

Species Composition, Richness and Diversity in Miombo Woodland of Bereku Forest Reserve, Tanzania

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ABSTRACT There is increased interest in the academic world with regards to tree and shrub species richness and diversity within the Miombo Woodlands and to determine the potential for biodiversity conservation. This study assessed species richness, diversity, dominance and exploitation of tree and shrub in Bereku Forest Reserve. Plant inventory was carried out in 80 systematically selected sample plots. The information recorded includes: diameter at breast height, species name and frequency of regenerants. Analysis of inventory data was done by using Microsoft Excel. A total of 110 species belonging to 53 families were identified. Results showed Shannon-Wiener Index and Simpson Diversity Index of 4.27 and 0.043 respectively for the Miombo woodland of Bereku. Moreover, the findings in this study show mean stems density and mean total density of regenerants of 616 stems per hectare and 2780 stems per hectare respectively. The paper concludes that despite the Miombo Woodland providing products and services to the surrounding communities the woodland is still fairly stocked with high tree and shrub species diversity. The study recommends in-depth forest inventory, preparation of management plan and promotion of good governance in management of Bereku forest reserve.

1. INTRODUCTION

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 et al. 1996). Miombo Woodland is distinguished from other African savanna, woodland and forest formations by the dominance of tree species in the family Fabaceae, subfamily Caesalpinioideae, particularly in the genera *Brachystegia*, *Julbernardia* and *Isoberlinia* (Frost 1996). These genera are seldom found outside Miombo. Although this dominance by Caesalpinioideae is characteristic, their contribution to numbers and biomass varies extensively within and between communities (Frost 1996). What factors favour this dominance is an interesting but as yet largely unanswered question, though the widespread occurrence of ectomycorrhizae in their roots may enable them to exploit porous, infertile soils more efficiently than groups lacking ectomycorrhizae (Högberg and Nylund 1981). The composition and structure of Miombo Woodland appears superficially to be relatively uniform over large regions, suggesting a broad similarity in key environmental conditions. Woody plants comprise 95-98% of the aboveground biomass of undisturbed stands; grasses and herbs make up the remainder (Chidumayo 1993a). The woodlands typically comprise an upper canopy of umbrella shaped trees; a scattered layer, often absent, of subcanopy trees; 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 species composition, diversity and structure are more apparent at a local scale. The origin of these differences is unclear: 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 1987c), have all been implicated. According to Chidumayo (1989a), anthropogenic activities play a big role in the dynamics of miombo woodlands. The species diversity and composition have been shaped 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 tree and shrub diversity have been shaped is inadequate. This study assessed species richness, diversity and dominance of tree and shrub in Bereku Forest Reserve (BFR). BFR is a Central Government owned forest located in Manyara region. It is managed through Joint Forest Management (JFM). It is against this background that the area is selected for this study since it is a good representative of a forest managed jointly in Northern part of Tanzania and as such it is worthy assessing species diversity under this forest management regime.

2. MATERIAL AND METHOD

2.1 The Study Area Description

Babati district is located at latitude 4°132 South and longitude 35°452 East, 1300-1800 m.a.s.l, Manyara Region, northern part of Tanzania. The district has a total area of 6069 km^2. It is bordered to the north by the Arusha Region, to the southeast by the Simanjiro District, to the south by the Dodoma Region, to the southwest by the Hanang District, and to the northwest by the Mbulu District. The Bereku forest has a total area of about 5670 ha (Fig. 1). The forest is typical dry Miombo woodland located within the Rift valley, about 20 km south of Babati township, accessed by road.

According to the 1988 population census of Tanzania, the district hosts 208,000 people compared to 95 411 people in 1928. Currently, more than 379 000 people live in Babati district. Bereku forest reserve is surrounded by 9 villages with a total population of about 17 000 people. Most of the villages are linked by paths except for a few that link the main roads. The main socio-economic activities of the people in study area include agricultural production and livestock keeping. Other activities include: beekeeping, fishing and lumbering. Cultivated food crops include: maize, beans, simsim, paddy and groundnuts. Cash crops which are given high priority in the area include: pigeon peas and sunflower. Livestock keeping is mainly extensive though there are some zero grazing and semi-intensive systems. Part of the grazing is done in the forest reserve, which is a key contributor to land degradation.

2.1 Data Collection

Forest inventory was conducted to understand tree and shrub species diversity, their distribution and estimate the available stock in the woodland. Forest inventory is defined as the procedure for obtaining information on the quantity and quality of the woodland resources and other characteristics of the land on which the trees and shrubs are growing (Malimbwi 1997). The actual inventory was preceded by a reconnaissance survey which involved establishing transects and plot laying-out on the map of the forest reserve. To cover the whole woodland area and variation between vegetation cover. Systematic sampling design was adopted in this study. In this study, systematic sampling design ensured an even

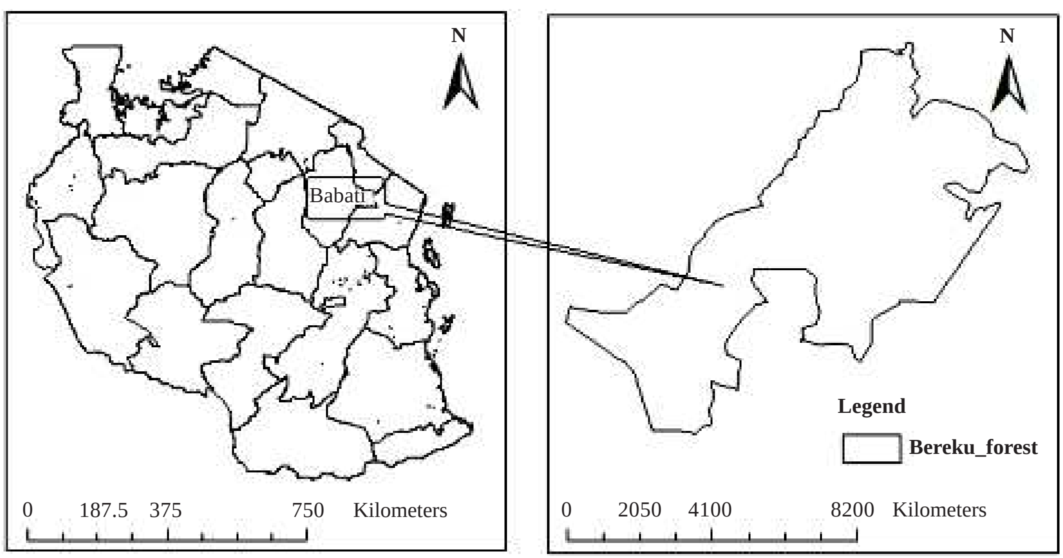

Fig. 1. The study area map

spread of the samples throughout the woodland area and thus increase the chances of including all vegetation types in the woodland (Philip 1994).

This study adopted a sampling intensity of 0.1% which is equivalent to 80 sample plots. Reasons behind this include limited finances and time constraint. Synnot (1979) recommended sampling intensity within a range of 0.5% to 0.7% for tropical natural forest inventories. However, according to Malimbwi and Mugasha (2002) and Malimbwi et al. (2005), financial and time constraints and purpose of the forest inventory may dictate the sampling unit to be as low as 0.01%. Circular shaped sample plots were adopted because they are easy to use, they reduce edge effects in the samples and counting errors during inventory of border trees are minimised. 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 includes: diameter at breast height (dbh), tree and shrub species names, regenerants frequency, Geographical Positioning System (GPS) readings, indicators of human disturbances such as trees cut, poles cut, charcoal kilns, pit sawing, burnt areas and grazing.

2.3 Data Analysis

The data were analysed for species composition, richness, diversity, Species Importance Value Index (IVI). Species importance values were computed as the average of the relative basal area, density and frequency. The IVI for a species is a composite of three ecological parameters – density, frequency and basal area, which measure different features and characteristics of a species in its habitat. Ecologically, density and frequency of a species measure the distribution of a species within the population while basal area measures the area occupied by the stems of trees. Species diversity was computed using Shannon's and Simpson's diversity indices. The Shannon Diversity Index was computed as ($H' = \Sigma Pi{*}\ln Pi$) where H' is the index of diversity, Pi is the importance value of a species as a proportion of all species. Simpson's Diversity Index was computed as $C = \Sigma Pi^2$ where C is the index number and Pi as defined above (Munishi et al. 2008). The knowledge of species diversity is useful for establishing the influence of biotic disturbance, and the state of succession and stability in the environment (Misra 1989). This species diversity index increases with the number of species in the community (Krebs 1989).

3. RESULT AND DISCUSSION

3.1 Species Composition and Richness

Table 1 shows the general characteristics of Bereku tree resources. A total of 110 tree and shrub species were identified, out of these trees constituted 75% while shrubs were 25%. The species richness (110) of trees and shrub observed in this study compares well with the Miombo forest occurring in other areas. Luoga (2000) enumerated 79 species in Kitulanghalo Forest Reserve while Backeus (2006) found 86 species around Ihombwa village. Njana (2009) and Mafupa (2006) found 82 and 46 species in Urumwa forest reserve and Igombe river forest reserve respectively. The high number of species richness in the study area is attributed to the presence of the riverine forest that contributes to the growth of many species. Climatic, edaphic variability and anthropogenic activities are other factors associated to the difference in species richness. Chidumayo (1989a) reported that anthropogenic activities play big role in the dynamics of Miombo Woodlands.

Table 1: Characteristics of tree and shrub resources in the Bereku forest reserve

Parameter	*Values*
Richness (Total number of species)	110
Density (stems/ha)	616
Density of regenerants (stems/ha)	2780
Shannon's Index	4.27
Simpson's Index	0.04

3.2 Species Diversity

The study revealed Shannon-Wiener Index of diversity (H') of 4.27 for the Miombo Woodland (Table 1). This index tells about species richness (number of species) and evenness (species distribution) (Magurran 1988), the larger the value of H' the greater the species diversity and vice versa. An ecosystem with H' value greater than 2 has been regarded as medium to high diverse in terms of species (Barbour et al. 1999). Thus, Miombo Woodland of Bereku has rationally high species diversity. Species noted to have contributed to high species diversity include: *Brachystegia microphylla* Harms (0.42), *Brachystegia spiciformis* Benth (0.22), *Julbernadia globiflora* (Benth.) Troupin (0.24), *Combretum molle* R.Br ex G. Don (0.17) and *Markhamia obtusifolia* (Baker) Sprague (0.14). Comparative studies elsewhere in Miombo Woodlands by a number of scholars have shown small values. Nduwamungu (1997) and Zahabu (2001) reported H' value of 3.79 and 3.13 respectively in Miombo Woodlands of Kitulangalo forest reserve in Morogoro, Tanzania. Recent studies in Miombo Woodlands of Urumwa forest reserve Tabora, Tanzania by Njana (2008), Igombe river forest reserve, Tabora, Tanzania by Mafupa (2006) and Handeni Hill forest reserve, Tanga, Tanzania by Mohamed (2006) reported H' values of 3.40, 2.90 and 3.10 respectively. The bigger the value (4.27) from present study is associated with the presence of riverine forest that found rich in species composition and diversity in miombo woodland of Bereku forest reserve.

3.3 Species Dominance

The study came up with index of dominance (ID) of 0.043 for Miombo Woodland (Table 1). The lower the index value, the lower the dominance of a single or few species (Edward 1996). Misra (1989) reported the greater the value of index of dominance the lower the species diversity and vice versa in the scale of 0 to 1. The index of dominance value in this study is relative smaller compared to what has been found by other studies in Miombo Woodlands implying that the probability of picking randomly two individuals belonging to the same species is very low or the probability that any species encountered at random would be different species. Njana (2008) reported ID value of 0.056 in miombo woodlands of Urumwa forest reserve Tabora, Tanzania, Mafupa (2006) reported ID value of 0.088 and 0.135 in undisturbed and disturbed strata of miombo woodlands of Igombe river forest reserve, Tabora, Tanzania respectively while Malimbwi and Mugasha (2002) and Mohamed (2006) recorded ID values of 0.073 and 0.063 respectively in miombo woodlands of Handeni Hill forest reserve, Tanga, Tanzania.

3.4 Importance Value Index (IVI)

Importance value index provides knowledge on important species of a plant community. Based on IVI *Brachystegia microphylla* Harms was most dominate species followed by *Brachystegia spiciformis* Benth, *Julbernadia globiflora* (Benth.) Troupin, *Combretum molle* R.Br ex G. Don, *Parinari curetellifolia* Planch. Ex Benth and *Markhamia obtusifolia* (Baker) Sprague. Others were *Dombeya rotundifolia* (Hochst.) Planch., *Vernonia amygdalina* Delile, *Faurea rochetiana* (A. Rich.) Pic.Serm and *Bridelia micrantha* (Hochst.) Baill. Figure 2 shows the distribution of important tree and shrub species in the woodland. These results disclose that, the most important species in Bereku forest reserve have high diversity in the scale of Shannon-Weiner Index of Diversity. The IVI rank species in a way as to give an indication on which species come out as important element of the miombo trees (Munishi et al. 2008).

3.5 Stem Density of Standing Trees and Shrubs (N)

The total mean stems density in UFR was found to be 616 ± 46 for trees and shrubs with greater than 4 cm diameter at breast height. Figure 3 shows an inverted 'J' shape which is common for natural forests with active regeneration (Phillip 1983) and recruitment. Accordingly, active regeneration and recruitment in miombo woodland of BFR as portrayed in this study is a good sign of sustainability of the woodland stock which has chances of insuring sustainable supply of products and services; and hence sustained livelihoods of the woodland dependants.

3.6 Stem Density of Regenerants

The results show that, mean total density of regenerants was 2780 ± 20 stems per hectare. Figure 3 shows the distribution of regenerants in the miombo woodland. It shows that, *Brachystegia microphylla* (19%), *Brachystegia spiciformis* (14%), *Jubernadia globiflora* (11%), *Brachystegia utilis* (8%), *Parinari curatellifolia* (5%), *Dodonea viscosa* (5%), and *Markhamia obtusifolia* (4%) are among the most regenerating species in Bereku forest reserve (Figure 4). From these results it suffices to conclude that, the most regenerating species are possibly the

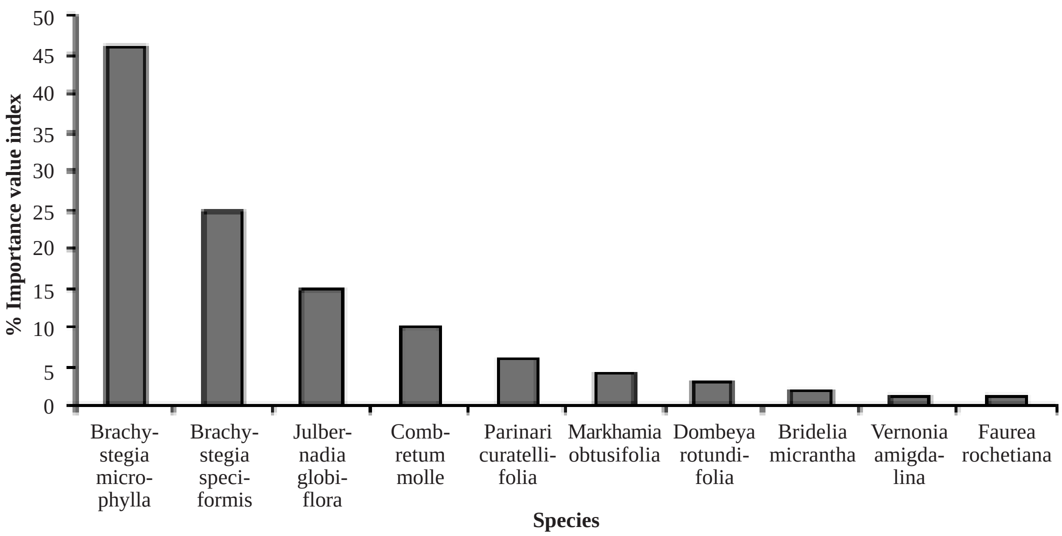

Fig. 2. Tree and shrub species richness according to IVI in Bereku forest

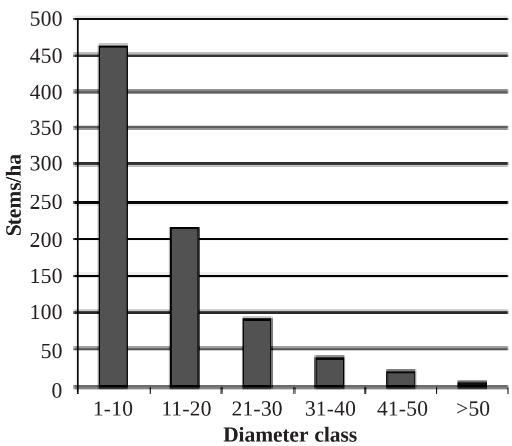

Fig. 3. Distribution of number of stems per hectare of standing trees by diameter class (Sample plots = 80)

most exploited species by local communities in their daily livelihood activities and the ones browsed by domestic animals. Regeneration in miombo is mainly from stump coppices, stump/root sucker shoots and recruitment from old stunted seedlings already present in grass layer at the time of tree cut, fall or death (Chidumayo 1993, 1997). Moreover, comparing Figure 4 with Figure 2, it can be deduced that the forest is moving towards a more balanced one with a different composition of species, as the regenerants of *B. microphylla*, which seems the "dominant" species as a tree, give place to other species (38% of trees against 19% of regenerants).

3.5 Tree and Shrub Species Exploitation

Regardless of high plant diversity in Bereku forest reserve, valuable timber tree species have been harvested illegally to the extent that it was very occasional to encounter mature stems in the forest during forest inventory. The tree species include: *Pterocarpus angolensis*, *Pterocarpus rotundifolius*, *Albizia verscolor and Dalbergia melanoxylon.* This was evident in the number of coppices observed from the stumps, indicating that stems were cut. Presence of pits and wooden platform for sawing in the forest also justifies illegal harvesting of the mentioned tree species. This is in line with study by Malambo and Syampungani (2008) in Miombo Woodlands of Zambia who reported that illegal and selective logging of valuable species such as *Pterocarpus angolensis, Afzelia quanzensis, Dalbergia melanoxylon* and *Isoberlinia angolensis* contribute to over exploitation of these tree species. Furthermore, the presence of cut stumps and old earth kilns in the forest revealed that charcoal making is crucial activity in the study area. Species frequently used for charcoal were *Combretum molle*, *Brachystegia* and *Julbernadia* species. A study in western Tanzania by Monela et al. (2007) reported that charcoal production venture is growing high because it is taken as part time job to supplement farmers' income. Sandalwood (*Osyris lanceolata*) was found to be vulnerable plant species in the reserve. This is because people illegally harvest entire plant

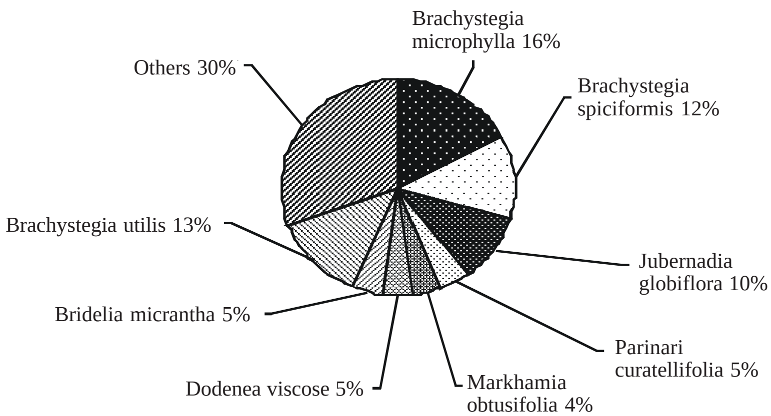

Fig. 4. Distribution of regenerant species in BFR (Number of species = 48)

body (root and stem) for sale. This limits the regeneration of this species by seeds and coppices from the stumps and roots. Sandalwood oil is used for perfume manufacture and it is one of the oldest known perfume materials.

4. CONCLUSION

The study revealed that the Miombo Woodland of Bereku forest reserve has a reasonably good tree and shrub species composition and richness. Species noted to be both dominant and with high species diversity indices include: *Brachystegia spiciformis* (0.41), *Brachystegia spiciformis* (0.23), *Julbernadia globiflora* (0.24), *Combretum molle* (0.18). These dominant as well as highly diverse tree and shrub species fit quite well within the general definition of Miombo Woodlands. However, species richness for some timber tree species such as *Pterocarpus angolensis, Dalbergia melanoxylon, Pterocarpus rontundifolius, and Albizia verscolor* was very poor due to overexploitation. The harvesting involves wood fuel collection and building materials like timber, poles and withies. Generally, the regeneration of the Miombo Woodland was found to be good. This indicates a good sign of sustainability of the woodland stock which has chances of ensuring sustainable supply of products and services and hence sustains livelihoods of the surrounding communities.

5. RECOMMENDATION

The study recommends in-depth forest inventory, preparation of management plan and promotion of good governance in management of Bereku forest reserve.

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REFERENCES

Backéus I, Pettersson B, Strömquist L, Ruffo C 2006. Tree communities and structural dynamics in Miombo (*Brachystegia-Julbernadia*) Woodland, Tanzania. *Forest Ecology and Management,* 230: 171 - 178.

Barbour M, Burk JH, Pitts WD, Gillians FS, Schwartz MW 1999. *Terrestrial Ecology*. Chicago, Illinois: Addson Wesley Longman, Inc.

Campbell BM, Swift MJ, Hatton J, Frost PGH 1988. Small-scale vegetation pattern and nutrient cycling in Miombo Woodland. In: JTA Verhoeven, GW Heil, MJA Werger (Eds.): *Vegetation Structure in Relation to Carbon and Nutrient Economy.* The Hague: SPB Academic Publishing, pp. 69-85.

Chidumayo EN 1989a. Land use, deforestation and reforestation in the Zambian Copperbelt. *Land Degradation and Rehabilitation,* 1: 209-216

Campbell BM 1996. *The Miombo in Transition*: *Woodlands and Welfare in Africa*. Bogor, Indonesia: CIFOR.

Chidumayo EN 1993a. Silvicultural Characteristics and Management of Miombo Woodlands. *Paper Presented in the Conference on International Symposium on Ecology and Management of Indigenous Forest in Southern Africa,* Victoria Fall Zimbabwe, July 27 –to 29, 1992.

Chidumayo EN 1993b. *Responses of Miombo to Harvesting: Ecology and Management*. Stockholm: Stockholm Environment Institute.

Chidumayo EN 1997. *Miombo Ecology and Management*: *An Introduction*. Intermediate Technology Publications. Sweden: Stockholm Environment Institute, pp. 22 – 30.

Cole M 1986. *The Savannas: Biogeography and Geobotany*. London: Academic Press.

Frost P 1996. The ecology of Miombo Woodlands. In: B Campbell (Ed.): *The Miombo in Transition*: *Woodlands and Welfare in Africa*. Bogor, Indonesia: Center for International Forestry Research (CIFOR), pp. 11 – 57.

Högberg P, Nylund JE 1981. Ectomycorrhizae in coastal miombo woodland of Tanzania. *Plant and Soil*, 63: 283-289.

Krebs CJ 1989. *Ecological Methodology*. New York: Hamper Collins Publishers, P. 654.

Luoga EJ 2000. *The Effect of Human Disturbances on Diversity and Dynamics of Eastern Tanzania Miombo Arborescent Species*. Ph.D. Thesis, Unpublished. Johannesburg: University of Witwaterrand.

Mafupa CJ 2006. *Impact of Human Disturbances in Miombo Woodlands of Igombe River Forest Reserve, Nzega District, Tanzania*. M.Sc. Thesis, Unpublished. Morogoro: Sokoine University of Agriculture.

Malambo MF, Syampungani S 2008. Opportunities and challenges for sustainable management of Miombo Woodlands: The Zambian perspective. *Paper Presented in* the *Conference on Research and Development for Sustainable Management of Semiarid Miombo Woodlands in East Africa*. Tanzania, March 3 to 8, 2008.

Magurran EA 1988. *Ecological Diversity and Its Measurement*. Princeton: Princeton University Press, P. 179.

Malimbwi RE 1997. *Fundamentals of Forest Mensuration*. Morogoro: Department of Forest Mensuration and Management.

Malimbwi RE, Mugasha AG 2002. *Reconnaissance Timber Inventory for Handeni Hill Forest Reserve in Handeni District, Tanzania*. Morogoro: FOCON-SULT.

Malimbwi RE, Shemweta DTK, Zahabu E, Kingazi SP, Katani JZ, Silayo DA 2005. *Inventory for Mvomero and Morogoro Districts, Tanzania*. Morogoro FOCONSULT.

Misra KC 1989. *Manual of Plant Ecology*. 3rd Edition. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Mohamed BS 2006. *Impact of Joint Forest Management on Handeni Hill Forest Reserve and Adjacent Communities, Tanga, Tanzania*. M.Sc. Thesis, Unpublished. Morogoro: Sokoine University of Agriculture.

Monela GC, Abdallah JM 2007. Principle Socio-economic Issues in Utilization of Miombo Woodlands in Tanzania. *Paper Presented in the Conference on Management of Indigenous Tree Species for Ecosystem Restoration and Wood Production in Semi-Arid Miombo Woodlands in Eastern Africa*, Tanzania, February 6 to 12, 2007.

Munishi PKT, Philipina F, Temu RPC, Pima NE 2008. Tree species composition and local use in agricultural landscapes of west Usambaras Tanzania. *African Journal of Ecology*, 46: 66–73

Nduwamungu J 1997. *Tree and Shrub Diversity in Miombo Woodlands. A Case Study at SUA Kitulanghalo Forest Reserve, Morogoro, Tanzania*. M.Sc. Thesis, Unpublished. Morogoro: Sokoine University of Agriculture.

Njana MA 2008. *Arborescent Species Diversity and Stocking in Miombo Woodland of Urumwa Forest Reserve and their Contribution to Livelihoods, Tabora, Tanzania*. M.Sc. Thesis, Unpublished, Morogoro: Sokoine University of Agriculture.

Philip SM 1994. *Measuring Trees and Forests*. 2nd Edition. Wallingford: CAB International.

Philips O, Gentry AH 1993. The useful plants of Tambopata, Peru: Statistical hypothesis tests with a new quantitative technique. *Economic Botany*, 47: 15 – 32.

Synnott TJ 1979. *A Manual of Permanent Plot Procedures for Tropical Rainforests*. University of Oxford: Tropical Forestry Papers.

WWF-SARPO 2001. *Conserving the Miombo Eco-region*. Reconnaissance Summary. WWF-Southern Africa Regional Programme Office, Harare, Zimbabwe.

Zahabu E 2001. *Impact of Charcoal Extraction to the Miombo Woodlands: The Case of Kitulangalo area, Tanzania*. MSc. Thesis, Unpublished. Morogoro: Sokoine University of Agriculture.