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Original Research

Status and Woody Plant Species Diversity in Tara Gedam Forest, Northern Ethiopia

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Abstract

The study was conducted in Tara Gedam forest with the objective of determining the status and the woody plant species diversity of Tara Gedam forest so as to recommend the conservation of the forest and rehabilitation of the degraded area.Sample plots were laid along line transects based on altitudinal variation of the study area. A systematic sampling of plot of (10 m x 20 m) in each site was established to take vegetation samples. Structural analysis was performed on the basis of density, frequency, DBH and basal area per hectare. The distribution of the size classes were evaluated by computing the density of individuals with DBH >10 cm and > 20 cm as well as the ratio of the former to the latter. The result revealed that a total of forty one different species of woody plants were identified in Tara Gedam forest. *Olea europaea* was the dominant one with recorded value of 598. *Allophylus abyssinicus* and *Albizia schimperiana* ranked the second and third in dominance with 556 and 474 numbers respectively. *Acanthus sennii* was the least dominant in the study site. Based on their higher IVI value, *Olea europaea*, *Allophylus abyssinicus, Nuxia congesta, Premna schimperi and Albizia schimperiana,* respectively are the leading dominant and ecologically most significant woody species in Tara Gedam forest. The density of vegetation in study area decreases with increasing of DBH and height classes, which implies the predominance of small sized individuals in the lower classes than that of higher classes implying good recruitment of the forest and the rare occurrence of large woody plant species.

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INTRODUCTION

Plants make up a vital part of the natural environment, and plant ecologists are well aware of this. In a healthy ecosystem, plants provide food and shelter for animals, secure the soil to prevent erosion, cast shade to create microclimates, conserve water to keep it in the ecosystem instead of allowing it to be lost, and participate in the breakdown and recycling of organic material to keep the ecosystem thriving. Plants are also of critical interest because they produce oxygen, and plants have been heavily implicated in the creation of the Earth's currently oxygen-rich atmosphere. The flora of Ethiopia is very heterogeneous and has a rich endemic element owing to the diversity in climate, vegetation and terrain. It is estimated to contain between 6,500–7000 species of higher plants, of which about 12% are endemic (Tewolde, 1991 as cited in Teshome Soromessa, *et al.*, 2004). Endemism is particularly high in the high mountains and in the Ogaden area, southeastern Ethiopia. Despite these realities, the vegetation resources, particularly forests, are disappearing at a very alarming rate in Ethiopia before we even have a chance to study and document them (EFAP, 1994; Teshome Soromessa *et al.*, 2004).

The plant populations on our planet must be sustained for all forms of life to exist on this planet being provided with the energy harvested from the sun by green plants through photosynthetic processes. The plant populations need to be maintained for the lives continue to exist on this planet as we know it through effective management measures. Various scholars also agreed on the urgency and importance of studying and documenting the vegetation resources of Ethiopia, among others, Teshome Soromessa*et al.* (2004); Ensermu Kelbessa and Teshome Soromessa (2008); Teshome Soromessa *et al.* (2011); Fekadu Gurmessa *et al*. (2011 and 2012); Adugna Feyissa *et. al.* (2013); Teshome Soromessa (2013); Teshome Soromessa and Ensermu Kelbessa (2013a and 2013b); Teshome Soromessa and Ensermu Kelbessa (2014); Mohammed Gedefaw *et al.* (2014) are the ones to mention. To implement the said effective management measures, one has to know relevant information pertinent to plant populations of a given ecosystem like plant diversity, composition and structures of a given habitat. Different methods have been developed to upgrade the knowledge of plant ecology by various scientific communities since time immemorial. Some methods and techniques are effective while others lack clarification and complicated.

Deforestation in the highlands of Ethiopia, specifically in the study area become an unstoppable process dating back many hundreds of years resulting patches of forest mainly around religious centers inaccessible and protected areas. They are the only areas covered by vegetation in Ethiopia (Alemayehu Wassie, 2007). The management and conservation of forests in all areas throughout the country has been becoming a big challenge since most of the activities did not involve the local community (Dessalegn Rahmato, 2001). The increasing of population growth increases the demand for forest products and this in turn puts a pressure on the natural forest to be degraded and facilitate the erosion process (Alemayehu Wassie and Demel Teketay, 2006).

Even if this study only covers very small area looking from the Ethiopian total forest coverage, it is important for sustainable forest management by achieving a win-win strategy. No study has been conducted in Tara Gedam forest that aimed at the status and floral diversity of vegetation. Therefore, the present study was initiated to investigate and document the diversity and status of species so as to provide information in order to manage the forest sustainably by planting trees and by conserving the natural forests as it is as well. The overall objective of this study is focused on the status and the floral diversity of Tara Gedam forest so as to recommend the conservation of the forest and rehabilitation of the surrounding area.

MATERIALS AND METHODS

Description of the Study Area

Geographical Location

The study was carried out in Tara Gedam forest located very close to Addis Zemen town, northeast of Lake Tana, northwestern Ethiopia (Figure 1). The study area is located in South Gondar Zone within the Amhara National Regional State. Addis Zemen town is located at 12°06'59" N–12°07'25" N and 37°46'14" E–37°47'02" E, on the Addis Ababa Gondar main road, about 82 km north of Bahir Dar and 93 km south of Gondar town. The altitude of Tara Gedam ranges from 2217 to 2457 m.a.s.l. with the highest peak at Wombera Mountain. The forest covers 875 hectares.

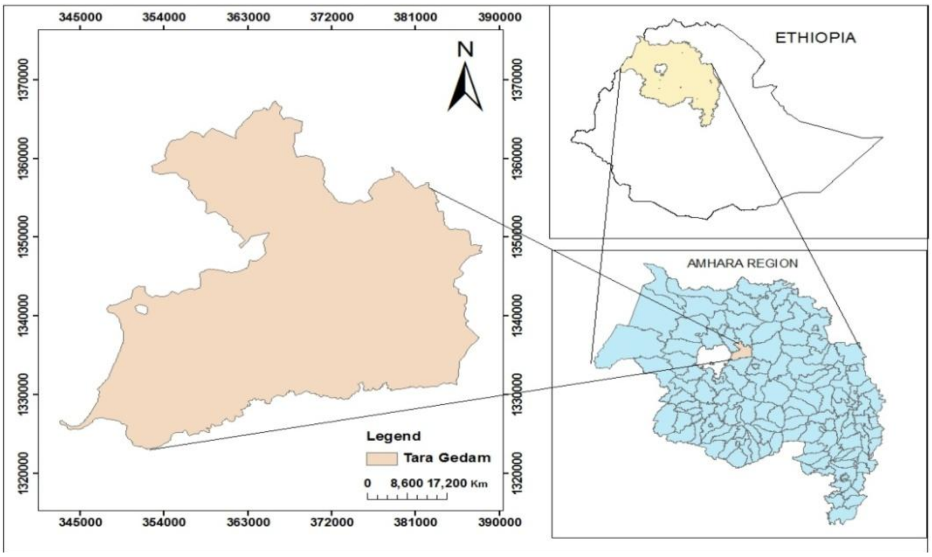

Figure 1: Location of Tara Gedam forest.

Climate

The study area is generally characterized by moderate climate, locally known as *Woina Dega*. The area has a mono modal rainfall distribution and the rainy season is from June to August. The dry season extends from December to March. Climatic data obtained from the National Meteorological Services Agency for the study area showed that the mean annual maximum and minimum temperatures are 27.9°C and 11.1°C, respectively, and the mean annual rainfall is from 900 mm to 1,200 mm.

Geology and Soil

Most of the areas are covered by volcanic rocks mainly basalt. The rocks are light dark, grey, whitish, reddish or brown. The fertility of the soils in the area deteriorated as a result of erosion and continuous cultivation.

Vegetation Cover

The vegetation of Tara Gedam consists of forests, bush lands, shrub lands and mixed/enrichment plantations. There is dense natural forest just around the monastery. Tara Gedam forests consist of different trees and shrubs interspersed with climbers and herbs.

Delineation of the Study Site

Delineation of theforest boundaries was the first step in floristic measurement.The boundary of the study forest area was delineated by taking geographic coordinates with GPS at each turning point. The GPS points that were taken from the study site to indicate each sample plots were recorded.

Sampling Techniques in the Field

Systematic sampling method was used to take samples. Sample plots were laid along line transects based on altitudinal variation of the study area. A systematic sampling of plot of (10 m x 20 m) in each site was established. To collect information of woody speciescomposition, all live trees with a diameter ≥ 5 cm were recorded as indicated by (Pearson *et al.,* 2005).

For simplification of the study seedling, sapling and tree are defined as plants with heights up to 150cm, between 150-300cm and above 300cm respectively as used by (Demel Teketay, 1997). To determine seedling, sapling and tree densities and their distribution along the altitudinal gradient nine transects were established following North-South orientation and with 100m distance interval between them. Sample plots were laid along line transects based on altitudinal variation of the study area. The diameter was measured at breast height (DBH, 1.3 m height from the ground) to estimate biomass and the size class distribution of trees in a sampling plot.DBH and height of plants were used to assess the structure of the study forest. Plant identification was done by using Flora of Ethiopia and Eritrea for those species difficult to identify in the field, fresh specimens were collected and then pressed properly and finally brought to the National Herbarium of Addis Ababa University.

Methods of Data Analysis

Different DBH classes were constructed, and the density distribution of tree and shrub species was computed in each class (McCune and Mefford, 1999; Magurran, 1988). Structural analysis was performed on the basis of density, frequency, DBH and basal area per hectare. The distribution of the size classes were evaluated by computing the density of individuals with DBH >10 cm and > 20 cm as well as the ratio of the former to the latter. According to Grubb *et al.* (1963), the ratio of 'density at DBH class >10 cm to density at DBH class >20 cm can be used as a measure of the distribution of the different size classes. The patterns of species population structure detected were interpreted as a sign for the alteration in population dynamics in the forests (Popma *et al.,* 1988). The following structural parameters were calculated for some species following Mueller- Dombois and Ellenberg (1974) and Martin (1995) as follows:

Percent frequency of a species = the number of plots in which that species occurs/total number of plots X 100

Relative frequency = Frequency of species/total frequency of all species X 100

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

Relative density = Density of species A/total density of all species X 100

Basal area (m^2) = $(DBH/200)^2$p where DBH is the Diameter at Breast Height (cm), p = 3.14

Dominance = Total of basal area / area sampled

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

Importance Value Index = Relative density + Relative frequency + Relative dominance.

RESULTS AND DISCUSSION

Floristic Composition of the Forest

A total of forty one different species of woody plants were identified in Tara Gedam forest, south Gondar Ethiopia. A total of 7,156 individuals of woody plants from the forty one different species were collected. Among the collected plant species, *Olea europaea* was the dominant one with recorded value of 598. *Allophylus abyssinicus* and *Albizia schimperiana* ranked the second and third in dominance with 556 and 474 numbers respectively. *Acanthus sennii* was the least dominant in the study site (Table 1).

Based on the results (Table 1) *Cupres suslusitanica* had the highest percentage frequency (12.50%). and the three tree species *Dovyalis abyssinica, Clausena anisata and Urtica urens* had the lowest percent frequency (0.45%).

Density

The overall density of mature woody species of Tara Gedam forest DBH$\geq$5cm was7, 156 stems ha^{-1}.

Frequency

Frequency is the number of quadrants in which a given species occurred in the study area. It gives an approximate indication for homogeneity and heterogeneity of vegetation. Lamprecht (1989) pointed out that high value in high frequency and lower value in the lower frequency classes indicate vegetation homogeneity. Conversely, high percentage of number of species in the lower frequency class and low percentage of number of species in the higher frequency classes indicates high degree of floristic heterogeneity (Simson Shibru and Girma Balcha, 2004). According to the result in Table 1 the highest frequency was recorded for *Acacia senegal* and the lowest for *Dovyalis abyssinica.*

Diameter at Breast Height and Height Distribution of trees

Diameter at breast height (DBH)

From the raw data collected from the field, the DBH of trees were classified into five classes: 0-10=, 11-20=, 21-30=, 31-40= and >40= (Figure 2). The majority of woody plants were distributed in the second class (11-20) followed by the third class (21-30) and the least woody plants on the other hand were recorded in the fifth and fourth classes respectively. This showed that the middle classes were occupied by dense and short plants.

Height distribution of collected trees

Like that of DBH distribution of plants, the height distribution of plants also was classified into five classes (0-10), (11-20), (21-30), (31-40) and (>40). The majority of tall plants were found in the second class like that of DBH classes followed by the first class. The shortest plants were recorded in the last two classes; fourth and five classes (Figure 3).

Important Value Index (IVI)

IVI is a combination of data from three parameters. These are: relative frequency, relative density and relative dominance (Kent and Cooker, 1992). Curtis and McIntosh (1951) pointed out that IVI gives a more realistic figure of dominance from structural point of view. It is useful to compare the ecological significance of species (Lamprecht, 1989) in which high IVI value indicates that the species sociological structure in the community is high. As a result ecologists consider IVI as the most reasonable aspect in the vegetation study (Curits and McIntosh, 1951). Based on their higher IVI value, *Olea europaea*, *Allophylus abyssinicus, Nuxia congesta, Premna schimperi and Albizia schimperiana,* respectively are the leading dominant and ecologically most significant woody species in Tara Gedam forest. The leading dominant and ecologically most significant species might also be the most successful species in regeneration, pathogen resistance, grow in shade, and in completion with other species, least preferred by animals, attractions of pollinators and seed predators that facilitate seed dispersal within the existing environmental conditions of the study area (Table 2).

Table 1: Species list collected from Tara Gedam forest with their average DBH, percentage of frequency, number of trees and the species that occurs more repeatedly in the whole plots.

Species name	No of trees	Average DBH(cm)	No. of plots that species found	Average height	% Frequency of species
Acacia senegal L.Wild	391	33.88	17	18.34	7.59
Acanthus sennii Chiov.	2	10.46	3	13.79	1.34
Albizia schimperiana Oliv**.**	474	38.52	16	19.00	7.14
Allophylus abyssinicus (Hochst) Radlkofer	556	27.42	11	39.12	4.91
Anethum graveolens L.	227	36.21	4	18.28	1.79
Bersama abyssinica Fresen.	224	18.50	5	18.50	2.23
Brucea antidysenterica J.f.Mill.	82	25.00	5	17.17	2.23
Buddleja polystachya Fresen.	120	15.96	5	18.06	2.23
Calpurnia aurea (Ait) Benth.	159	20.44	3	14.77	1.34
Carissa spinorum L.	305	12.66	5	16.28	2.23
Celtis africana Brum.f.	90	35.22	3	12.81	1.34
Clausena anisata (willd.) Hook.	10	5.58	1	19.00	0.45
Combretum molle R.Br.ex G.Don	233	20.55	3	16.34	1.34
Cordia africana Lam.	75	31.00	2	13.77	0.89
Croton macrostachyus Del.	379	37.59	10	20.61	4.46
Cupressus lusitanica Mill.	312	60.67	28	32.56	12.50
Dombeya torrida J.F.Gmel.	127	30.89	4	16.67	1.79
Dodonaea angustifolia L.f.	222	18.00	10	17.03	4.46
Dovyalis abyssinica (A.Rich.)Warb.	19	36.85	1	14.42	0.45
Ekebergia capensis Sparrm**.**	11	35.25	2	9.77	0.89
Eucalyptus globulus Labill.	75	28.00	5	20.99	2.23
Euclea divinorum Hiern.	80	14.35	6	13.23	2.68
Ficus sur Forssk.	111	39.80	8	16.89	3.57
Grewia ferruginea Hochst.ex A.Rich.	347	26.00	3	10.71	1.34
Hibiscus vitifolius L.	157	28.50	4	14.05	1.79
Hypericum quartinianum A.Rich.	57	10.65	4	14.95	1.79
Jasminum grandiflorum L.	38	9.53	4	12.16	1.79
Maytenus arbutifolia (A.Rich.)Wilczek.	181	22.34	5	14.50	2.23
Maytenus gracilipes (Welw.ex Oliv.) Exell.	44	25.85	2	7.71	0.89
Myrsine africana L.	135	26.50	4	13.77	1.79
Nuxia congesta R.Br.ex Fresen.	426	34.54	5	17.22	2.23
Olea europaea subsp.cuspidata.	598	38.57	6	18.61	2.68
Osyris quadripartita Decn.	100	24.75	6	15.60	2.68
Phytolacca dodecandra L'Herit	3	16.00	2	12.00	0.89
Premna schimperi engl.	356	38.80	5	17.75	2.23
Pterolobium stellatum (Forsk.) Brenan.	133	10.25	6	13.94	2.68
Rosa abyssinica lindly.	17	10.78	3	11.65	1.34
Schefflera abyssinica (Hochst.ex.A.Rich) Harms	88	37.53	3	9.79	1.34
Schrebera alata (Hochst.)Welw.	119	35.55	2	6.36	0.89
stereospermum kunthianum Cham.	59	37.50	2	25.16	0.89
Urtica urens L.	14	18.50	1	18.17	0.45

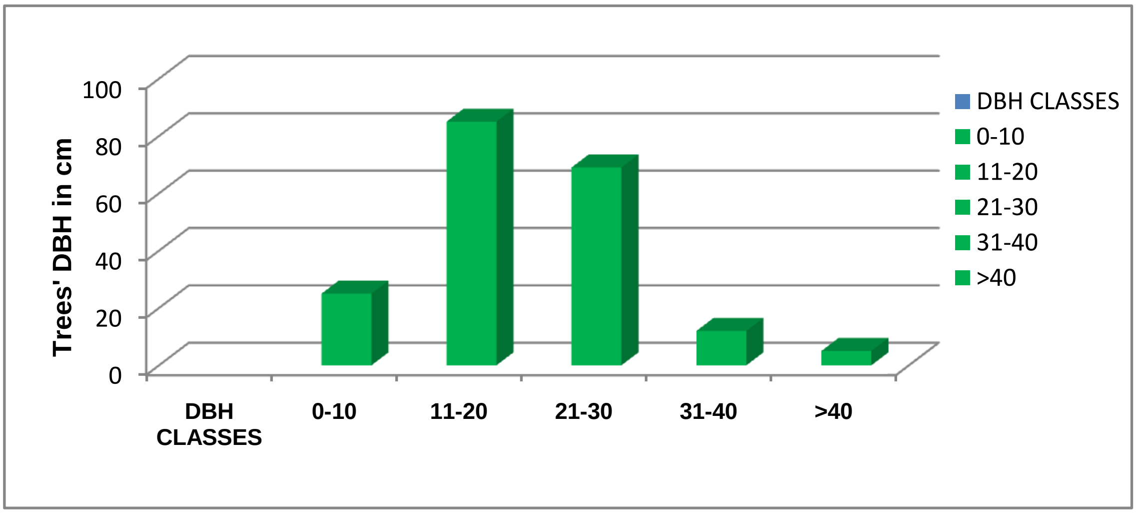

Figure 2: DBH distribution of plants in Tara Gedam forest

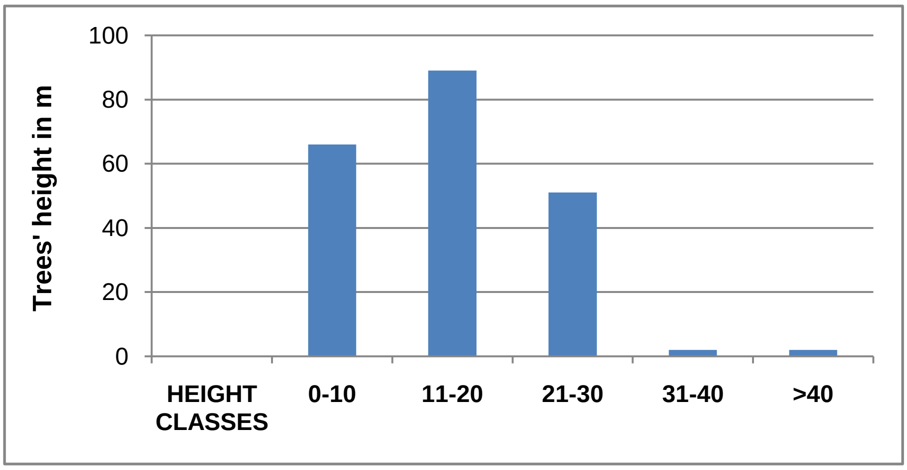

Figure 3: Height distribution of plants in the study forest

Table 2: Relative frequency, relative density and relative dominance and importance value index of the dominant woody species of Tara Gedam forest

Name of species	Relative frequency	Relative density	Relative dominance	IVI
Acacia senegal L. Wild	7.59	5.463946	5.942738	18.99668
Acanthus sennii Chiov.	1.34	0.027949	0.002897	1.370846
Albizia schimperiana Oliv**.**	7.14	6.623812	9.312663	23.07648
Allophylus abyssinicus (Hochst) Radlkofer	4.91	7.769704	5.535192	18.2149
Anethum graveolens L.	1.79	3.172163	3.940995	8.903158
Bersama abyssinica Fresen.	2.23	3.13024	1.015113	6.375354
Brucea antidysenterica J.f.Mill.	2.23	1.145892	0.678605	4.054496
Buddleja polystachya Fresen.	2.23	1.676914	0.404734	4.311649
Calpurnia aurea (Ait) Benth.	1.34	2.221912	0.879593	4.441505
Carissa spinorum L.	2.23	4.262158	0.647277	7.139435
Celtis africana Brum.f.	1.34	1.257686	1.478237	4.075923
Clausena anisata (willd.) Hook.	0.45	0.139743	0.004123	0.593866
Combretum molle R.Br.ex G.Don	1.34	3.256009	1.302874	5.898883
Cordia africana Lam.	0.89	1.048072	0.95435	2.892421
Croton macrostachyus Del.	4.46	5.296255	7.09099	16.84724
Cupressus lusitanica Mill.	12.5	4.359978	15.20637	32.06635
Dombeya torrida J.F.Gmel.	1.79	1.774734	1.604584	5.169319
Dodonaea angustifolia L.f.	4.46	3.102292	0.952404	8.514695
Dovyalis abyssinica (A.Rich.)Warb.	0.45	0.265511	0.341627	1.057138
Ekebergia capensis Sparrm**.**	0.89	0.153717	0.180981	1.224699
Eucalyptus globulus Labill.	2.23	1.048072	0.778575	4.056646
Euclea divinorum Hiern.	2.68	1.117943	0.218131	4.016074
Ficus sur Forssk.	3.57	1.551146	2.328156	7.449302
Grewia ferruginea Hochst.ex A.Rich.	1.34	4.849078	3.105984	9.295061
Hibiscus vitifolius L.	1.79	2.193963	1.688544	5.672507
Hypericum quartinianum A.Rich.	1.79	0.796534	0.085605	2.672139
Jasminum grandiflorum L.	1.79	0.531023	0.045697	2.36672
Maytenus arbutifolia (A.Rich.)Wilczek.	2.23	2.529346	1.196101	5.955447
Maytenus gracilipes(Welw.ex Oliv.) Exell.	0.89	0.614869	0.389311	1.89418
Myrsine africana L.	1.79	1.886529	1.255303	4.931832
Nuxia congesta R.Br.ex Fresen.	2.23	5.953046	6.729414	14.91246
Olea europaea subsp.cuspidata.	2.68	8.356624	11.77941	22.81603
Osyris quadripartita Decn.	2.68	1.397429	0.811098	4.888527
Phytolacca dodecandra L'Herit	0.89	0.041923	0.010169	0.942092
Premna schimperi engl.	2.23	4.974846	7.096373	14.30122
Pterolobium stellatum (Forsk.) Brenan.	2.68	1.85858	0.185022	4.723602
Rosa abyssinica lindly.	1.34	0.237563	0.026158	1.603721
Schefflera abyssinica (Hochst.ex.A.Rich) Harms	1.34	1.229737	1.641205	4.210942
Schrebera alata (Hochst.)Welw.	0.89	1.66294	1.991357	4.544297
stereospermum kunthianum Cham.	0.89	0.824483	1.098595	2.813078
Urtica urens L.	0.45	0.19564	0.063445	0.709085

CONCLUSION

The study conducted in Tara Gedam forest showed that, the forest harbors many plant species. Based on the structural composition of DBH and height class distribution on Tara Gedam forest, similar trends have been shown in both DBH and height class classifications. The density of vegetation in the study area decreases with increasing of DBH and height classes, which implies the predominance of small sized individuals in the lower classes than that of higher classes implying good recruitment of the forest and the rare occurrence of large woody plant species.

The analysis of these two parameters in the study forest indicated that higher percentage numbers of plant species are found in the lower than in the higher frequency classes implying that the forest is floristically heterogeneous. The assessment of the status of vegetation in the study area showed that there was a significant proportion of woody species decline as a result of deforestation implying that they are under threat. Therefore, it is essential to develop and implement an effective conservation measures to save and use the biodiversity resources found in the forest in a sustainable manner.

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