TRACKING FOREST RESOURCE CONDITION THROUGH PERMANENT SAMPLE PLOTS ESTABLISHED IN BUKOMBE-MBOGWE FOREST RESERVE IN SHINYANGA REGION, TANZANIA

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ABSTRACT

After decades of decentralized forest management in Tanzania, few scientific studies exist that provide baseline information on forest resources condition and eventual impact of decentralization policy. This paper presents efforts by Tanzania Forestry Research Institute (TAFORI) to establish Permanent Sample Plots (PSPs) as a means of setting baseline information on forest resources condition and eventual assessment of the impact of decentralization policy for Bukombe-Mbogwe Local Authority Forest Reserve (BLAFR). The BLAFR is surrounded by seven villages namely Kasaka, Isungabula, Ituga, Bukombe, Nasihukulu, Rubeho, and Mgaya. A total of 132 nested circular PSPs were established and assessed as baseline information in order to track forest condition in terms of stand parameters, species diversity, species composition and stand structure. Results indicated that the stock was dominated by small diameter class trees, stems ha^{-1} averaged 588, stand volume was 46.67 $m^3ha^{-1.}$, and stand basal area was 6.60 m^2 ha^{-1}. Species Diversity Index value was 94.11. High stocking levels were recorded for less preferred species. The Shannon-Wiener Index of Diversity was 3.47 and Index of Dominance was 0.95. A total of 89 different tree species were recorded. Illegal anthropogenic activities and resource extraction are on the increase. In conclusion, regeneration status of trees found in the BLAFR is good, with low stand basal area and volume, which result in failing to reach PFM goals if extraction trends are not controlled.

Key words: Forest condition, baseline information, Joint Forest Management, species diversity, basal area, species dominance.

INTRODUCTION

Forests and woodlands serve as immediate refuge to most of poor people mostly in developing countries. For a long time, local communities especially the rural poor have depended on forest resources in order to improve their livelihoods (Goldman 2003). The World Bank's Forest Strategy (WB, 2004) notes “More than 1.6 billion people in the world depend to varying degrees on forests for their livelihoods. Of these, about 60 million indigenous people are almost wholly dependent on forests. Some 350 million people who live within or adjacent to dense forests depend on them to a high degree for subsistence and income” (Vedeld *et al.* 2007). This shows how important forests are to livelihood of local communities. Therefore, attention should be paid to livelihood dimensions of the local communities in order for conservation of forest to be successful.

Tanzania has about 48 million ha of forests and woodlands that constitute 55 % of the total land area in the mainland (Mgoo,

2013). Forest resources management regime has been changing in the country since prior to colonial times, during colonial times and after independence. Before colonialism, forests were traditionally managed using informal institutions. Social structures were organized according to clans and lineage groups that were led by groups of elders who made decisions for areas within their territorial jurisdiction. These informal institutions ensured sustainable use of natural resources from one generation to the next (Kowero 1990). The coming of colonialists in the 1880s witnessed introduction of new management regimes. The forest management regimes established by the German (1885-1916) and the British (1918-1961) authorities ensured that the indigenous people had no ownership rights over the forests. Murphree (2000) pointed out that protected areas were established at the expense of local people and deprived them of their livelihoods. This was done through relevant legal instruments such as establishment of Forestry Department (1909), Forest Policy (1953) and enactment of Forest Ordinance (1957) which led to forests becoming the property of the colonial state (Luoga *et al.* 2005). This mechanism enabled only the colonizers to exploit the forests.

After independence in 1961, Tanzania's Government continued to use colonial rules and regulations in managing forests. However, it is realized that centralized forest management has failed to provide adequate protection to the resources and has therefore resulted in increased deforestation and forest degradation. This situation drew Government's attention to review its forest policy so as to involve the local communities in the management of forest resources in a decentralized process under Participatory Forest Management (PFM). PFM aims at achieving improved forest governance, forest resource condition and livelihood of forest adjacent communities (Blomley *et al.* 2008).

In the early 1990s, a number of pilot PFM projects were initiated. These projects collectively showed promising results regarding PFM and its contribution to social and economic benefits of the communities (Blomley and Ramadhani 2007). In 1998, the Forest Policy of 1953 was reviewed (URT 1998). One of the objectives of the 1998 National Forest Policy is to decentralize power to lower levels through PFM (URT 1998). The National Forest Policy of 1998 was operationalized by the Forest Act Cap 323 [R.E. 2002]. There are two approaches to PFM namely Joint Forest Management (JFM) and Community Based Forest Management (CBFM). CBFM takes place on village land, on forests that are owned or managed by the Village Council on behalf of Village Assembly leading to Village Land Forest Reserves (VLFRs) or Community Forest Reserves (CFRs) (URT 2007a). Whereas JFM is based on a management agreement between local communities and Government authorities regarding the management of Central or Local Government forest reserves (FRs). Under JFM, forest ownership remains with the Government while the local communities are duty bearers and in turn get user rights and access to some forest products and services (Kajembe 1994; Wily 1998).

According to Mgoo (2013), PFM is implemented in 2,285 villages which cover 7.8 million ha of forestland. These statistics include VLFRs under CBFM covering 2.4 million ha in 899 villages. The remaining 5.4 million ha are under JFM in 580 FRs which include Bukombe-Mbogwe Local Authority FR (BLAFR). In Bukombe District, there is five other FRs namely Uyovu, Biharamulo, Nyantakara, Runzewe and Ushirombo. These FRs are threatened by population growth and settlements, land clearance for agriculture,

extraction of charcoal and timber, fire, lack of tree planting initiatives, mining, and breakdown of traditional forest management system (Omary *et al*. 2009).

It is estimated that 40-50% of the district's forest cover of 598, 200 ha has been cleared for agricultural expansion (BDC 2005). This situation endangers species diversity, genetic resource and livelihood of people who depend on the forest. To prevent further deforestation, the Ministry of Natural Resources and Tourism (MNRT) through the Lake Zone Forest and Beekeeping Extension and Publicity section in collaboration with Bukombe District Council are implementing JFM in BLAFR. The need to understand current forest condition is necessary in order to be able to assess the impact of JFM. To this end, in 2012 TAFORI established a total of 132 PSPs distributed in the whole forest in the Village Forest Management Areas (VFMAs) with overall objective of establishing baseline data for tracking dynamics of forest condition over time. This will be used to assess effectiveness of forest management over time. Specifically, the study aimed at assessing stand parameters (density, basal area and volume), species diversity, species composition and stand structure.

METHODOLOGY

Description of study area

The study was conducted in BLAFR located at Bukombe District in Shinyanga Region. The District lies in the western apex of Shinyanga Region, Tanzania, between Longitudes 31-32° East and Latitudes 30.30'-3.31'0'' South. Administratively, the district is divided into the Masumbwe, Siloka and Mbogwe Divisions; the population is about 396,423 people, predominantly from the closely related Wasukuma and Wasumbwa ethnic groups. Climatically, the District is sub-humid, with annual rainfall varying from about 600 mm to 1200 mm, with a mean of 900 mm. The rainy season begins in November and ends in April-May, with a short dry spell between January and February. Annual temperatures vary from 15° C minimum to 30° C maximum. Topographically, the District is characterized by flat, gently undulating plains interspersed with ridges and hill blocks. The altitude varies from 1000 m to 1500 m. Soils are mainly clayish but vary tremendously from hill tops to valley bottoms. The District covers 10,482 km^2. Out of this, 6,133 km^2 are estimated to be public land while 4,349 km^2 are FRs including BLAFR. BLAFR is located at 30 31' S and 320 2' 60'' E with an area of 9,324 ha of miombo woodlands. BLAFR is located within the Mbogwe Division and is surrounded by seven villages namely Kasaka and Isungabula in the north, Ituga and Bukombe on the western side, Nasihukulu and Rubeho in the south and Mgaya located on the eastern part. Each village has its own VFMA within the BLAFR.

Data collection

This study was carried out using participant (field) observation and forest inventory. The number of sample plots was determined using equation 1 developed by Phillip (1994) to account for variation in the distribution, structure and composition of vegetation. The sampling intensity used was 0.1% which gives 132 plots.

$$n = \frac{t^2 * cv^2}{E^2} \quad \text{.....(1)}$$

Where n = number of estimated PSPs, cv = coefficient of variation of the forest, t = student`s t value, E = allowable error in percent (Tolerance error).

Due to the nature of the forest and the heterogeneity of species distribution, sample plots varying between 0.071 and

0.001 ha in size were used. Plots were laid on transect at an interval of 200 m while inter-transect distance was 200 m. Nested circular sample plots (Figure 1) were adopted to address efficiency (Malimbwi *et al*. 2005; MNRT 2010). In every plot, all trees with greater than 5 cm diameter at breast height (DBH) found in 5, 10 and 15 m radius plots were identified, numbered, and measured for diameter and height (Table 1). Signs of any human activities such as stumps were also recorded. In the 2 m radius subplot all individuals greater than 1 but less than 5 cm DBH were identified, and numbered. Parameters recorded were plot location, altitude, species name and co-ordinates of sample plot.

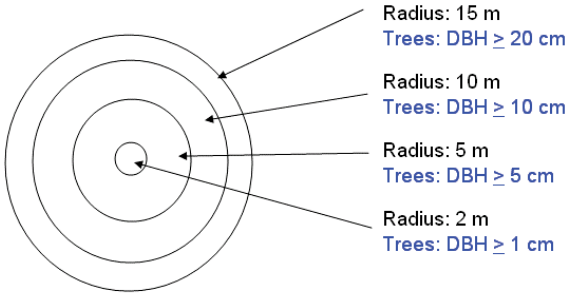

Figure 1: Nested circular sample plots used in this study (Adapted from MNRT, 2010)

Table 1: Sample plot sizes and measured trees sizes

Plot radius (m)	bh of trees measured (cm)
2	Regenerants and all tree species with 1≥ DBH<5
5	5 ≥ DBH <10
10	10 ≥ DBH<20
15	DBH ≥ 20

Data analysis

Inventory data was analysed by using Microsoft Excel Software to generate figures and tables. Before analysis, forest inventory data for trees having DBH ≥ 5 cm were categorized into seven diameter classes namely class I (0-10 cm), II (11-20 cm), III (11-30 cm), IV (31-40 cm), V (41-50 cm), VI (51-60 cm) and VII (>70cm). The DBH measurements were used to calculate the number of stems per ha (N), basal area (G-m^2/ha) which was used to assess dominant tree species and the volume per ha (V- m^3/ha). The number of stems per ha was calculated using equation 2 based on Philip (1994):

$$N = \frac{\sum\left(\frac{n_1}{a_1}\right)}{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where N is number of stems (seedlings) per hectare, n_i is tree (seedlings) counts in the *i*th plot, a_i is area of the *i*th plot in hectares, *n* is total number of sample plots.

Species diameters data from all the plots were arranged in pre-determined diameter classes based on other studies in miombo woodlands for easy comparison. This gives size distribution of trees. The distribution of frequency was modelled using the Weibull function which follows inverse J- shape. The summed stems per tree species derived from the total number of individuals recorded on the sample plots from the forest inventory were used as a measure of species abundance. Tree species were identified using local names in Kisukuma language and later their respective botanical names were obtained using an established checklist. However, some identified local species were not found in the checklist. These unidentified specimens were taken to TAFORI herbarium in Lushoto for further identification. The complete list of species found in the reserve is presented in Appendix 1.

Basal area and volume were computed using DBH recorded in the field for all trees across the entire plots. Based on equation 3, the basal areas for all trees in

each plot were summed and divided by the size of the plot to get basal area per ha:

$$G = \frac{0.0000785 dbh^2}{Plotarea} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where: G = Basal area per ha, dbh = Diameter at breast height

For BLAFR, which is woodland, the total tree volume was calculated from the allometric equation developed by Malimbwi *et al*. (2005b), $R^2 = 0.98$:

$$V = 0.000011972\, D^{3.191672} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Where V = tree volume (m^3) and D = tree DBH (cm).

Diversity indices provide information about community composition rather than species richness. They also take relative abundances of different species into account. Diversity indices including Species Diversity Index (SDI), Shannon - Weiner's diversity index (H') and Index of Dominance were calculated using the following formula:

(i) Species Diversity Index (SDI) (Kohli *et al.* 1996):

$$SDI = \frac{\sum \log_{10} p_i}{\log_{10}(\frac{1}{S})} \quad \ldots\ldots\ldots (5)$$

Where: SDI=Species Diversity Index, S = the number of species at that site, $P_i = n_i/N$, n_i = total number of individuals in the i^{th} species, N = total number of individual of all species

(ii) Shannon-Weiner diversity index (H') (Kent and Coker 1992):

$$H = -\sum_{i=1}^{s} P_i \ln P_i \quad \ldots\ldots (6)$$

Where: H = the Shannon index of diversity, s = the number of species, p_i = the proportion of individuals or the abundance of species *i* in the sample, ln = the logarithm to base *e*, - = the negative sign multiplied with the rest of variables in order to make H' Positive.

(iii)Index of dominance (Misra 1989):

$$ID = \sum \left[\frac{n_i}{N} \right]^2 \quad \ldots\ldots\ldots\ldots (7)$$

Where: ID = the index of dominance, n_i = the number of individuals of species *i* in the sample, N = the total number of individuals (all species) in the sample.

RESULTS AND DISCUSSION

Stand parameters

Parameters used to describe forest stand at BLAFR were number of stems per ha (N), basal area per ha (G m^2/ha) and volume per ha (V m^3/ha). Number of stems per ha shows the total number and presence of stems in a specified area. The average number of stems per ha in BLAFR was 588 and the value of N across all DBH classes ranged from 509 to 1550. These results concur with findings from other studies which found the number of stems per ha ranging from 355 to 1988 in the miombo woodlands (Malimbwi *et al.* 2002; Malimbwi, 2003; Chamshama *et al.* 2004). Results from studies conducted at Kitulang'alo area in Morogoro show that number of stem per ha ranged from 628 to 845 (Zahabu 2008). Similar results were observed in Urumwa FR in Tabora region (Njana 2008; Nuru *et al.* 2008; Nuru 2009).

Basal area is a useful measure of stocking and a good indicator of forest degradation. Results show that the average basal area was 6.602 m^2ha^{-1} with a range between 5.81 and 7.39 m^2ha^{-1}. These results are in agreement with other studies (Malimbwi 2003; Backeus *et al*. 2006; Isango 2007). Chidumayo (2002) postulated that basal

area in heavily used re-growth miombo varies from 3-15 m^2ha^{-1}. A study by Nuru *et al.* (2008) at Urumwa FR revealed basal area of 8.4 m^2 ha^{-1}. So, the basal area observed in this forest appears to be reasonably good compared to other forests.

Results from the study show that the stand volume was 46.67 m^3ha^{-1}. The results are similar to the value of 47 m^3 ha^{-1}reported by Luoga *et al*. (2000) in a reserved miombo in eastern Tanzania. However, the volume is lower than those by Malimbwi *et al.* (2002) in Duru- Haitemba (97.32 m^3ha^{-1}) and Malimbwi (2003) in Handeni hill (108.99 m^3ha^{-1}). The observed stand volume for miombo forest at Kitulang'alo area ranged between 55.3 m^3 ha^{-1} and 88.2 m^3 ha^{-1} (Zahabu 2008) and 57.74 m^3ha^{-1} in Urumwa FR (Nuru *et al.* 2008). Other reported stand volume from various studies in Tanzania include a study by Lowore *et al*. (1994) who reported that basal area is linearly related to volume and mean harvestable volume. Based on available volume which mostly constitutes small diameter class trees, little can be realized in the forest terms of timber extraction.

Diversity indices, tree species dominance, composition and structure

The Species Diversity Index (SDI) value obtained at BLAFR was 94.11 which implies stability of the forest. The Shannon-Wiener Index of Diversity (H') value was 3.47. This implies that BLAFR had slightly high species richness and more diverse compared to other forests whose H' values range from 2.31-3.16 (Tuite 1992, Malimbwi *et al.* 1998, Zahabu 2001, Malimbwi 2002, Isango 2004). However, the diversity for this forest can be considered to be lower when compared to that of Bereku FR whose H' value is 4.27 (Giliba *et al.* 2011). The high value observed in Bereku FR could be due to the presence of riverine forest, which creates favourable conditions for many species to grow.

In this study, Index of Dominance was 0.95, which indicates high species diversity. The dominance index is higher than values recorded in Urumwa FR, Igombe river forests (Malimbwi and Mugasha 2002) and Duru-Haitemba and Kitulagh'alo (Malimbwi and Mugasha 2001, Zahabu 2001). The difference could be attributed to different sample sizes employed in each study but as well due to influence of site conditions and the level of anthropogenic activities taking place in each forest.

The forest is dominated by *Terminalia sericea, Combretum zeyheri* and *Combretum molle* and 159, 146 and 134 individuals recorded per ha respectively (Figure 2). The dominant species are those which have low community preference. This may explain their existence in higher numbers in the FR. However, they are likely to be harvested in the very near future if there are no proper management arrangements due to scarcity of preferred species and increased demand of forest products in the Lake Victoria zone. The remaining tree species namely *Brachystegia spiciformis, Combretum adenogonium* and *Brachystegia boehmii* represent a good number in dominance as observed in Figure 2. Species such as *Pericopsis angolensis, Pterocarpus angolensis* and *Dalbergia melanoxylon* with larger diameters appeared in insignificant numbers due to their very high value. However, these species have significant number of regenerants, showing that ensured protection of the BLAFR can revamp the situation.

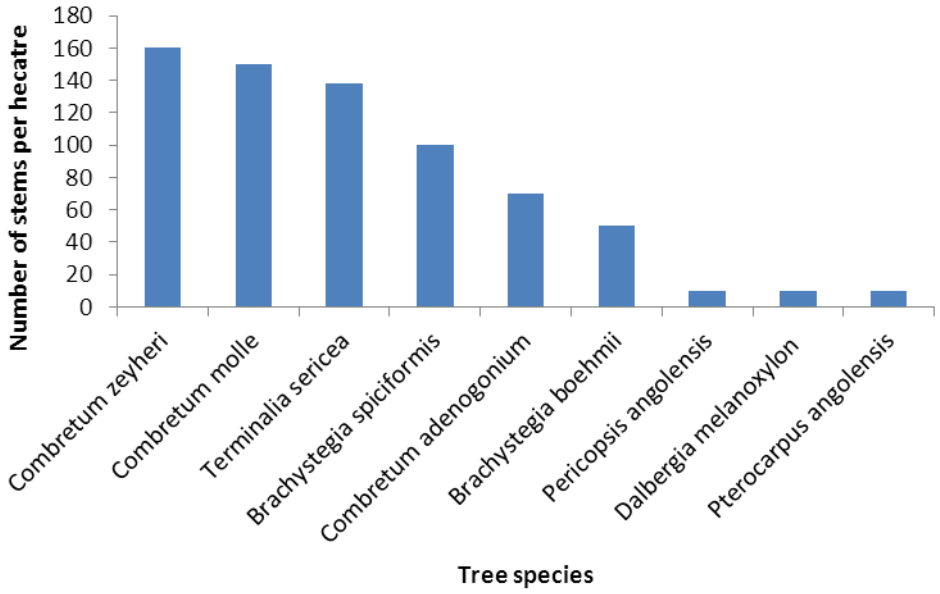

Figure 2: Tree species dominance in BLAFR

Tree species composition as defined by Martin (1996) is the assemblage of plant species that characterize the vegetation. In this study, it was found that there are 89 different tree species in BLAFR (Appendix 1). These results are in agreement with those reported by Isango (2007) and Malimbwi *et al.* (1998) who found that species diversity in miombo woodlands in Tanzania ranges from 79 to 95 and occasionally reaches 102 species. The number of species in this study was slightly lower than values reported elsewhere (Luoga 2000, Dondeyne *et al.* 2004). Differences in number of species could be attributed to varying site specific characteristics and biotic interference, particularly illegal harvesting.

Stand structure is shown in Figure 3 which presents tree distribution based on DBH classes in BLAFR. The figure shows that the forest is dominated by trees with 1-10 and 11-20 cm diameter classes while there were very few trees in diameter classes above 50 cm. This could be attributed to high rate of exploitation in the forest which has led to removal of most of big trees. Remaining big trees of certain species suggests that tree felling is selective. This represents an obvious fact that the miombo woodlands suffer from the deforestation especially by human exploitation mainly for fuel wood and other uses like timber and building poles. The study observed charcoal kilns and pit sawing sites. If conservation measures are not taken to stop illegal activities such as grazing, pit sawing and charcoal extraction, the forest condition will be seriously affected.

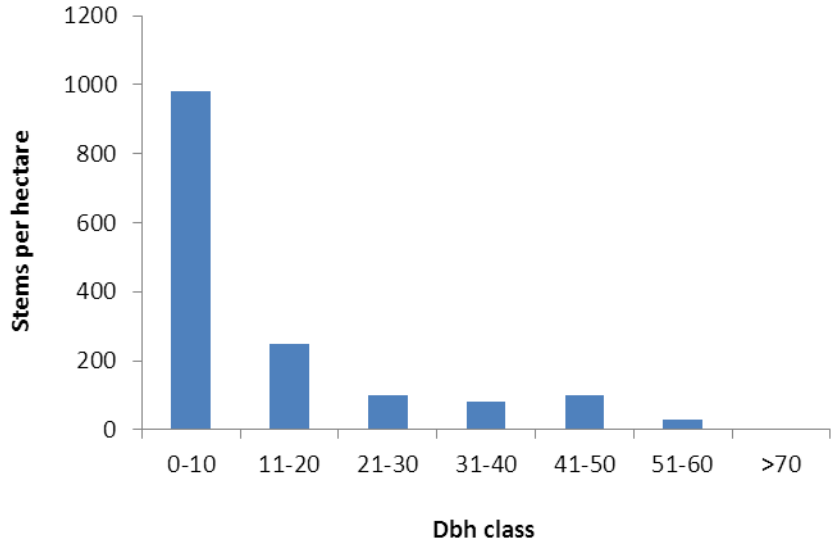

Figure 3: Forest stand stock distribution at BLAFR.

CONCLUSIONS AND RECOMMENDATIONS

The baseline information for BLAFR has been set in terms of stand parameters, species diversity indices, species composition and structure. This can be used to track forest condition over years while implementing JFM. Observed stocking levels indicate some similarities with other studies in Miombo woodlands, skewed towards degradation. In terms of species diversity indices, the forest has a good numbers of tree species compared to other forests hence a good sign of becoming a stable forest community. In terms of diameter class distribution, the study results can be interpreted that the FR has many juveniles and less harvestable trees and dominated with Terminalia and Combretum species which are less preferred in the market. Since BLAFR shows active regeneration and if left protected from disturbance, the forest cover will be restored. Destructive human activities such as charcoal extraction and timber harvesting (pit sawing) were observed in the FR. This study recommends that all on-going human activities in the FR be controlled through proper implementation of JFM. Improving cooperation between the District Council and the surrounding communities will also ensure protection of the forest (promoting good governance). Improved beekeeping activities can also serve as an alternative source of income for communities living adjacent BLAFR. Based on the fact that there are continual efforts to put FRs under JFM in the Lake Victoria zone and elsewhere in the country, it is very important to consider establishing PSPs for tracking forest condition and impact of JFM.

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Appendix 1: List of plant species found in Bukombe-Mbogwe LAFR

Species code	Vernacular name	Botanical name
1	Mzima	*Terminalia sericea*
2	Msana	*Combretum zeyheri*
3	Mgando	*Burkea Africana*
4	Mgongwa	*Acacia mellifera*
5	Msongati	*Diplorhynchus condylocarpon*
6	Mbelebele	*Strophantus eminii*
7	Mkamu	*Psydrax livida*
8	Mbapa	*Markhamia obtusifolia*
9	Mshenene	*Xylopia odoratissima*
10	Msalasi	*Friesodielsia obovata*
11	Mtundu	*Brachystegia spiciformis*
12	Mtwetwe	*Unidentified*
13	Mjundu	*Xeroderris stuhlmannii*
14	Ng'ochangoko	*Catunaregam spinosa*
15	Mkonola	*Annona senegalensis*
16	Mkome	*Strychnos pungensis*
17	Mgada	*Albizia anthelmintica*
18	Mpalaa	*Haymenocardiaacida*
19	Msungululu	*Strophanthus eminii*
20	Mshishigulu	*Albizia petersiana*
21	Mgogondi	*Phyllanthus engleri*
22	Nzegezege	*Cassia obtusifolia*
23	Mbanga	*Pericopsis angolensis*
24	Nhungu	*Zanthoxylum chalybeum*
25	Myogoyogo	*Multidentia crassa*
26	Mlagaja	*Feretia apodanthera*
27	Mbotolwa	*Unidentified*
28	Mninga	*Pterocarpus angolensis*
29	Nkumbwambizo	*Unidentified*
30	Mlembela	*Isoberlinia angolensis*
31	Mpilipili	*Albizia antunesiana*
32	Mponda	*Commiphora mossambicensis*
33	Mbudika	*Royena fisicher*
34	Mkondokondo	*Rothmannia engloriana*
35	Mgumbu	*Lannea schimperi*
36	Mkuwa	*Hexalobus monopetalus*
37	Myenze	*Brachystegia boehhmii*
38	Mlama	*Combretum molle*
39	Mhinyavana	*Pavetta schumanniana*
40	Mpuguswa	*Flacourtia indica*
41	Mluzyaminzi	*Combretum adenogonium*

42	Msoma	*Harrisonia abyssinica*
43	Mtinje	*Lannea humilis*
44	Busolwanghulu	*Unidentified*
45	Usekela	*Antidesma venosum*
46	Mbambangoma	*Balanites aegyptica*
47	Mtindwambogo	*Piliostigma thonningii*
48	Mtundulu	*Dicrochtachis cinerea*
49	Mgembe	*Dalbergia melanoxylon*
50	Mwitankole	*Unidentified*
51	Msungwi	*Vitex mombassae*
52	Mselya	*Lannea fulva*
53	Myuguyu	*Balanites aegyptica*
54	Ihushi	*Acacia goetzei*
55	Mgwata	*Acacia Senegal*
56	Mtulangoye	*Unidentified*
57	Mpogolo	*Albizia harveyi*
58	Ngemambula	*Entada abyssinica*
59	Mkoyoyo	*Unidentified*
60	Mpande	*Strychnos pataturum*
61	Mhoja	*Sterculia mhosya*
62	Bulululwambori	*Ormocarpum triochocarpum*
63	Mkindwanzagamba	*Albizia versicolor*
64	Sambilya	*Senna singueana*
65	Msisi	*Tamarindus indica*
66	Msekelya	*Unidentified*
67	Mmpundu	*Strychnos innocua*
68	Mtundwa	*Ximenia cafra*
69	Vulula	*Acacia drepanolobium*
70	Mkola	*Afzelia quanzensis*
71	Mjunguluji	*Hymenodictyon parvifolium*
72	Mpulu	*Vitex payos*
73	Nhago	*Unidentified*
74	Mfifi	*Dalbergia boehmii*
75	Mkonze	*Manilkara mochisia*
76	Mmale	*Lanchocarpus capassa*
77	Mkulungu	*Pterocarpus tinctorius*
78	Mlago	*Unidentified*
79	Msingisa	*Boscia mossambicensis*
80	Kasanda	*Swartzia madagascariensis*
81	Mgukulama	*Combretum psidioides*
82	Mtobolwa	*Azanza garkeana*
83	Milwa	*Unidentified*
84	Mgeyegeye	*Acacia pentagona*

85	Mkalya	*Zanha Africana*
86	Mwicha	*Kigelia Africana*
87	Mgazi	*Elacis guinensis*
88	Kalalwanghuba	*Erythrina abyssinica*
89	Muvunzwandimi	*Phyllanthus reticulates*