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Floristic Composition, Structure and Regeneration Status of Hamdo Natural Forest, Gursum Woreda East Hararghe Zone, Ethiopia

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Abstract: This study was conducted on Hamdo Natural Forest located in Gursum woreda, east Hararghe Zone. The aim of this study was to assess floristic composition, population structure and identifying regeneration status. Systematic sampling method was employed to collect vegetation data by focusing on vegetation homogeneity. A total of 36 quadrats having (30x30m=900 m^2) size were sampled. Within each of main quadrat all woody species>2.5cm dbh and 2m height was measured dbh and height. where species <2.5 and <2m height was counted within sub-plot 1mx1m size laid at four corners each and one at the center of the large plot to assess regeneration status. The collected data was organized first on excel and analysis by shaman index and IVI. A total of 50 plant species, representing 36 families and 24 genera were recorded from study area. Fabaceae was the dominant family represented by 3 genera and 10 species. Followed by Anacardiaceae had (6 species, 25%). Combretaceae, Oleaceae and Tiliaceae were the third highest family (3species, 12.5%). The total density of seedling, sapling and mature tree in Hamdo forest was 1007, 648, and 1651 individuals per ha respectively whereas the basal area of the forest was 30.4 m^2ha^{-1}. The evidence of population structure and regeneration status of the forest showed the existence of anthropogenic disturbances like overgrazing, illegal cutting of tree for fire wood charcoal and construction. Hence, the establishment of in-situ site through exclosure was sound approach for the sustainable conservation of the study are biodiversity before threatened.

Keywords: Floristic Composition, Hamdo Forest, Structural Analysis, Wood Diversity

1. Introduction

Ethiopia is one of tropical country found in the horn of Africa between the geographical coordinates of 3° 24′ and 14° 53′ North and 32° 42′ and 48° 12′ East [65] and has an area of 1,113,677 km^2 [22]. It has diverse geographical and climatic condition from the Lowest altitude in the country is 126 meters below sea level found in the Dalol (Afar) depression and the highest altitude is 4,620 meters above sea level which is Ras Dejen (the highest mountain in the country) in the Semen Mountains [50]. As a result, of this made Ethiopia includes 6,000 species of higher plant taxa of which 10% are endemic [30, 29]: poses a great biological diversity [36]. As well as, Ethiopia is rich in faunal, flora and microbial diversity, has the fifth largest flora in Africa [37], and has rich endemic plants and animal. According to UNDP project on mainstreaming incentive for biodiversity conservation (MIBC), Ethiopia is one of the top 25 biodiversity-rich countries in the world. It is also among the countries in the horn of Africa regarded as major center of diversity and endemism for several plant species.

Forest is among biological resource which are depositories and gene pools for several domesticated and/or important wild plants and wild relatives of domesticated plants [36]. It has many benefits as an important ecological service, wood and non-wood forest product (NFPs) for the well-being of humans at local, national and global levels like timber, firewood, NTFPs, pasture, fodder and recreation [9].

Despite this importance, forest resource in Ethiopia is depleting from time to time before we even have a chance to study and document them [21]. Cited in [17], once Ethiopia forest covered 35% of Ethiopian land area which were reduced to 16% of the total land area in early 1950's and by the early 1980's, land area covered by forest had declined to 3.6%; by 1989, it was reduced to about 2.7% which indicate that forest resource is declining at an alarming rate. The major factors for the destruction of natural forests are mainly anthropogenic factors including agricultural activities (expansion conversion of natural vegetation to farmland) and overexploitation for various purposes such as fuel wood, cultivation purpose, charcoal production, construction material and timber, unsustainable utilization of natural resources (over-consumption), deforestation [2].

Reduction in forest resource due to aforementioned factors has many consequences including soil erosion and reduced capacity for watershed protection with possible flooding, reduced capacity and loss of biodiversity [16]. This in turn leads to instability of ecosystem and reduced availability of various forest products and services [6].

Study of floristic composition and vegetation structure are useful in understanding the extent of plant diversity in forest ecosystem [69] and it is important in identifying essential elements of plant diversity, protecting threatened and economic species and monitoring the status of forest [67, 64]. In addition to this, it is important to understand the status of regeneration and diversity for conservation purposes [51].

In Ethiopia, floristic composition and vegetation studies have been conducted in different parts of the country [63, 30, 48, 62, 33, 26, 65, 34, 11, 10]. However, the study of floristic composition in eastern part of Ethiopia is scarce particularly in Hararghe except few cases [14, 10, 9]. No studies have been conducted on Hamdo Natural forest. Hence, this study was needed to investigate floristic composition and vegetation structure of Hamdo natural forest for sustainable conservation.

2. Materials and Methods

2.1. The Study Area

This study was conducted on Hamdo natural forest, which is found in Gursum woreda, eastern Hararghe Zone of Ethiopia (Figure 1). Gursum is bounded on the south by Babile, on the west by the Harari Region, on the north by Jarso, and on the east by the Somali Region. The woreda is located at about 562 km southeast of Addis Ababa and 75km from Harar Town. The current study of Hamdo forest is remnant patch of natural forest and now established as in situ conservation site by Ethiopian biodiversity institute, Harar center and MoU signed with the Gursum district and Misro kebele administrative offices. It has covered an area of 223ha. The woreda is delimited a latitude and longitude of 9°21′N 42°24′ECoordinates with an elevation between 1980 – 2049m.a.s.l.

The mean annual rainfall and temperature of the study area taken from the estimated data by [43]. According to the distribution of rainfall in study area from July to October, with the highest rain falling in August, September and October. The rainfall distribution of the study area was bimodal occurring from February to April (short rain season) and June to September (long rain season). Whereas, mean annual rainfall is 740.6mm/year. This indicated high variation from year to year, ranging from 470.6 mm to 1270.4 mm/yea. The mean annual temperatures of the area are 20.7°C. This shows only a slight difference in temperature throughout the year, with the hottest months during April to June (maximum 29.4°C) and the coldest during October to December (minimum 12.8°C). The vegetation of the woreda belongs to the *Acacia- Commiphora* woodland, semi-desert scrubland and evergreen scrub types. There are also riverine woody species in the area that include species *of Acacia robust burcha, Tamarindus indica L. Oncoba spinosa Forssk., Acokanthera schimperi* (A. DC.) Schweinf and *Capparis tomentosa* Lam [8]. The demography of this woreda show that include 151,931 the total populations, of whom 77,112 were men and 74,819 were women; 12,048 or 7.93% of its population were urban dwellers [57].

2.2. Data Collection

2.2.1. Reconnaissance Survey

Before starting actual data collection, we discussed the objective of our studies with woreda focal offices and administrator. Then, we conducted a preliminary of forest area before actual data collection from September 27-29 through a field visit and physical observation across the Hamdo natural forest to obtain vegetation patterns of the study area and identify representative sampling sites about the forest.

2.2.2. Sampling Design

The actual vegetation data collection was conducted from October 1 to October 25. Following reconnaissance survey 36 main Plots of 30mx30m ($900m^2$) were systematically established at 50maltitudinal gradients from each other along six transect line from south to north direction. Within each of major plots regularly, five subplots ($1m^2$) were established one at the center and at four corners for seedlings and saplings data collection. From six of transect the largest transects are 1 and 2 contains 9 plots each. The distance between each transects line were 500m far from each other to each other.

2.2.3. Vegetation Data Collection

In each plot, the local name of each species was recorded and specimens for each species were collected and handled properly. Then, collected specimens was pressed and dried and brought to Herbarium of Ethiopian Biodiversity Institute for further taxonomic identification. The specimens were identified by referring to available literature such as the specimens and using taxonomic keys in the Flora of Ethiopia and Eritrea [27, 20, 29].

In each plots, the number of all Woody species and DBH with DBH≥2.5cm and Height≥2m) were measured dbh by caliper and diameter tape at breast height (DBH=1.3m) and height by hypsometer. Seedling and sapling of each species occurring in each plot were counted and recorded. In case unable to measure their Height due to topographic feature, it was estimated visually.

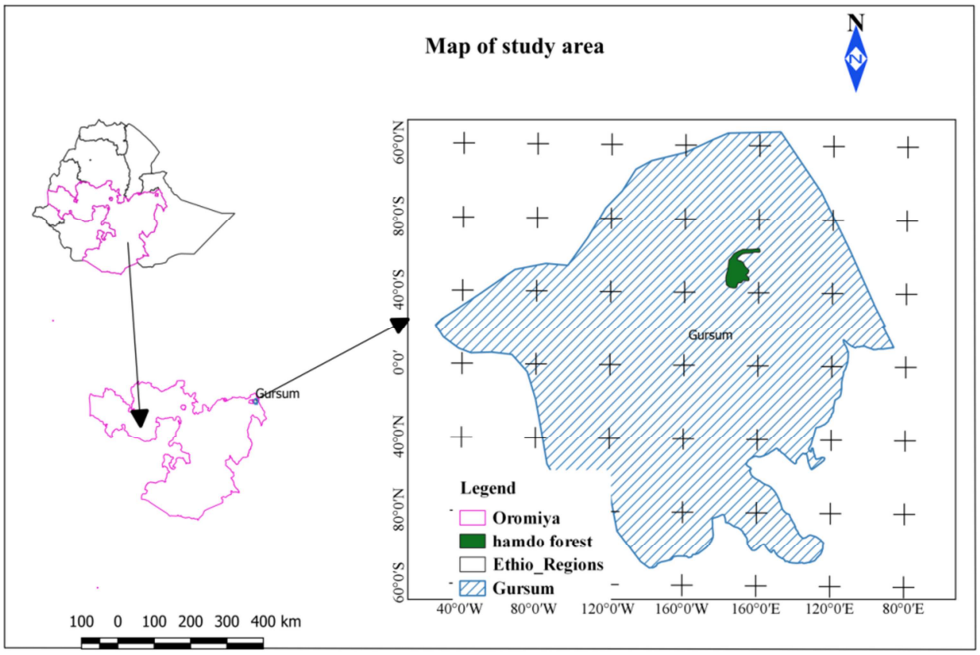

Figure 1. *Map of study area Hamdo natural forest in Gursum woreda.*

2.2.4. Data Analysis

The collected data of height, diameter and number of species encountered and measured in each plot for tree and shrub species of study area was arranged first on excel sheet. Following this, woody species diversity was calculated for each species at every plot was analyzed by using the Shannon-Wiener Diversity Index the following equation [42, 46]. The index takes into account the species richness and proportion of each species in all sampled quadrats of the study site. The value of Shannon diversity index usually found to fall between 1.5 -3.5 and rarely surpasses 4.5 [45].

The Shannon diversity index is calculated from the formula:

$$H'=-\Sigma pilnpi$$

Where: H'=Shannon-Wiener Diversity Index; Σ=Summation symbol; pi=the proportion of individuals or the abundance of *ith* species expressed as a proportional of total cover in the sample and ln=log bases (natural logarithms).

Evenness or equitability, a measure of similarity of the abundances of the different woody species in the study site, was analyzed by using Shannon's Evenness or Equitability Index [42, 46].

Equitability or evenness index was calculated using the subsequent formula:

$$E=H'/\ln(S)=H'/Hmax$$

Where: E=Evenness; H'=Shannon-Wiener Diversity Index; Hmax=lnS; S=total number of species in the sample. The value of evenness index falls between 0 and 1. The higher the value of evenness index, the more even the species is in their distribution within the given area.

Importance value indices (IVI) were computed for dominant woody species based on their relative density (RD), relative dominance (RDO) and relative frequency (RF) to determine their dominance and indicates the relative ecological importance of a given woody species at study site [40].

$$\text{Relative Density (RD)}=\frac{\text{The number of all individuals of a specie}}{\text{total number of all individuals}}\times 100$$

$$\text{Relative Frequency (RF)}=\frac{\text{Frequency of a species}}{\text{Total frequency of all species}}\times 100$$

$$\text{Relative Dominance (RDO)}=\frac{\text{Basal area of all individuals of a species}}{\text{Total basal area of all species}}\times 100$$

$$\text{IVI}=\text{Relative Density}+\text{Relative Dominance (basal area)}+\text{Relative Frequency}$$

The population structures were analyzed using histograms with the grouped diameter classes. It was constructed by

using the density of individuals of each species (Y-axis) and categorized into ten diameters classes (X-axis) following [56] i.e. 1=< 2 cm; 2=2-5cm; 3=5^{-1}0cm; 4=10^{-1}5cm; 5=15-20cm; 6=20-25cm; 7=25-30cm; 8=30-35; 9=35-40; 10=> 40cm. The purpose of using size class distributions in diameter at breast height (DBH) is to investigate the regeneration status of the woody plant species [56].

3. Result and Decision

3.1. Floristic Composition of Hamdo Forest

The result conducted on Hamdo forests shown that, 50 woody species were belonging to 24 families and 36genera were recorded from 36 plots. Fabaceae was the richest family in study area, which had (10species, 41.6%). Following, Anacardiaceae the second highest family which had (6species, 25%). Combretaceae, Oleaceae and Tiliaceae were the third highest family, which had (3species, 12.5%). Rutaceae, Apocynaceae, Phyllanthaceae, Rhamnaceae, Moraceae and Sapindaceae each of them were holds (2 species, 8%). the remaining of each 14 families were holds 1species (Figure 2). Similarly, [66] reported Fabaceae family was representing high proportion of documented from Participatory Assessment of Forest Biodiversity Resources Hararge Area, Eastern Ethiopia. Likewise, other finding of [53] reported Fabaceae families hold species that are more floristic from Jello-Muktar Forest, Southeastern of Ethiopia.

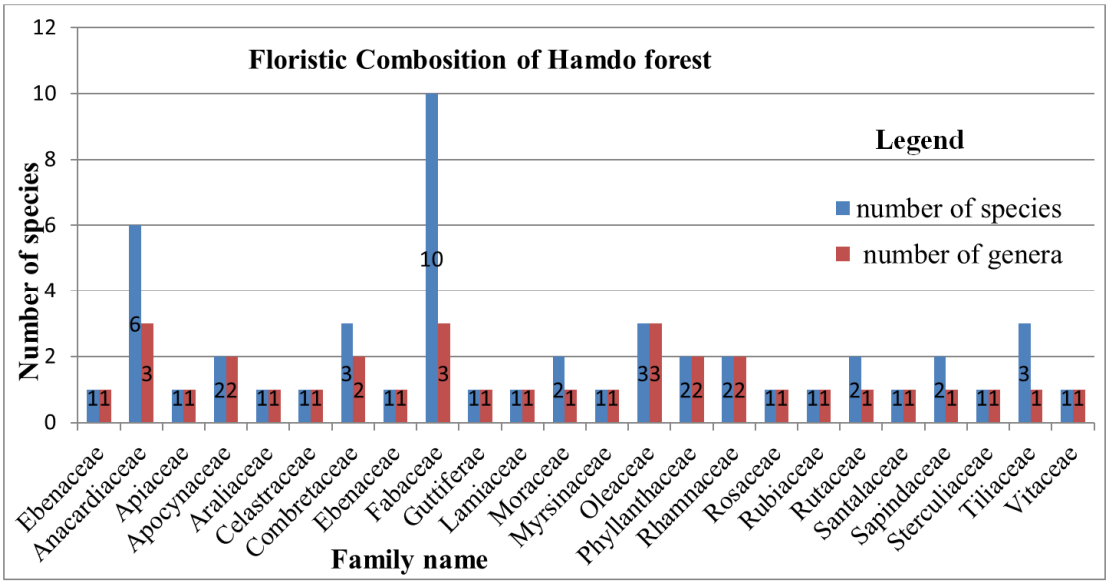

Figure 2. *Floristic composition of Hamdo forest.*

In this study, most recorded wood species growth form was 56 (28, 56.%), followed by shrubs (18, 36%), climber (3, 6%) and (1, 2%) was an herb (Figure 3).

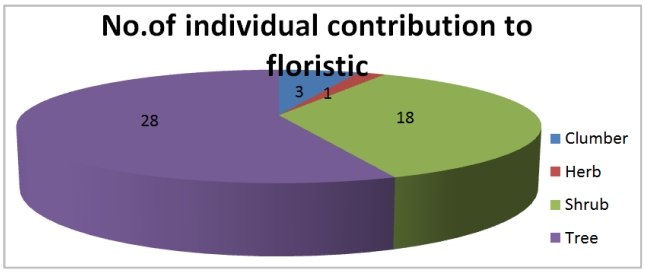

Figure 3. *Habit of plant species in the forest.*

3.2. Species Diversity and Evenness of Hamdo Forests

The estimated Shannon index of diversity of tree and shrub species in this study ranged between 0.0044 to 0.28 with the overall H'=3. *Calpurnia aurea (0.28), Olea europaea (0.250), Dodonaea angustifolia (0.242), Euclea divinorum (0.22), Combretum molle (0.149), Acokanthera schimperi (0.133), Carissa spinarum (0.33), Acacia tortolis (0.131), Galiniera saxifrage (0.126)* and *Teclea nobilis (0.11)* were those species contributed to the high Shannon index value. The overall average diversity index; Shannon (H`), evenness and richness values for the study area forest were 2.9, 0.8 and 50 respectively. This index noted about species richness and evenness [48]. Normally the value of the Shannon diversity index varies from 1.5 and 3.5 and rarely exceeds 4.5 value, high when it is above 3.0, medium when it is between 2.0 and 3.0, low when it is between 1.0 and 2.0 and very low when it is smaller than 1.0 [13]. While the Lower evenness indicates the dominance of a few species in the area [58] and an ecosystem having high species diversity has also a larger value of Shannon index of diversity and vise-versa [15]. According, Hamdo dry afromontane forest belongs to medium diversity.

The study had shown Shannon-Wiener Index of diversity (H') of 2.99 for the Hamdo dry Afromontane forest. Thus, the result of Hamdo forest was high compared with others similar study like Yemrehane Kirstos Church, Forest H'=2.88 [7], Menagesha Suba Forest with 112 species and H'=2.57 [18] and Ades forest H'=2.82 [52]. Relative value with Gemechis forest H'=3.04 [14]. However, less accounted

number of species than Belete forest with 79 [35], Lammo Natural Forest with 54 woody species [11], Dindin forest with 81 species [61], Denkero with 109 species [1] and Senkameda with 139 species [61]. This may be happening due to agricultural expansion, over grassing and illegal extraction of forest. Loss of forest cover and biodiversity due to human-induced activities are a growing concern in many parts of the. This supported by another study on Gemechis forest, which stated human induced disturbance contribute to the low diversity [14].

The overall evenness value of Hamdo forest was 0.81. *Calpurnia aurea (0.052), Olea europaea (0.048), Dodonaea angustifolia (0.047), Euclea divinorum (0.044), Combretum molle (0.034), Acokanthera schimperi (0.031), Carissa spinarum (0.031), Acacia tortolis (0.031), Galiniera saxifrage (0.030)* and *Teclea nobilis* (0.029) were trees and shrubs that showed higher evenness values. The result of evenness value of Hamdo forest depicts high compared to Ades forest E=0.67 [52], Gemechis forest E=0.77 [14] and E=0.46 Assosa forest field gene bank [2]. This implies, a high evenness values show that little dominated by any single species, but repeated co-existence of species over all plots in the forest as reported [3].

3.3. Important Value Index (IVI) Data from Relative Density

The analysis of the importance value index (IVI) of woody species revealed that the dominant of a very few species varies between species types. It indicates the relative ecological importance of a given woody species at a particular site, and also used for setting priority species needed for management and conservation practices and helps to identify the species as dominant or rare species [40].

The IVI described, *Acacia seyal (19.5), Olea europaea (16.46), Calpurnia aurea (16.1), Dodonaea angustifolia (13.6), Acacia gerrardii (12.8), Schefflera abyssinica (12.4), Combretum molle (11.5), Euclea divinorum (11.1), Acacia tortolis (10.9), Acokanthera schimperi (10.8), Acacia nilotica (10.6)* and *Lannea schimperi* (10.2) were the dominant and ecologically the most significant tree species in Hamdo forest in decreasing order (Table 1). These were the most important species with high importance value index is due to their high values of density, frequency and dominance. The higher IVI of these species Hamdo forest and play crucial role in the ecological functioning of the area. Contrary to this*, Ziziphus mucronata, Zanthoxylum chalybeum, Combretum aculeatum Ficus thonningii, Grewia ferruginea, Grewia tembensis, Osyris quadripartite, Dichrostachys signore, Rhus glutinosa, Terminalia brownie* and *Hypericum quartinianum* were species accounted with low IVI. This could be due to the major anthropogenic disturbances such as overgrazing and selective cutting were observed during the study period. It is, therefore, it was needed urgent appropriate conservation. The above woody species contributed 51.76% of all the woody species involved in the IVI calculation while 48.24% were contributed by the remaining species.

Table 1. *Important value index (IVI) of tree and shrubs.*

Specie name	MD	BA (m^2ha^{-1})	RD	R Do	RF	IVI
Acacia gerrardii	25	1.5	1.5	5.0	6.3	12.8
Acacia seyal	7	3.5	0.4	11.5	7.6	19.5
Acacia tortolis	68	0.5	4.1	1.5	5.4	11.0
Acokanthera schimperi	69	0.8	4.2	2.5	4.1	10.8
Calpurnia aurea	247	0.2	15.0	0.5	0.6	16.1
Combretum molle	82	1.6	5.0	5.3	1.3	11.6
Dodonaea angustifolia	180	0.3	10.9	0.9	1.9	13.6
Euclea divinorum	159	0.4	9.6	1.2	0.3	11.2
Galiniera saxifraga	64	0.7	3.9	2.2	1.6	7.7
Lannea schimperi	2	3.0	0.1	9.8	0.3	10.2
Myrsine africana	18	0.2	1.1	0.5	0.9	2.5
Olea europeae	192	1.4	11.6	4.5	0.3	16.5
Ozoroa insignis	60	1.7	3.6	5.5	0.6	9.8
Premna schimperi	14	0.5	0.8	1.6	1.9	4.3
Rhamnus staddo	2	0.0	0.1	0.2	0.9	1.2
Rhoicisus revoilii	11	0.1	0.7	0.3	5.7	6.6
Rhus glutinosa	12	0.3	0.7	0.9	2.2	3.8
Rhus natalensis	33	0.3	2.0	0.8	0.3	3.1
Rhus ruspolii	7	0.4	0.4	1.3	0.6	2.4
Rosa abyssincia	8	0.3	0.5	0.9	5.4	6.7
Schefflera abyssinica	42	2.9	2.5	9.5	0.3	12.4
Schrebera alata	37	0.8	2.2	2.6	1.9	6.7
Teclea nobilis	57	0.2	3.5	0.6	0.3	4.4
Terminalia brownii	12	0.7	0.7	2.4	0.3	3.5
Zanthoxylum chalybeum	13	0.5	0.8	1.7	0.9	3.4
Osyris quadripartita	20	0.3	1.2	1.0	0.3	2.5
Ziziphus mucronata	1	0.2	0.1	0.5	0.3	0.9
Total	1651	30.4	100	100.0	98	298

MD: Mean density, BA: Basel area, RD: relative density, RDo: relative dominance
RF: relative frequency

3.4. Density and Dominance of Woody Species

The total density of all woody species recorded in Hamdo forest was 1651 individuals' ha^{-1} (Table 1). The most ten densest individual species were *Calpurnia aurea* (247 ha^{-1}), *Olea europeae* (192ha^{-1}), *Dodonaea angustifolia* (180ha^{-1}), *Euclea divinorum* (159ha^{-1}), *Combretum molle* (82ha^{-1}), *Acokanthera schimperi* (69ha^{-1}), *Carissa spinarum* (69 ha^{-1}), *Acacia tortolis* (68 ha^{-1}), *Galiniera saxifraga* (64 ha^{-1}) and *Ozoroa insignis* (60 ha^{-1}) (Table 2). The total density of Hamdo forest is high, compared with Yerer Mountain Forest [70]. However, lower than Gemechis forest 3430 ha^{-1} [14], Dindin forest 1750 ha^{-1} [61], Kimphee forest 3059 ha^{-1} [59], Masha Anderacha forest 1709 ha^{-1} [31]. This maybe happened due to distinctions in landscape topographic gradients, as well as habitat qualities linked to ecological requirements of component tree species in the respective forests. As well as selective removal of stand steam for charcoal, house construction and expansion of agricultural land.

The estimated normal basal area for intact tropical forests in Africa is 23–37 m^2/ha cited in [44]. Thus, the Basel area from Hamdo forest with diameter at breast height (DBH) of > 2.5cm was 30.4m^2/ha^{-1} is with in normal range (Table 1). The most dominant tree species were *Acacia seyal*, *Lannea schimperi, Schefflera abyssinica, Ficus vasta, Ozoroa insignis, Acacia gerrardii, Olea europeae.* despite, this value of Basel area from Hamdo forest Compared with some other vegetation's of the country showed that it was lower than Gemechis (31.13m^2/ha), Dindin (49 m^2/ha), Denkoro (45 m^2/ha), Menagesha-Suba (158.68m^2/ha) and Sanka Meda (34.7m^2/ha) (Table 2). This is may be due to the trees belonging to higher DBH class selectively used for charcoal in Hamdo Forest which makes are fewer than the forest mentioned. This consistence to [14].

Table 2. *Comparison of Basel area of Hamdo forest with other study in Ethiopia.*

Forests	BA (m^2ha^{-1})	Source
Gemechis	31.13	[14]
Dindin Forest	49	[61]
Denkoro	45	[1]
Menagesha Suba	158.68	[18]
Sanka Meda	34.7	[60]
Hamdo	30.4	Present study

3.5. Distribution of Diameter at Breast Height (DBH)

The distribution density of all individuals in different DBH class shows an inverted J-shape (Figure 4). This general pattern shows the majority of species had the highest number of individuals at relatively low DBH classes with gradual decrease towards high DBH classes. This pattern shows healthier population dynamics of the vegetation under study. This result is analogous with elsewhere study like Menna angetu [32] and Belete moist evergreen forest [25]. This means, where species distribution had the very best frequency within the lower diameter and height classes and a gradual decrease towards the upper classes. In this respect, 60% of the total frequency lies between the first and second diameter classes, whereas, about 40% of the frequency were found to be in the middle diameter classes. This indicated that there was selective removal of middle and high diameter class trees for various socio-economic purposes by local people like for, fencing, farm implementing, house construction, and fuel wood when allowed by the community leaders.

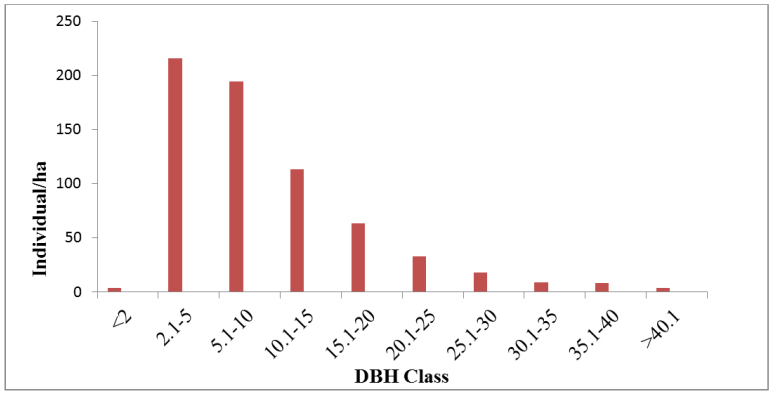

Figure 4. *Diameter class frequency distribution of woody species.*

3.6. Regeneration Status of Woody Species

The regeneration status of a given natural vegetation is considered as good if seedling >sapling > matures [31, 19, 68]. Contrary to this, the total density of seedling, sapling and mature tree in Hamdo forest was 1007, 648, and 1651 individuals per ha respectively (Figure 5). The density of seedlings obtained from the study area was less 1915ha^{-1} in Dindin forest [61]. The distribution of regeneration status of the study area (Figure 5) revealed with more matures> sapling> seedling individuals. It indicates problem regenerated seedlings. This happened have been loose of seedling by the free Grazing animals as observed during study period. Similarly, other factors regeneration of forest like grazing and human impacts via tree cutting for firewood, house construction and timber production reported [5].

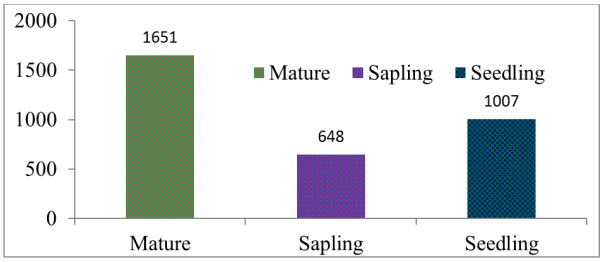

Figure 5. *Regeneration status of woody species.*

Moreover, some species found in this study no individual in seedling and sapling stages. This pattern also shows poor reproduction and hampered regeneration [12, 41]. This implies a need to develop and implement effective forest management in the study area. Inversely to this, *Calpurnia aurea*, *Olea europeae*, *Dodonaea angustifolia, Euclea divinorum* and *Myrsine africana* species have high regeneration status.

4. Conclusion

The Hamdo natural forest is remaining dry afromontane forests in Ethiopia. The result come up with the composition of the harbors important tree species for instance *Olea europeae*, *Myrsine africana, Euclea divinorum and Dodonaea angustifolia*.

With dominant Fabaceae family followed with Poaceae, Euphorbiaceae, Lamiaceae and Rubiaceae. despite the forest population structure shows abnormal population structures with interrupt of regeneration due to free grazing, agricultural expansion, illegal cutting of tree for construction, over consumption of trees and shrubs for fire wood and charcoals. Beside, *Ziziphus mucronata, Zanthoxylum chalybeum, Combretum aculeatum Ficus thonningii, Grewia ferruginea, Grewia tembensis, Osyris quadripartite, Dichrostachys signore, Rhus glutinosa, Terminalia brownie and Hypericum quartinianum* were those species depict very low IVI due to overgrazing and selective cutting construction and fire wood. Thus, to develop sound and implement effective conservation measures to save the biodiversity of this area in sustainable way. Based on the evidence of this study the consequently recommendation is forwarded for effective conservation;

1) The woody species had low IVI show under threat and for the entire forest area, need to establish in-situ site through demarcation and exclosure. This, appropriate conservation and management actions mandatory to ensure the sustainability of the Hamdo forest.
2) Increase awareness creation on the value forest genetic resource for local people and responsible body
3) Further study should carry out on soil seed bank, socioeconomic effect on forest and population distribution of priority species

Conflict of Interests

The authors declare that they have no competing interests.

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