

Woody Plant Species Diversity of Dembeza Natural Forest, Enebsae Sarmider District, North Western Ethiopia

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Abstract: The natural forest in Ethiopia has significant contribution to the ecological and economy of the country. The study was conducted at Dembeza natural forest to explore woody plant species diversity. Systematic and predetermined sampling method was followed to collect the inventory data. The main objective of the study was to undergo inventory of indigenous woody plant species, record regeneration status, determining floristic composition and list out the plant species which have threatened and need immediate conservation. The study was conducted during December to January 2021. A total of four transect and 40 plots were used to collect the inventory data. From the natural forest a total of 66 plant species belongs to 41 families were recorded. The life form distribution of this species was 2 (3.17%) herb, 4 (6.34%) liana, 41 (65.07%) shrub and 16 (25.39%) tree. Fabaceae was found the most species rich families comprising 7 (11.11%) also Lamiaceae and Celastraceae follow with the same 4 (6.34%). The variation of the species frequency ranges between 2.5- 85% showing high heterogeneity in species distribution. Among those *Acacia lahai* 2.5%, *Ekebergia capensis* 2.5% *Apodytes dimidiata* 5% held less in distribution while, *Abutilon figarianum* 22.5%, *Acacia abyssinica* 60%, *Carissa spinarum* 65% and *Croton macrostachyus* 85% are comparatively recorded high in frequently appearing or widely distributed woody plant species. The total seedling density per hectare of the forest was 6606.25, which have highest density in the forest were *Juniperus procera* (206.25), *Acanthus sennii* (218.75), *Carissa spinarum* (381.25), *Myrsine africana* (293.75), *Calpurnia aurea* (418.75) and top *Croton macrostachyus* (1375). While species which have lowest density were *Acacia lahai*, *Acokanthera schimperi*, *Calusena anisata*, *Dovyalis abyssinica*, *Dodonaea angustifolia*, *Rhus glutinosa*, *Rosa abyssinica*, *Steganotaenia araliacea* which mean species not recorded seedling during the inventory. The major factor recorded in the forest were browsing, cutting and logging. Minimizing human intervention, eradicating of invasive alien species and prevent forest disturbance should applied in Dembeza natural forest.

Keywords: Conservation, Forest, Dembeza, Disturbance, Inventory

1. Introduction

Ethiopia is one of the few countries in the world that possess unique characters of flora and fauna with high endemic species [1]. The flora of Ethiopia estimated from 6500 to 7000 plant species with high endemic in number [1]. The country has great geographical diversity with different agro ecological zones [7]. That play great role for great diversity of animal, plant and microbial genetic resources [2]. The natural forest in Ethiopia has significant contribution to the ecological and economy of the country, most of the natural vegetation is highly degraded [3]. The natural vegetation affected by different factors among those agricultural exploitation, illegal settlement, deforestation

and invasive alien species, human dependence for fuel wood, non timber forest products, and grazing of livestock are the main [15, 4, 5]. The forests in northern highlands are found only as isolated small patches at inaccessible locations and around the numerous churches and burial grounds [6]. Conservation and sustainable utilization of natural resource use to eradicate poverty [8]. In Ethiopia there is change on plantation of trees or maintain the existing trees as an agroforestry practice Which in agroecological, socio-economic, cultural, institutional and personal factors [9]. Plantation practice is better on woody species diversity on their land holdings [10]. Dembeza natural forest is one of the greatest gene pools for the indigenous plant species that has not been

investigated. This study was conducted with the objective of inventory data collection on the woody species composition and structure, investigating the woody species diversity and richness with the regeneration status of the forest.

2. Materials and Methods

2.1. Description of the Study Area

Dembeza forest is located in EnbiseSarMidir district of east Gojjam zone Amhara regional state at about 220km from Bahir Dar capital city of Amhara region. This district

is named in part after the historic district of Enbise, which was first mentioned in the 16th century. Part of the east Gojjam zone Enbise Sar Midir is bordered on the south by Enarj Enawga, on the west by Goncha Siso Enese, and on the north and east by Abay River which separates it from the Debub Gondar Zone and Debub Wollo Zone. The administrative center of this district is Mertule Mariam. Based on [16] this district has a total population of 133,855, an increase of 23.20% over the 1994 census, of whom 66,139 are men and 67,716 women; 12,259 or 9.16% are urban inhabitants.

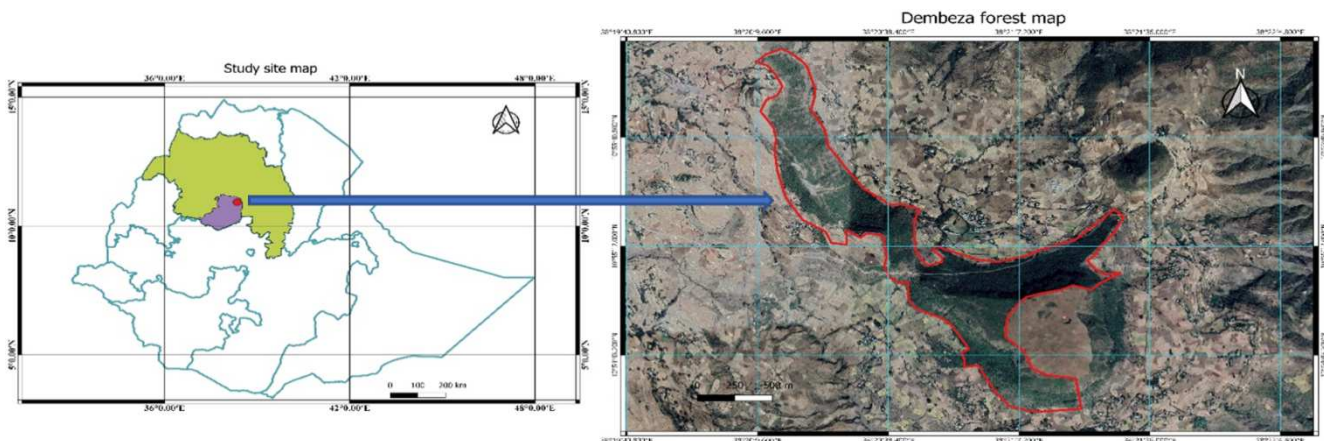


Figure 1. Study area map.

2.2. Materials

There are materials used during the inventory and study. Thus, are compass, measuring tap, digital camera, not book, data sheet, GPS (digital positioning system), DSH/DBH measurement (caliper) meter, laptop computer, pressing materials and plastics.

2.3. Methods

2.3.1. Sampling System and Design

The forest inventory was conducted in 2013/2021 for 20 consecutive days in Dembeza natural forest systematic and predetermined sampling techniques were followed. Data were collected in the main quadrates of 50mx 10mx size and a sub-quadrat of 10 mx² size was established within the main quadrat at the longest side of both ends. A total of 40 plots within 20000 m² were discovered and representative plant specimens with basic information/passport date were collected.

2.3.2. Transect and Quadrat Layout

Four transect were laid along the gentle to flat landscapes perpendicular to the base line. The gravel rods either crossing or bordering the vegetation were used as a base line. The forest and the second transect were laid to the north east, the 3rd to the southeast, the 4th and the 5th laid to the south east direction. The transect were 200m far apart each other and the quadrates were established with regular interval of 200m from each other. In general a total of 4 transects, 40

quadrates were used to collect the inventory data from the Dembeza natural forest.

2.4. Data Collection

Topographic characteristics slop gradient and depth, slop position and aspect were collected following the woody plant species diversity assessment field manual organized by Ethiopian Institute of Biodiversity. To collect the vegetation data woody plant species inventory and regeneration status assessment form were used. Each woody plant species appeared in the sample plots and for trees and shrubs having the DBH2.5 cm, DSH/DBH was measured using the graduated caliper. For shrubs possessing several steams were also counted duly. The data of sapling and seedling of woody plant species were recorded from Dembeza natural forest.

3. Results and Discussions

Environmental Data: Land use/land cover of the study area showed as open woodland, wooded shrub land and bush land. Her were factors which are observed and recorded during the study in and around the forest. Thus are grazing, deforestation agricultural explanation cutting, flooding, invasive plant species, less concern of community to the forest, illegal house constriction around forest bounders.

3.1. Forest Disturbance

Dembeza natural forest subjected factors like

deforestation for settlement and agricultural expansion; over utilization particularly selected plant species by the community. The above listed and other factors are cause for the loss of species diversity and distribution. During the study result for the forest disturbance showed that browsing, cutting and logging (Table 1). Similar study conducted by [11], because of unlimited human disturbance the natural

forest of the Ethiopia was fragmented into small isolated forest patches now largely restricted in the gorges and other inaccessible areas. In contrast study conducted by [12], community awareness on the importance of forest resources and its link with biodiversity, ecosystem services and human wellbeing in Ethiopia is increasing and forests are planted and conserved.

Table 1. Forest disturbance type and scale.

Forest Name	Disturbance type	Disturbance scale					Total
		1 (Negligible)	2 (Light)	3 (Moderate)	4 (Intensive)	5 (Heavy)	
Dembeza forest	Browsing	12	14	6	-	-	32
	Grazing	12	35	4	-	-	50
	Logging		14	4	-	-	18

Where; 1 (Negligible) 0-20%, 2 (Light) 20-40%, 3 (Moderate) 40-55%, 4 (Intensive) 55-70%, 5 (/Heavy) above 70% Total (%).

Geographical Aspects: The geographical aspect with slope position of the study area is upper, middle, lower and altitude, slope gradient, aspect soil depth and bearing are registered. As

indicated in Table 2, the data were taken from eight topographic aspects and at three slope positions (2460 –2720 m.a.s.l.) and within the 11–48% slope gradients.

Table 2. Topographic features and level of forest disturbance.

Slope position	Altitude (m.a.s.l.)	Slope gradient (%)	Aspect	Number of quadrates	Forest disturbance types	Forest disturbance intensity	Proportion of sample plots (%)
Upper	2460–2545	11–27	NW, S, E	7	Browsing, Grazing and logging	Negligible	17.5
Middle	2546–2631	25–42	All except S & SW	19		Light	47.5
Lower	2632–2720	40–48	All Aspect	14		Moderate	35
Total				40			100

3.2. Floristic Composition

From the study area of Dembeza natural forest a total of 66 plant species were collected, out of which 63 were identified and the rest 3 were recorded by their local name. The plant species lays on 41 families with the dominant number of Fabaceae. In floristic analysis 66 woody plant species belonging to 41 families were identified in protected natural vegetation. Which lie in altitudinal range between 2460 and 2716 m.a.s.l. the life form distribution of this species were 2 (3.17%) herb, 4 (6.34%) liana, 41 (65.07%) shrub and 16 (25.39%) tree. Fabaceae was found the most species rich families comprising 7 (11.11%) also Lamiaceae and Celastraceae with the same 4 (6.34%).

3.3. Species Dimensions

The maximum height recorded in Dembeza natural forest was 32m by *Albizia gummifera* plant species. While, the maximum DBH/DSH was 46 cm by species *Schefflera abyssinica* species. The tree species highest in terms of mean height (10.93 m) and mean DBH/DSH (46.20 m). The maximum number of steams sampled and measured was for other tree species that are the most frequently appearing in the inventoried Dembeza natural forest. On the other hand the least size of DSH/DBH and total height recorded was 2.5 cm

and 3 m respectively.

3.4. Frequency and Relative Frequency of Woody Species

The result of the study showed that the variation of the species frequency ranges between 2.5- 85%. This showed that there is high heterogeneity in species distribution in Dembeza natural forest. Among those *Acacia lahai* 2.5%, *Ekebergia capensis* 2.5 *Apodytes dimidiata* 5% held less in distribution while, *Abutilon figarianum* 22.5%, *Acacia abyssinica* 60%, *Carissa spinarum* 65% and *Croton macrostachyus* 85% are comparatively recorded high in frequently appearing or widely distributed woody plant species.

3.5. Density and Relative Density of Woody Species

The density of a given species is expressed as a number of stems per hectare. Species were classified in to five density classes, A-E as follows: A>100.1; B=50.1-100; C=10.1-50; D=1.1-10 and E=<1. Six species were fall in density class A, four species in density class B, sixteen species in density class C, twenty species in density class D and four species were found in density class E. In Denbeza natural forest the highest density of species was recorded species like *Apodytes dimidiata*, *Vernonia amygdalina*, *Dombeya torrid*, *Euclea racemosa* and *Ficus sur*.

Table 3. Species density class and distribution.

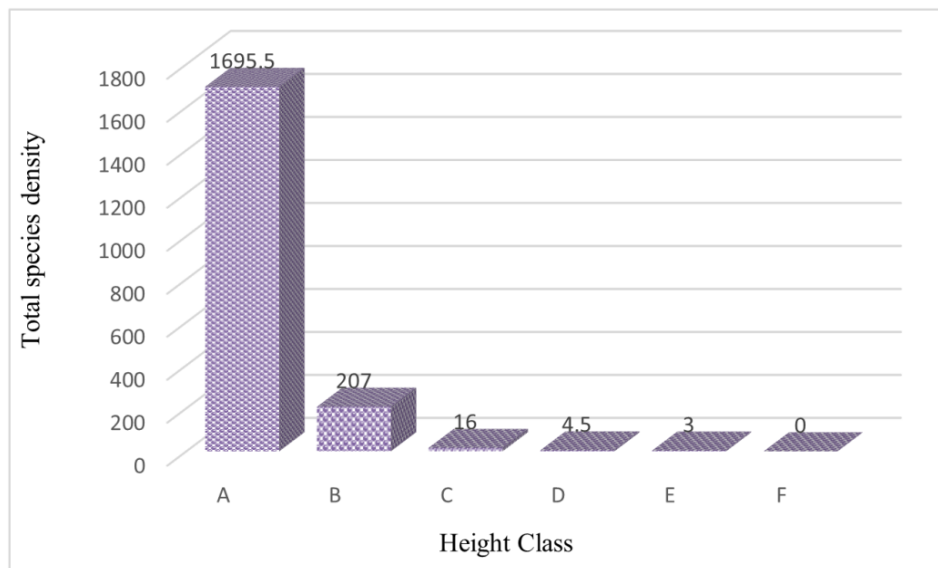
Species density class	Total density	Relative density	Number of species	Proportion (%)
A (>100)	1147	59.51	6	11.76
B (50.1–100)	307	15.93	4	7.84
C (20.1–50)	292.5	15.18	10	19.61
D (1–20)	180	9.34	29	56.86
E (<1)	1	0.06	2	3.92
Total	1927.5	100	51	100

3.6. Stand Diameter and Height Profile

3.6.1. Stand Height Value

In determining the stand height profile A (5m), B (5.1–10m), C (10.1–15m), E (20.1–20m) and F (>25m) the result from analysis showed that >5 m 43 species exist, 5.1–10m 23

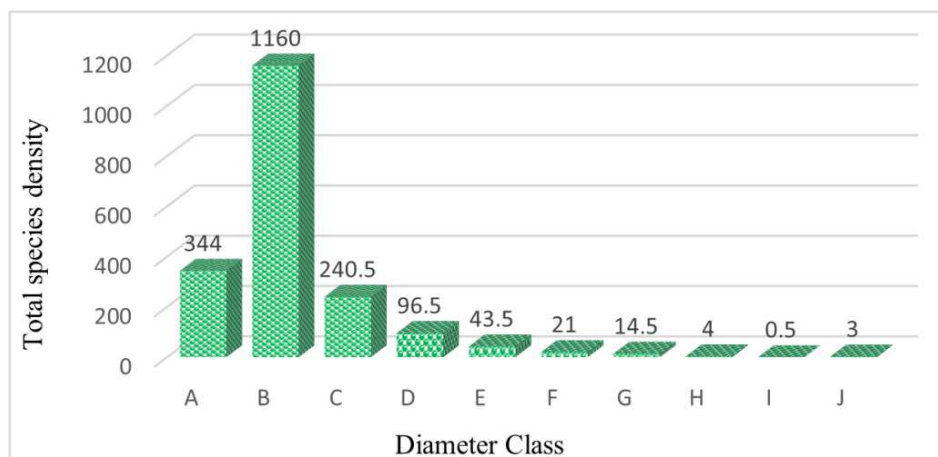
species, 10.1–15m 4 species, 15.1–20m 3 species and >20m 2 species. This indicates that the majority of species belongs to in group A and list numbers of species exist in class F. in Dembeza natural forest *Croton macrostachyus* and *Albizia gummifera* were exist in species class F. This showed that cutting is highly practiced inside the forest.

**Figure 2.** Number and total species density by height class.

3.6.2. Stand Diameter Profile

The diameter classes in the forest were putted in nine groups. A 2.6–7.5 cm; B (7.6–12.5 cm); C (12.6–17.5 cm); D (17.6–22.5 cm); E 22.6–27.5 cm); F (27.6–32.5 cm); G 32.6–37.5 cm); H (37.5–42.5 cm) and I (>42.6 cm). The result showed that

majority of species were recorded in group A (2.6–7.5 cm). The lowest numbers of tree species were recorded in group E, F, G, H and I classes. This indicates those mature trees which attend in the higher diameter size should have been selectively exploited by the local community live near by the forest.

**Figure 3.** Number and total species density by diameter class.

3.7. Basal Area and Dominance of Woody Plant Species

The total basal area for the inventoried woodland is 18.39 the biggest basal area recorded by plant *Ficus sur* which is 0.050 m² while the largest dominance and relative dominance were held by one species called *Croton macrostachyus* (1.84m/ha) and (19.92%) respectively. Other species which are recorded in top range in terms of dominance were *Acacia abyssinica* (1.28m/ha) *Juniperus procera* (0.99m/ha), *Albizia gummifera* (0.7m/ha) and *Allophylus abyssinicus* (0.61m/ha).

3.8. Regeneration Status

The density of seedling and sapling for woody species were analyzed to record regeneration status of the forest. The seedling status was recorded for 41 plant species. This becomes 87.23% have recorded seedling and sapling in the natural forest. The total seedling density per hectare was 6606.25. The species which have highest density in the forest were *Juniperus procera* (206.25), *Acanthus sennii* (218.75), *Carissa spinarum* (381.25), *Myrsine Africana* (293.75), *Calpurnia aurea* (418.75) and top *Croton macrostachyus* (1375). While species which have lowest density were *Acacia lahai*, *Acokanthera schimperi*, *Calusena anisata*, *Dovyalis abyssinica*, *Dodonaea angustifolia*, *Rhus glutinosa*, *Rosa abyssinica*, *Steganotaenia araliacea* which mean species not recorded seedling during the inventory. To sum up the seedling regeneration status the analysis result showed low

and show the intensive trampling by livestock, browsing and grazing in the forest with less germination from soil seed bank are the main reason for the less recorded of seedling in Dembeza natural forest. Study conducted by [13], that the major factors contributed for lack of regeneration for some woody species could be a result of existing disturbance in the study areas like, free grazing, firewood collection, and poor biotic potential of tree species; these could either affect the fruiting or seed germination or successful conversion of seedling to sapling stage.

3.9. Vegetation Environmental Relation Ship Floristic Richness by Aspect

The result of the study pointed out that the species distribution varies with aspects. In accord with this, about 21.6% of the species were recorded from the northwest, 13.7% from East and North respectively, 11.8% from southwest and northeast respectively, 15.7% from west and 5.9% on south and southeast direction of the forest topographic feature. In terms of the individual species, maximum number of woody plant species (11) was inventoried on the northwest direction followed by eight species in east aspects as depicted in Figure 4. This entails that the floristic composition of plant species is affected by aspects and vary accordingly.

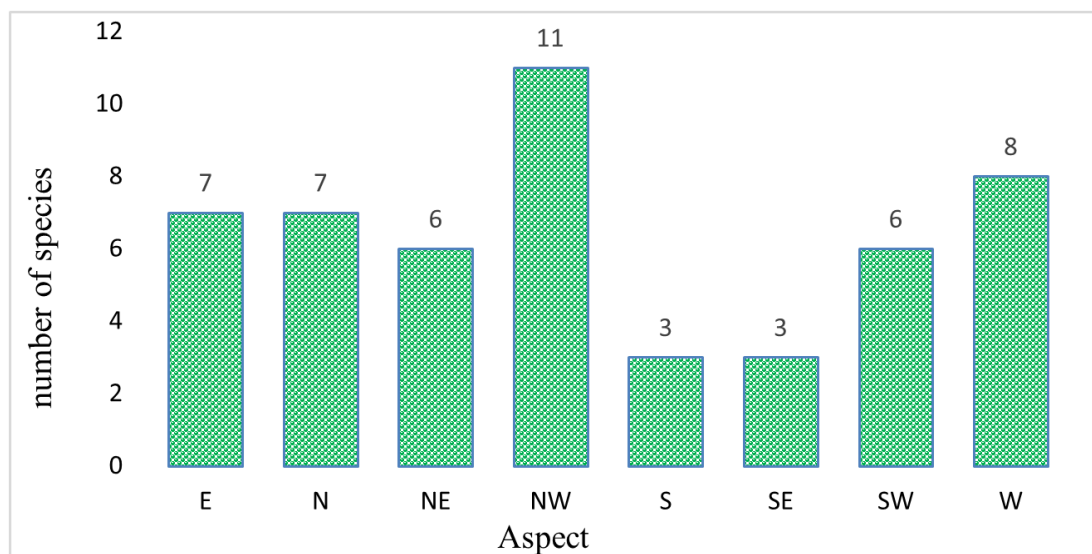


Figure 4. Number of species recorded as per the topographic aspects.

3.10. Importance Value Index

The ecological significance of the structure of the tree species in community structure is known in IVI values [14]. In this case, the IVI value of species of Dembeza forest calculated relative density, relative dominance and relative frequency *Croton macrostachyus* (34.41) *Acacia abyssinica* (24.48) *Acanthus sennii* (19.39) and *Maytenus obscura* (19.35) were recorded relatively higher values.

The lower IVI class indicates that those species are threatened and should take action for conservation. In Dembeza forest species which has <1 IVI were *Apodytes dimidiata* (0.64), *Cordia Africana* (0.85), *Ekebergia capensis* (0.43), *Euclea racemosa* (0.6), *Jasminum abyssinicum* (0.92), *Leonotis ocymifolia* (0.28) are among species which need immediate action for conservation on ecological values of the species.

Table 4. Relative density (RD), relative dominance (RD), relative frequency (RF) and Importance value index (IVI) of plant species.

No	Scientific name	Local name	RD	RDO	RF	IVI	Percent	Rank
1.	<i>Abutilon figarianum</i>	Nechachile	1.56	0.35	2.2	4.11	1.4	18
2.	<i>Acacia abyssinica</i>	Girar	4.77	13.86	5.85	24.48	8.2	3
3.	<i>Acacia lahai</i>	Chebagirar	0.08	0.03	0.24	0.35	0.1	49
4.	<i>Acanthus sennii</i>	Kosheshila	13.18	2.31	3.9	19.39	6.5	4
5.	<i>Acokanthera schimperi</i>	Meranze	1.12	0.42	1.22	2.76	0.9	25
6.	<i>Albizia gummifera</i>	Sesiye	0.99	7.64	2.68	11.31	3.8	10
7.	<i>Allophylus abyssinicus</i>	Embis	4.49	6.61	5.37	16.47	5.5	7
8.	<i>Apodytes dimidiata</i>	Donga	0.13	0.02	0.49	0.64	0.2	40
9.	<i>Bersama abyssinica</i>	Azamera	2.7	3.13	3.41	9.24	3.1	12
10.	<i>Buddleja polystachya</i>	Anfar	1.97	2.24	2.44	6.65	2.2	13
11.	<i>Calpurnia aurea</i>	Digita	3.97	1.42	3.9	9.29	3.1	11
12.	<i>Carissa spinarum</i>	Agam	7.03	1.7	6.34	15.07	5.0	9
13.	<i>Cassipourea amalosana</i>	Tekurinchet 2	0.47	0.33	0.49	1.29	0.4	31
14.	<i>Clerodendrum myricoides</i>	Miserch/Un1	0.96	0.16	2.2	3.32	1.1	21
15.	<i>Clutia abyssinica</i>	Fyelefej	0.96	0.15	1.71	2.82	0.9	23
16.	<i>Colutea abyssinica</i>	Un1 / fabaceae	1.22	0.31	1.46	2.99	1.0	22
17.	<i>Cordia africana</i>	Wanza	0.08	0.53	0.24	0.85	0.3	38
18.	<i>Croton macrostachyus</i>	Bisana	6.2	19.92	8.29	34.41	11.5	1
19.	<i>Dodonaea angustifolia</i>	Kitkita	14.5	4.46	7.8	26.76	8.9	2
20.	<i>Dombeya torrid</i>	Wolkifa	0.36	0.63	0.98	1.97	0.7	29
21.	<i>Dovyalis abyssinica</i>	Koshim	1.58	1.49	1.71	4.78	1.6	16
22.	<i>Ekebergia capensis</i>	Lol	0.05	0.14	0.24	0.43	0.1	46
23.	<i>Euclea racemosa</i>	Dedebo	0.1	0.01	0.49	0.6	0.2	43
24.	<i>Ficus sur</i>	Shola	0.16	1.59	0.49	2.24	0.7	26
25.	<i>Ficus vasta</i>	Warka	0.13	0.83	0.24	1.2	0.4	32
26.	<i>Grewia ferruginea</i>	Lenkuata	1.95	0.57	1.71	4.23	1.4	17
27.	<i>Jasminum abyssinicum</i>	Tembelele	0.18	0.01	0.73	0.92	0.3	36
28.	<i>Juniperus procera</i>	MisarGenfo	1.56	10.74	4.15	16.45	5.5	8
29.	<i>Leonotis ocyimifolia</i>	Tsid	0.03	0.01	0.24	0.28	0.1	50
30.	<i>Maytenus gracilipes</i>	Dabiza	0.57	5.17	0.73	6.47	2.2	14
31.	<i>Maytenus obscura</i>	Atat	12.32	0.44	6.59	19.35	6.5	5
32.	<i>Maytenus undata</i>	GeramAtat	0.26	0.2	0.49	0.95	0.3	35
33.	<i>Myrsine africana</i>	Qechema	0.36	0.05	0.49	0.9	0.3	37
34.	<i>Nuxia congesta</i>	Atequar/Asquare	0.1	0.01	0.49	0.6	0.2	43
35.	<i>Olea europaea</i>	Waira	1.35	1.42	2.2	4.97	1.7	15
36.	<i>Olinia rochetiana</i>	Tefi	6.28	7.88	5.12	19.28	6.4	6
37.	<i>Osyris quadripartita</i>	Qerete	0.88	0.19	2.68	3.75	1.3	19
38.	<i>Otostegia integrifolia</i>	Tunjut/Tuzit	1.37	0.21	1.22	2.8	0.9	24
39.	<i>Pavetta abyssinica</i>	Chicho	0.29	0.08	0.73	1.1	0.4	34
40.	<i>Pittosporum viridiflorum</i>	Un2 / Pitosporum	0.36	0.18	0.98	1.52	0.5	30
41.	<i>Protea guedi</i>	Awera	0.36	0.43	1.22	2.01	0.7	28
42.	<i>Prunus africana</i>	Tekurinchet	0.1	0.02	0.49	0.61	0.2	42
43.	<i>Rhamnus prinoides</i>	Gesho	0.13	0.01	0.24	0.38	0.1	48
44.	<i>Rhus glutinosa</i>	Takima	0.16	0.16	0.49	0.81	0.3	39
45.	<i>Rhus retinorrhoea</i>	Telem	0.26	0.04	0.24	0.54	0.2	45
46.	<i>Rosa abyssinica</i>	Qega	1.5	0.29	1.95	3.74	1.2	20
47.	<i>Salix subserata</i>	Akiya	0.05	0.33	0.24	0.62	0.2	41
48.	<i>Schefflera abyssinica</i>	Getem	0.03	0.91	0.24	1.18	0.4	33
49.	<i>Steganotaenia araliacea</i>	Yejibbeter	0.08	0.01	0.49	0.58	0.2	44
50.	<i>Vernonia amygdalina</i>	Gerawa	0.13	0.03	0.24	0.4	0.1	47
51.	<i>Vernonia rueppellii</i>	Gerawa2/Reji	0.6	0.31	1.22	2.13	0.7	27
Total			100	100	100	300	100	

4. Conclusion

Dembeza natural forest belongs to the moist evergreen afromontane forest type of ecosystem. The forest is located with altitudinal range of 2460 –2720 m.a.s.l. during the

inventory study a total of 66 plant species belongs to 41 families were recorded. This showed that the forest is high in terms of species richness and species diversity. Like other forests in Amhara region Dembeza natural forest has different natural and creature factors. Among natural factor invasive alien species (*Senna didymobotrya*, *Argemone mexicana*)

were observed. Also, other factors recorded during the study were browsing, grazing and selective exploitation of some plant species for traditional/cultural and construction use. The regeneration status of most plant species is low. Species which have low regeneration status in the forest were *Acacia lahai*, *Acokanthera schimperi*, *Calusena anisata*, *Dovyalis abyssinica*, *Dodonaea angustifolia*, *Rhus glutinosa*, *Rosa abyssinica* and *Steganotaeni aaraliacea*. Preparing appropriate conservation method should apply for species that has low regeneration status and less in distribution inside the natural forest. The conservation method may be ex-situ or field gene bank or enrich inside the natural forest. Species that have better regeneration status also protect from cutting and over exploitation. To sum up this study report, the forest needs responsible communities who take care as key resource and conserve in sustainable way.

5. Recommendations

Based on the study result on Dembeza natural forest the following recommendations are significant

- 1) Awareness creation should be practice to minimize communities dependence on the forest and find alternate way for the surrounding community;
- 2) Increase afforestation and plantation program for the forest and around the forest;
- 3) Documentation of plants use and traditional knowledge of communities around the forest;
- 4) Further studies necessary specially on plants which have low seedling and sapling regeneration status.

Conflict of Interest

The authors declare that they have no competing interests.

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