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Woody Species Composition and Community Analysis in Managed and Community Used Forest Sites in Gelesha Kebele, Mejengir Forest, Gambella National Regional State

Damena Edae [1], Teshome Soromessa[2], Feyera Senbeta[3]
1,2Center for Environmental Science, College of Natural Science, Addis Ababa University,
P.O. Box No; 1176, Addis Ababa, Ethiopia.
3Center for Environmental and Development, College of Development Studies, Addis Ababa University, P.O. Box No; 1176, Addis Ababa, Ethiopia.

Abstract

Comparative analysis was undertaken, in managed and community used forest sites of Gelesha Kebele, Mejengir forest, southwest Ethiopia; with the objective to determine woody species diversity of both forest types. A total of 60 plots, with dimension of 20 x 20m were established for trees and shrub sampling following transect line at distance of 200m interval across gradient. For seedling, sapling and climber-woody, five subplots of 5x5m were established with in main plots. Information about number of individuals, number of seedlings and saplings, matured individuals for each species were collected from each plots including relative physical characteristics of the area. Various statistical tools and ecological software were used for the data analyses. A total of 71 species belonging to 56 genera and 30 families were identified. Community types (clusters) analysis indicated that three different community types were identified in each forest. For community used forest, diversity and evenness value of its communities indicated high value as compared to managed forest. The dissimilarity between managed and community used forest types indicates that each forest is unique and need conservation from biodiversity point of view.

Key words:community used forest, manage forest, Mejengir Forest, plant community, species diversity,

INTRODUCTION

Forest ecosystem provide various services that living organism derive from ecosystem functions that maintain the earth's life supporting system (Samuel, 2007). The ecosystem service and the natural capital in this regard become critical to function of the earth's life supporting system. However rapid deforestation activities and uncontrolled utilization can irreversibly and substantively impair forest ecosystem functions, thereby endangering the flow of several socially valuable goods and services from the standing forests.

The 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. Hence, management of intact forest and restoration of degraded forest landscape is the best alternative to maintain ecological integrity and meet social need.

Community-based natural resource management distinguishes the emerging approaches from an earlier concept of communitynatural resource management, which refers to communities having full and generally autonomous responsibility for the protection and use of natural resources (Uphoff, 1998). This approach has derived from or been modeled after indigenous systems of natural resource management, where local knowledge, norms and institutions have co-evolved over long periods of time with the ecosystem in question. This often makes for well-attuned management regimes as shown by some of the case studies in (Clay, 1988; Berkes, 1989).

Ethiopia has diverse physiographic features which helped the nation being endowed with a great variety of vegetation types. The study results of different researchers categorized Mejengir forest under transitional rainforest vegetation type. This forest was composed of afromontane and Guineo Congolian floral elements as well as transitional species which are only restricted in distribution to this area of Ethiopia (Yeshitela, 2008; Woldemariam, 2003).

Mejengir forest is one of the few remaining forest blocks in southwestern Ethiopia. Ecological assessments of this forest will be important for planning, sustainable utilization and conservation. On the other hand management planning requires detailed baseline information regarding ecology of the forest. The comparative analysis of woody species in managed and community used site of the forest has not yet been investigated in the study forest. As a result, the current ecological study on woody species floristic composition 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. The study of woody species floristic composition is essential in understanding the forest ecosystem (WCMC, 1992). 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).

In the study forest, Participatory Forest Management (PFM) initiative has been driven for sustainable utilization of forest. The area was divided in managed forest which is intact in biotic community and community used forest that was degraded as result of multiple extractive social uses. The intact forest is vital in maintaining ecological integrity as well as maintains biological diversity. The community used forest can meet the society's well-being and maintain ecosystem of the area. Comparative study was carried out on biological potential of managed forest and adjacent community used forest area. The comparative study can provide information about change taking place in managed forest in wider context.

MATERIALS AND METHODS

The study was undertaken in Godere district, Mejengir Zone, Gambella National Regional State. Mejengir zone is located at 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 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.

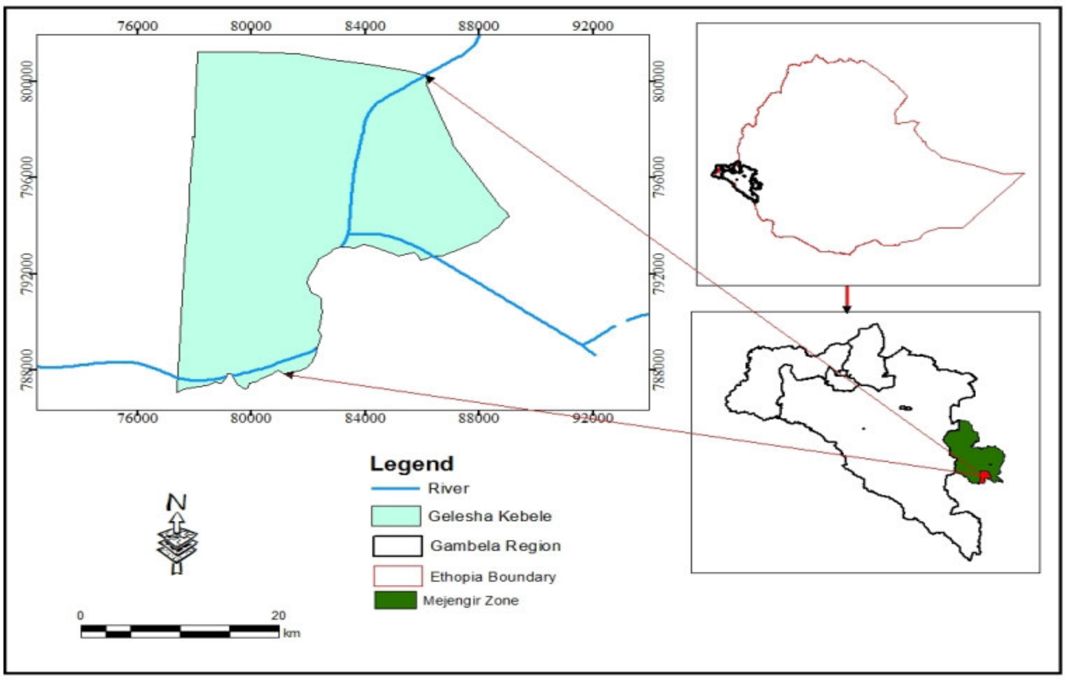

Figure1: Location map of the study area

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 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 plot.

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.

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

Plant community, Diversity and similarity analysis

PC-ORD window version 4.20 software was used for plant community analysis. Cluster analysis was employed to repeatedly cluster the plots into groups, based on the abundance of the species (the number of individuals).Shannon diversity index was used to measure species richness, evenness and diversity within in study site. The Shannon–Wiener index takes into account species richness and proportional abundance to calculate diversity. This index measures of evenness of species abundances in a sample with more even samples gaining a higher value (Shannon and Weiner, 1949).

RESULTS AND DISCUSSION

Woody species composition

A total of 71 woody species representing 30 families and 56 genera were recorded in both managed and community used forest sites. From the total number of plant families recorded in the study site, top species-richest families include: Euphorbiaceous (10species), Moraceae (9species), Rubiaceae(5species), Spotaceae (5species), Sapindaceae and Asteraceae each has (4species). The two families including Fabaceae, Celastraceae each has (3species). On the other hand; about 7 families (23%) had two species each. Those remaining 15 families (50%) had a species number of 1 per family indicates that the forest was affected in terms of family composition beside species loss. The recorded species were composed of 73% trees, 14 % shrubs and 13 %woody- climber.

In the managed forest site 47 woody species were recorded which belongs to 21 families and 39 genera. On the other hand 56 woody species which belongs to 27 families and 45 genera were recorded in community used forest area. The result of the study revealed that both managed and community used forest sites are rich in few families like Euphorbiaceae, Moraceae, Rubiaceae, Sapindaceae, and Sapotaceae. However, managed forest did not have some families whereas the community used forest site is more rich in number of families from comparison of the two forests (Figure 2).The study of Widodo (2010) reported that number of family found in a stands influences the number of family of the forest vegetation as a whole. As a consequence, the number of family diversity is parallel to the number of the genus and species diversity. From the conservation perspective, the forest stand with higher number of families has the highest potential of genetic conservation because they contain a relatively high number of species, genus, and family diversity. But, in reverse the taxonomic diversity in the finding of this study is not proportional to number of familiesand species.

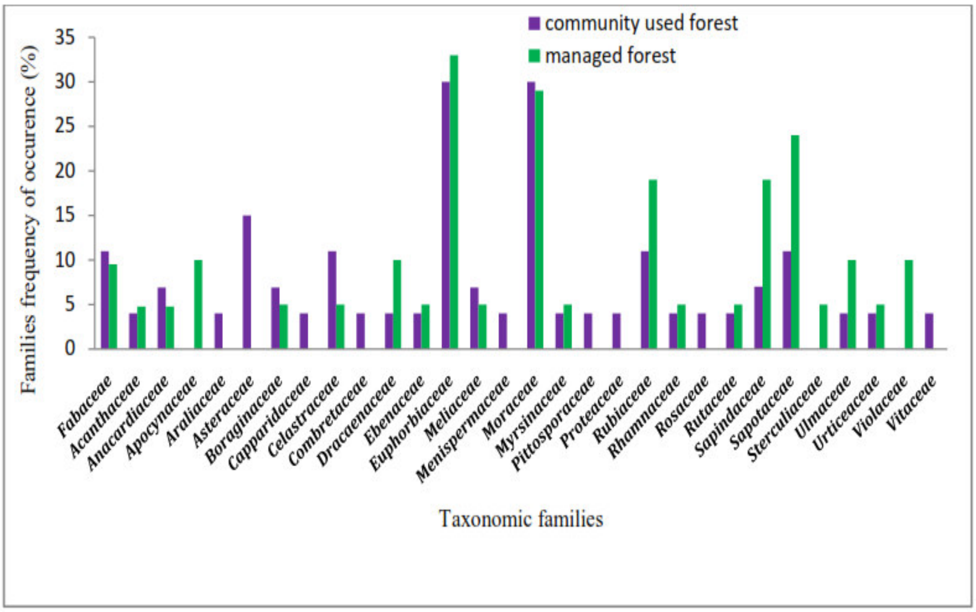

Figure 2: Frequency of occurrence for families in both managed and community used forest sites

The analysis of floristic composition also indicates that only few families like Euphorbiaceae, Moraceae, Spindaceae and Sapotaceaeare richest in number of species they have comprised; while other families have less number of species. From species comparison of the two forest sites the community used forest has more number of species than managed forest sites (Figure3).

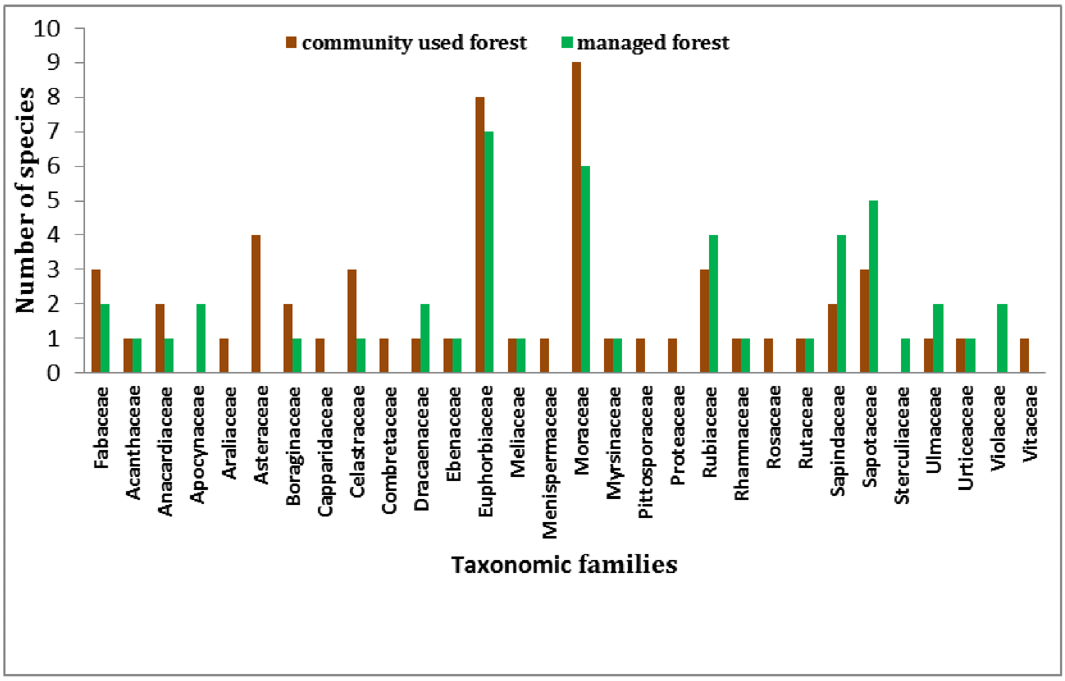

Figure3: Distribution of species per families in both managed and community used forest sites

Both forest sites share some species in common; but also they differently contain some other species. The difference in species composition of the two forest sites might be due to difference in environmental variables. The growth of trees in an ecosystem is determined by moisture, soil characteristics, landscape and specific species growth requirement (Savadogo et al., 2007). Some of the species were restricted only to the community used forest site. This may possibly resulted from the difference in altitudinal range, slope, edaphic condition (chemical and physical property of soil). The soil condition of managed forest is mostly rocky surface which will limit the availability of moisture and nutrient for some species. It also can inhibit the regeneration of some woody species of managed forest. In reverse the community used forest site is gentle slope and devoid of rocky surface that could enhance heterogeneity of the forest. The better floristic compositions of the community used forest also require great concern from biodiversity conservation point of view. The current community reliance for different uses on community used forest site could be cause for loss of those species which are rare in occurrence and limited only to this forest.

Plant community classification

Three plant community types (clusters) were identified at 25% similarity level from hierarchical cluster analysis of PC-ORD software by using Euclidean (Pythagorean) and wards method for community used and managed forest (Figure 4). Plant community types were given names after one or two dominant or characteristic species and the input data matrix has 30 plots and 43 species for managed forest whereas it was 30 plots and 48 species for community used forest.

Community types of managed and community used forests

Managed and community used forest types were classified in to three communities each and represented with relative attitude range and number of plots (Table1).

Table 1: Total number of sample plots and their relative altitude range for each community of both forests.

Forest type	Community type	Total plots	Altitude(m)
Managed forest	C1	13	971-1094
	C2	2	1024-1027
	C3	15	984-1066
Community used forest	C4	5	1075-1105
	C5	16	985-1112
	C6	9	1016-1118

Community types of managed forest

Argomullera macrophyla - Baphia abyssinica - Community type

This plant community class was located between altitudinal ranges of 971-1094 ma.s.l in the managed forest site. It was represented by 13 plots and 32 species. In addition to the dominant species used in naming of the community, Blighia unijugata, Pouteria altissima,Diospyros abyssinica, Mimusops lanceolata, Mallotus oppositifolius, Morus mesozygia, Dracaena steudneri, were the dominant species in the tree stratum of the community. Whitfieldia elongata, Erythrococca trichogyne, Dracaena fragrans were the common species in the shrub layer of the community. On the other hand Whitfieldia elongate was the most abundant shrub in the lower stratum of the community, could be as result of closed canopy of this community type by dominant tree or moisture condition, stability of the species to this site.

Rinorea ilicifolia – Erythrococca trichogyne- Community type

This community was located between elevations of 1024 -1027 ma.s.l. It includes 2 plots and 10 species in the group. Baphia abyssinica, Celtis zenkeri, Blighia unijugata, Mimusops lanceolat, Ficus ovata, Argomullera macrophyla, Rinorea ilicifolia were the dominant species of tree in the community type. The shrub layer of the community comprised Erythrococca trichogyne, Whitfieldia elongata, and Dracaena fragrans.This community was very much abundant with Whitfieldia elongata. The community was represented with only two plots and few numbers of species.The unique characteristics of this community type perhaps are the microsite variables.

Whitfieldia elongate - Dracaena fragrans - Communitytype

This community was situated between 984-1066 ma.s.l. It consists of 15 plots and 40 plant species in the group. Baphia abyssinica, Mimusops lanceolata, Celtis zenkeri, Landolphia buchananii,Trichilia prieurian, Blighia unijugata, Manilkara butugi were main tree species in the upper stratum of community. The dominant shrub layers were; Whitfieldia elongata, Dracaena fragrans, Erythrococca trichogyne. Whitfieldia elongata was the most dominant species in the lower stratum of the woody species community.

Community types of community used forest

Celtis zenkeri - Pouteria altissima- Community type

This plant community was located between altitudinal ranges of 1075-1105 ma.s.l. It was represented by 5 plots and 26 plant species in the group. Pouteria altissima ,Celtis zenkeri, Diospyros abyssinica, Argomullera macrophyla, Trichilia prieuriana, Croton macrostachyus, Rothmannia urceliformis, Baphia abyssinica, Blighia unijugata, Antiaris toxicaria are the dominant woody species in the tree layer. Mytenus gracilipes, Dracaena fragrans, Whitfieldia elongate were frequent woody species in shrub layers of the community.

Coffea arabica – Albizia grandibracteata - Community type

The plant community was situated at 985-1112 ma.s.l. It was represented by 16 plots and 38 plant species in the group. Coffea Arabica, Albizia grandibracteata, Pouteria altissima, Mallotus oppositifolius, Focus carica, Antiaris toxicaria, Lecaniodis fraxinifolius were dominant species inthe tree stratum. Vernonia theophrastifolia, Whitfieldia elongata, Erythrococca trichogyne, Gounia longispicata were the common woody species in the shrub layer. From the comparison of communities of managed and community used forests, this community type was richest in number of trees and shrub species maybe due to altitudinal ranges and other environmental variables.

Lecaniodiscus fraxinifolius -Mallotus oppositifolius-Community type

This plant community was found at altitude of 1016-1118 ma.s.l. It was represented by 9 plots and 28 plant species in the group. Albizia grandibracteata, Lecaniodiscus fraxinifolius, Pouteria altissima, Mallotus oppositifolius, Coffea arabica, Ficus carica, Antiaris toxicaria, and Cordia Africana were the dominant species in tree stratum of the community. The frequent shrub species in the cluster were Erythrococca trichogyne, Whitfieldia elongata,Vernonia theophrastifolia.The reason for frequent occurrence of shrub and woody-climber in the communities was the existing deforestation to higher stratum tree composition. Excessive cutting of higher canopy tree layer is mostly enhances dominance of shrub and woody climbers in the lower stratum of the forest. Elevation, temperature, soil moisture, and soil type are the primary controls on species distribution patterns (Poulos et al.,2006).Plant communities are separated from each other based on distinctive floristic composition which is considered as one of the major distinguishing characters of a community (Rad et al., 2009).Community assembly emerges from the interaction of different mechanisms involving both dispersal and niche based processes(Norden et al.,2009).The environmental variables and biotic factors might influence the plant community formation of the present study in a similar manner.

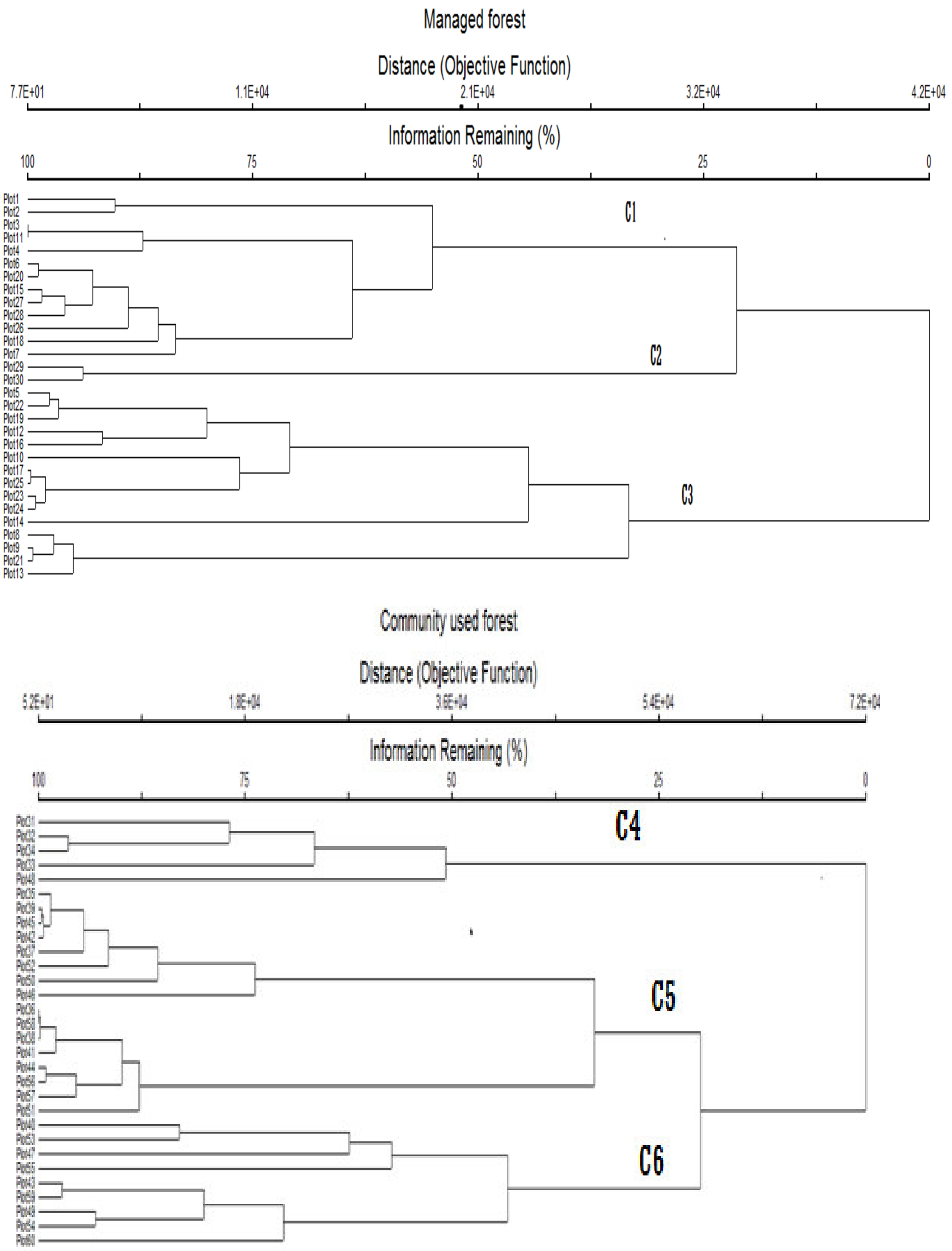

Figure 4: Dendrogram of managed and community used vegetation data obtained from the hierarchical cluster analysis with the level of grouping based on 25% information remaining.

Table2: Synoptic table of species reaching a value of ≥ 0.1 in at least one community type of managed forest

Cluster Number	**1**	**2**	**3**
Cluster Size	**13**	**2**	**15**
Argomullera macrophyla	**30.6**	31.5	14.5
Baphia abyssinica	**9.8**	5	7.3
Rinorea ilicifolia	0	**48**	0
Whitfieldia elongata	7.8	6	**35.8**
Blighia unijugata	7.6	0.5	1.4
Ficus ovate	0	0.5	0
Erythrococca trichogyne	2.8	**8**	1.1
Pouteria altissima	2.8	0	0.5
Diospyros abyssinica	2.4	0	0.4
Dracaena fragrans	2.4	3.5	**29.6**

Table 3: Synoptic table of species reaching a value of ≥ 0.1 in at least one community type of community used forest

Cluster Number	4	5	6
Cluster Size	5	16	9
Celtis zenkeri	**50.8**	0.4	1.9
Pouteria altissima	**32.4**	4.4	15.9
Coffea arabica	0	**19.6**	15.59
Albizia grandibracteata	0.2	**8.6**	33.1
Lecaniodiscus fraxinifolius	0	4.9	**23.8**
Ficus carica	0	5	7.7
Whitfieldia elongata	10.2	1	3.3
Diospyros abyssinica	7	0.1	0.1
Rothmannia urceliformis	7	0	1.9
Mallotus oppositifolius	6.8	5.4	**17.1**
Vernonia theophrastifolia	0	4.4	1.8

Woody species diversity, richness and evenness of the plant community types

The value of species diversity was reliant on the value of species relative abundance and number of species in the sampled area. The value of diversity index increases proportionally with the increment of species richness and evenness values. Shannon– Wiener diversity index (H'), was computed for both communities of managed and community used forests (Table 4). The difference among the communities of both forest imply the difference in species richness and evenness for the forests. Shannon–Wiener diversity index analysis reveal that communities of community used forest (C5and C6) had better value as compared to value of managed forest communities (C1, C2, C3). On the other hand a lower woody species diversity and evenness was observed in communities of the managed area as compared to the community used forest.

Table 4: Shannon - Wiener indices, species richness and evenness of the plant communities

Forest sites	Community type	Altitudinal range (m)	species richness	diversity index (H')	H' max	species evenness(J)
Managed forest	C1	971-1094	1.0200	2.1788	3.4657	0.6287
	C2	1024-1027	0.6337	2.1788	3.4657	0.6287
	C3	984-1066	0.9980	2.0704	3.6887	0.5613
Community used forest	C4	1075-1105	0.9837	2.0985	3.2581	0.6441
	C5	985-1112	1.0486	2.8456	3.6376	0.7823
	C6	1016-1118	0.7521	2.5288	3.3322	0.7589

Kharkwal et al. (2010) stated that the changes in topography, altitude, precipitation, temperature and soil conditions contribute to the diverse bioclimate that results in a mosaic of biotic communities at various spatial and organizational levels. It may be such environmental variables in combination with anthropogenic disturbance that affect diversity, evenness and richness of the plant communities.

Similarity among the Plant Communities

Jaccard's similarity coefficient was used to distinguish the similarity among communities of both managed and community used forests, as well as similarity with in communities of both forests sites. The communities of managed forest were represented by (C1, C2, and C3) and communities of community used forest were denoted by (C4, C5, and C6) as described in (Table 5). Jaccard's similarity coefficient for communities of managed forest shows highest similarity between community (C1and C3) with value of (Sj=0.71) but low value of similarity was observed between community (C1 and C2), (C2 and C3) with value of 0.24 and 0.22 respectively.

The similarity coefficients among community used forest communities indicated higher similarity between (C5, C6) with value of (0.60). Whereas, community (C4, C6) and (C5, C4) registered lower value 0.43 and 0.46 respectively. Similarity coefficient from comparison of the two forest types revealed that there was a low similarity value among the two forest communities. However, the similarity value from comparison of each community did not approximate 1. The lower similarity value among communities of each forest reflects that each community is unique in number of species it has consisted of in context of diversity of species. This requires concern from ecological conservation point of view to control biodiversity loss in community used forest landscape.

The study result of Prudy et al. (2005) described that a graded series of plant communities was found along elevation gradients, with the vegetation responding to changes in edaphic conditions. Patterns of similarity in community composition between different areas reflected similarity in level of salinity. Possibly in this study lower similarity values among communities may be variability in edaphic condition of different community sites in combination with the effect of human disturbance.

Table 5: Jaccard's similarity coefficient among the plant communities of managed and community used forests

Communities	Managed Forest			Community Used Forest		
	C1	C2	C3	C4	C5	C6
C1	1.00	0.24	0.71	**0.38**	**0.37**	**0.43**
C2	0.24	1.00	0.22	**0.09**	**0.14**	**0.15**
C3	0.71	0.22	1.00	**0.40**	**0.34**	**0.36**
C4	0.38	0.09	0.04	1.00	0.42	0.43
C5	0.37	0.14	0.34	0.42	1.00	0.60
C6	0.43	0.15	0.36	0.43	0.60	1.00

In the Table (C1, C2, C3,) represented communities of managed forest whereas (C4, C5, C6) represented communities of community used forest type.

CONCLUSION

Mejengir forest is composed of floral elements which are restricted in distribution to this area of the country. The forest was found habitat of diverse groups of plant species. From floristic composition analysis few families were found most frequent and richest in terms of species it comprised. However majorities of the families were limited in number of species and frequency of occurrence suggesting that the forest was affected in terms of species beside family loss. From comparison of the two forest types the managed forest does not consist of some families which were included in community used forests. It indicated that only the managed forest could not completely guarantee to solve species loss, since totally similar floristic compositions were not shared among the two forests. Community types (clusters) analysis indicated that three different community types were identified in each forest. For community used forest, diversity and evenness value of its communities indicated high value as compared to managed forest. The dissimilarity between managed and community used forest types indicates that each forest is unique and need conservation from biodiversity point of view.

RECOMMENDATION

Great consideration is important for conservation and management of Mejengir forest. Therefore, the following recommendations are expected to meet desired objectives:

- The woody species regeneration, diversity and structural analysis information of this study 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.
- 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.

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