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COMPARATIVE ANALYSIS OF STRUCTURE AND REGENERATION STATUS OF WOODY SPECIES IN MANAGED AND COMMUNITY USED FOREST SITES IN GELESHA KEBELE, MEJENGIR FOREST, GAMBELLA NATIONAL REGIONAL STATE

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Comparative study with the objective to determine woody species structure and regeneration status was undertaken in managed and community used forest sites of Gelesha Kebele, Mejengir forest, Southwest Ethiopia. A total of 60 plots, 20m x 20m were established following transect line at distance of 200m interval across altitudinal gradient. For seedling, sapling and lianas, five subplots of 5m x 5m were established with in main plots. Information about number of individual, diameter at breast height, number of seedlings and saplings, matured individuals and height of individuals for each species were collected from each plots including relative physical variables of the area. Various statistical tools and ecological software were employed for the data analyses. The respective density ratios of managed and community used forest is 1.28 and 1.36. The total basal area of the managed forest was 51.42 m2ha-1 and community used forest was 39.86 m2ha-1. Importance Value Index showed highest value for Agromullera macrophyla and Pouteria altissima with their respective value 43.48 and 29.99 for managed and community used forests. Comparative analysis of regeneration, did not show significant differences for seedling and sapling ha-1 between both forests with their respective p-values (p=0.461, p=0.588). The population structure demonstrated there is a need for conservation priority of species with poor regeneration. The presence of anthropogenic factors affecting the forest indicated that it needs concern for its conservation and sustainable utilization.

Keywords: Community Used, Managed Forest, Regeneration, Structure, Woody Species

INTRODUCTION

Natural forest is rapidly changing due to increasing pressure from extractive uses, burning and conversion to cultivated land with the population growth as ultimate cause (Backeus, et al., 2006). Agriculture and other forest degradation activities are diminishing the forest and its vast ecosystem services. Management of intact forest and restoration of degraded forest landscape is the best alternative to maintain ecological integrity and meet social need. Therefore, availability of ecological data on forest resources is an essential requirement for planning and management within the context of sustainable development (FAO, 2007). Forest stand structure is the distribution of species or tree size within the stand. The structure of individual forest stands at specific locations is determined by multiple interacting physical and biotic factors, including elevation, slope, aspect, relief, soil properties, climate, recent physical disturbance history, distant physical disturbance history, and a host of co-occurring biota. The result of these interactions is the dynamic composition and architecture of the plant community (Stelfox and Wynes, 2005). Knowledge of floristic composition and structure of forest resources is also useful in identifying important elements of plant diversity, protecting threatened and economic species and monitoring the state of reference among others (Segawa and Nkutuu, 2006). Vertical structure of a forest refers to its structural complexity, which is influenced by the presence of different plant life forms at different heights. Vertical structure has a major influence on the provision of habitat for wildlife and promotion on regeneration on undergrowth species (Brokaw and Lent, 1999). Natural forest stands are composed predominantly of native tree species established naturally. This can include natural regeneration that enhance the recruits of forest stand and ensures sustainability. Surveys of natural regeneration are often carried out to support the development of forest management plans, and can also provide valuable insights into the ecology of individual tree species. According to Demel (2005) forests are subjected to both natural and anthropogenic disturbances, which disrupt the process of plant regeneration. In response to these disturbances, succession is triggered in which different plants use various strategies to regenerate themselves. Mejengir forest is one of the few remaining forest blocks in southwestern Ethiopia. In Gelesha forest, Participatory Forest Management (PFM) initiative has been driven for its sustainable utilization. The area was divided in managed forest which is intact in biotic community and community used forest which was degraded as result of multiple extractive social uses (Woldemariam and Senbeta, 2006). The intact forest is vital in maintaining ecological integrity as well as preserving biological diversity. The community used forest can meet the societies well being and maintain ecosystem of the area. Management planning of this forest requires detailed baseline information regarding its ecology. The comparative analysis of woody species in managed and community used site has not yet been investigated in the this forest. As a result, the current ecological study on woody species structural analysis and regeneration status is believed to contribute to the effort being made in the development of an efficient management plan, effective conservation of the forest and sustainability of the forest resource.

OBJECTVE

General Objective

The main objective of this study is to undertake comparative analysis on woody species structure and regeneration status of Gelesha forest.

Specific Objectives:

- To assess the structure of both managed and community used forest area;
- To investigate the species population-structure of both forests; and
- To analyze the regeneration status of the woody plant species of managed and community used forest area.

MATERIALS AND METHODS

Description of the study area

The study was undertaken in Godere district, Mejengir Zone, Gambella National Regional State, southwestern Ethiopia. Meti Town which is capital of Mejengir zone is located at about 620 km away from Addis Ababa. Gelesha forest is located between 788000 - 800000N latitude and between 76000 - 92000E longitude. It is located 12 km southwest of Meti Town and has a total area of 9187.298 hectares (Figure1). Mejengir forest is categorized under transition rainforest type; occur at altitudinal range of 500m – 1500m (Yeshitela, 2008; Woldemariam, 2003). The major vegetation types of the Megengir zone are montane evergreen forest, low land semi evergreen forest and riparian vegetations (WBISPP, 2000). In addition the vegetation of this area has different categories in terms of life form like high natural forest, woodlands, bush lands, and grasslands are the major vegetation types in the Megengir Zone. The species of this area are restricted in their ranges of distribution and occur only in this part of Ethiopia although they may extend toward west to the western Africa.The climate of the area is a hot and humid type. This region is marked on most rainfall maps of Ethiopia as being the wettest part of the country. Ten years data (2001-2010) was taken from the National Meteorological Services Agency (NMSA, 2011) and calculated. The mean annual rainfall is approximated to be around 1594mm. The mean temperature ranges between 15 and 30°C. The study of WBISPP (2000) reveals that soil of this area is recognized as a red brown to dark brown, of mostly Dystric Nitosol.

Delineation the forest boundary and Stratification

A reconnaissance survey was undertaken in the first week of November 2011. During this period, overall information of the study forest was obtained and the desired stand for the study was identified. Selection of stands (contiguous areas of vegetation that are reasonably uniform in physiognomy and floristic composition) both in managed and community used forest sites was done. Identification of boundaries for the managed and community used forest was done by assistance of local field guides.

Sampling Design

Systematic sampling design was used to select the first transect line and first plot at randomly. The representative sampling transect lines were selected considering altitudinal gradients for managed forest but gradient and disturbance

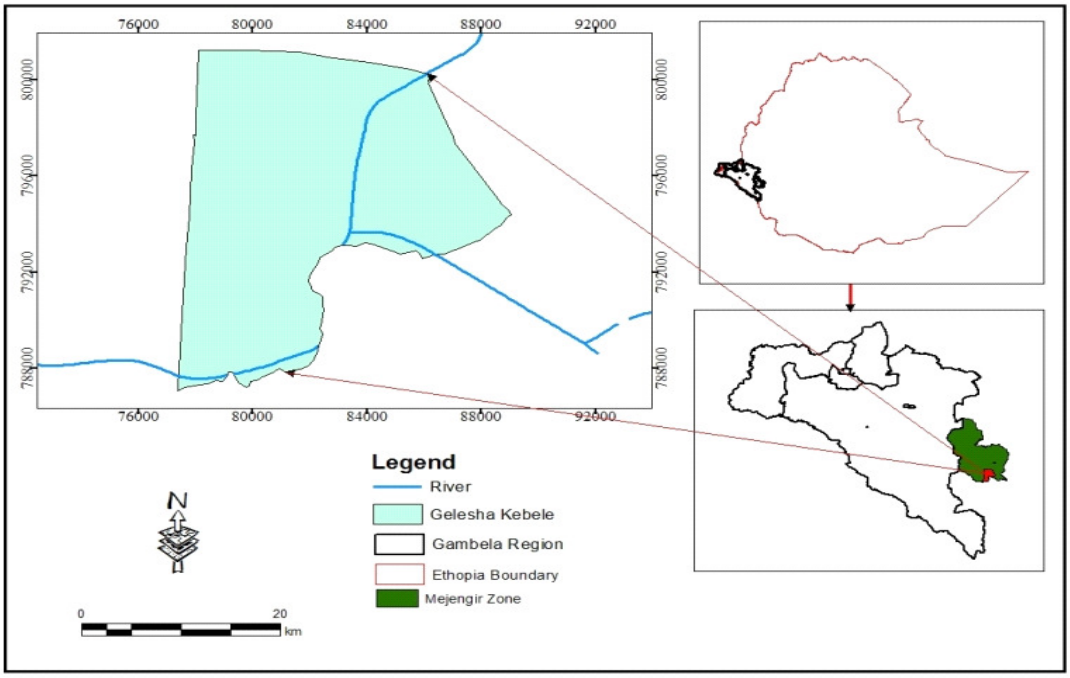

Figure1: Location map of the stud area (Gelesha Kebele)

as result of human intervention in case of community used forest was considered. Three transect lines across managed forest and two transect lines across community used forest were laid. The transect lines were laid at distance of 400m apart across both forest types and quadrates of size 20m x 20m were established systematically at every 200m interval along these line of transects following altitudinal gradient. A total of 60 sampling plots 20m x 20m were systematically established for the documentation of trees, shrubs and lianas following the Braun-Blanquet approach (Mueller-Dombois and Ellenberge, 1974; Kent and Coker, 1992). For the ground flora (seedlings and saplings), five 5m x 5m subplot were established within the main sampling.

Vegetation data collection

Vegetation data was collected between November and December 2011. During this time some relevant physiographic variables (latitude and longitude coordinates, slope, aspect, and altitude) of each plot and all information of woody species encountered (trees, shrubs, woody climbers, saplings and seedlings) in each plots were recorded. Physiographic variables such as altitude and UTM were recorded using GPS receiver. Compass and Clinometer were used for measurement of aspect and slope respectively in each sampled plots. In each plot, trees and shrubs with DBH > 2.5 cm were measured and recorded for height and diameter at 1.3m (DBH). Diameter tape and caliper were used to measure DBH of trees and shrubs. Counting of trees and shrubs with DBH > 2.5 cm and conversion of DBH to basal area was done. Height measurement was taken for trees and shrubs with height > 2 m and DBH > 2.5 cm using hypsometer and visual estimation. For trees and shrubs that are forked around the breast height, the circumference was measured separately and average was taken (Garcia, 2004). In each subplot, the number of seedlings and saplings were recorded to determine the regeneration. The undergrowths of woody species with the height less than 1 m were considered as seedlings, single-stemmed individuals with the height of greater than 2 m were considered as trees and those with height in between 1-2 m were considered as saplings (Singhal, 1996).Voucher specimens were collected for identification of the species and brought to the National Herbarium (ETH), Addis Ababa University. The identification was done using the Flora of Ethiopia and Eritrea and by comparing the specimens with the authentic specimens in the National Herbarium. The vouchers were deposited at the National Herbarium.

Data Analysis

Structural Data Analysis

Excel spreadsheet was used for summarizing data before analysis. SPSS version 20 window version software was used for both structural and regeneration status data analysis. The structure of the vegetation was determined based on the analysis of species density, DBH, height, basal area, frequency and important value Index (IVI). The regeneration status of the trees and shrubs was also determined by computing density ratios between seedlings and mature individuals, seedlings and saplings, and sapling and mature individuals. The Diameter at Breast Height (DBH) and tree height were classified into DBH classes and height classes respectively. The percentage frequency distribution of individuals in each class was also calculated. The tree/ shrub density and basal area, were computed on hectare basis. The following structural parameters were calculated for species (Mueller-Dombois and Ellenberg ,1974; Kent and Coker, 1992).

The frequency distribution of tree species was calculated as:

Frequency (F): Is the chance of finding a species in a particular area in a particular trial samples.

F=(Number of plots in which all species occur)/(total number of plots laid in the study site)*100

Relative Frequency (RF): It is the frequency of species A/ sum of frequencies of all species x 100.

Density of a species = the number of individuals of that species /area sampled.

Relative density = Density of species A /total density of all species x 100.

Basal area (BA): It is the cross-sectional area of a plant near ground surface for trees. It was measured through diameter, usually at breast height (DBH) that is 1.3 m above ground level.

The analysis of species dominance was done using basal area measurements.

$BA=(\pi d^2)/4$

Where, BA = basal Area in m2 per hectare

d= diameter at breast height in meter

$\pi = 3.14$

Dominance = Total of basal area / area sampled

Relative dominance = Dominance of species A / total dominance of all species X 100

The importance value index is useful for comparisons of ecologically significant species. Lamprecht (1989) stated that, for instance the role played by a given species in nutrient recycling, influence to the under canopy growth which is considered to be ecological significance of the species. It also represents the relative dominance of a tree species in its ecology (Barker et al., 2001). Relative importance of woody species was calculated using the Importance Value Index (IVI) of (Curtis and McIntosh, 1951). Important values index (IVI) was analyzed for woody species by computing from the sum of relative dominance (RDO), relative density (RD) and relative frequency (RF) (Kent and Coker, 1992).

IVI = RDO + RD + RF

RESUSLTS AND DISCUSSION

The structure of woody species in managed and community used forest

Density of Woody Species

Woody species density was expressed as the number of trees per unit area and it is a fundamental parameter for sustainable forest management intervention. Woody species densities for managed and community used forests were analyzed and the result was described as average number of stem ha-1. It shows that the density of woody species of community used forest is 2879 stems ha-1 where as for managed forest is 1659 stems ha-1. It indicates difference from comparison of the two forest sites types. In community used forest small individuals are predominant as result of disturbance; inversely large size individuals dominated the managed forest. The total density of matured woody species with DBH : > 2.50 cm, > 10 cm, and > 20 cm was computed for both managed and community used forest and the values for respective DBH classes were shown as 283, 215, 163 individuals ha-1 and 511, 215,157 individuals ha-1 respectively for managed and community used forest. It indicates that there was greater difference in number of individual ha-1 of both forest types for DBH > 2.5cm (Table 1).The human disturbance can be main cause for considerable increase in number of individuals ha-1 in lower DBH classes of community used forest. Grubb et al. (1963) described that the ratio of density at DBH >10cm and density at DBH > 20cm can be used as measure of the different size classes. The study report of Kennard (2002) also stated that generally total stem density decrease during stand development as tree DBH > 10cm, however, basal area and height increases inversely. The ratio of individual ha-1 with DBH >10 cm to individual ha-1 with DBH >20 were 1.28 and 1.37 respectively for managed and community used forest. The ratio indicates large number of trees with DBH >20 for both forests; however from comparison of the ratio of both forest the managed forest has high density of trees with DBH > 20 cm than community used forest. Over exploitation could be the major possible threat for limited number of tree with DBH >20 in community used forest (Table 1).

Table 1: Density of trees with DBH greater than 2.5 cm, 10 cm and 20 cm in managed and community used forest

Species	**DBH > 2.5cm**		**DBH > 10cm**		**DBH > 20cm**	
	Individual ha^{-1}		Individual ha^{-1}		Individual ha^{-1}	
	Managed forest	Community used forest	Managed Forest	Community used forest	Managed forest	Community used forest
Baphia abyssinica	79.17	2.50	77.50	2.50	58.33	2.50
Blighia unijugata	8.33	0.00	7.50	0.00	6.67	0.00
Manilkara butugi	16.67	0.00	15.00	0.00	11.67	0.00
Mimusops lanceolata	14.17	1.67	14.17	1.67	14.17	1.67
Trichilia prieuriana	6.67	4.17	5.83	3.33	4.17	0.00
Argomullera macrophyla	40.00	0.00	0.00	0.00	0.00	0.00
Cordia Africana	5.83	32.50	5.00	29.17	3.33	26.67
Pouteria alnifolia	4.17	2.50	4.17	1.67	3.33	1.67
Lepisnthes senegalensis	1.67	0.00	1.67	0.00	1.67	0.00
Celtis zenkeri	13.33	19.17	13.33	10.83	13.33	3.33
Diospyros abyssinica	1.67	250	0.83	1.67	0.83	1.67
Croton macrostachyus	2.50	4.17	2.50	4.17	2.50	3.33
Deinbollia Kilimandschrica	4.17	3.33	2.50	3.33	1.67	3.33
Canthium oligomarpum	3.33	0.00	2.50	0.00	2.50	0.00
Margaritaria discoidea	5.83	5.83	3.33	4.17	1.67	0.83
Pouteria altissima	11.67	9.17	10.83	8.33	10.00	5.83
Allophylus macrobotrys	3.33	0.00	2.50	0.00	0.00	0.00
Ficus exasperate	5.00	17.50	5.00	15.00	4.17	12.50
Antiaris toxicaria	2.50	23.33	1.67	22.50	1.67	17.50
Morus mesozygia	1.67	3.33	1.67	3.33	1.67	0.83
Croton sylvaticus	9.17	0.00	9.17	0.00	5.00	0.00
Celtis Africana	1.67	1.67	1.67	1.67	1.67	1.67
Maesa lanceolata	0.83	0.83	0.83	0.83	0.83	0.00
Erythrococca trichogyne	3.33	0.00	0.00	0.00	0.00	0.00
Lannea welwitschii	4.17	1.67	4.17	1.67	3.33	0.83
Sterculia sp	0.83	0.00	0.83	0.00	0.83	0.00
Rinorea friisii	1.67	0.00	0.83	0.00	0.00	0.00
Ficus umbellate	1.67	0.83	0.83	0.83	0.00	0.83
Landolphia buchananii	6.67	0.00	6.67	0.00	5.00	0.00
Rothmannia urceliformis	0.83	0.00	0.83	0.00	0.00	0.00
Ficus mucuso	2.50	24.17	2.50	23.33	2.50	22.50
Celtis toka	2.50	0.00	2.50	0.00	1.67	0.00
Teclea nobilis	1.67	0.00	0.00	0.00	0.00	0.00
Dracaena steudneri	1.67	0.00	1.67	0.00	0.00	0.00
Ficus ovate	1.67	2.50	1.67	2.50	1.67	25.00
Breonadia salicina	1.67	0.00	1.67	0.00	1.67	0.00
Mallotus oppositifolius	2.50	1.67	0.83	0.83	0.00	0.83

Continuation of **Table 1**

Oxyanthus speciosus	0.83	0.83	0.83	0.83	0.83	0.83
Lecaniodiscus fraxinifolius	0.00	4.17	0.00	250.00	0.00	2.50
Rinorea ilicifolia	5.83	0.00	0.00	0.00	0.00	0.00
Ritchiea albersii	0.00	2.14	0.00	2.14	0.00	0.00
Ficus sur	0.00	6.67	0.00	6.67	0.00	4.17
Albizia grandibracteata	0.00	29.17	0.00	29.17	0.00	19.17
Ehretia cymosa	0.00	0.83	0.00	0.83	0.00	0.00
Vernonia amygdalina	0.00	8.33	0.00	5.83	0.00	0.83
Vernonia theophrastifolia	0.00	10.83	0.00	0.83	0.00	0.00
Ricinus communis	0.00	0.83	0.00	0.00	0.00	0.00
Ficus carica	0.00	9.17	0.00	7.50	0.00	7.50
Vernonia hochstetteri	0.00	6.67	0.00	0.00	0.00	0.00
Mangifera indica	0.00	6.67	0.00	3.33	0.00	1.67
Sapium ellipticum	0.00	0.83	0.00	0.83	0.00	0.83
Grevillea robusta	0.00	10.00	0.00	9.77	0.00	6.67
Ficus thonningii	0.00	0.83	0.00	0.83	0.00	0.83
Warbugia ugandensis	0.00	0.00	0.00	0.71	0.00	0.71
Pittosporum viriflorum	0.00	0.83	0.00	0.83	0.00	0.83
Polyscias fulva	0.00	0.83	0.00	0.83	0.00	0.83
Coffea arabica	0.00	247.50	0.00	0.00	0.00	0.00
Total	**283**	**511**	**215**	**215**	**168**	**157**

Distribution DBH

The DBH of woody species was classified into seven classes as follows: 1) < 20 cm, 2) 20.01- 40 cm, 3) 40.01 – 60 cm, 4) 60.01 – 80 cm, 5) 80.01 – 100 cm, 6) 100.01 – 120 cm, and 7) > 120 cm. The trees distribution in these different DBH classes was expressed in terms of density ha-1 and the percentage distribution of trees in both forests site in different DBH classes was computed. Majority of the tree individuals were distributed in the DBH class 1 (DBH < 20 cm) for both managed and community used forest with 117 individuals ha-1 (41.2%) and 360 individuals ha-1 (69.63%) respectively (Figure 2). The pattern of DBH class distribution shows more or less similar pattern for both managed and community used forest sites.

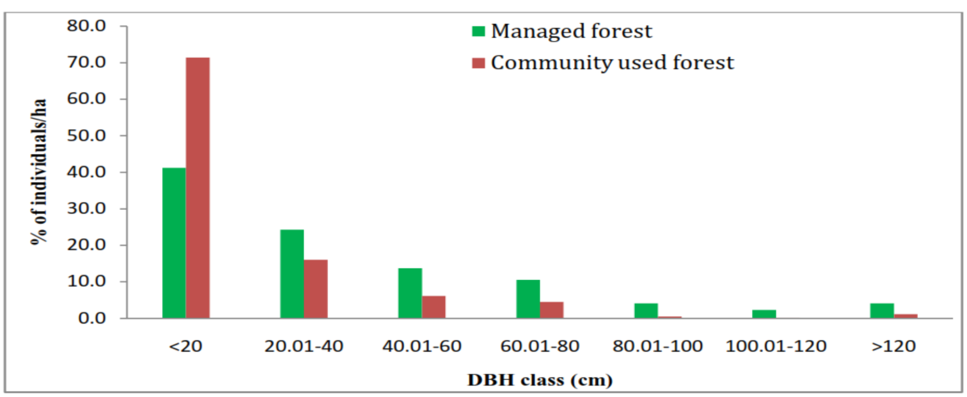

Figure 2: DBH-classes and percentage of number of individual ha^{-1} for managed and community used forests.

The result of this study shows greater number of individuals ha-1 of woody species for both managed and community used forest in the lower DBH classes. On the other hand, it indicates decrement for individuals ha-1 in both forest sites in higher successive DBH classes. However the percent of individuals ha-1shows sharp decline in the middle and highest DBH classes by demonstrating inverted J-shape which express good condition of forests in terms of their recruitment. However, the number of individual ha-1 is better for managed forest as compared to community used forest. The distribution of diameters in different DBH classes is a reflection of the history of the forest (Meyer et al., 1961).

Highly disturbed or dynamic forests usually have high tree stem densities, low tree basal area, low tree basal area to stem ratio (Laurance et al., 2001 cited in Geertje et al., 2008). The findings of this study also confirm similarity with these studies results for pattern of DBH distribution of community used forest and managed forest types. DBH class distribution took the shape of an ‘inverse J’ curve Mori et al. (1989) is an indication that the forest has consistently maintained a size class distribution. However anthropogenic activities have retarded the recruitment rate of community used forest.Tree individuals recorded in the both managed and community used forest sites were classified into eight height classes: I) < 5 m, II) 5.01 – 10 m, III) 10.01 – 15 m, IV) 15.01 – 20 m, V) 20.01 – 25 m, VI) 25.01 – 30 m, VII) 30.01 – 35 m and VIII) > 35 m. There was higher number of individuals in the height class (I) which encompass 19.36% for managed forest and 51.50 % for community used forest of the total height classes. There were some species that contributes significantly to the lowest height classes of community used forest. Coffea arabica was the most abundant species in the lower stratum of the community used forest. On the other hand, disturbance and subsequent regeneration of understory species was the reason for significant value of woody specie abundance in the lower height class of the community used forest.The result of the study revealed that there was higher number of individual in the first height classes and declined in the height class II. It shows increment in the middle height classes except decrement in the succeeding higher classes. However significant increase in number of individual in the highest height class (VIII) for managed forest which confirms absence of anthropogenic effect or excessive logging of dominant tree species (Figure 3). The significant decline of individuals for community used forest in higher height classes is possibly due to excessive logging effect and other disturbances during coffee plant establishment. For both forests only few species have significant contribution to the highest height classes. Baphia abyssinica (8.43%), Blighia unijugata (27.23%), Manilkara butugi (12.05%), Mimusops lanceolata (14.16%), Cordia africana (4.82%), Celtis zenkeri (12.05%) Pouteria altissima (10.84%), Ficus exasperate (6.02%) and Landolphia buchananii (7.23%) are among woody species which contributed to the highest height classes in managed forest. whereas, Trichilia prieuriana (7.69%), Diospyros abyssinica (7.29%), Pouteria altissima (23.08), Ficus exasperata (30.77%), and Antiaris toxicaria (23%) in community used forest of the area.Unsustainable exploitation of the forest by the local communities can critically affect population structure of the forest. This is evidenced by the dominance of individuals at lower diameter and height classes (Alelign et al., 2007). In similar way, the result of this study showed abundance of individual in the lower height classes for community used forest which can be evidence for disturbance of the forest. The forest stand with relatively few individuals in the lower height classes and a higher concentration in the intermediate or larger classes probably had more small individuals in the past (Felfili, 1997). The managed forest has highest number of individual in the higher height class which confirm that limited human disturbance to the forest.

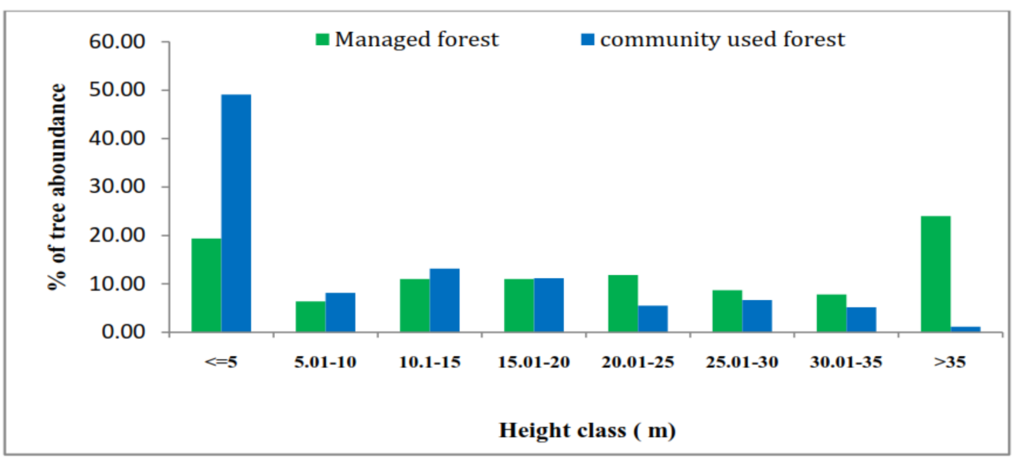

Figure 3: Percentage distributions of trees in height classes

Basal area

The total basal area of all woody species with DBH > 2.5cm in managed and community used forest was calculated from DBH data and it was found to be 51.46 m2 ha-1 and 39.86 m2 ha-1 for managed and community used forests respectively. Greater basal area (m2 ha-1) was distributed in the middle and highest diameter classes IV (22%), VII (25%) for managed forest and in classes IV (25%), VII (21%) for community used forest (Figure 4). Generally the study showed better distribution of basal area (m2 ha-1) for both managed and community used forest in the middle DBH classes. The basal area (m2 ha-1) highly decreased for community forest in the DBH classes (V &VI) but there are large DBH trees but few in number for this forest type could be related to human disturbances.Some of the woody species contributed high values of basal area (m2ha-1) for managed forest are: Baphia abyssinica, Manilkara butugi, Celtis zenkeri, Pouteria altissima, Landolphia buchananii. The greater basal m2ha-1 for managed forest verifies that the numbers of higher DBH woody species were predominant as compared to community used forest. In reverse the decline of higher DBH trees in community used forest is due to multiple human influence and excessive logging for establishment of Coffea arabica to the site. Cordia africana, Pouteria altissima, Antiaris toxicaria, Albizia grandibracteata, Celtis zenkeri were the dominant species contributed highest basal area value to community used forest. Similarly, predominance of these large DBH woody specie in community used forest is due to its retention for the purpose of coffee shade.

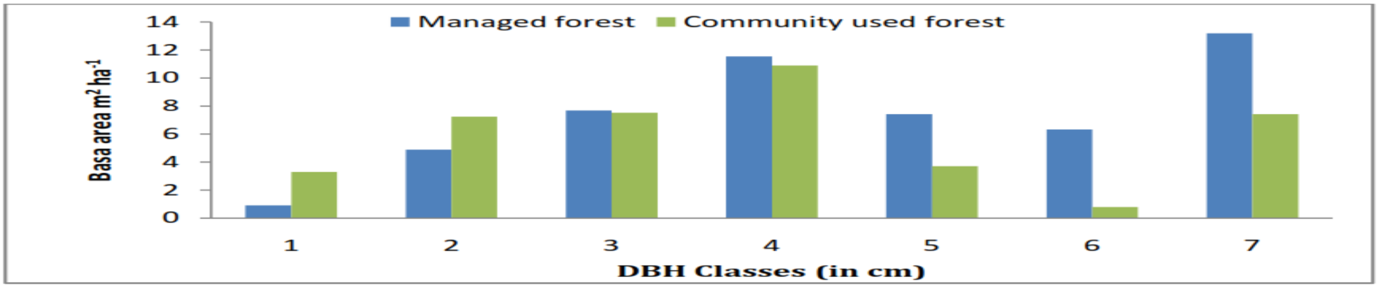

Figure 4: Basal area distributions over DBH classes in the study Forest: 1) 20 cm, 2) 20.01-40 cm, 3) 40.01-60 cm, 4) 60.01-80 cm, 5) 80.01-100 cm, 6)100.01-120 cm, 7) >120 cm.

Uneven-aged stands contain trees of different ages that are spatially intermixed throughout the stand. In uneven-aged stands it is convenient to consider stocking in terms of total basal area by diameter class groupings (Smith 1986). Basal area provides a better measure of the relative importance of the species than simple stem count (Bekele, 1994). It was also indicated that species with the highest basal area do not necessarily have the highest density, indicating size difference between species. The result of this study approximately exhibited normal distribution for both forest types. However; large basal areas are predominant in the highest DBH classes of both forests types.

Frequency Distribution of Species

Frequency percent and relative frequency of woody species were analyzed and frequent species were described as follows. In the managed forest the most frequent species were Argomullera macrophyla (90%), Baphia abyssinica (73.33%), Whitfieldia elongata (70%), Dracaena fragrans (53%) Mimusops lanceolata (43.33%), Pouteria altissima (36.67%), Manilkara butugi (36.67%) Trichilia prieuriana (26.67%) and Celtis zenkeri (33.33%) whereas, the frequent species of community used forest were Pouteria altissima (46.67%), Cordia africana (60%), Ficus exasperata (40%), Antiaris toxicaria (60.33%), Ficus mucuso (50%), Mallotus oppositifolius (40%), Lecaniodiscus fraxinifolius (43.33%), Coffea arabica (50%), Albizia grandibracteata (45.71%) and Ficus carica (43.33). From relative frequency analysis the result shows dissimilarity in percent and the type of most frequent woody species occurred in the two forest types. In addition the managed forest consists of few species which were most abundant within the highest frequency classes, which were not occurred in community used forest (Figure 5).

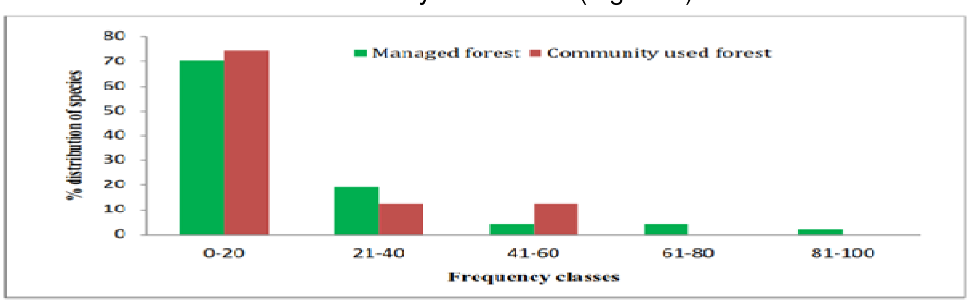

Figure 5: Frequency distribution of species in the Galesha forest

The frequency gives an approximate indication of the homogeneity or heterogeneity of the stand. Lamprecht (1989) revealed that, high value in higher frequency classes and low values in the lower frequency classes indicate constant or similar species composition and conversely, high values in percentage of number of species in lower frequency classes and low percentage of number of species in higher frequency classes on the other hand indicate a high degree of floristic heterogeneity. In the present study high values were obtained in lower frequency classes whereas low values were obtained in higher frequency classes. Therefore, according to the above explanation it is possible to conclude that there exists a high degree of floristic heterogeneity in both forest sites.

Importance Value Index(IVI)

From the analysis of important value index the two forests have different values. In managed forest Argomullera macrophyla has the highest IVI value (43.48) where as Pouteria altissima has the highest IVI value (29.99) in community used forest. These shows, the IVI value and the species which are frequent and dominant in the two forests are not identical. However, the two forest types share some similar species which are dominant; they vary with IVI Values. In managed forest Baphia abyssinica, Pouteria altissima, Manilkara butugi, Mimusops lanceolata, Blighia unijugata with their respective IVI value (35.16), (19.25), (15.25), (14.77), and (11.36) are most frequent and dominant species. In community used forest Coffea arabica, Albizia grandibracteata, Ficus mucuso, Celtis zenkeri, Antiaris toxicaria, Cordia africana with their respective IVI values (24.62), (21.85), (19.77), (19.60), (19.46), and (18.04) are among species which are frequent and dominant (Table 2). IVI classes, values, sum of species belonging to each class and their percentage value for both managed and community used forests showed in (Table 3).the IVI values vary for both forest types; this indicates the dominant species in both forest types different.

Table 2: Species with higher IVI in both managed and community used forest types

Species	Managed forest	Community used forest
	IVI value	IVI value
Cordia africana	8.92	18.04
Celtis zenkeri	12.75	19.60
Baphia abyssinica	35.16	0.00
Pouteria altissima	19.25	29.99
Blighia unijugata	11.36	0.00
Manilkara butugi	15.25	0.00
Antiaris toxicaria	0.00	19.46
Ficus mucuso	0.00	19.77
Mimusops lanceolata	14.77	0.00
Mallotus oppositifolius	0.00	10.47
Argomullera macrophyla	43.48	0.00
Lecaniodiscus fraxinifolius	0.00	11.60
Coffea arabica	0.00	24.62
Albizia grandibracteata	0.00	21.85
Ficus carica	0.00	10.37
Ficus exasperata	7.07	0.00
Landolphia buchananii	10.18	0.00

Species importance value index is used for setting priority /ranking species management and conservation practices and helps to identify their sociological status in a plant community as dominant or rare species (Kent and Coker, 1992). This have an implication that conservation priority for the two forest sites could not be the same since IVI value shows difference for different IVI classes of the species. The study result of Curtis and McIntosh (1951) also reported that, importance value index is the extents of dominance of a species in the structure of a forest stand. According to Yadav and Gup (2006) higher IVI value of a species in the highly disturbed forest was reported due to the protection provided by local people to the forest stand. A similar result was showed in this study, may be due to retention of higher DBH woody species in community used forest for coffee shade and apiculture. Micro-environment difference can be factor for the difference in the IVI value of the two forest types. Ecological significance of woody species for both forest sites was different based on the type of species and related IVI computed. Hence it was suggested for different approach of conservation priority.

Table 3: IVI classes, values, sum of species belonging to each class and their percentage value.

IVI classes & value	Managed forest			Community used forest		
	No. of species	Sum of IVI	Percent (%)	No. of species	sum-IVI	Percent (%)
1) >20	2	78.65	31.3	3	76.42	27.76
2) 15.01-20	2	34.48	13.7	4	76.87	27.92
3) 10.01-15	4	49.06	19.6	3	32.37	11.76
4) 5.01-10	4	26.34	10.5	3	21.70	7.88
5) 1.01-5	20	57.67	23.0	24	62.52	22.71
6) <1 IVI	7	4.74	1.9	10	5.40	1.96

Population Structures of Woody Species

The study of population distribution in a forest using DBH and height classes was important parameter to determine the horizontal and vertical stratum of the forest which is fundamental for understanding the population dynamics of a forest and to prioritize conservation approach for population of species based on existing condition. From analysis of relative density distribution over DBH classes, four representative pattern of population distribution for both forests were identified: (a) represents population of managed forest and (b) represents population of community used forest. The selected representative species were based on their relative density ha-1 (Figure 6).
The pattern of distribution (I) exhibited J-shape. It was represented by Pouteria altissima in both forests. In the managed forest, the population of Manilkara butugi, Blighia unijugata and Landolphia buchananii species exhibits this pattern of distribution. For community used forest this pattern was exhibited by Ficus mucuso. The pattern of distribution show lower density of population in the lower DBH classes and gradual rise of density in the middle and higher DBH classes. In community used forest, Coffea arabica cultivation in the understory has played role for retention of Pouteria altissima population in the higher DBH classes (V&VII).

The pattern of population (II) shows normal distribution. This pattern was represented by Celtis zenkeri in both forest sites. From comparison of the two forests the population pattern of this species showed similarity in density distribution for middle and higher DBH classes. However comparison of density of the population is different for lower DBH classes while the population of the species is devoid of regeneration in the managed forest might be as result of different biotic or physical factors.

The possible reason for good regeneration in community used forest for Celtis zenkeri population was perhaps due to good soil condition and open canopy of the forest. Ficus mucuso exhibits this pattern in community used forest while Mimusops lanceolata and Baphia abyssinica are among species that exhibited this pattern of density distribution in managed forest.

The pattern of distribution (III) approximates inverse –J-shape for managed forest. It was represented by Baphia abyssinica population in managed forest and Cordia africana population in community used forest. From comparison of these populations they exhibited good pattern of distribution in the lower and middle DBH classes but demonstrate low density or devoid in the higher DBH classes. Baphia abyssinica ensure good regeneration and stability of the population to the managed forest site possibly due to its adaptability.

Many populations in community used forest exhibited the density distribution pattern of Cordia africana population such as Antiaris toxicaria, Albizia grandibracteata, Lecaniodiscus fraxinifolius, Mallotus oppositifolius, and Ficus carica. They show higher density in the lower DBH classes and sharp decline or devoid in the upper and middle DBH classes which ensure their potential of regeneration under existing threat of deforestation.

The pattern of distribution (IV) was represented by two populations of different species for the two forest sites, Argomullera macrophyla and Coffea arabica in managed and community used forest respectively. These two different populations represented only the lower DBH classes of the forests. In managed forest Argomullera macrophyla was the most abundant small tree in this forest community of few species exhibiting this pattern of distribution.According to Ribbens et al. (1994) recruitment limitation on population dynamics is ambiguous, especially in tropical habitats. Recruitment limitation occurs when an abiotic or biotic variable decreases the transitional probabilities between one or more stages of plant recruitment, thereby causing a bottleneck in juvenile recruitment. In similar to this, environmental factors may be reason for limitation of recruitment in managed forest while combination of human impact and habitat requirement of a species can be considered as limitation for community used forest.

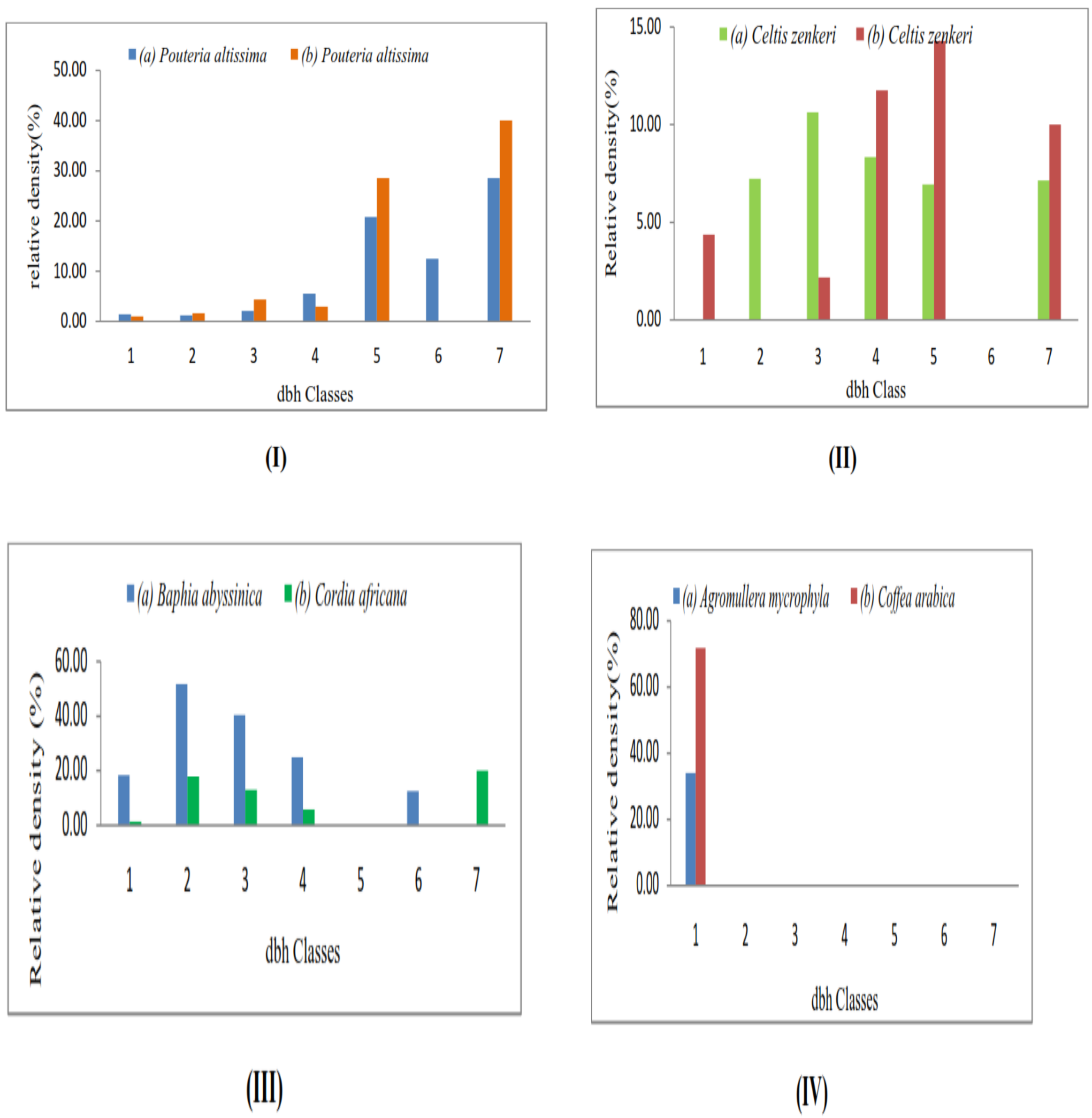

Figure 6: Comparison of population structure for the managed forest (a) and community used forest (b) The selection of these representative species was based on IVI > 10.The DBH classes (cm) are:
1) < 20cm, 2) 20.01 - 40, 3) 40.01 - 60, 4) 60.01 - 80, 5) 80.01 - 100, 6) 100.01- 120, 7) > 120.

Regeneration Status of Woody Species

From the analysis of seedlings and saplings data, the total seedling density of woody species is 4733 ha-1 for managed forest. The total density of sapling is 2283 ha-1 and the total densities of matured tree and shrub is 225 stems ha-1. The total density of community used forest was 5060.57 stems ha-1, 2507.4 ha-1, and 531.43 stem ha-1 respectively for

seedling, sapling, and tree (matured individuals and shrubs).
Mann-Whitney test was employed for comparison of seedlings, saplings and matured trees of total mean density ha-1 between managed and community used forest. The result for seedlings density ha-1 did not show significant difference between the managed and community used forests (at Z= - 0.541, P= 0.588), whereas, it shows greater value for managed forest. The statistical result also reveals that there was no significant difference in density ha-1 of sapling for both forests (at Z= - 0.738, P = 0.461), but shows greater value for managed forest, and also the comparative result of mean density of tree ha-1 showed insignificant statistical result for its difference (at Z= - 1.437; P= 0.151) between both forests. The comparable proportion of seedling ha-1 for community used forest to the managed forest may be due to its soil condition and open upper canopy. The major reason for comparable proportion of sapling density ha-1 in community used forest to managed forest could be due the open canopy that enhances the growth of sapling for some woody species.Different study results states that the regeneration is fair if the ratio of (seedling: sapling) ≥ 1 and/or (sapling: stem) ≥ or ≤ 1; Poor regeneration if the ratio of (seedling: sapling) < 1 and (sapling: stem) > 1 or ≤ 1; No regeneration if a species is represented only by stem individuals; and New if the species is represented only by seedling stage (Pandey and Shukla, 2003; Khumbongmayum et al., 2006; Mwavu and Witkowski, 2009). Based on the total density ha-1 of seedling, sapling and matured tree proportion; the regeneration is good for managed forest since the ratio of (seedlings: saplings) and (saplings: stems) are 2.07 and 10.15 respectively. From regeneration status analysis the community use forest also has good regeneration with the proportion of (seedling: sapling) and (Sapling: matured) tree having the value of 2.02 and 4.72 respectively. However, in community used forest the current saplings and seedling cannot promise mature tree community of future forest stand since it is frequently removed as result of human disturbance.Generally regeneration of woody species in this study area were represented by five patterns (a-e) based on number of individuals ha-1 for seedling, sapling and mature trees (Figure 7). The regeneration pattern (a) have higher number of seedling and sapling exhibits reverse-J-shape which indicates good recruitment. The pattern (b) represented only with mature tree individual, pattern (c) represented with few number of individual ha-1 for sapling and greater number of seedling and matured individual still indicating good recruitment, regeneration pattern (d) represented with larger number of sapling and few number of seedling and matured individual and pattern (e) exhibits J-shape pattern with predominance of matured individuals in the population. Depending upon the general density proportion of seedling, sapling and trees individuals ha-1 all species were grouped under either of five groups (a-e). Nagel et al. (2006) raveled that establishment, growth, and survival of different species of tree seedlings are known to vary with forest floor micro-site heterogeneity caused by disturbance or the influence of over story or understory plants. Gap formation by death of individual or small groups of canopy trees is often noted as the dominant process driving forest dynamics. The study of Ranel and Vargas (2000) also revealed that Canopy structure is one of the key variables influencing the structure and functioning of money forest ecosystem components, such as spatial heterogeneity and temporal dynamics of the under story vegetation and pattern in regeneration mosaic.

CONCLUSION

There was greater woody species density within higher DBH classes for managed forest as compared to community used forest due to human disturbance on the later one. Percent of individual per ha-1 in all DBH classes of managed forest showed greater value as compared to community used forest area. The predominance of individuals in the highest DBH classes for managed forest shows greater difference as compared to community used forest. The two forest sites were different in IVI values and the types of species ecologically important. Based on IVIs, four representative patterns of population distributions were demonstrated using relative density (%) versus DBH classes. From Comparison of both forest types, some woody species population exhibited almost similar pattern for few species. Comparisons of woody species regeneration status at both forest sites do not show significant difference, however it shows greater value for managed forest. Generally the inverted J-shape was exhibited by both forest types indicates good recruitment condition of the forest. However, in community used forest saplings and seedlings were continuously removed and will not promise the future stand of the forest.

RECOMMENDATIONS

There is need for great consideration for conservation and management of Mejengir Forest. Therefore the following recommendations are expected to meet desired objectives:

- The woody species structural analysis information of this study forest can serve as baseline information for management intervention of the forest as well as for comparative monitoring within managed forest and adjacent community used forest. So that, changes taking place within the managed forest can be understood in a wider context.
- The population distribution pattern for few woody species indicated the absence of seedling and sapling in

- managed forest suggesting for further investigation on regeneration condition of this species. In addition the population
- pattern shows predominance of matured individuals than sapling and seedling of some species for both forests that need for management intervention to guarantee sustainability of the forest.
- Further studies are suggested to be carried out for better understanding of ecological processes within natural forests such as seed dispersal and germination, seedling establishment and growth.
- Multi-storey agroforestry systems that involve combination of native species from different forest strata can serve for income diversification and reduce pressure on woody species of in the natural forest.

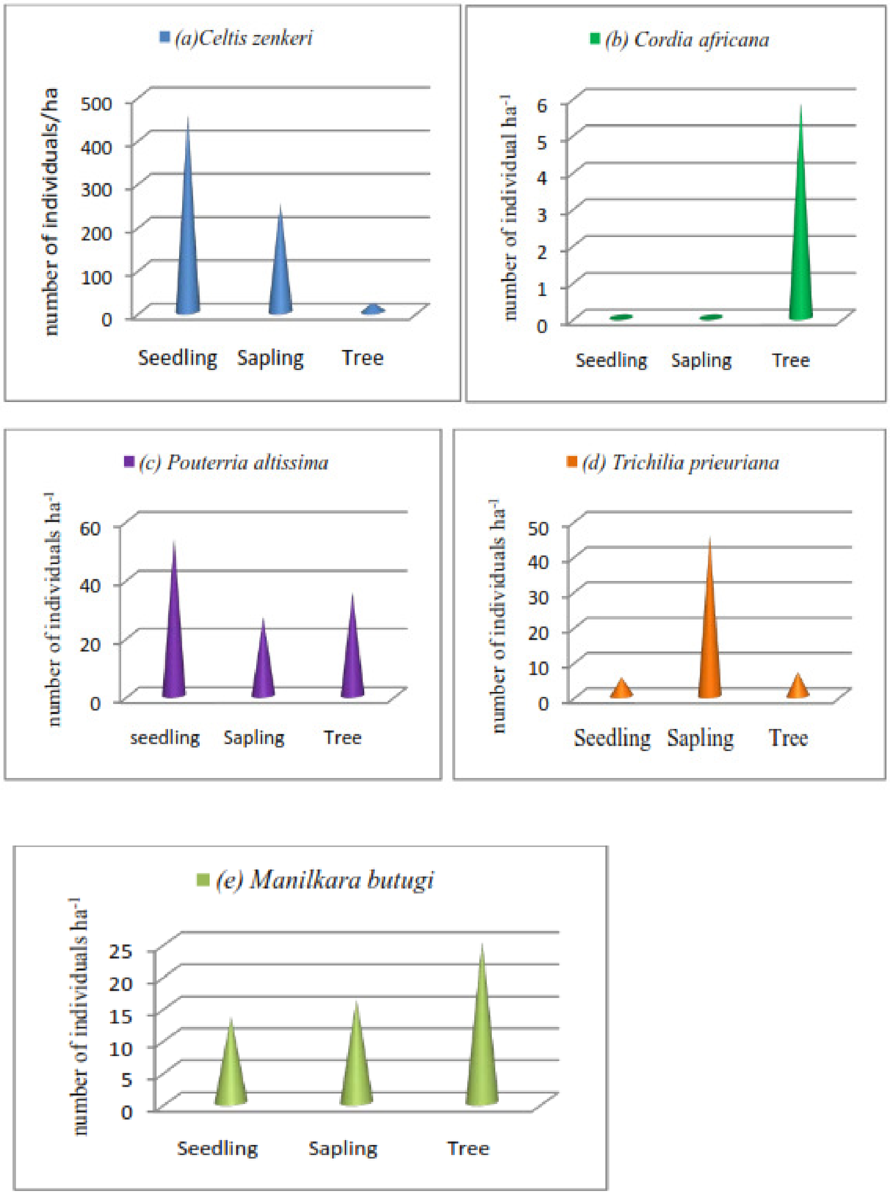

Figure 7: Representative pattern of frequency distribution individuals ha^{-1} for seedling, sapling and trees

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