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Assessment and Characterization of Plant Species Diversity of Gaba Forest in Buno Bedele Zones, South West Ethiopia

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Research Article

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ABSTRACT

This study was conducted in Buno Bedele Chora district Gaba forest aimed to assess and characterize plant species diversity, composition, structure and regeneration status. The species diversity data was collected from six transects, line which are 500 m apart were laid systematically across the sample sites with fifty quadrats, 20 m × 20 m (400 m) were established along transects at every 50 m interval and for seedlings and sapling, five sub-plots of 5 m × 5 m one at each corner and one at the center of the big plots were arranged. Shannon diversity index, species evenness, density, relative density, relative frequency, and relative dominancy, basal area and importance value indexes data was analyzed. Accordingly, 67 plant species representing 37 families were identified in the Gaba forest. The identified plant species were collected of trees (53.73%), shrubs (26.87%), liana (14.93%) and herbs (4.48). The most species rich families were *Fabaceae, Celastraceae, Euphorbiaceae*, respectively. Shannon diversity index and evenness of plant species of study area were 2.43 and 0.58 respectively. The total density of plant species was 2561/ha and total basal area of Gaba forest was 75.02 m^2/ha). The most dominant and ecologically important plant species in Gaba forest based on their important value index were *Coffea arabica* (52.81%), *Ficus vasta* (24.96), *Maytenus gracilipes* (18.09), and *Apodytes dimidiate* (17.43). The regeneration of Gaba forest was showed fair regeneration status. Lastly, further, study is recommended to be conducted on the distribution of plant species based on disturbance, altitudinal gradient and slope of the forest.

Keywords: Basal area; Plant species; Important value index; Regeneration

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INTRODUCTION

The services of forests are environmental and socio-cultural. They also provide habitats for several fauna and flora, as described under the ecosystem's diversity. The major environmental functions of forests are ecosystem stability, particularly in times of climate change, climate amelioration (shade, soil improvement, etc.), soil and water conservation, and carbon sink. The major sociocultural values of forests are in maintaining traditional lifestyles (building and furnishing houses), providing important secondary forest products, aesthetic, for ritual/religious practices and other ceremonies.

Forest cover changes is a dynamic, widespread and accelerating process, mainly driven by natural phenomena and anthropogenic activities, which in turn drives changes that would impact natural ecosystem. Understanding forest patterns, changes and interactions between human activities and natural phenomenon are essential for proper forest management and decision improvement.

Today, data from satellites are very applicable and useful for forest cover change detection studies. Detecting forest conditions as well as monitoring the changes of various forest structural and biophysical variables can enable accurate understanding of forest ecosystem services. The forest resources of the country are grouped in 5 categories, namely, natural closed forests, woodlands, bush lands, plantations and on-farm trees. It is often reported that about 35 percent of the landmass of Ethiopia was once covered with closed forests, but this figure is based on a study of the possible climatic climax vegetation types of the country which was included in reports by FAO. Historical records and archeological studies indicate that the forest cover has been much lower since prehistoric times. The revised estimate of the closed forest cover of Ethiopia is less than 3.5 percent. The total number of woody species of Ethiopia is estimated to be 1017, out of which 29 tree species, 93 shrub species and 2 liana species are endemic. These species represent 104 families and 387 genera. A new tree species, *Acacia fumosa*, has been identified from the Ethiopian Somali Region.

World forest resources are depleting continually. Although the problem exists all over the world, it is serious in developing countries, like Ethiopia. Oromia has about half of the country's remaining forest area, estimated at nearly 7 million hectares (*i.e.* 70,000 km^2).

Large scale commercial agriculture accounts for about 40% of deforestation in the tropics and subtropics, local subsistence agriculture for 33%, infrastructure for 10%, urban expansion for 10% and mining for 7%. The key drivers of forest biodiversity losses are originated from population and consumption increase, increasing trade in food and agricultural products, rising demand for forest products including biomass for energy generation, the expansion of human villages and infrastructure and climate modification.

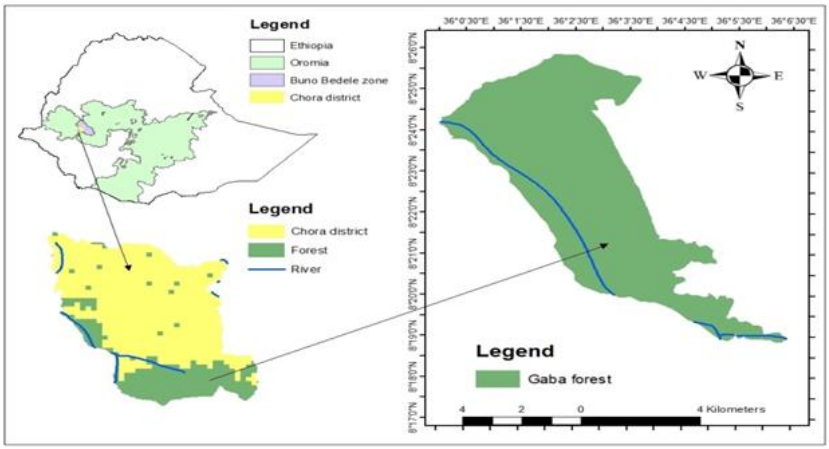
Land degradation as a result of agricultural expansion, soil erosion, deforestation and low vegetative cover is among the major conservation and development challenges in Ethiopia [1]. According to Duguma et al, forest and agro-biodiversity is being degraded in the UNESCO registered Yayo Coffee Forest Biosphere Reserve which was identified as a result of crop land expansion and intensified coffee plantation in the area. The availability of accurate data on forest resources is an essential requirement for management and planning within the context of sustainable development. Reduction in forest cover has a number of consequences including loss of biodiversity and instability of ecosystems and reduced availability of various wood and non-wood forest products and services. Various research works have been done with the forest. But, the study on characterization of trees and shrubs species diversity selected forest information limited. Thus, the aim of present study was to assess and characterize tree and shrub species diversity, Characterization tree and shrub species structure and composition and describe regenerating status of trees and shrub species in Gaba forest.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Gaba forest Chora districts of Buno Bedele zone of the Oromia regional state, South Western Ethiopia (Figure 1). Chora district is located at the latitude of 8°13'33.7"-8°33'55.0" N and longitude of 35°59'59.7"-36°15'15.8". The district is bordered on the south by the Jimma zone, on the west by Yayo district, on the North by Dega district and on the East by Bedele district. The district is distanced about 36 km from the zonal administrative town of Buno Bedele and 519 km from Addis Ababa, which is the capital city of Ethiopia. It has an elevation ranging from 1450–2300 m.a.s.l and characterized by the annual rainfall ranges between 1500 and 2200 mm, and daily mean temperature ranges between 9°C and 31°C. Gaba forest is located between geographical coordinate of 8°18′48.6″- 8°25′53.04″ N and 36°0′2.16″-36°6′23.04″ E. The altitude of this forest is ranged from 1470 to 2021 meters above sea level.

Figure 1. Map of the study area.



Vegetation data collection

Sampling techniques: A reconnaissance survey was made before actual survey, to gather relevant information about study area. To compute the actual survey vegetation data collection was conducted followed reconnaissance survey. Accordingly, the assessment of species diversity data was collected from six transect lines, which are 500 m apart and parallel to each other laid systematically across the sampled site. The first quadrat was laid down randomly and other quadrats systematically at equal interval in each of transect lines. Overall, fifty quadrats with a size of 20 m × 20 m (400 m^2) were established along transects at every 50 m interval, and their GPS coordinate points of each quadrat was taken. In the case of seedlings and sapling, five sub-plots of 5 m × 5 m one at each corner and one at the center of the big plots were arranged [2]. In each plots the census of each plant species was noted with their local name and growth form. In each quadrat, for all plants having Diameter at Breast Height (DBH) ≥ 2 cm, the circumference measurements were made at breast height (around 1.3 m) by using measuring tape and caliper following the methods described by Martin. The stems born from the same root were considered as a single plant during the census of plants, the diameter of stems branching below or at the breast height was measured separately for each branch and summed and take average. Individual trees and shrubs with DBH<2 cm and height <0.5 m counted as seedlings while those having DBH<2 cm and height ≥0.5 m considered as saplings.

Data analysis

Data collected from the field were arranged and coded in an excel work sheet. Thereafter, the necessary vegetation diversity indices namely Shannon diversity index (H'), species evenness (E), Sorenson's similarity (Ss) coefficient, Density (D), Relative Density (RD), Relative Frequency (RF), Relative Dominancy (RDo), Basal area and Importance Value Indexes (IVI) were determined by using their respective mathematical equations mentioned below.

Diversity indices

A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide more information about community composition than simply species richness (*i.e.,* the number of species present); they also take the relative abundances of different species into account. Diversity indices provide important information about rarity and commonness of species in a community. Species richness is a measure of the number of different species present in an ecosystem, while species evenness measures the relative abundance of the various populations present in an ecosystem.

Shannon-Wiener index (H')

The Shannon indices are the most widely used species diversity indices for examining overall community characteristics [3]. It is one of the diversity indices which are used as a measure of species diversity in particular community. Species diversity includes both species richness and evenness. This index is used for calculating the species richness and species evenness of the species. The number of species in a community is referred to as species richness. The relative abundance of species is also important. The relative abundance of rare and species is called evenness. Communities dominated by one or a few species have a low evenness while those that have a more even distribution of species have a high evenness. The Shannon diversity index is calculated as:

$$H' = -\sum_{i=1}^{s} pi \ln pi \qquad (1)$$

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Where,

H'=Shannon-Wiener index of species diversity

S=number of species in community

Pi=proportion of total abundance represented by the species

Evenness

Species evenness is a diversity index, a measure of biodiversity which is used to measure the homogeneous distribution of tree species in sample plot. The evenness of a population can be represented by:

$$E = \frac{H^1}{H\max} = \frac{H^1}{\ln S} \qquad (2)$$

Where,

E=Evenness

H'=Calculated Shannon-Wiener diversity

Hmax=ln(s) (species diversity under maximum equitability conditions)

S=the number of species, in community

Similarity indices (Ss)

Similarity indices measure the degree to which the species composition of different systems is alike. The Sorensen similarity coefficient is applied to qualitative data and is widely used because it gives more weight to the species that are common to the samples rather than to those that only occur in either sample. The Sorensen coefficient of similarity (Ss) is given by the formula:

Where,

Ss=Sorensen similarity coefficient

a=number of species common to both samples

b=number of species available only in study area (sample 1)

c=number of species available only in other area (sample 2)

Vegetation structure analysis

Density is the number of individual plants of particular species with specific area, typical measured per unit area and relative density of plant species refers to the density that species as percentage. For the determination of density and relative density the following respective equations were used.

$$\text{Density (D)} = \frac{\text{Total number of individual species}}{\text{Total sample size in hectar}} \qquad (3)$$

$$\text{Relative density (RD)} = \frac{\text{Density ofones pecies}}{\text{Total density}} \times 100 \qquad (4)$$

Frequency (F)=Number of plots in which that species accrued

Relative frequency of a species was computed as the ratio of the frequency of the species to the sum total of the frequency of all species in the study site.

$$\text{Relative frequency (RF)} = \frac{\text{Frequency of one species}}{\text{Total frequency}} \times 100 \qquad (5)$$

The basal area was calculated using the diameter of each individual of the species as follows:

$$\text{Basal area (BA)} = \frac{\pi d^2}{4} (3) \quad \text{Where: d=diameter at breast height, } \pi=3.14$$

Relative dominance was calculated as the percentage of the total basal area of a species out of the total basal areas of all species at the study site.

$$\text{Relative dominance (RDo)} = \frac{\text{Total basal area of individual species}}{\text{Total basal area of all species}} \quad (6)$$

Important Value Index (IVI) is a measure used in ecology to determine the overall importance of plant species within a given ecosystem. It combines of relative density, relative frequency and relative dominance as follow.

IVI=Relative density + Relative frequency + Relative dominance (7)

Regeneration status of the forest

The regeneration status of plant species was determined based on the density of seedlings, saplings, and mature. According to Dhaulkhandi et al.

- Good regeneration, if seedling is greater than sapling and mature tree/adult (seedling density>sapling density>mature tree/adults).
- Fair regeneration, if seedling > or ≤ sapling ≤ mature tree.
- Poor regeneration, if a species survives only in the sapling stage, but has no seedlings (even though saplings may be, or=mature).
- Not regenerating, if a species is present only in an adult form.
- New, if a species has no matured trees, but only sapling and/or seedling stages.

RESULTS AND DISCUSSION

Characterization and species diversity, richness and evenness of plant species

A total of 67 plant species were identified and documented at study area, and the identified plant species belongs to 37 families (Table 1). All of these plant species were documented from the sample laid quadrats for the study. The identified plant species were composed of trees (53.73%), shrubs (26.87%), liana/climber (14.93%) and herbs (4.48%) (Figure 2). The studies showed that trees are the high proportional of habit in Gaba forest. The most species rich families were *Fabaceae* represented six species (8.96%), followed by *Celastraceae* and *Euphorbiaceae* with four species each (5.97%), *Moraceae* three species (4.48%) and 17 families with two species each (2.99%) while, the remaining 16 families had a single species (1.49%) representation (Table 1). The dominance of *Fabaceae* might be due to its efficient pollination and a successful seed dispersal mechanism that helps them adapt to a wide range of environmental conditions [4]. This study indicated that, the number plant species of Gaba forest is higher than plant species composition of other forest in Ethiopia previous study, including Gemechis forest with 51 species West Hararghe zone, Lammo natural forest with 54 species Kembata Tembaro zone, Yemrehan Kirestos church forest with 39 species North Wallo, Wabero forest with 47 species Bale zone, however Gaba forest has less number of plant species than, Gedo forest with 235 species in West Shewa, Mengesha Suba forest with 112 species and Belete forest with 157 species. This may be for the reason that climate, environmental factor variance and disturbance happening such as deforestation, agricultural and other factor in the area by local community. The Shannon-wiener index (H') and evenness value of Gaba forest (E) were 2.43 and 0.58 respectively (Appendix 1). The Shannon-wiener index of Gaba forest was enclosed the value of Shannon diversity index for most vegetation, which usually falls between 1.5 and 3.5, so this forest is proper diversity. The Shannon-wiener index (H') and evenness value of Gaba forest (E) for each plants life form (habit) determined. In this study, the Shannon index value of trees the highest (2.82), followed by Liana (2.06), Shrub (1.05) and Herbs (0.92), while Liana the highest by evenness value (0.89) followed by Herbs (0.83), Trees (0.79) and Shrub (0.36) (Table 2). The results displayed that; the evenness value of shrubs is low when comparing with other life forms of plants. This means in Gaba forest the shrubs habit dominated by one or a few species.

Table 1. List of plant species and families with representative species number.

No	Scientific name	Local name	Family	Species no.	%	Habit
1	*Albizia grandibracteata*	Halalee	*Fabaceae*			T
2	*Millettia ferruginea*	Sotalloo	*Fabaceae*	6	8.96	T

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3	*Albizia gummifera*	Ambabessaa	*Fabaceae*			T
4	*Entada abyssinica*	Abaalta	*Fabaceae*			T
5	*Senna didymobotrya*	sena maki	*Fabaceae*			S
6	*Acaccia abyssinica*	Laafto	*Fabaceae*			T
7	*Maytenus gracilipes*	Haacacii	*Celastraceae*			S
8	*Maytenus arbutifolia*	Kombolchaa	*Celastraceae*			S
9	*Elaeodendron buchananii*	Wasoo	*Celastraceae*			T
10	*Hippocrata africana*	Xiyoo	*Celastraceae*	4	5.97	L
11	*Macaranga capensis*	Warangoo	*Euphorbiaceae*			T
12	*Croton macrostachyus*	Bakkanissaa	*Euphorbiaceae*			T
13	*Sapium ellipticum*	Bosooqa	*Euphorbiaceae*			T
14	*Ricinus communis*	Qobboo	*Euphorbiaceae*	4	5.97	S
15	*Ficus vasta*	Qiltuu	*Moraceae*			T
16	*Ficus thonningii*	Danbii	*Moraceae*			T
17	*Ficus sur*	Harbuu	*Moraceae*	3	4.48	T
18	*Coffea arabica*	Buna	*Rubiaceae*			S
19	*Psyhotria orophila*	Xuuphannoo	*Rubiaceae*	2	2.99	S
20	*Measa lanceolata*	Abbaayii	*Myrsinaceae*			T
21	*Myrsine africana*	Qacaama	*Myrsinaceae*	2	2.99	S
22	*Dracaena steudneri*	Sarxee (Afarfata)	*Asparagaceae*			T
23	*Asparagus africanus*	Sariiti	*Asparagaceae*	2	2.99	H
24	*Acokanthera schimperi*	Qararoo	*Apocynaceae*			T
25	*Landolphia buchananii*	Hidda Gebboo	*Apocynaceae*	2	2.99	L
26	*Vernonia amygdalina*	Eebicha	*Asteraceae*			S
27	*Vernonia auriculifera*	Reejii	*Asteraceae*	2	2.99	S
28	*Clausena anisata*	Ulmaayii	*Rutaceae*			S
29	*Teclea nobilis*	Hadheessa	*Rutaceae*	2	2.99	S
30	*Grewia ferruginea*	Bururii	*Tiliaceae*			S
31	*Grewia bicolor*	Rapsoo	*Tiliaceae*	2	2.99	S
32	*Schefflera abyssinica*	Gatama	*Araliaceae*			T
33	*Polyscias fulva*	Xarasoo/Qarasoo	*Araliaceae*	2	2.99	T
34	*Olea capensis*	Gagamaa	*Oleaceae*			T
35	*Jasminum abyssinicum*	Hidda Ilchimee	*Oleaceae*	2	2.99	L
36	*Ocimum lamiifolium*	Damakasee	*Lamiaceae*			S
37	*Premna shimperi*	Urgeessa	*Lamiaceae*	2	2.99	T
38	*Rosa abyssinica*	Goraa	*Rosaceae*			S
39	*Prunus africana*	Hoomi	*Rosaceae*	2	2.99	T
40	*Withania somnifera*	Gizaawaa	*Solanaceae*			S
41	*Solanum campylacanthum*	Hiddii	*Solanaceae*	2	2.99	S
42	*Allophylus abyssinicus*	See'oo	*Sapindaceae*			T
43	*Paullinia pinnata*	Hidda Gafarsaa	*Sapindaceae*	2	2.99	L
44	*Pavonia schimperiana*	Xooqee	*Malvaceae*			S
45	*Pavonia urens*	Hincinnii	*Malvaceae*	2	2.99	H
46	*Tiliacora troupinii*	Hidda liqixii	*Menispermaceae*	2	2.99	L

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47	*Stephania abyssinica*	Kaalala Saree	*Menispermaceae*			L
48	*Ehretia cymosa*	Ulaagaa	*Boraginaceae*			T
49	*Cordia africana*	Waddessaa	*Boraginaceae*	2	2.99	T
50	*Diospyros abyssinica*	Lookoo gurracha	*Ebenaceae*	2		T
51	*Diospyros abyssinica*	Lookoo adii	*Ebenaceae*		2.99	T
52	*Apodytes dimidiata*	Wandabiyyoo	*Icacinaceae*	1	1.49	T
53	*Cheilanthes farinose*	Marga Karkarroo	*Sinopteridaceae*	1	1.49	H
54	*Phoenix reclinata*	Meexii	*Arecaceae*	1	1.49	T
55	*Bersama abyssinica*	Loolchisaa	*Melianthaceae*	1	1.49	T
56	*Brucea antidysenterica*	Qomoonyoo	*Simaroubaceae*	1	1.49	S
57	*Celtis africana*	Caayii	*Ulmaceae*	1	1.49	T
58	*Combretum paniculatum*	Hidda Baggee	*Combretaceae*	1	1.49	L
59	*Syzygium guineense*	Baddeessa	*Myrtaceae*	1	1.49	T
60	*Mimusops kummel*	Qolaatii	*Sapotaceae*	1	1.49	T
61	*Dombeya torrida*	Daanissaa	*Sterculiaceae*	1	1.49	T
62	*Clematis hirsute*	Hidda feeti/gundoo	*Ranunculaceae*	1	1.49	L
63	*Helinus mystacinus*	Hidda Homechoo	*Rhamnaceae*	1	1.49	L
64	*Justicia schimperiana*	Dhummugaa	*Acanthaceae*	1	1.49	S
65	*Rhoicissus tridentata*	Laaluu	*Vitaceae*	1	1.49	L
66	*Capparis tomentosa*	Harangamaa	*Capparidaceae*	1	1.49	S
67	*Flacourtia indica*	Akuukuu	*Flacourtiaceae*	1	1.49	T

Figure 2. The distribution of plants species by their habits in the study area.

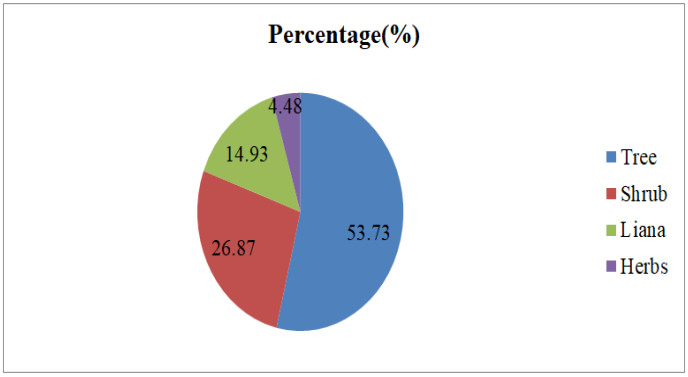


Table 2. Diversity for plant species of Gaba forest.

	Life form of plant species			
Characteristics	**Tree**	**Shrub**	**Liana**	**Herbs**
Shannon diversity index (H')	2.82	1.05	2.06	0.92
Evenness (E)	0.79	0.36	0.89	0.83

Comparison of composition similarity of Gaba forest with other forest in Ethiopia

Gaba forest was compared with seven other forests in Ethiopia by species composition. The result showed that, Gaba forest had highest similarity in species composition with Belete forest (59%) and followed by Sagi Tagata forest and Gura Farda forest each (50%), while it showed the list similarity with Wabero and Magada each (30%), Gemechis (37%) and Abbo scared (41%), forests (Table 3).

Table 3. Comparison of the similarity in species seven forest of country with Gaba forest.

No	Forest	Altitudinal	a	b	c	Ss%
1	Belete	1850-2250	43	24	36	59
2	Sagi Tagata	1818-2041	34	33	35	50
3	Magada	1750-2100	39	24	158	30
4	Gemechis	2118-3017	22	45	29	37
5	Abbo scared	1700-3200	27	40	36	41
6	Wabero	1500-2500	17	50	30	30
7	Gura Farda	800-1900	33	34	33	50
Note: a=number of species common to Gaba and selected forest, b=number of species unique to Gaba, c=number of species unique to selected forest, Ss=Sorenson's coefficient similarity						

Vegetation structures

Density, relative density, Relative Frequency (RF), basal area, relative dominance and important value index plant species at Geba forest: The total density of plant species was 2561 individual /ha in forest. *Coffea arabica* had highest density (1121/ha), followed by *Maytenus gracilipes* (288.5/ha), *Apodytes dimidiate* (173/ha) and *Albizia grandibracteata* (122.5/ha), *Dracaena steudneri* (89.5/ha), *Justicia schimperiana* (82.5/ha), *Teclea nobilis* (54.5/ha) of total density species at study area. The high abundance of *Coffea arabica* in forest might be due to the study area was covered by forest coffee and the community base cash income [5].

The result indicates that, *Coffea arabica* had highest relative frequency (9.04%), followed by *Maytenus gracilipes* (6.78%), *Apodytes dimidiate* (6.40%), *Albizia grandibracteata* (6.21%), *Millettia ferruginea* and *Cordia africana* had similar relative frequency value of (4.14%).

Total basal area of Gaba forest was 75.02 m^2/ha). Out of these *Ficus vasta* had highest value of basal area (16.58 m^2/ha) and followed by, *Ficus thonningii* and *Schefflera abyssinica* which recorded the same value of (7.07 m^2/ha), *Acokanthera schimperi* (4.14%) and *Sapium ellipticum* (4.02%). This study displayed that, the basal area of Gaba forest is higher than basal area of some other forest in Ethiopia previous study, including Gemechis forest with 31.13 m^2/ha, Sagi Tagata forest with 31.01 m^2/ha, Jibat natural forest with 60.9 m^2/ha, Wergan Bula forest with 32.07 m^2/ha, however Gaba forest had less basal area than, Wurg forest with 126.47 m/ha, *Mengesha suba* forest with 158.68 m^2/ha and Belete forest with 103.5 m^2/ha.

The Importance Value Index (IVI) of the vegetation Gaba forest was calculated from data of Relative Density (RD), Relative Frequency (RF) and Relative Dominance (RDo). It indicates the relative ecological importance of a given woody species at a particular site [6]. The species having value of IVI greater than 5.00 can be considered dominant because of the relative ecological role it plays in the ecosystem. In this study the highest value of important value index was *Coffea arabica* (52.81), followed by *Ficus vasta* (24.96), *Maytenus gracilipes* (18.09), *Apodytes dimidiata* (17.43) (Table 4). This result revealed that, *Coffea arabica* was the dominant and ecological most significant plant species in Gaba forest rather than other plant species.

Table 4. Plant species Gaba forest with their Density (D), Relative Density (RD), Relative Frequency (RF), Basal area (Ba m^2/ha), Relative Dominance (RDo) and Important Value Index (IVI).

No	Scientific name	D	RD	RF	Ba/ha	RDo	IVI
1	*Coffea arabica*	1121	43.77	9.04	0	0	52.81
2	*Albizia grandibracteata*	122.5	4.78	6.21	1.77	2.36	13.36
3	*Measa lanceolata*	38	1.48	3.39	0.35	0.47	5.35
4	*Millettia ferruginea*	55.5	2.17	4.14	0.8	1.06	7.37
5	*Psyhotria orophila*	36.5	1.43	3.58	0.4	0.53	5.53
6	*Diospyros abyssinica*	53	2.07	1.32	1.11	1.48	4.87
7	*Dracaena steudneri*	89.5	3.49	3.58	2.23	2.97	10.05
8	*Ficus vasta*	10.5	0.41	2.45	16.58	22.1	24.96
9	*Ficus thonningii*	3	0.12	0.19	7.07	9.42	9.72
10	*Maytenus gracilipes*	288.5	11.27	6.78	0.03	0,04	18.09
11	*Acokanthera schimperi*	25.5	1	2.26	4.14	5.52	8.77

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12	*Apodytes dimidiata*	173	6.76	6.4	3.2	4.27	17.43
13	*Cheilanthes farinose*	3	0.12	0.38	0	0	0.49
14	*Ehretia cymosa*	15	0.59	2.07	0.62	0.82	3.48
15	*Phoenix reclinata*	32	1.25	1.69	0.24	0.32	3.26
16	*Cordia africana*	26	1.02	4.14	1.99	2.65	7.81
17	*Albizia gummifera*	28	1.09	3.39	2.51	3.35	7.83
18	*Vernonia amygdalina*	3.5	0.14	0.19	0.57	0.76	1.08
19	*Bersama abyssinica*	20.5	0.8	2.64	0.47	0.63	4.07
20	*Brucea antidysenterica*	2.5	0.1	0.19	0.2	0.26	0.55
21	*Celtis africana*	46	1.8	3.58	0.82	1.09	6.47
22	*Clausena anisata*	34.5	1.35	2.07	0.04	0.06	3.48
23	*Maytenus arbutifolia*	2	0.08	0.38	0.5	0.67	1.12
24	*Grewia ferruginea*	4.5	0.18	1.13	0.41	0.55	1.86
25	*Combretum paniculatum*	6	0.23	1.32	0	0	1.55
26	*Rosa abyssinica*	4	0.16	0.38	0	0	0.53
27	*Myrsine africana*	10.5	0.41	0.38	0	0	0.79
28	*Teclea nobilis*	54.5	2.13	3.77	0.44	0.58	6.48
29	*Withania somnifera*	1	0.04	0.38	0	0	0.42
30	*Macaranga capensis*	2.5	0.1	0.75	0.95	1.27	2.12
31	*Ficus sur*	3	0.12	0.56	1.16	1.55	2.23
32	*Polyscias fulva*	4	0.16	0.75	1.87	2.49	3.4
33	*Croton macrostachyus*	21.5	0.84	2.26	0.29	0.39	3.49
34	*Olea capensis*	12.5	0.49	1.51	0.75	0.99	2.99
35	*Sapium ellipticum*	3	0.12	0.75	4.02	5.36	6.23
36	*Ocimum lamiifolium*	1.5	0.06	0.19	0	0	0.25
37	*Syzygium guineense*	7	0.27	0.56	2.64	3.52	4.36
38	*Jasminum abyssinica*	3.5	0.14	0.38	0	0	0.51
39	*Landolphia buchananii*	8	0.31	1.32	0	0	1.63
40	*Mimusops kummel*	3.5	0.14	0.94	0.8	1.07	2.15
41	*Dombeya torrida*	0.5	0.02	0.19	0.71	0.94	1.15
42	*Allophylus abyssinicus*	0.5	0.02	0.19	0.33	0.44	0.65
43	*clematis hirsute*	1.5	0.06	0.19	0	0	0.25
44	*Prunus africana*	2.5	0.1	0.38	2.27	3.02	3.5
45	*Helinus mystacinus*	2	0.08	0.38	0	0	0.45
46	*Ricinus communis*	1	0.04	0.19	0.05	0.07	0.29
47	*Elaeodendron buchananii*	4	0.16	0.94	1.19	1.58	2.68
48	*Justicia schimperiana*	82.5	3.22	1.13	0	0	4.35
49	*Pavonia schimperiana*	1.5	0.06	0.19	0	0	0.25
50	*Vernonia auriculifera*	2.5	0.1	0.19	0	0	0.29
51	*Paullinia pinnata*	4	0.16	0.56	0	0	0.72
52	*Tiliacora troupinii*	5	0.2	0.94	0	0	1.14
53	*Rhoicissus tridentata*	0.5	0.02	0.19	0	0	0.21
54	*Hippocrata africana*	3	0.12	0.38	0	0	0.49
55	*Diospyros abyssinica*	31.5	1.23	2.64	1.24	1.66	5.52
56	*Solanum campylacanthum*	16	0.62	1.32	0	0	1.94

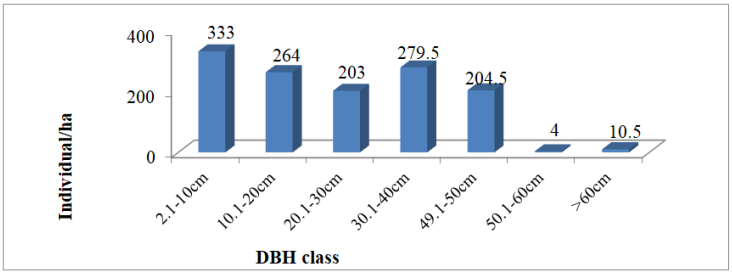
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57	*Asparagus africanus*	2	0.08	0.56	0	0	0.64
58	*Entada abyssinica*	1	0.04	0.19	0.44	0.59	0.82
59	*Pavonia urens*	0.5	0.02	0.19	0	0	0.21
60	*Capparis tomentosa*	2.5	0.1	0.19	0	0	0.29
61	*Flacourtia indica*	6.5	0.25	0.19	0.07	0.09	0.54
62	*Stephania abyssinica*	1	0.04	0.19	0	0	0.23
63	*Senna didymobotrya*	3	0.12	0.19	0	0	0.31
64	*Acaccia abyssinica*	2.5	0.1	0.19	1.77	2.35	2.64
65	*Premna shimperi*	1.5	0.06	0.19	0.95	1.27	1.51
66	*Schefflera abyssinica*	1	0.04	0.38	7.07	9.42	9.83
67	*Grewia bicolor*	1	0.04	0.19	0	0	0.23
	Total	2561	100	100	75.02	100	300

DBH class distribution

Population structure is the distribution of individuals of each species in arbitrarily diameter height size classes to provide the overall profile of species under study. Based on this the DBH of Gaba forest plant species were divided into seven DBH classes [7]. The lower DBH (2.1-10 cm) class of Gaba forest had most density (333/ha) and gradually decrease, followed the invert J-shape structure, for first pattern but not constant continued this pattern. This was described as irregular distribution or no define pattern (Figure 3). It displayed that, as their selected trees disturbance by local people for different purpose. *Maytenus gracilipes, Clausena anisata, Flacourtia indica, Brucea antidysenterica* and *Ricinus communis* were the most dominant small size trees and shrubs in Gaba forest with DBH 2.1-10 cm, whereas *Schefflera abyssinica, Ficus thonningii* and *Ficus vasta* were the large size trees with DBH ≥ 60 cm.

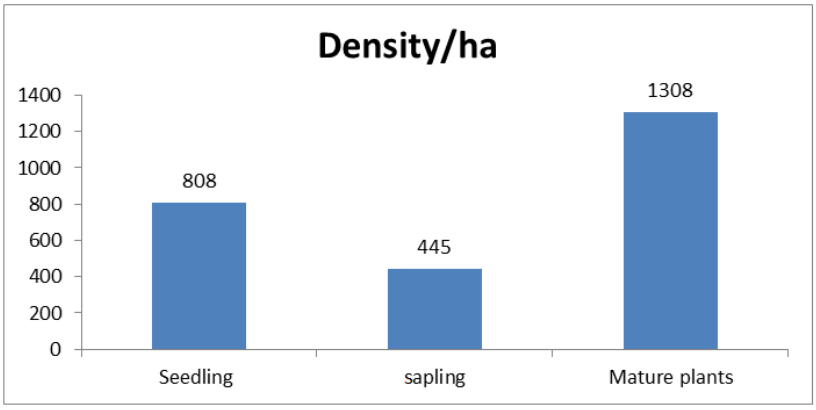
Figure 3. DBH class distribution of plant species at study area.



Regeneration status of Gaba forest

The overall density of plant species Gaba forest was 2561 individual/ha. Out of this total density of seedling 808 individual/ha, sapling 445 individual/ha and mature plants 1308 individual were counted from all sample quadrats. Dhaulkhandi et al. stated that, density of plant species was fair regeneration, if seedling > or ≤ sapling ≤ mature tree. Therefore, the results revealed that the Gaba forest was fair regeneration status (Figure 4). As observed during assessment there are a disturbance selected cutting trees for different purpose. This also had negative impact on regeneration [8]. However not all plant species category only in fair regeneration status accordingly, *Grewia bicolor, Senna didymobotrya* and *Capparis tomentosa* plant species were available only in seedling or sapling stage, at study area so these species considered as new regeneration [9]. The good regenerating plant species were *Maytenus gracilipes*, *Dracaena steudneri, Clausena anisata, Measa lanceolata, Bersama abyssinica* and *Solanum campylacanthum* while, *Coffea arabica, Apodytes dimidiata, Justicia schimperiana, Albizia grandibracteata, Millettia ferruginea, Diospyros abyssinica, Celtis africana, Teclea nobilis*, and *Elaeodendron buchananii* had fair regeneration from top density at study area. Same species which found in not regeneration status category were *Maytenus arbutifolia, Combretum paniculatum, Ocimum lamiifolium, Jasminum abyssinicus* and *Allophylus abyssinicus* (Appendix 2). This similar with Hana et al., stated that, Hurubu forest in North Shewa the density of seedling (513 individual/ha), sapling (306 individual/ha) and mature trees (756 individual/ha).

Figure 4. Density of plant species of Gaba forest.



CONCLUSION

The plants species diversity, structure and composition and regeneration status in Gaba forest was studied. The results showed that, 67 plant species belongs to 37 families were recorded. The recorded plant species were composed of trees, shrubs, liana and herbs. *Fabaceae* were the dominant families followed by *Celastraceae*, *Euphorbiaceae* and *Moraceae*. The Shannon-wiener index (H') and evenness value of Gaba forest (E) were 2.43 and 0.58 respectively. This studies displayed that the, total density of plant species was 2561/ha in Gaba forest. Out of these *Coffea arabica* had highest density (1121/ha). Total basal area of Gaba forest was 75.02 m^2/ha). Out of these *Ficus vasta* had highest value of basal area followed by *Ficus thonningii*. The study indicated that, *Coffea arabica* highest value of important value index followed by *Ficus vasta, Maytenus gracilipes*, and *Apodytes dimidiata*. The lower DBH class of Gaba forest had most density and gradually decrease, followed the invert J-shape structure, for first pattern but not constant continued this pattern is described as irregular distribution. As observed during assessment there are a disturbance selected cutting trees for different purpose. This also had negative impact on regeneration. As result displayed Gaba forest had fair regeneration.

RECOMMENDATIONS

Based on the result, recommended that, awareness should be given for local community about forest use and sustainability, attention should be given for plant species have low IVI value on conservation and managing, this study limited to species diversity, structure and composition and regeneration status. So, further study should be done on distribution of plant species within disturbance, altitudinal variation and slop.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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