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Research Article

Floristic Composition, Diversity, and Vegetation Structure of Woody Species in Kahitassa Forest, Northwestern Ethiopia

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Kahitassa forest is one of the State Forests of Ethiopia with great floral diversity. However, the forest is under threat due to selective cutting of important indigenous tree species and encroachment of the forest area for agricultural purpose. Therefore, the study was intended to explore the floristic composition, structure, and regeneration status of Kahitassa forest. Vegetation data were collected from June to November 2020 using systematic sampling technique from 6 parallel transect lines laid out 500 m apart each other. A total of 101 plots (20 × 20 m) were laid with 100 m apart along transect lines. Vegetation description parameters including Shannon–Weiner Index, evenness, density, DBH, basal area, frequency, and importance value indices (IVI) were computed to characterize both species diversity and vegetation structure. Hierarchical cluster analysis was used to identify plant communities using R (Version 3.1.2) software. A total of 46 woody plant species belonging to 45 genera and 36 families were identified in the forest. Fabaceae and Rosaceae were the dominant families both constituting 34.78% of the total species. The Shannon diversity index (H') and evenness (E) values of the study area were 2.92 and 0.72, respectively, showing the healthy status of the forest. Five plant community types, namely, Croton macrostachyus–Embelia schemperi, Maytenus undata–Olea europaea subsp. cuspidata, Pavetta abyssinica–Bersama abyssinica, Peucadanum mattiroli, Albizia schimperiana, and Rubus apetalus–Phytolacca dodecandra were identified. The most dominant species as indicated by their important value index (lVI) were Pavetta abyssinica (34.08), Vachellia abyssinica (IVI = 25.13), and Albizia schimperiana (IVI = 21.45). Analyses of DBH revealed that the forest exhibits an inverted J-shape which is typical for selective cutting of multipurpose trees from the forest. Conservation approaches such as enrichment of selected species as well as in situ and ex situ conservation are needed for some plant species under threat.

1. Introduction

The altitudinal variation, ranging from the highest peak at Ras Dejen, 4620 m above sea level down to the depression of the Kobar Sink (Afar Depression) which is 116 m below sea level, Ethiopia is endowed with a highly diversified climatic conditions and topography with a wide range of habitats and vegetation types [1, 2]. Consequently, the country is ecologically diverse harboring an exceptionally rich botanical diversity [3] of about 6,027 species of vascular plants, with approximately 10% endemic, hence making it one among the six-plant biodiversity-rich regions [4, 5] providing economical, sociocultural, and environmental benefits [6].

Forests are the most diverse terrestrial ecosystems playing important economic, social, and cultural roles particularly in the lives of many local communities [7]. Studies [6, 8] confirmed that forests have an important role in maintaining the environmental productivity; trees provide food for animals, serve as a standing cover to protect the land from wind and water erosion, stabilizing the water cycle, assist the hydrological cycle, and keep the soil structure well; they are also used for construction as well as for household paraphernalia (homemade wooden utensils in this context), medicine, grass, and herbage and for forage and provide edible fruits as well as source of income [9]. Moreover, forests serve to absorb more than 80% of all terrestrial carbon above ground and more than 70% of all soil organic carbon to reduce global warming, give off oxygen, and renew the atmosphere [10–12].

However, the forest resource of the country is under serious threat from deforestation, forest fire, land degradation, overexploitation, overgrazing, shifting cultivation, habitat loss, and invasive species [13, 14]. As a result of these threats, the trend in the conservation status of biodiversity is declining at an alarming rate. Besides anthropogenic activities, forests can be influenced by different environmental factors such as altitude, slope, and aspect by affecting the patterns of tree species distribution [6].

Vegetation studies are imperative to address ecological issues, for biological conservation and management purposes, as an input to environmental impact assessments, to monitor management practices, or to provide the basis for prediction of possible future changes in plant species distributions which could be linked to human impacts directly on habitats and via land-use practices involving land-use changes [15]. Therefore, the current study presents the vegetation composition, structure, and diversity of Kahitassa forest that is helpful for planning their future conservation and sustainable management of the remnant vegetation and to halt the tangible as well as possible consequences of loss of vegetation. The study tried to collectively address the following questions: What is the floristic composition of the vegetation in the Kahitassa Forest? How does the vegetation structure of the forest look alike? What are species richness, evenness, and diversity of plant communities in the study area? What are the major community types in the forest? What is the level of regeneration of the woody species?

2. Materials and Methods

2.1. Description of the Study Area. Kahitassa forest is one of the forests in Awi Administrative Zone, Amhara National Regional State, Ethiopia, with a total area of about 272,912 ha [16]. Geographically, Kahitassa forest is found between geographic coordinates of 8°34′00″ to 10° 59′ 02″ latitudes and 36° 47′ 00′ to 36° 48′ 26″ longitudes (Figure 1). The forest area has altitudes ranging from 1500 to 3200 m.a.s.l.

According to AAZAO [16], topography of Kahitassa forest is characterized by plain, plateau, hills, and valley land features. Based on AAZAO [16], the diverse topographic features of the area have resulted in diverse climatic conditions, and agro-ecologically, the forest is classified as Dega (35%) and Woyna Dega (65%) zones. The forest area is humid retaining heavy intensity of rain with mean monthly and an average annual rainfall of 156.41 mm and 1700 mm, respectively, showing a unimodal raining pattern (Figure 2). Cloud condition covers 92% of the sky during the wet season [16]. The mean maximum and the mean minimum temperatures are 23°C and 9.47°C, respectively (Figure 2).

2.2. Sampling Design. Reconnaissance survey was done from June 1 to 30/2020 for site selection and method validation. Systematic sampling technique was used to collect vegetation data. Sampling sites were arranged along the 6 transects. The number of plots per transect varies depending on the length of transect. The distances between two consecutive plots and transect were 100 and 500 m apart in the forests, respectively, to include variations for maximum vegetation distribution patterns. Accordingly, a total of one hundred one sampling plots of each 20 × 20 m (400 m^2) in size were established for woody plant species and 505 subplots of each 4 × 4 m (16 m^2) in size for seedling and sapling collection in the forest following Kent [15]. All plant species in each quadrant were recorded and their growth habits were noted.

2.3. Data Collection. In each plot, height and diameters at breast height (DBH) of woody plant species with height ≥2 m and DBH ≥2.5 cm were measured. Individuals having a height less than 2 m and DBH less than 2.5 cm were counted. Accordingly, seedlings having heights of ≤1 m and DBH ≤2 cm and saplings with heights of >1 m and DBH ≤2.5 cm were counted. The DBH of woody plants at 1.3 m above the ground was measured. Plant species were counted on each plot and their vernacular names were recorded during field work following Amanuel [17]. Voucher specimens corresponding to all plant taxa studied were collected, pressed, dried, and brought to Hawassa University for identification using volume 1–8 of Flora of Ethiopia and Eritrea.

2.4. Data Analysis

2.4.1. Diversity and Similarity Indices. Shannon–Weiner diversity indices and Shannon's evenness were computed to describe species diversity of the study area [18].

$$H = -\sum_{i=1}^{s} pi\,\mathbf{ln}\,pi, \quad (1)$$

where: **H** = Shannon–Weiner's diversity index; ∑ = the sum of calculations; **p** = the proportion (*n*/*N*) of individuals of one particular species found (*n*) divided by the total number of individuals found (*N*); ln = natural logarithm; and **s** = number of species.

Shannon's evenness index (*J*) was also calculated using the following equation:

$$J = \frac{H'}{LnS}, \quad (2)$$

where *H*' = Shannon–Wiener Diversity Index; and *H*' max = LnS' where *s* is the number of species in the sample.

2.4.2. Plant Community Classification. Agglomerative hierarchal cluster analysis was performed using R Packages (Version 3.1.2), mgcv, and ggplot2 (R Development Core Team 2014) to categorize the vegetation into community types. Cophenetic correlation coefficient (CP) was used to assure the goodness of fit for clustering. The 101 studied plots were clustered with R software using the synoptic abundance cover value (Table 1). The estimated cover-

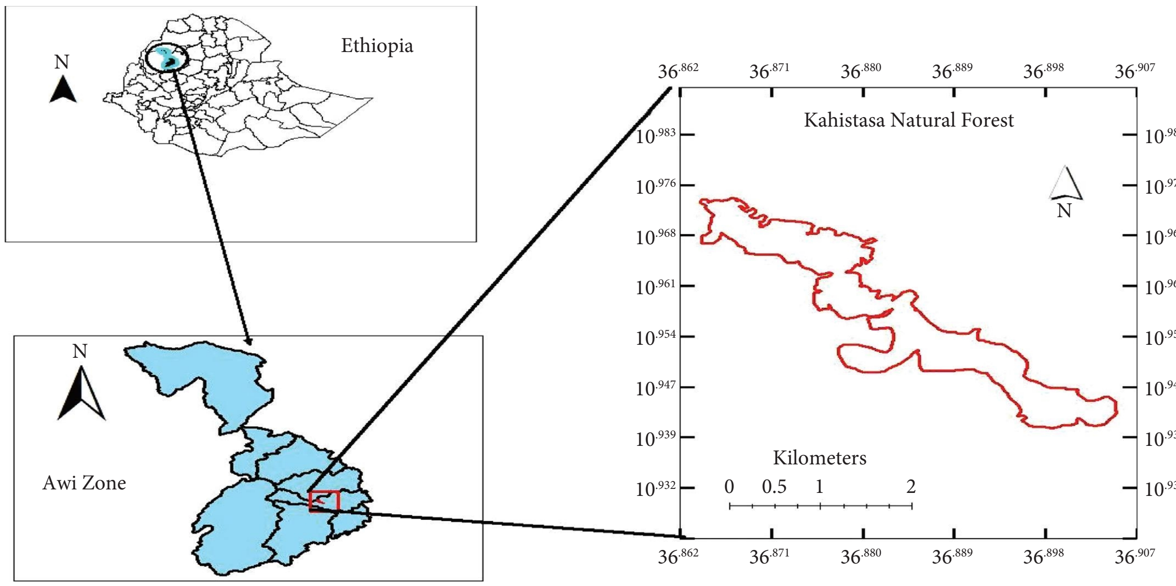

Figure 1: Map of the study area.

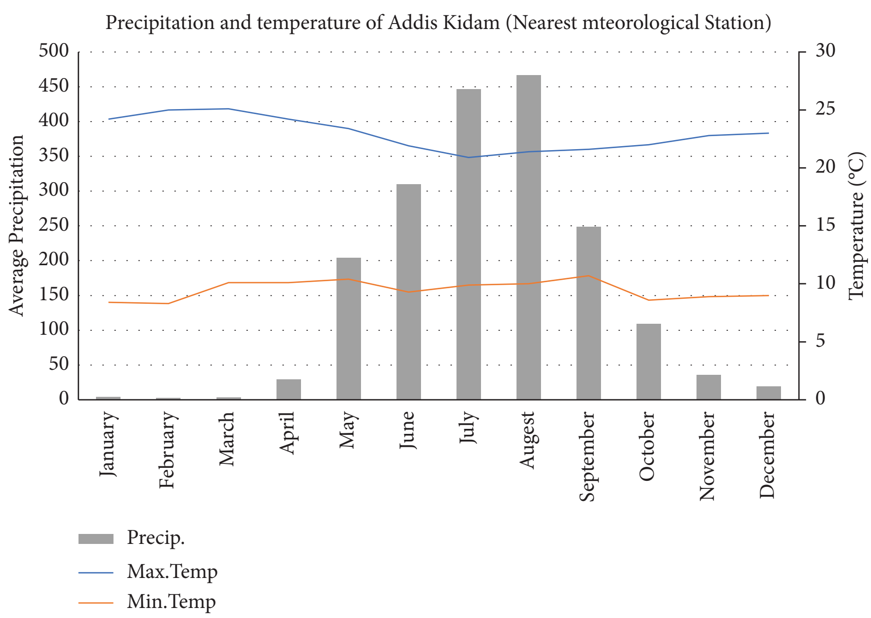

Figure 2: Climate diagram of Addis Kidam district (from 2011 to 2020).

Table 1: Species list with synoptic cover-abundance value for species having a value of ≥1 in at least one community.

Species	Community 1	Community 2	Community 3	Community 4	Community 5
Rubus apetalus	0	0	0.64	1.3	**6.15**
Phytolacca dodecandra	0	0	0	0	**0.65**
Peucedanum mattirolii	0	0	0	**7.7**	0
Albizia schimperiana	2.87	0	2.32	**3.2**	2
Combretum molle	1.83	2.19	0	3	0.1
Urera hypselodendron	0	0	0.6	2.2	0.75
Carissa spinarum	0.13	0	1.76	1.9	0
Vachellia abyssinica	0.23	0	0.6	1.5	0
Terminalia brownie	0	0	1.28	1.5	0
Syzygium guineense subsp. guineense	0	0	0.6	1.2	0.45
Pavetta abyssinica	1.23	0	**5.84**	3.4	5.55

Table 1: Continued.

Species	Community 1	Community 2	Community 3	Community 4	Community 5
Bersama abyssinica	2.6	0	**5.36**	3.1	0.15
Apodytes dimidiate	0.77	0	3.96	2.1	1.3
Cassia alexandrina	0	0	2.8	0	0.1
Nuxia congesta	0.4	0	2.68	0	0
Calpurnia aurea	0	0	0.6	0	0
Rubus apetalus	0	0	2.56	0	0
Rosa abyssinica	0	0	1.92	1.5	0
Ximenia americana	0	0	1.28	0.5	0
Maytenus undata	6.67	**8.81**	0	5.9	1.65
Olea europaea subsp. cuspidata	0.87	**1.06**	0	0	0
Croton macrostachyus	**4.07**	0	0	2.6	0.3
Embelia schimperi	**2.6**	1.31	0	0	0.1
Clausena anisata	2.43	0	0	0	0
Clutia abyssinica	2.13	0	0	1.5	0.25
Clerodendron alatum	1.73	0	0	0	0.45
Dombeya torrida	1.67	0	0	1.5	0
Carduus macracanthus	1.27	0	0	0	0.5
Ficus sur	1.13	0	0	0.6	0
Ekebergia capensis	1.03	0	0	0.9	0.05
Euphorbia abyssinica	1	0	0	0	0
Hypericum quartinianum	0.73	0	0	0	0.1
Kalanchoe petitiana	0.73	0	0	1.1	0.05
Clerodendron alatum	0.5	0	0	0	0

abundance values for each species in each plot were converted to the Braun-Blanquet 1–9 scales modified by Maarel [19] as follows:

(1) Rare, generally one individual;
(2) occasional <5% cover;
(3) abundant <5% cover;
(4) very abundant <5% cover;
(5) cover values between 5 and 12%.
(6) cover values between 12 and 25%;
(7) 25–50% cover;
(8) 50–75% cover; and
(9) 75–100% covers of the total plot area.

2.4.3. Structural Data Analysis. Density, basal area, frequency, IVI, and DBH class distributions were calculated for each woody plant species for description of vegetation structure. Thus, the following formulas were used to calculate frequency, density, and basal area of woody species.

$$\text{Frequency}\,(F) = \frac{\text{Number of plots in which a species occurs}}{\text{Total number of plots}} \times 100,$$

$$\text{Density} = \frac{\text{Total number of indi vidu als of a species in all plots}}{\text{Sample size in hectare}}, \tag{3}$$

$$BA = \left(\frac{DBH}{2}\right)^2 \times \pi,$$

with ($\pi = 3.14$) where DBH is diameter at breast height.

An Importance Value Index (IVI) was computed for all woody species based on their relative density (RD), relative dominance (RDO), and relative frequency (RF). These indices were used to determine the overall importance of each species in the forest system [15] using the following formula:

$$RDO = \frac{BA}{TBA} \times 100, \tag{4}$$

where RDO = relative dominance, BA = basal area, and TBA = total basal area.

$$\text{Relative Density} = \frac{\text{Number indi vidu als of each species per ha}}{\text{Total number of indi vidu als of all species per ha}} \times 100,$$

$$\text{Relative Frequency} = \frac{\text{Number of sample plots containing a species}}{\text{Sample units for all species of the sample}} \times 100, \tag{5}$$

$$\text{IVI} = \text{relative de nsity} + \text{relative do minance} + \text{relative f requenc.}$$

3. Results and Discussion

3.1. Floristic Composition. A total of 46 woody plant species belonging to 45 genera and 32 families were identified from the study area (Table 1, Supplementary Material). From the recorded 46 plant species, 8 of them were recorded out of the study plots and hence were excluded from different diversity computations except for floristic composition descriptions. The distribution of plant species against their families has revealed variation (Figure 3) Fabaceae and Rosaceae families were the most species-rich families with 4 species (8.69% each). Similarly, two families, namely, Euphorbiaceae and Myrtaceae were represented by 3 species (6.52% each), whereas Asteraceae, Combretaceae, Cupressaceae, and Oleaceae were represented by two species (4.35%) each. The rest 24 families were represented by single species (2.17% each). Concerning to the species composition of families, the higher species proportion of families Fabaceae and Rosaceae was also supported by similar studies from Menagesha Suba Forest [20] and Gelawoldie Forests [21]. The plant species distribution across the 41 families is shown in Figure 3.

The number of species composition of Kahitassa Natural Forest (46 species, 45 genera, and 32 families) was higher than Dugda Woreda protected forest (19 species), Yemrehane Kirstos Church Forest (39 species), and Tara Gedam Forest (41 species), [17, 22, 23] indicating forest conservation efforts employed for ecological value of the area. Nonetheless, the forest is also lower than other forests in the country such as 52 plant species in Lammo forest [24], 59 plant species in Gelawoldie forests [21], and 70 plant species in Kafta Sheraro National Park Dry Forest [25]. Spatial and temporal weighbridges resulted from diverse environmental variables and anthropogenic disturbances could contribute for the species richness values of the aforementioned forest sites.

3.1.1. Growth Forms of Kahitassa Forest. The identified woody plant species were grouped into four different plant growth forms (Figure 4). The result shows that majority (52.17%) of the plant species were trees followed by shrubs, lianas, and climbers constituting 36.96, 8.69, and 2.17%, in that order, of the total number of species. The present study indicated that trees and shrubs were found to be more dominating than climbers and liana plant growth forms (Figure 5). This study is in line with the reports of Tegene [26] and Balemlay [27] in which larger number of trees followed by shrubs and lianas observed in that order.

3.2. Floristic Diversity. According to Magurran [28], H' values usually fall between 1.5 and 3.5, and rarely exceed 4.0. The general Shannon–Weiner diversity index of Kahitassa forest was found to be 2.76. This relatively medium diversity index value showed that there were moderate representations of individual plant species. The overall evenness value of the forest is 0.79, which shows the relative equality of the proportion of each species within the community of Kahitassa forest (Table 2). However, some species have shown greater contribution for the allover evenness of the study area.

3.2.1. Diversity and Evenness of Plant Communities. The Shannon–Weiner diversity index at community level showed variation across communities (Table 2). As a result, *Croton macrostachyus–Embelia schimperi* community type, *Peucadanum-mattiroli–Albizia schimperiana* community type and *Maytenus undata–Olea europaea subsp. cuspidata community* type had medium diversity indices of 2.83, 2.82, and 2.51, respectively (Table 2). This closeness of diversity index values could be attributed to relatively comparable altitudinal ranges as also described by Sewale and Mammo [27]. On the contrary, *Maytenus undata–Olea europaea* subsp. cuspidata community type and *Rubus apetalus–Phytolacca dodecandra* community type have smaller Shannon–Weiner diversity index with 2.1 and 1.0 values, respectively (Table 2), which may be an indication of presence of few species (Sewale and Mammo) [27]. When compared to the overall diversity index (2.76), Communities 1 and 4 revealed higher value for the same index while Communities 2, 3, and 5 had relatively lower diversity. Conversely, the evenness index revealed variation across the five communities. Communities IV, III, and I showed greater evenness values (0.93, 0.91, and 0.90, respectively), whereas Communities 2 and 5 had lower values than the total evenness of the study forest. As with Fikadu et al. [7] and Sewale and Mammo [27], the reason for this low diversity might be attributable to anthropogenic factors, topographic, and/or biological, whereas high species diversity was possibly ascribed to the existence of preference of environmental/ecological gradients to which the biotic community interacts.

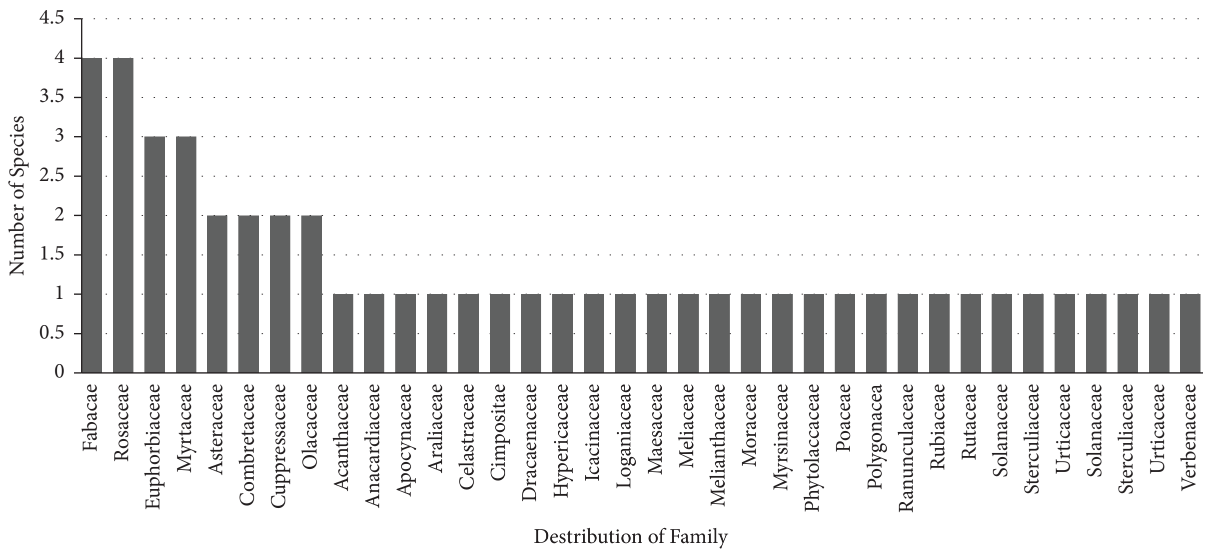

Figure 3: Species distribution per family.

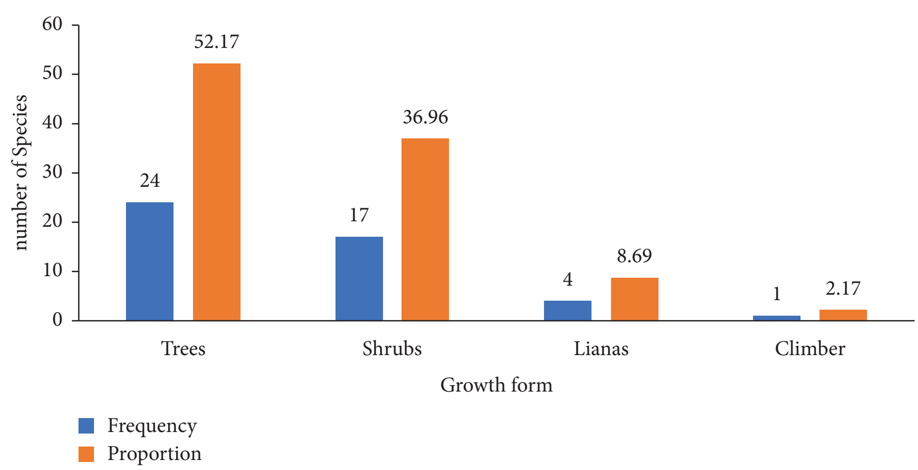

Figure 4: Plant growth forms of the study area.

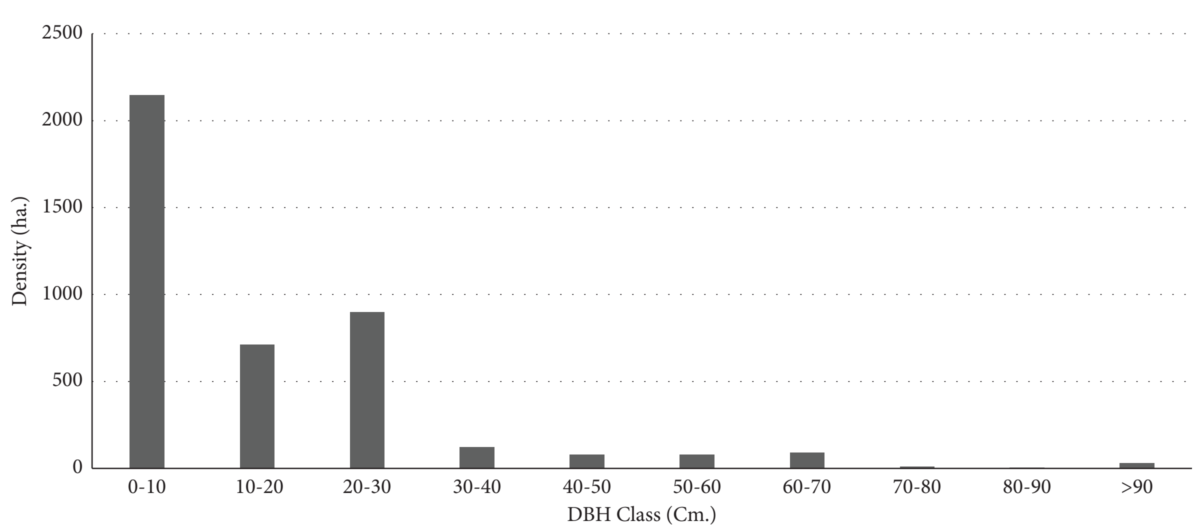

Figure 5: DBH class distribution of woody plant species in Kahitassa forest.

Table 2: Plant species richness, Shannon diversity, and evenness indices of the five community types.

Community type	Richness	Shannon diversity (H')	Evenness (Shannon)
Community 1	23	2.83	0.90
Community 2	4	1.0	0.72
Community 3	16	2.51	0.91
Community 4	21	2.82	0.93
Community 5	19	2.1	0.71

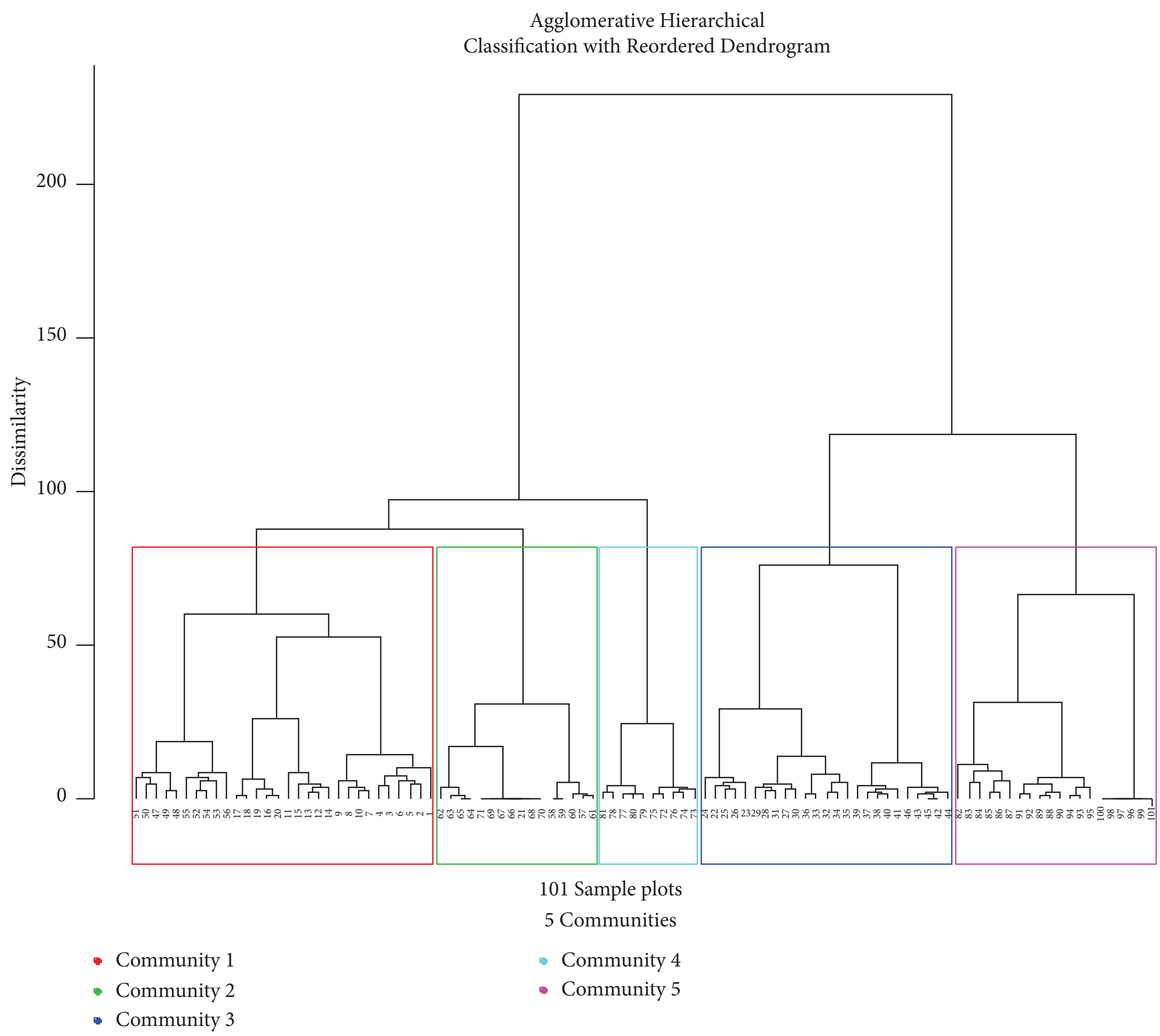

Figure 6: Dendrogram showing plant communities in the study forest.

3.3. Vegetation Structure

3.3.1. Diameter at Breast Height (DBH). A total of 4127 woody shrubs and tree plants were counted with DBH ≥2.5 cm. Most (91.06%) of the plants were found in the lower DBH classes with a DBH value ≤40 cm. Consequently, the present study identified that the Kahitassa forest exhibits the DBH class distribution of woody species along density in the study area showed an inverted *J*-shape which is dominated by individuals with low DBH, which could indicate the possible exploitation of mature trees for multipurpose use by the local people (Figure 6). For example, *Vachellia abyssinica* and *Pavetta abyssinica*, which are mainly used for fire wood and charcoal productions (where relatively smaller tree sizes are needed) and household paraphernalia requirements (where it needs a relatively larger tree size), are found in fragmented DBH classes (Figure 7). Notwithstanding this, as to Balemlay and Siraj [29] and Geneme et al. [30], such forests are known for their reproductive and recruitment potentials. Concerning the vegetation structure of the study area, the dominance of small-sized individuals and the presence of high regeneration forming an inverted J-shape population distribution were also supported by findings of Balemlay and Siraj [29], Geneme et al. [30], and Gerbaba and

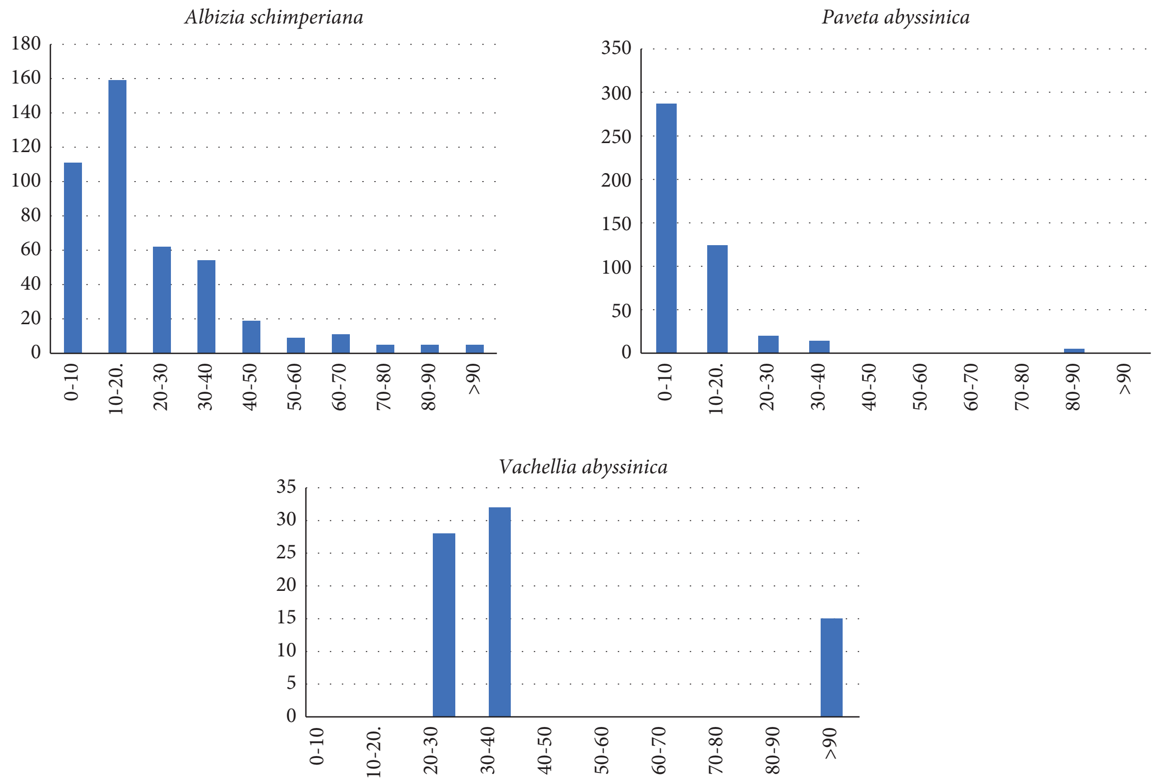

Figure 7: DBH class distribution of selected dominant plant species (where X-axis indicates DBH class and Y-axis indicates plant density/ha).

Abebe [31] in similar forests of the country. On the other hand, the relative curtailment of large-sized plants indicates the selective logging of timber as described by Senbeta and Teketay [32].

The five most important woody plant species having greater number of plants with wide-ranging DBH classes were *Bersama abyssinica* (420, 10%), *Vachellia abyssinica* (408, 9.9%), *Albizia schimperiana* (352, 8.5%), *Croton macrostachyus* (297, 7.2%), and *Pavetta abyssinica* (294, 7.1%) in a decreasing order.

3.3.2. Tree Density and Basal Area of Woody Species. The current study has shown that the study area is blessed with dense woody plant species. Accordingly, a total of 19150 individual plants were collected in 4.04 ha forest land which is equivalent with 4,740 plants ha^{-1} (Table 3). *Pavetta abyssini*ca (1444 individual plants ha^{-1}), *Vernonia auriculifera* (877.88 individual plants ha^{-1}), *Maytenus undata* (662.5 individual plants ha^{-1}), *Rubus apetalus* (363.46 individual plants ha^{-1}), and *Vachellia abyssinica* (323.08 individual plants ha^{-1}) were the five most densely populated plant species in the forest having greater stocking shares. On the other hand, the overall basal area of Kahitassa forest was about 39.54 m^2 ha^{-1}. *Vachellia abyssinica*, *Apodytes dimidiata, Prunus africana,* and *Albizia schimperiana* were the four most dominant plant species with a basal area of 6.3 m^2 ha^{-1}, 5.16 m^2 ha^{-1}, 4.71 m^2 ha^{-1}, and 4.28 m^2 ha^{-1}, respectively, constituting about 51.71% of the total basal area ha^{-1}.

3.3.3. Frequency. Vegetation homogeneity and heterogeneity can be expressed by the relative occurrences of species along frequency classes [33].

The top four most frequently encountered plant species were *Pavetta abyssinica* (F = 61.54%), *Maytenus undata* (F = 57.69%), *Combretum molle* (F = 57.69%), and *Albizia schimperiana* (F = 50%) with the occurrence at 50% and above of the sample quadrates (Table 2). Based on the percentage frequency values, the plant species were grouped into five frequency classes (Figure 8). The frequency class patterns of our study showed high percentage of species in lower frequency classes and relatively low proportion of species in higher frequency classes. As to Shibru and Balcha [34] and Dibaba et al. [35], such patterns could reveal the occurrence of high degree of floristic heterogeneity in the study area.

3.3.4. Important Value Index. The IVI values have been helped to understand the ecological significance of the tree species in the community structure [36]. According to Fikadu et al. [7], those species with high IVI values are well adapted to high pressure of disturbance, natural and environmental factors, and the effect of local communities. Based on the current finding, it is observed that the majority of plant species in the study area contribute to comparatively low ecological significance. In the contrary, small number of plant species contributes to high IVI values. As to Tegene et al. [26], those species which exhibit lower IVI values need

Table 3: Density, relative density, frequency, relative frequency, basal area, relative dominance, and IVI of Kahitassa forest.

No.	Species name	Density (ha^{-1})	Relative density	Frequency (%)	Relative frequency	Basal area (ha^{-1})	Relative dominance	IVI
1	*Albizia schimperiana*	302.9	4.934	50	5.685	4.28	10.827	21.45
2	*Apodytes dimidiata*	55.77	0.909	46.154	5.248	5.16	13.05	19.21
3	*Bersama abyssinica*	282.7	4.605	37.179	4.227	1.65	4.1931	13.03
4	*Calpurnia aurea*	3.846	0.063	3.8462	0.437	0.02	0.0588	0.559
5	*Carduus macracanthus*	269.2	4.386	19.231	2.187	0.03	0.074	6.647
6	*Carissa spinarum*	9.615	0.157	15.385	1.749	0.12	0.3017	2.208
7	*Cassia alexandrina*	48.08	0.783	23.077	2.624	0.43	1.0837	4.491
8	*Clausena anisata*	29.81	0.486	11.538	1.312	0.16	0.4079	2.205
9	*Clematis simensis*	53.85	0.877	23.077	2.624	0.05	0.1138	3.615
10	*Clerodendron alatum*	7.692	0.125	3.8462	0.437	0.07	0.1688	0.731
11	*Clutia abyssinica*	85.58	1.394	26.923	3.061	0.05	0.1199	4.575
12	*Combretum molle*	109.6	1.786	57.692	6.56	1.09	2.749	11.09
13	*Croton macrostachyus*	226	3.681	42.308	4.81	2.98	7.544	16.04
14	*Cupressus lusitanica*	19.23	0.313	3.8462	0.437	0.14	0.351	1.102
15	*Dombeya torrida*	24.04	0.392	26.923	3.061	0.59	1.5015	4.954
16	*Ekebergia capensis*	31.73	0.517	23.077	2.624	0.73	1.8512	4.992
17	*Embelia schimperi*	84.62	1.378	30.769	3.499	0.44	1.1176	5.995
18	*Erythrina brucei*	4.808	0.078	3.8462	0.437	0.06	0.1442	0.66
19	*Eucalyptus globulus*	152.9	2.491	3.8462	0.437	0.41	1.0318	3.96
20	*Euphorbia abyssinica*	18.27	0.298	7.6923	0.875	0.67	1.6995	2.872
21	*Ficus sur*	11.54	0.188	15.385	1.749	1.06	2.6782	4.615
22	*Hagenia abyssinica*	28.85	0.47	3.8462	0.437	1.35	3.4268	4.334
23	*Hypericum quartinianum*	35.58	0.58	15.385	1.749	0.26	0.6601	2.989
24	*Juniperus procera*	7.692	0.125	7.6923	0.875	1.76	4.4586	5.459
25	*Maesa lanceolata*	79.81	1.3	38.462	4.373	0.42	1.0508	6.724
26	*Maytenus undata*	662.5	10.79	57.692	6.56	0.10	0.2539	17.61
27	*Nuxia congesta*	44.23	0.721	15.385	1.749	0.63	1.6008	4.071
28	*Oldeania alpina*	33.65	0.548	3.8462	0.437	0.04	0.0929	1.079
29	*Olea europaea subsp. cuspidata*	126	2.052	11.538	1.312	1.31	3.3104	6.674
30	*Pavetta abyssinica*	1444	23.53	61.538	6.997	1.41	3.5532	34.08
31	*Prunus africana*	75	1.222	38.462	4.373	4.71	11.906	17.5
32	*Rosa abyssinica*	39.42	0.642	15.385	1.749	0.15	0.3965	2.788
33	*Rubus apetalus*	363.5	5.921	26.923	3.061	0.04	0.1062	9.088
34	*Syzygium guineense subsp. guineense*	35.58	0.58	11.538	1.312	0.25	0.6242	2.516
35	*Urera hypselodendron*	75.96	1.237	15.385	1.749	0.43	1.0756	4.062
36	*Vachellia abyssinica*	323.1	5.263	34.615	3.936	6.30	15.933	25.13
37	*Vernonia amygdalina*	53.85	0.877	3.8462	0.437	0.02	0.0417	1.356
38	*Vernonia auriculifera*	877.9	14.3	42.308	4.81	0.17	0.4436	19.56
	Total	6138	100	879.49	100	39.54	100	300

high conservation efforts, whereas those with higher IVI values require monitoring management.

Based on their IVI value (Table 3), the leading dominant and ecologically significant species in forest were *Pavetta abyssinica* (IVI = 34.08), *Vachellia abyssinica* (IVI = 25.13), *Albizia schimperiana* (IVI = 21.45), *Vernonia auriculifera* (IVI = 19.56), and *Apodytes dimidiata* (IVI = 19.21), which accounted for 39.81% of the total IVI value (Table 3). According to Fikadu et al. [7], those species with high IVI values are well adapted to high pressure of disturbance, natural and environmental factors, and the effect of local communities. On the contrary, *Clerodendron alatum* (0.731), *Erythrina brucei* (0.66), and *Calpurnia aurea* (0.559) were the least ecologically important plant species in the forest. On the other hand, 27 (71.05%) of plant species share only 35% of the total IVI value. Based on the current finding, it is observed that the majority of plant species in the study area contribute to comparatively low ecological significance. In the contrary, small number of plant species contributes to high IVI values. As to Tegene et al. [26], those species which exhibit lower IVI values need high conservation efforts, whereas those with higher IVI values require monitoring management. Hence, plant species with low IVI values such as *Clerodendron alatum*, *Erythrina brucei,* and *Calpurnia aurea* need higher priority for conservation interventions following Dinkissa [20].

3.3.5. Population Structure of Woody Species. The woody plant species in the Kahitassa forest could be expediently categorized into ten DBH classes. The result (Figure 5) showed that there is a decrease in plant density/ha^{-1} with an

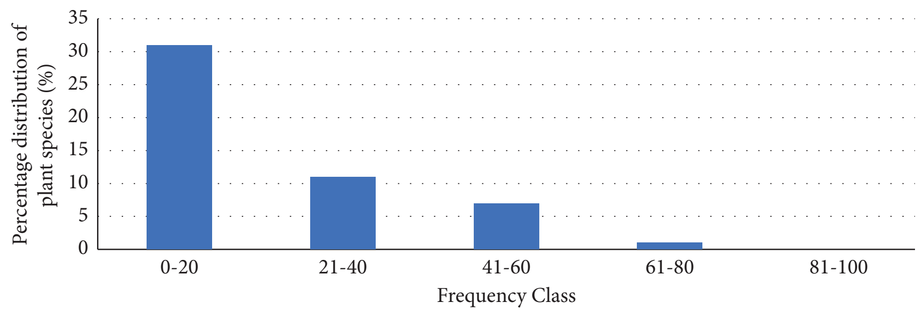

Figure 8: Percentage distributions of plant species against frequency class.

Table 4: Phytogeographical comparison of Kahitassa forest with other forest areas.

No	Forest name	Diversity (H')	Evenness (E)	Species richness	Source
1	Kahitassa	2.92	0.72	59	Present study
2	Kurib	1.86	0.91	39	[39]
3	Gatira Giorgis	2.47	0.78	34	[40]
4	Menagesha Suba	2.57	0.92	112	[20]
5	Chato	3.64	0.93	154	[41]
6	Aba Asrat Monastery	3.60	0.93	120	[42]

increase in DBH class size, which is also supported by previous studies of Tegene et al. [26] and Feyera [37]. The population structure analysis of dominant woody species reveals three population distribution structures (Figure 7). The first population distribution was represented by *Albizia schimperiana* forming an inverted *J* shape. Whereas, population distribution represented by *Pavetta abyssinica* and *Vachellia abyssinica* deviated from what was seen in the overall woody plants DBH distribution of the forest.

3.3.6. Plant Community Types. Five plant communities were identified from the agglomerative hierarchical cluster analysis after checking the cophenetic correlation coefficient using distance as input for computation (Table 1) following [38]. The community is named after one or two dominant species (Figure 6). The identified communities were *Maytenus undata–Olea europaea subsp. cuspidata, Croton macrostachyus–Embelia schimperi, and Pavetta abyssinica–Bersama abyssinica.*

(1) Croton Macrostachyus–Embelia Schimperi Community Type. This community comprised 30 plots (1.2 ha.) with *Croton macrostachyus* and *Embelia schimperi* indicator species. The community is represented by 23 species.

(2) Maytenus Undata—Olea Europaea Subsp. Cuspidata Community Type. This community comprised 4 species recorded in 16 quadrates. Smallest numbers of species were recorded in this community. *Maytenus undata* and *Olea europaea subsp. cuspidata were the indicator species of the community.*

(3) Pavetta Abyssinica—Bersama Abyssinica Community Type. This community is represented by 16 species recorded in 10 quadrates (0.4 ha.). *Pavetta abyssinica* and *Bersama abyssinica* were the indicator species of the community.

(4) Peucedanum mattiroli—Albizia schimperiana Community Type. This community is represented by 21 species recorded in 25 quadrates (1 ha.). Peucedanum mattiroli and *Albizia schimperiana were the indicator species of the community.*

(5) Rubus Apetalus–Phytolacca Dodecandra Community Type. This community is represented by 19 species recorded in 20 quadrates (0.8 ha.). *Rubus apetalus* and *Phytolacca dodecandra* are the indicator species of the community.

3.3.7. Phytogeographical Comparison. From the current study, it has been found that the diversity indices of the study area are comparable with other similar forests in the country. Based on this, Gatira Giorgis, Menagesha Suba, Chato, and Aba Asrat Monastery forests were taken as comparison (Table 4). Accordingly, when compared with the forests from the abovementioned studies, Kahitassa forest is the third highest with plant diversity and species richness. Conversely, the Kahitassa forest had the lowest evenness value recorded than the five forests in Table 4, which may be ascribed to the narrower ranges of environmental variables.

4. Conclusion and Recommendation

The results of the current study showed that Kahitassa forest was a relatively diverse forest in the plant species composition. In this study, 46 plant species distributed under 45 genera and 32 families were identified. The different diversity indices and structural descriptions showed that the forest had a good regeneration status and is significantly diverse. The population structure indicated that there is an inverted J-shape which is an indication of healthy forest with active regeneration and recruitment of new individuals. However, there is inconsistency of regeneration status at individual plant species levels that shows selective logging of certain plant species. Similarly, the IVI value showed that some plant species were ecologically more important than others such that the majority (about 70%) of plant species contribute 35% of the total IVI value proportion. The basal area values showed small number of densely populated plant species in the forest having greater stacking shares. However, the relatively small number of large size plants may indicate the probable logging of timber for one or another use. Therefore, it may be better to see whether sustainable utilization of natural resources is under practice or not by the local community. The following recommendations were given for the stakeholders related with forest resource:

(i) Further investigation on resource identification, production potentials, and commercialization approaches should be carried out to sustainably use the forest resources.

(ii) Awareness creation on sustainable use of forest resources should be given for the local community.

(iii) Conservation approaches such as domestication of selected species, *in situ* and *ex situ* conservations, and conservation through biotechnology are urgently needed.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Supplementary Materials

Table 1: list of woody plant species in Kahitassa Forest: the material illustrates species name, family name, growth form, vernacular name, and collection number (growth form: T = tree, Sh = shrub, Cl = climber, L = liana). (*Supplementary Materials*)

References

[1] D. Teketay, “Human impact on a natural montane forest in southeastern Ethiopia,” *Mountain Research and Development*, vol. 12, no. 4, pp. 393–400, 1992.

[2] Ethiopian Forestry Action Program, “Ethiopian Forestry Action Program,” *The Challenge for Development*, Ministry of Natural Resources, Addis Ababa, Ethiopia, 1994.

[3] I. Friis, S. Demissew, and P.v. Breugel, *Atlas of the potential vegetation of ethiopia*Royal Danish Academy of Science and Letters Copenhagen, 2010.

[4] K. Ensermu and D. Sebsebe, “Diversity of vascular plant taxa of the flora of Ethiopia and Eritrea,” *Ethiopian Journal of Biological Sciences*, vol. 13, pp. 37–45, 2014.

[5] M. Didita, S. Nemomissa, and T. W. Gole, “Floristic and structural analysis of the woodland vegetation around dello menna, southeast Ethiopia,” *Journal of Forestry Research*, vol. 21, no. 4, pp. 395–408, 2010.

[6] M. Kuma and S. Shibru, “Floristic composition, vegetation structure, and regeneration status of woody plant species of oda forest of humbo carbon project, wolaita, Ethiopia,” *Journal of Botany*, vol. 2015, Article ID 963816, 9 pages, 2015.

[7] E. Fikadu, M. Melesse, and A. Wendawek, “Floristic composition, diversity and vegetation structure of woody plant communities in Boda dry evergreen Montane Forest, West Showa, Ethiopia,” *International Journal of Biodiversity and Conservation*, vol. 6, no. 5, pp. 382–391, 2014.

[8] D. Ekhuemelo, J. Amonum, and I. Usman, “Importance of forest and trees in sustaining water supply and rainfall,” *Nigeria Journal of Education, Health and Technology Research*, vol. 8, pp. 273–280, 2016.

[9] B. Cbd and Tourism, “Guidelines for tourism partnerships and concessions for protected areas: generating sustainable revenues for conservation and development,” in *Convention on Biological Diversity*, 2007.

[10] D. Brack, “Forests and climate change: background study prepared for the fourteenth session of the united nations forum on forests,” in *Global Forest Goals*, pp. 1–56, Forests and SDG13, 2019.

[11] FAO, *Instruments Related to the United Nations Framework Convention on Climate Change and Their Potential for Sustainable forest Management in Africa*, Food and Agriculture Organization, Rome, Italy, 2003.

[12] N. Worku, *Carbon Stock and its Variations along Environmental Factors in Gendo Moist Montane forest, East Wollega Zone, Western Ethiopia*, Addis Ababa University, Addis Ababa, Ethiopia, 2016.

[13] I. Friis, “Forests and forest trees of north east tropical Africa: their natural habitats and Distribution pattern in Ethiopia, Djibouti and Somalia,” *Kew Bulletin Additional Series*, vol. 15, p. 396, 1992.

[14] EPA, *Conservation Strategy of Ethiopia*, 1997.

[15] M. Kent and P. Coker, *Vegetation Description and Analysis: A Practical Approach*, John Wiley & Sons, New York, NY, USA, 1992.

[16] Aazao, *Annual Report of the year*, A. A. Z. A. Office, Ed., Awi Administrative Zone Agriculture Office, Injibara, Ethiopia, 2020.

[17] A. Ayanaw Abunie and G. Dalle, “Woody species diversity, structure, and regeneration status of Yemrehane Kirstos Church forest of lasta Woreda, north wollo zone, Amhara region, Ethiopia,” *International Journal of Financial Research*, vol. 2018, Article ID 5302523, 8 pages, 2018.

[18] C. Shannon-Wiener, W. Weaver, and W. Weater, *The Mathematical Theory of Communication*, EUA: University of Illinois Press, Champaign, IL, USA, 1949.

[19] E. Maabel, “Transformation of cover-abundance values in phytosociology and its effects on community similarity,” *Vegetatio*, vol. 39, no. 2, pp. 97–114, 1979.

[20] B. Dinkissa, *Floristic Composition, Diversity, and Structure of Woody Plant Species in Menagesha Suba State Forest, Central Ethiopia*, Addis Ababa University, Addis Ababa, Ethiopia, 2011.

[21] M. Getie and Y. Getahun, “Pecies composition, structure and regeneration status of woody plant species in a dry Afromontane forest, Northwestern Ethiopia,” *Cogent Food & Agriculture*, vol. 6, no. 1, 2020.

[22] M. Gedefaw and T. Soromessa, “Status and woody plant species diversity in Tara Gedam forest, northern Ethiopia,” *Science, Technology and Arts Research Journal*, vol. 3, no. 2, pp. 113–118, 2014.

[23] G. Boz and M Maryo, "Woody species diversity and vegetation structure of wurg forest, southwest Ethiopia," *International Journal of Financial Research*, vol. 2020, Article ID 8823990, 17 pages, 2020.

[24] M. Bekele Hemade and A. Wendawek, "Floristic composition and vegetation structure of woody species in Lammo natural forest in tembaro Woreda, kambata-tambaro zone, southern Ethiopia," *American Journal of Agriculture and Forestry*, vol. 4, no. 2, pp. 49–55, 2016.

[25] F. Temesgen and B. Warkineh, "Woody species structure and regeneration status in Kafta Sheraro national Park dry forest, tigray region, Ethiopia," *International Journal of Financial Research*, vol. 2020, Article ID 4597456, 22 pages, 2020.

[26] A. S. Tegene, F. W. Gamo, and S. S. Cheche, "Woody vegetation composition, structure, and community types of Doshke forest in Chencha, Gamo Gofa zone, Ethiopia," *International Journal of Biodiversity*, vol. 2018, Article ID 4614790, 16 pages, 2018.

[27] B. Sewale and S. Mammo, "Analysis of floristic composition and plant community types in kenech natural forest, kaffa zone, Ethiopia," *Trees, Forests and People*, vol. 7, Article ID 100170, 2022.

[28] A. E. Magurran, *Measuring Biological Diversity*, BlackWell, Oxford, UK, 2004.

[29] S. Balemlay and M. Siraj, "Population structure and regeneration status of woody species in kenech forest, southwest Ethiopia," *International Journal of Financial Research*, vol. 2021, Article ID 6640285, 14 pages, 2021.

[30] K. K. Geneme, K. Hundera, and G. Dalle, "Species diversity and structural analysis of Komba-Daga moist evergreen forest, Kaffa Zone, Southwest Ethiopia," *Res Rev AJ Life Sci*, vol. 5, no. 3, pp. 14–23, 2015.

[31] G. Gerbaba and W. Abebe, "Diversity and vegetation structure of shrubs and trees in magada forest, bule-hora District, borena zone, oromia region, southern Ethiopia," *Journal of Plant Sciences*, vol. 4, no. 6, pp. 165–171, 2016.

[32] F. Senbeta and D. Teketay, "Diversity, community types and population structure of woody plants in Kimphe Forest, a virgin Nature Reserve in Southern Ethiopia," *Ethiopian Journal of Biological Sciences*, vol. 2, pp. 169–187, 2003.

[33] H. Lamprecht, *Sericulture in the Tropics. Tropical forest Ecosystems and Their Tree Species Possibilities and Methods Are the Longterm Utilization*, 1989.

[34] S. Shibru and G. Balcha, "Composition, Structure and regeneration status of woody species in Dindin Natural Forest, Southeast Ethiopia: an implication for conservation," *Ethiopian Journal of Biological Sciences*, vol. 1, no. 3, pp. 15–35, 2004.

[35] A. Dibaba, T. Soromessa, E. Kelbessa, and A. Tilahun, "Diversity, structure and regeneration status of the woodland and riverine vegetation of Sire Beggo in Gololcha District, Eastern Ethiopia," *Momona Ethiopian Journal of Science*, vol. 6, no. 1, pp. 70–96, 2014.

[36] D. Premavani, M. T. Naidu, and M. Venkaiah, "Tree species diversity and population structure in the tropical forests of North Central Eastern Ghats, India," *Notulae Scientia Biologicae*, vol. 6, no. 4, pp. 448–453, 2014.

[37] S. Feyera, "Biodiversity and ecology of afromontane RainforestswithWildCoffeaarabicaL.PopulationsinEthiopia," in *Ecology and Development Series No.38*Center for Development Research: University of Bonn, 2006.

[38] S. Saraçli, N. Doğan, and İ. Doğan, "Comparison of hierarchical cluster analysis methods by cophenetic correlation," *Journal of Inequalities and Applications*, vol. 2013, no. 1, p. 203, 2013.

[39] B. Mola, *Identification of Floristic Diversity and Structure in Kurib forest*, Addis Ababa University, Addis Ababa, Ethiopia, 2016.

[40] A. Ayalew, A. Tesfaye, and Y. Mulatu, "Relation between regeneration status of woody species and soil properties of Gatira george's Church and gemeshat remnant forests, north eastern Ethiopia," *Black Sea Journal of Agriculture*, vol. 3, no. 2, pp. 110–119, 2020.

[41] A. Feyera, *Floristic Composition and Structure of Vegetation of Chato Natural Forest in Horo Guduru Wollega Zone, Oromia National Regional State, West Ethiopia*, Addis Ababa University:, Addis Ababa, Ethiopia, 2010.

[42] B. Gojjam, *Floristic Composition and Diversity Analysis of Vegetation of Aba Asrat Monastery Forest, Ethiopia*, Addis Ababa University, Addis Ababa, Ethiopia, 2013.