, Mbwambo (2000) enumerated a total number of 34 species in miombo woodlands adjacent to five villages in Tabora, while Isango (2007), Luoga (2000), Backeus (2006) and Malimbwi *et al.*(1998) enumerated a total number of 81, 79, 86 and 95 tree/shrub species respectively. Similarity confirms that most of miombo woodlands have similar vegetation structure and species composition.

Important value index and distribution of dominant trees/shrub species

Important value index (IVI) in this study ranged between 4.29 and 10.00 for Mughuunga and Ngimu village forest reserves respectively (Table 5). Values for relative frequency, density, dominance and IVI for *Brachystegia spiciformis* were higher than other species (Table 4.79).

However, other most abundant tree species include Julbernadia globifolia, Brachystegia microphylla, Combretum zeyheri, Dalbergia stulmannii, Dalbergia nitidula, Combretum molle, Cassipourea mollis, Lochocarpus bussei and Commiphora mosambiensis (Table 6). These types of tree species are the most dominant ones in miombo woodlands (Frost 1996; Chidumayo and Frost 1996).

White (1993) also presents that *Julbernardia*, *Brachystegia* and *Isoberlinia* are the most dominant genera in miombo woodlands. Figures 6, 7 and 8 present distribution of tree/shrub species at MFR in terms of cumnulative frequency, stem and basal area, respectively.

Coverage of dominant tree/shrub species by frequency at MFR was the highest for *Brachystegia spiciformis*, which accounted for 11%. This was followed by *Brachystegia microphylla* (7%), *Julbernadia globifolia* (6%) and *Commiphora mosambiensis* (6%) (Figure 6). Distribution of tree/shrub species by stems was the highest for *Brachystegia spiciformis* (27%) (Figure 4.8). This was followed by *Julbernadia globifolia* (12%) and *Commiphora mosambiensis* (8%) (Figure 7). Distribution of species by basal area followed the same trend that *Brachystegia spiciformis* had 31% coverage compared to other species such as *Julbernadia globifolia* (14%), *Brachystegia microphylla* (8%) and *Commiphora mosambiensis* (7%) (Figure 8). The distribution of the tree/shrub species by frequency stems and basal area ha^{-1} confirms that these are important dominant tree/shrub species in miombo woodlands. The observation is similar to other previous studies such as White (1983), Chidumayo and Forst (1996) and Isango (2004, 2007).

Shannon Weiner diversity index (H')

Shannon Weiner diversity index (H') for Mgori forest reserve ranged between 2.54 and 3.04 for Ngimu and Pohama village forest reserve respectively (Table 5). The overall value for MFR was 2.87. According to Kent and Coker (1992), most often the value of the index lies between 1.5 and 3.5, while Krebs (1989) points out that the maximum value of the index should not exceed 5.0. Increase in the value of the index reflects to also an increase in the number of species. The values in this study are similar to other studies conducted in miombo woodlands. Zahabu (2001) reported the index values of Kitulangalo forest reserve ranged between 2.9 and 3.1, while Isango (2004) reported between 2.3 and 2.9 and Munishi *et al.* (2004) presented between 2.9 and 3.3. However, the values reported in this study are lower than those reported by Nduwamungu (1996), which were 3.3 and 3.8. On the other hand, the values of this

study are higher than those reported by Isango (2007) and Otieno (2000) for community based forest reserves in Iringa and Duru-Haitemba in Babati respectively. Isango (2007) reported values ranged between 1.3 and 1.5, while Otieno (2000) reported the values ranged between 1.0 and 2.0. The values given in this study provide an indication that the species diversity at MFR is high.

Index of Dominance

The values for dominance index averaged at 0.07 from the range of 0.03 to 0.11 for Ngimu and Unyampanda VFRs respectively (Table 5). These values reported in this study are higher than those reported by Nduwamungu (1996) when studying Kitulang'alo SUA Training Forest Reserve (0.03 to 0.06) and Munishi *et al.* (2004) from Usambara and Uluguru mountains forests (0.04 to 0.05). However, the results are similar to those reported by Otieno (2000) when studying Duru-Haitemba Forest Reserve (0.16 to 0.47 with a mean of 0.09). The findings suggest that tree/shrub species at MFR are more diversified than Duru-Haitemba forest reserve. This is attributed to the fact that the index of dominance is lower. However, the species diversity is less than those reported by Munishi *et al.*, (2004) and Nduwamungu (1996).

Species diversity index, richness and evenness

Species diversity index (SDI) is among the measures of biodiversity (Kohli *et al.* 1996). The SDI, in this study ranged between 38.46 to 89.36 for Ngimu and Mughuunga village forest reserves, respectively (Table 5). With exception of Ngimu VFR, the SDI values reported in this study are higher than those reported for community based forest reserve in Iringa, which ranged between 50.2 and 75.9. The overall value of SDI in this study was 76.3 (Isango, 2007). This provides an impression that MFR has more stable vegetation than Community based forest reserve in Iringa as reported by Isango (2007).

Species richness (SR) and evenness (E) are sometimes used to assess the stability of vegetation community (Kent and Coker 1992). The same indices are included in Shannon Weiner diversity index. However, this study computed the indices. The SR ranged between 9.65 and 21.04 for Ngimu and Mughuunga VFRs, respectively with the average of 17.45. For species evenness index, it was observed to range from 1.06 for Mughuunga VFR to 1.81 for Ngimu VFR with the average of 1.55 (Table 5). The species richness values for this study are similar to other studies such as Isango (2007) and Odum (1971).

High values for SDI and SR confirm that the vegetation community in the reserve is of high speicies diversity and richness. The evidence is observed in the study that with exception of Ngimu forest reserve that had few number of species enumerated, the other village forest reserves had high values for sDS and SR. Further, the study observes that low value for speices richness provides information that the forest reserves are of high species diversity as reference is made to Ngimu forest reserve and others (Table 5). The study, generally, confirms that the vegetation community at MFR is stable as for toehr woodlands that are under reserves (Banda *et al.* 2006; Bauckes *et al.* 2006; Isango 2007).

CONCLUSION

Study concludes that the standing parameters for Mogori forest reserve provide similar information as for other forest reserves within miombo woodlands. Species composition and diversity indices are also similar to other miombo woodlands in Tanzania as well as other countries in Africa. This provides evidence that participatory forest management model is effective in conservation of forest reserves as the ecology values are being maintained considering MFR was formerly not under community. An inverted 'J' shape indicates high regeneration takes place in the reserve confirming former human activities within the reserves have been abandoned.

Table 6 : Relative frequency, density, dominance and important value index for the most abundant tree/shrub species at Mgori Forest Reserve in Singida District, Tanzania

Species	Parameters	Ngimu	Pohama	Unyampanda	Mughuunga
	RF (1)	4.65	6.98	9.19	5.19
	RD (2)	7.89	8.67	9.24	5.62
Brachystegia microphylla	RDo (3)	9.65	10.47	6.92	7.22
	IVI (4)	22.19	26.12	25.34	18.03
	1	10.47	12.29	11.66	10.71
	2	24.36	28.95	29.23	27.82
Brachystegia spiciformis	3	27.19	32.58	20.13	51.07
	4	62.01	73.82	61.02	89.61
	1	2.33	1.12	2.47	2.92
	2	1.18	1.41	1.11	2.26
Cassipourea mollis	3	0.54	0.89	2.89	0.77
	4	4.05	3.42	6.48	5.95
	1	8.14	5.59	6.01	3.57
	2	7.20	4.05	5.64	3.25
Combretum molle	3	11.45	2.50	5.31	1.11
	4	26.79	12.13	16.95	7.94
	1	10.47	3.91	3.89	2.27
Combretum zeyheri	2	5.82	4.05	2.88	3.04
	3	1.89	1.78	5.48	1.82
	4	18.18	9.74	12.25	7.13
	1	3.49	5.59	7.07	7.14
	2	1.68	8.10	6.88	8.87
Commiphora mosambiensis	3	0.69	11.61	8.38	4.69
	4	5.85	25.29	22.32	20.70
	1	9.30	2.23	0.35	3.25
	2	6.02	1.07	0.20	3.15
Dalbergia nitidula	3	5.86	0.58	0.16	1.49
	4	21.18	3.88	0.71	7.88
	1	8.14	3.91	0.71	1.62
	2	9.86	3.82	0.39	0.94
Dalbergia stulmannii	3	12.39	3.48	0.66	0.41
	4	30.40	11.21	1.76	2.98
	1	6.98	5.87	6.36	7.47
	2	17.55	7.45	10.94	15.28
Julbernadia globifolia	3	18.64	14.94	7.32	17.39
	4	43.17	28.25	24.63	40.13
	1	2.33	2.51	4.24	3.90
	2	1.28	1.22	2.56	3.10
Lochocarpus bussei	3	0.5	0.80	4.41	1.70
	4	4.10	4.54	11.20	8.69

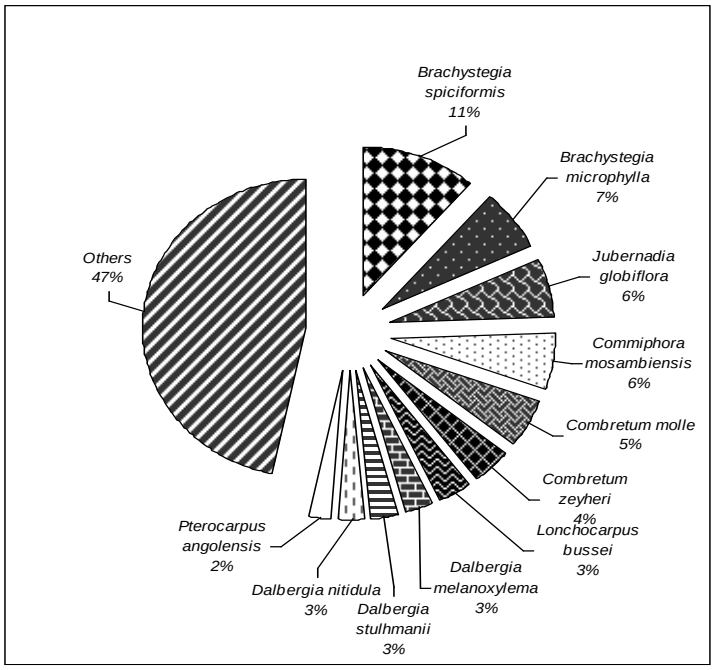

Figure 6: Distribution of important dominant tree/shrub species by frequency at Mgori forest reserve in Singida district, Tanzania

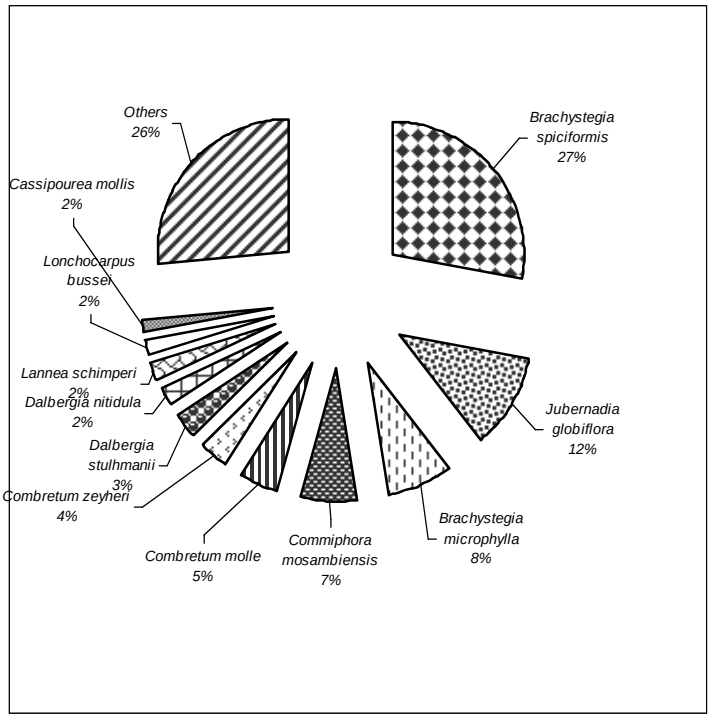

Figure 7: Distribution of important dominant tree/shrub species by number of stems at Mgori forest reserve in Singida district, Tanzania

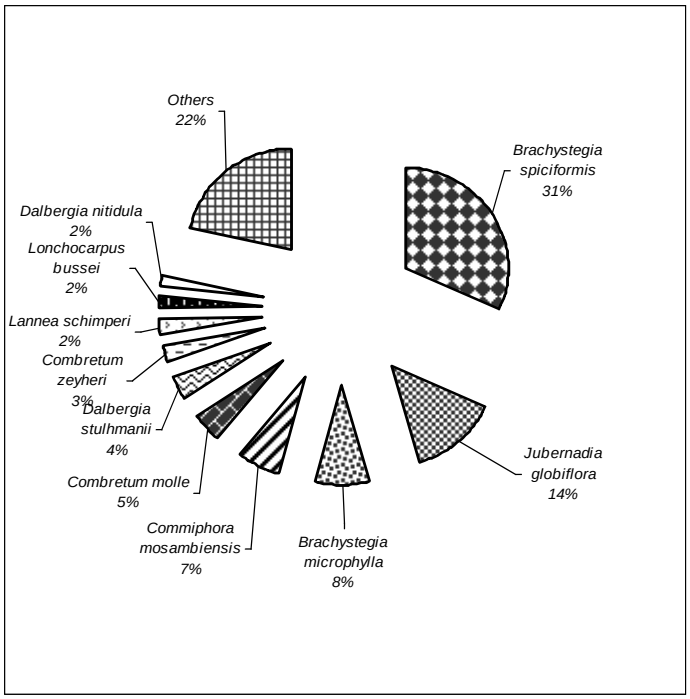

Figure 8: Distribution of important dominant tree/shrub species by basal area at Mgori forest reserve in Singida district, Tanzania

REFERENCES

Ambasht, R.S., 1990. *A test book of plant Ecology*. 10th edition, Students' Friends & Co., Varanasi (India), 373 pp.

Backeus, I., Pettersson, B. and Ruffo, C., 2006. Tree communities and structural dynamics in miombo (*Brachystegia-Julbernadia*) woodlands, Tanzania. *Forest Ecology and Management* 230: 171 – 178.

Banda, T, Schwartz, M. W and Caro, T., 2006. Woody vegetation structure and composition along a protection gradient in a miombo ecosystem of western Tanzania. *Forest Ecology and Management* 230: 179 – 185.

Blomley, T. and Ramadhani, H., 2006. Going to scale with participatory forest management: early lessons from Tanzania. *International Forestry Review* 8 (1): 93 – 100.

Boaler, S. B., 1966. Ecology of miombo site, Lupa North Forest Reserve, Tanzania II. Plant communities and seasonal variation in vegetation. *Journal of Ecology* 54: 465 – 479.

Chamshama, S. A. O., Mugasha, A. G. and Zahabu, E., 2004. Stand Biomass and volume estimation for miombo woodlands at Kitulangalo, Morogoro, Tanzania. *Southern African Forestry Journal* 200: 59 – 70.

Chidumayo E. N. and Frost, P., 1996. Population biology of miombo trees. In: Campbell, B. M. (ed) *The miombo in transition: woodlands and welfare in Africa*. Center for International Forest Research (CIFOR), Bogor, Indonesia, pp 59 – 72.

Chidumayo, E. N., 1995. *Hand book of miombo ecology and management.* Environmental Institute, Stockholm, Sweden.

Chidumayo, E.N., 1990. Above ground woody biomass structure and productivity in Zambezian woodland. *Forest Ecology and Management* 36: 33 – 46.

Clarke, J. M., Cacwndish, W. and Coote, C., 1996. Rural households and miombo woodlands: use, value and management. In: Campebell, B (ed) *The miombo in transition: woodlands and welfare in Africa*. Center for International Forestry

Research (CIFOR), Bongo, Indonesia, pp 101 – 135.

FAO 2003. Practical guidelines for the assessment, monitoring and reporting on national level criteria and indicators for sustainable forest management in dry forests in Asia. Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, Bangkok, Thailand, pp 94.

Frost, P., 1996. The ecology of miombo woodlands. In: Campbell, B (ed) *The miombo in transition: woodlands and welfare in Africa*. Center for International Forestry Research, Bongor, Indonesia, pp 11 - 58

Hobley, M and Shah, K., 1996. *What makes a local organization robust? Evidence from India and Nepal*, London, UK: Overseas Development Institute.

Hobley, M., 1996. Participatory forestry: the process of change in India and Nepal. Rural Development.

Ikakau, T.C., 2002. Mgori forest reserve, Orgut Project Annual Report, Singida, Tanzania, 48 pp.

International Resource Groups, Limited (IRG)., 2000. *Community-based conservation: Experience in Tanzania: An assessment of Lessons Learned*, USAID/Tanzania, Washington DC, USA, pp 42.

Isango, J. A., 2007. Stand Structure and Tree Species Composition of Tanzania Miombo Woodlands: A Case Study from Miombo Woodlands of Community Based Forest Management in Iringa District. *In: Proceedings of the First MITMIOMBO – Management of Indigenous Tree Species for Ecosystem Restoration and Wood Production in Semi-Arid Miombo Woodlands in Eastern Africa Project Workshop*, held in Morogoro, Tanzania, 6th–12th February 2007, Working Papers of the Finnish Forest Research Institute 50: 43–56 MITMIOMBO. http://www.metla.fi/julkaisut/workingpapers/2007/mwp050.htm

Isango, J.A., 2004. Impact of fire on the woody vegetation in Mgori forest reserve, Singida, Tanzania. MSc. Dissertation, Addis Ababa, University, 93 pp.

Janzen, D.H., 1993. Taxonomy: Universal and essential infrastructure for development of tropical woodland biodiversity. In: (eds. Sandland, O.T and Schei, P.J.) *Proceedings of the Norway/UNEP expert conference on biodiversity*, Trontheim, Norway.

Kajembe, G.C., Namubiru, E.L., Shemwetta, D.T.K Luoga, E.J. and Mwaipopo, C.S. 2004b. The impact of rules in forest conservation in Tanzania: Case of Kwizu forest reserve, Same District, Kilimanjaro. *In*: Shemwetta, D.T.K, Luoga, E.J., Kajembe, G.C. and Madoffe, S.S.(eds) *Institutions incentives and conflicts in forest management: A perspective, Proceedings of the IFRI East African Regional Conference*, Held on 12th – 13th January 2004 in Moshi, Tanzania, pp 92 – 107.

Kajembe, G.C., Nduwamungu, J and Luoga, E.J. 2004a. The impact of community based forest management and joint forest management on the forest resource base and local people's livelihoods. Case studies from Tanzania. Commons Southern Africa Occasional Paper Series No. 8. Centre for Applied Social Science and Programme for Land and Agrarian Studies.

Kent, M. and Coker, P., 1992. *Vegetation description and analysis, a practical approach*. Belhaven press, 25 Flora Street, London. 363 pp.

Kielland-Lund, J., 1990. Phytosociology and productivity of four forest and woodland communities near Morogoro. In: Mgeni, A.S.M, Abeli, W.S., Chamsahama, S.A.O. and Kowero, G. (eds). *Proceedings of a joint seminar/workshop on Management of natural resources of Tanzania*, under SUA/AUN on cooperation. 5-10th December 1990, Arusha, Tanzania. Faculty of Forestry, Records, Sokoine University of Agriculture, No. 43 pp 2 – 15.

Kochhar, S.L., 1981. *Tropical crops*. Macmillan publishers, Ltd, London.

Kohli, R. K., Singh, H. P. and Rani, D., 1996. Status of floor vegetation under some

monoculture and mix culture plantations in North India. *Journal of Forest Research* 1: 205 – 209.

Krebs, C. J., 1989. *Ecological methodology*. Harper Collins Publishers, New York. 654 pp.

Lovett, J. C., 1996. Elevational and latitudinal changes in tree associations and diversity in the eastern arc mountains of Tanzania. *Journal of Tropical Ecology* 12:629 – 650.

Luoga, E. J., 2000. The effects of human disturbances to population dynamics and diversity of miombo woodlands of eastern Tanzania. PhD thesis, University of Witwatersrand, Johannesburg, South Africa.

Malimbwi, R. E. Solberg, B. Luoga, E.J., 1994. Estimation of biomass and volume in miombo woodlands at Kitulangalo Forest Reserve Tanzania. *Journal of Tropical Forest Sciences. 7(2): 230 - 242.*

Malimbwi, R. E., 2003. Inventory reports of Ayasanda, Bubu, Duru, Endagwe, Endanachan, Gidas, Hoshan and Riroda village Forest Reserves in Babati, Manayra, Tanzania. Land Management Programme (LAMP), Babati District Council, Manyara Region, Tanzania.

Malimbwi, R. E., Kielland-Lund, J., and Nduwamungu, J. 1998. Species diversity and standing crop development in four miombo vegetation communities. Faculty of forestry, Sokoine University of Agriculture, Morogoro. Tanzania.

Malimbwi, R.E. and Mugasha, A.G., 2000. *Inventory report for Chome catchment forest reserve in Same District, Tanzania*. South Kilimanjaro Forest Project, FORCONSULT, Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture, Morogoro, Tanzania, 48 pp.

Malimbwi, R.E., Misana, S., Monela, G.C., Jambiya, G. and Zahabu, E., 2000. Impact of charcoal extraction to the forest resources of Tanzania: The case of Kitulangalo area, Tanzania. *Proceedings of the first University wide Scientific conference.* Held at the Institute of Continuing Education (ICE), Sokoine University of Agriculture, Morogoro, Tanzania, on 5th – 7th April 2000, pp 386 – 406.

Meshack, C.K., Adhikari, B., Doggart, N., Lovett, J.C., 2006. Transaction Costs of Community Based Forest Management: Empirical evidence from Tanzania. *African Journal of Ecology* 44: 468 - 477.

Misra, K.C., 1989. *Manual of plant ecology*. 3rd edition, Oxford and IBH Publishing Co. Pvt Ltd, New Delhi, 491 pp.

Molnar, A., Scherr, S.J. and Khare, A., (2004). Who conserves the world's forests? A new assessment of conservation and investment trends. Forest Trends, Washington DC, pp 83.

Munishi, P.K.T., 2001. The eastern Arc Mountain Forests of Tanzania: Their role in biodiversity, water resource conservation and net contribution to atmospheric carbon. PhD Thesis, College of Natural Resources, North Carolina State University, USA, 128 pp.

Munishi, P.K.T., Shear, T.H., Wentworth, T., Temu, R.P.C. and Maliondo, S.M., 2004. Sparse distribution patterns of some plant species in two Afromountane rain forests of the Eastern Arc Mountains of Tanzania. *Tanzania Journal of Forestry and Nature Conservation* 75: 74 – 90.

Nduwamungu, J., 1996. Tree and shrub diversity in miombo woodland: A case study at SUA Kitulungalo Forest Reserve, Morogoro, Tanzania. MSc. Dissertation, Sokoine university of Agriculture, Morogoro, Tanzania, 135 pp.

Njana, R., 1998. Prospects of local people's involvement in the management of catchment forest reserves. A case study of North Mawiwa-Kissara catchment forest reserve, Morogoro, Tanzania. MSc. Dissertation, Sokoine University of Agriculture, Morogoro, Tanzania, 137 pp.

Odum, E. P., 1971. *Fundamentals of Ecology*. 3rd edition. W.B. Saunders, Philadelphia. 574 p.

Oosterhoorn, M and Kappelle, M., 2000. Vegetation structure and composition along an interior-edge-exterior gradient in Costa Rican montane cloud forest. *Forest Ecology and Management* 126: 291 – 307.

Otieno, J. N., 2000. Biomass inventory and potential of indigenous medical plants: A case study of Duru-Haitemba community forests in Babati district, Arusha, Tanzania. MSc. Dissertation, Sokoine University of Agriculture, Morogoro, Tanzania, 122 pp.

Perkulis, A. M., Prado, J.M.R., and Jimenez-Osornio, J.J. 1997. Composition, structure and management potential of secondary dry tropical vegetation in two abandoned henequen plantations of Yucatan, Mexico. *Forest Ecology and Management* 94: 79-88.

Phillip, M.S., 1994. *Measuring Trees and Forests*. 2nd Edition. CAB International. Oxon, UK, 310 pp.

Plumptre, T and Graham, J., 1999. *Governance and Good Governance: International and Aboriginal Perspectives*. Institute On Governance, Ottawa, Ontario, Canada, pp 27.

Scott, C. T., 1997. Sampling methods for estimating change in forest resources. *Ecological Applications* 8 (2): 228 – 233.

Sunseri, T., 2005. Something else to burn: forest squatters, conservationists, and the state in modern Tanzania, *Journal of Modern African Studies* 43(4): 609 - 640.

Temu, A.B., 1980. Miombo woodlands inventory design, a response to fuel wood scarcity in Tabora. Unpublished PhD thesis. University of Dar es Salaam.

URT 1998. *Tanzania forestry policy*. Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism, Dar es Salaam, Tanzania, 59 pp.

URT 1999. *Village Land Act No 5 of 1999*. Ministry of Lands and Human Settlements. Dar es Salaam, Tanzania, 227 pp.

URT 2001. *National Forest Programme 2001 – 2010*. Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism. Dar es Salaam, Tanzania, 133 pp.

URT 2002. *The Forest Act No 7n of 7th June 2002*. Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism, Dar es Salaam, Tanzania, 174 pp.

Western, D and Wright, R. M., 1994. Natural connections perspectives on community-based conservation. In: Roe, D. (ed.) *Promoting partnership, managing wildlife resources in central and West Africa.* Evaluating Eden Series No. 3. International Institute for Environment and Development, London, UK .

White, F., 1993. *Vegetation of Africa*. National Resources Research No. 20 UNESCO, Paris, 356 pp.

Wily, A.L., 2002. *Participatory forest management in Africa. An overview of progress and issues*. (CBRNM Net series.) Retrieved on 28th April 2005 from the world wide web: www.cbnrm.net/pdf/aldenwily_l_002_cfm.pdf.

Wily, L. A., 1998. Devolution: the critical institutional change in future resource management -- A case from the forestry sector of Tanzania. The World Bank/WBI's CBNRM, Washington DC, USA.

Wily, L.A. and Dewees, P.A., 2001. *From Users to Custodians-Changing relations between people and the state in forest management in Tanzania*. Policy research Working Paper, WPS 2569, Environment and Social Development Unit, The World Bank, 31 pp.

Wily, L.A., 1996. *Collaborative forest management - villagers and government: the case of Mgori Forest, Tanzania.* FAO Forest Trees and People Programme, Working Paper. Rome, FAO .Retrieved on 28th April 2005 from a world wide web: http://treesandpeople.lbutv.slu.se.

Wily, L.A., 1997. Villagers as forest managers and governments 'learning to let go' The case of Duru-Haitemba and Mgori forests in Tanzania. *Forest participation Series* (9). IIED, London, UK.

Wily, L.A., 2001. Forest *Management* and Democracy in East and Southern Africa: Lessons from *Tanzania*. No. 95 Gatekeeper Series, IIED, London.

World Rainforest Movement (WRM) 2002. Tanzania: Improving forest management through joint management with communities. WRM bulletin; no. 64.

Zahabu, E., 2001. *Impact of charcoal extraction on the miombo woodlands: The case of Kitulangalo area, Tanzania*. MSc. Dissertation, Sokoine University of Agriculture, Morogoro, Tanzania, 106 pp.

Appendix 1 : List of woody species found at Mgori forest reserve in Singida District, Tanzania

Botanical Name	Local Name	Botanical Name	Local Name	Botanical Name	Local Name
Acacia hockii	Munying'anyi	*Commiphora mosambiensis*	Muntonto	*Ozoroa insignis*	Munyongwampee
Acacia senegalsis	Mujighulu	Commiphora ngogensis	Mujuhu	*Pavetta schumanniana*	Munkuharii
Acacia sieberana	Mukese	*Commiphora ugogensis*	Musake	*Phylanthus ingleri*	Mubolomi
Acacia tortilis	Mughuunga	*Dalbergia melanoxylema*	Mufako	*Pleuurostylia africana*	Mufafati
Acaia tanganyikensis	Mughangachuma	*Dalbergia nitidula*	Mubibi	*Pramna senensis*	Munyukinyuki
Accacia drepandobium	Mwandui	*Dalbergia stulhmanii*	Musisi	*Pseudolachostylis maprouneifolia*	Muranghambili
Adansonia digitata	Mwandui	*Dichrostachys cinerea*	Mutunduru	*Pterocarpus angolensis*	Muhinga
Afzelia quanzensis	Mukola	*Diospyros usambarensis*	Muriyoriyo	*Pterocarpus rotundifolius*	Musalaka
Albizia antunesiana	Munyingafumbu	*Dolichos oliveri*	Mughongoafage	*Pyrenacantha kaurabassana*	Muiro
Albizia harvei	Mupogowa	*Erythrina abyssinica*	Mupipiti	*Schreberia tricoclada*	Muuma
Albizia petersiana	Musimihi	*Euphorbia candelabrum*	Mwange	*Sclerocarya birrea*	Muhuvi
Albizia zetersiana	Mpilo	*Ficus stuhlmanii*	Musaghaa	*Shrebera trichoclada*	Mwama
Azanza garckeana	Mutongho	*Greela arborea*	Mudoghwe	*Solanum incanum*	Mutula
Boscia angustifolia	Mutii	*Grewia platyclada*	Musuna	*Strychnos cocculoides*	Mukuhughundu
Boscia salicifolia	Muhuka	*Hymenodictyon parvifolium*	Mukumiankoo	*Strychrios potaforum*	Mupande
Brachystegia microphylla	Mukinki	*Isoberlinia angolensis*	Mukonjee	*Terminalia mollis*	Mughuka
Brachystegia spiciformis	Mufumbu	*Jubernadia globiflora*	Mufumbu 2	*Terminalia sericea*	Mufuru
Bridelia duvigneaudii	Musekea	*Kigelia africana*	Mugunghu	*Tricalysia ruandensis*	Muhuti
Canthium burtii	Musule	*Lannea humilis*	Muhinti	*Vangueria infausta*	Mulade
Cassipourea mollis	Mutuampiti	*Lannea schimperi*	Mughumbu	Vangueria madascaensis	Mukukutu
Catunaregam spinosa	Mupongwa	*Lonchocarpus bussei*	Muvae	*Vitex mombassae*	Musasati
Cissus rubiginosa	Mubwammwaka	*Margaritaria discoidea*	Museka	*Xeroderris stunhlmannii*	Mujimbua
Combretum collinum	Mufafage	*Markamia lutea*	Mughwanda	*Ximenia caffra*	Mutundwi
Combretum molle	Murama	*Markamia obtsifolia*	Mulili	*Zanha africana*	Mujijiu
Combretum obovatum	Mughianduata	*Multidentia crassa*	Mukukumaka		
Combretum zeyheri	Muhanyati	*Mundulea sericea*	Muheruheni		
Commellina beghalensis	Mungo'ngo	*Ormmocarpum trichocarpum*	Murori		
Commiphora africana	Mulalahai	*Ormocarpum trichocarpum*	Musimbwa		