

Research Article

Woody Species Diversity and Structure of Protected Woodlands Adjacent to Free Grazing Land Woodland at Dugda Woreda, Oromia, Ethiopia

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The study was conducted in protected woodland and free graze woodland located in Dugda Woreda, Oromia state, Ethiopia. The objective of the study was to explore the floristic composition, structure, and regeneration of woody species. In the park, the vegetation ecology has not been studied up to date, which is necessary for conservation. The systematic sampling technique was used to collect vegetation and human disturbance (presence and absence) data from August to December 2017. The vegetation data were collected from 30 plots from each woodland with a size of 900 m² (30 m × 300 m) for tree/shrub, while subplots of size 400 m² (20 m × 20 m) for sapling, respectively, were established in the main plots. Individual tree and shrub diameters at breast height (DBH) ≥ 2.5 cm and height ≥ 2 m were measured using a tape meter and clinometer, respectively. Diameter at breast height (DBH), frequency, density, basal area, and importance value index (IVI) were used for vegetation structure description, while the densities of mature trees, sapling, and seedling were used for regeneration. A total of 446 individual stems from free grazed woodland and 641 individual stems from protected woodland with a DBH of ≥ 2.5 cm were encountered from 30 studied sample plots that are protected and free grazed woodlands. Of these, from the total woody species, 68.42% were trees and 31.57% shrubs found in protected woodland; 76.92% were trees and 23.07% shrubs found in free grazed woodland. The total basal area of the woody plant was 3.1 ± 1 m²/ha in free grazed woodland and 4.2 ± 2 m²/ha in protected woodland, calculated for 19 woody species. Fabaceae, Balanitaceae, Capparidaceae, Verbenaceae, and Boraginaceae families were the most abundant families in both woodlands. However, there is a good initiation for the conservation of the park; still, the vegetation of the park was threatened by human-induced fire following intensive farming, gold mining, and overgrazing.

1. Introduction

Globally, 40% of tropical forest areas and 14% of total African surface area have been covered by woodland [1]. Woodland is defined as frost-free regions with 500–2000 mm annual precipitation and a dry season of four to seven months [2]; its diverse species composition, leafing phenology, and other functional aspects were studied. Next to forest resources, protected woodland has a huge wealth of biological resources [3]; thus, the woody diversity and vegetation structures are crucial elements to clearly visualize the human activities and environmental factors affecting the vegetation of a given area [4]. However, about 97% of the

remaining woodland area is at the risk of being further fragmented and degraded by fire, fuelwood collection [5], and grazing damage [6]. Above half of Ethiopia's land surface is located in dry areas and associated with woodland [7]. These woodlands are a highly fragile ecosystem adapted to semiarid conditions with erratic rainfall, growing on a complex and vulnerable hydrological system [8]. Most woodlands of the world are concentrated in protected areas [9]. Recently, the depletion of vegetation resources in woodland and environmental degradation has become an issue of national and global concern [10]. Dugda Woreda woodland is found in Girba Korke Adi kebele, East Shewa zone, Ethiopia. The woodland benefited the local community

by providing pasture, fuelwood, medicine, and honey and served as a habitat for different biodiversity. However, due to habitat degradation, livestock encroachment, illegal logging, and agricultural expansion, and lacking of scientific and essential baseline investigation on woody species diversity, these woodland areas are being imposed to being destroyed at the highest rate. Therefore, the main objective of this study was to complete the current information gap in woody species diversity and structure of the woodland.

2. Materials and Methods

2.1. Study Area

2.1.1. Description of the Study Area. The study area, protected woodlands at Dugda Woreda, East Shewa, Ethiopia (Figure 1), extends from 8°6'00" to 8°10'00"N latitude and 38°42'30" to 38°51'30"E longitude. The capital city of the Woreda, Meki, is located 132 km south of Addis Ababa, the capital of Ethiopia. The study area is characterized by varied land features, including mountains, flatland, and agricultural fields. The altitude varies from 1600 to 2020 meters masl. Dugda Woreda has 2 major traditional agroclimatic zones, 45% Woyna Dega (midhighland), and 55% Kola (low land). Temperature and rainfall data were collected from the National Meteorological Agency (NMA). The mean annual temperature of the study area was 12.7°C. The mean maximum and minimum temperatures recorded in March and November were 28°C. The area receives a mean annual rainfall of 750 mm with a monomodal pattern, which falls much between October and November. Dugda Woreda has a total population of 163099 people; of these, 85478 were males and 77621 were females. According to [18], a survey of land in this Woreda shows that 65.25% of its land is cultivated, 8.32% is forest, 3.55% is pasture, 12.54% is water bodies, and 0.31% and 10.03% are swampy and rocky mountain areas [11]. Dugda Woreda protected woodland communities are broadly categorized as *Acacia-Commiphora* woodland with dominant *Acacia tortilis*, *Vachellia gerrardii*, and *Balanites aegyptiaca* species. Thus, the decline in severity and vegetation cover is higher in these lowland protected areas because they are remote and have a scarcity of resources [12].

2.2. Sampling Design. A reconnaissance survey was undertaken for this study from the first week of November 2017 to have an impression of the woodland sites and vegetation distribution and to decide the reasonable sampling methods. During the surveying period, supportive information was collected from the woreda administrative office and local households living near the woodland. A systematic sampling method was used for collecting vegetation data. For protected and open graze land woodland, 30 plots with 30 m × 30 m (900 m²) quadrants for woody species and 10 m × 10 m (100 m²) at two opposite corner of the plot were laid out for collecting shrub data at every 100 m along 12 parallel transect lines. All transects and plots were located using a compass and Geographical Positioning System (GPS) of a navigation system.

2.3. Data Collection. Woody vegetation: the detailed vegetation data were collected during the flowering and fruiting season from August 26 to December 30, 2017. Trees and shrubs: in the main plot (600 m²) area, each plant (stem) of all tree and shrub species with a diameter at breast height (DBH) ≥ 2.5 cm abundance was counted and their circumference was recorded (diameter). Plant species outside plots were also recorded to give a complete list of species. Height of individual trees and shrubs ≥ 2 m was recorded for every individual woody plant having a diameter at breast height (DBH) ≥ 2.5 cm [13]. Diameter at breast height (DBH) was measured using a tree caliper and tape meter, while height was measured using a clinometer and visual estimation. Trees with multiple stems arising from the ground level were measured individually and developed a common diameter at breast height (DBH) of all stems by summing up their square roots following the guidelines in [14]. Anthropogenic disturbance: in addition to recording the physiographic variables (altitude, latitude, and longitude), human disturbances such as grazing intensity, illegal logging, and collection firewood signs were recorded in 30 sampled plots. Based on the reconnaissance survey, grazing intensity, illegal logging frequency, and agricultural land explanation were identified as the most pronounced negative impacts in the protected woodland and open graze land; the degree of impact was estimated based on the qualitative presence and absence method/us. If any disturbance sign was present in the plot, it was scaled as presence = one; while if there was no disturbance sign in the plots, it was scaled as absence = zero.

Plant species identification was started in the field by recording the local name by asking local elders and referring to the scientific name identification using Flora of Ethiopia and Eritrea Volume 1–Volume 8 [15–21]. Specimens of identified and unidentified species were collected, pressed, and dried properly, following standard Ethiopian Herbarium (ETH) procedures, and taken to Addis Ababa University Herbarium for further confirmation and identification of specimens of those species, which could not be identified in the field.

2.4. Data Analysis

2.4.1. Structural Data Analysis. Diameter at breast height, height, basal area, tree density, frequency, and importance value index were used to describe the woody vegetation structure of a given forest. The following formulas were utilized in the Microsoft Excel spreadsheet program and presented in descriptive statistics.

Diameter at breast height (DBH): diameter of woody species was arbitrarily arranged in diameter class intervals by referring to the study of Atsbha et al. [21]. The diameter of trees/shrubs of plant species of Dugda Woreda protected woodland was classified into nine classes of 7 cm interval. 0 = <2 cm; 1 = 2–5 cm; 2 = 5–10 cm; 3 = 10–15 cm; 4 = 15–20 cm; 5 = 20–25 cm; 6 = 25–30 cm; 7 = >30 cm.

Height: height of individuals' trees/shrub plant species was arbitrarily defined by height class intervals [29]. The height of the park was classified into seven classes of 5 m intervals: ≤4, 4.1–9, 9.1–14, 14.1–19, 19.1–24, 24.1–29, and

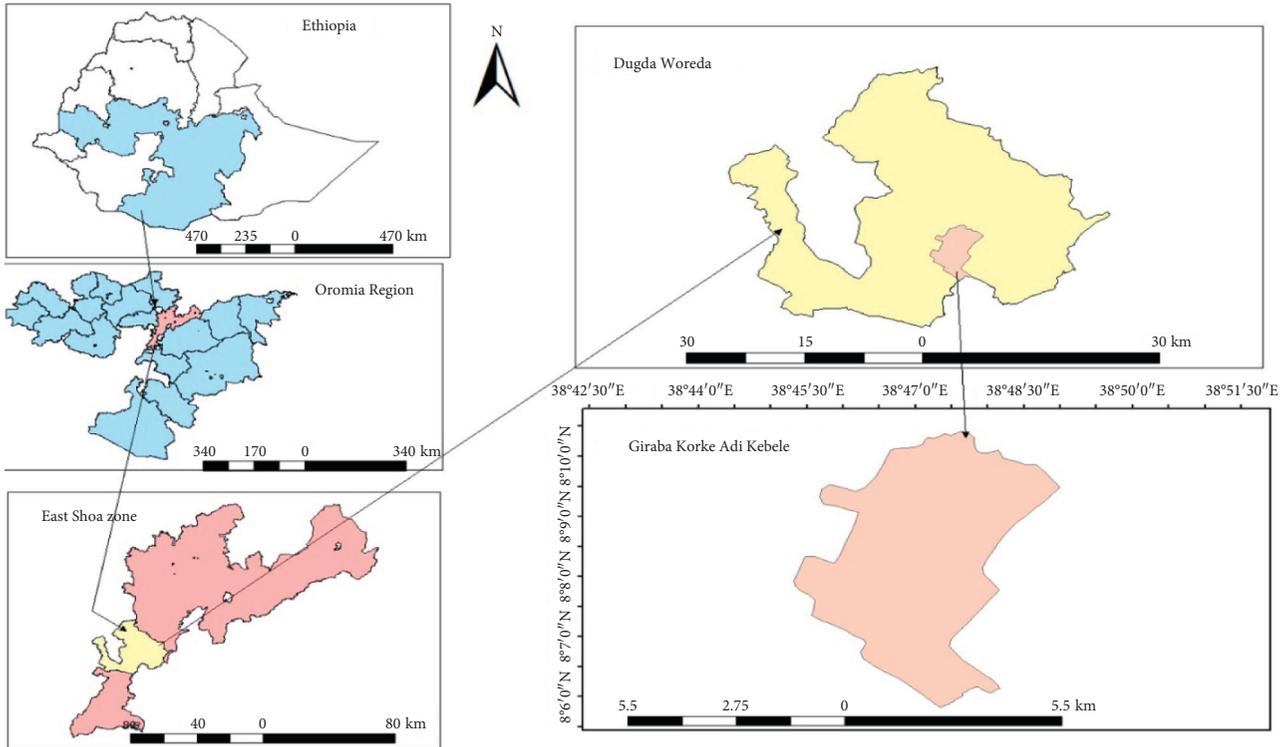


FIGURE 1: Map of the study area.

>29.1 m. The densities of individuals falling in the diameter at breast height (DBH) or height classes were summed up.

Frequency of species: the probability of finding a species in a given sample area was as follows [22]:

$$\text{frequency (F)} = \frac{\text{number of plots in which a species occurs}}{\text{total number of plots laid out in the study site}} * 100, \tag{1}$$

$$\text{relative frequency (F)} = \frac{\text{frequency of a single species}}{\text{total frequency of all species}} * 100.$$

Finally, the frequency was summarized by class interval following the study of Lamprecht [23]. The frequency of the park was arranged into seven classes of 15% intervals: ≤5, 5.1–20, 20.1–35, 35.1–50, 50.1–65, 65.1–80, and >80.1%.

Density of species: it is a count of the numbers of individuals of each species within the quadrat [30]. The sum of individuals per species is analyzed in terms of species density ha^{-1} [24]:

$$\text{density (D)} = \frac{\text{number of aboveground stems of a species}}{\text{number of quadrats} * \text{quadrat area}} * 100, \tag{2}$$

$$\text{relative density (RD)} = \frac{\text{density of a single species}}{\text{total density of all species}} * 100.$$

Density was arranged by class intervals following the dry forest study of Atsbha et al. [21]. The protected woodlands were classified into five density class intervals: ≤2, 2.1–10, 10.1–50, 50.1–100, and >100.1 stems· ha^{-1} .

Basal area: it is the area outline of a plant near the ground surface and expressed in $\text{m}^2 \cdot \text{ha}^{-1}$ [22]:

$$\text{basal area} = \frac{\pi d^2}{4}, \tag{3}$$

where $\pi = 3.14$ and d is diameter at breast height (m).

Dominance: the degree coverage of species occupied a space at ground level was as follows [24]:

dominance = the mean basal area per species

* abundance (no) of the species, (4)

$$\text{relative dominance (RDO)} = \frac{\text{dominance of a single species}}{\text{total dominance of all species}} * 100.$$

Importance value index (IVI): it indicates the relative ecological importance of a given woody species on a particular site [22]:

$$\text{IVI} = \text{relative density (RD)} + \text{relative frequency (RF)} + \text{relative dominance (RDO)}. \quad (5)$$

2.4.2. Statistical Analysis. The *n* human disturbance variables (Illegal logging, explanation agricultural land, charcoal production, and grazing intensity) were analyzed using regression and correlation statistical method. All analyses were facilitated using the R-statistical package [25]. For qualitative analysis, descriptive statistics were used and these descriptive statistics graphs were performed with the Microsoft Office Excel 2007 software.

3. Results

3.1. Species Composition and Diversity. A total of 446 individual stems from free grazed woodland and 641 individual stems from protected woodland with a diameter at breast height (DBH) of ≥ 2.5 cm were collected. A total of 19 woody species were identified from 30 studied sample plots from protected and free grazed woodlands. Out of these, 18 woody species belonging to 17 genera and 7 families were identified from protected woodlands and 13 woody species belonging to 14 genera and 4 families were recorded from free grazed woodland (Table 1).

Twelve species are commonly found in both sites. Fabaceae, Balanitaceae, Capparidaceae, Verbenaceae, and Boraginaceae families were the most abundant families in both woodlands. From the total woody species, 68.42% were trees and 31.57% shrubs found in protected woodland; 76.92% were trees and 23.07% shrubs found in free grazed woodland (Figure 2).

3.2. Diversity of Woody Species. The mean of the Shannon–Wiener diversity index of woody species is 1.69 for free grazed woodland and 2.26 for protected woodland (Table 2). The Shannon–Wiener diversity index is higher at protected woodland than free grazed woodland. The Simpson diversity index and evenness of woody species in protected woodland are 0.82 and 0.51, respectively. On the other hand, the Simpson diversity index and evenness of woody species in free protected woodland are 0.86 and 1.69, respectively. The species richness between the two study sites is also slightly different, with protected areas having higher (8.6) species richness than free grazed woodland (7.28) (Table 2).

3.3. Vegetation Structure of Woodland. Except for the mean of the height and diameter branch, the other structural parameters in the studied woodland varied significantly ($P < 0.05$) (Table 3). The height and branch of the tree are not varied because the management of the woodland and environmental factors influence the growth of the species more or less the same.

3.4. Woody Species Frequency. The frequency occurrence of woody species in protected woodland and free grazed woodland is different in Figures 3 and 4. In protected woodland, *Acacia tortilis*, *Dichrostachys cinerea*, *Faidherbia albida*, *Acacia senegal*, *Acacia gerrardii*, and *Balanites aegyptiaca* were among the most frequent species frequently. On the other hand, *Carissa spinarum*, *Acacia oerfota*, and *Rhus vulgaris* were among the least recorded woody species (Figure 3).

Similarly, *Acacia tortilis*, *Balanites aegyptiaca*, *Acacia seyal*, *Acacia amythethophylla*, *Acacia gerrardii*, and *Dichrostachys cinerea* were commonly found in free grazed woodland (Figure 4). The frequency of woody species in woodland is determined by human intervention and ecological factor.

3.5. Importance Value Index. The dominant and ecologically most significant tree species in free grazed woodland were *Acacia tortilis*, *Dichrostachys cinerea*, *Acacia amythethophylla*, and *Acacia gerrardii* (Table 4) and in protected woodland were *Acacia tortilis*, *Dichrostachys cinerea*, *Acacia gerrardii*, *Balanites aegyptiaca*, *Acacia Senegal*, and *Faidherbia albida* (Table 5). *Acacia tortilis* was the most dominant and ecologically significant in both woodlands.

3.6. Size Distribution. The first pattern was represented by *Acacia tortilis* (Figure 5(a)). This pattern indicates the presence of the highest density in the lower DBH classes, with a gradual decrease in density towards the bigger classes. It represents an inverted J-shaped curve except for a slight decline in the first DBH class, and it suggests good reproduction and recruitment.

The second pattern is represented by *Dichrostachys cinerea* (Figure 5(b)). This pattern indicates the presence of the highest density in the middle DBH classes, with a gradual decrease in density towards the bigger classes. It represents an inverted J-shaped curve except for a slight decline in the first DBH class, and it suggests good reproduction and recruitment.

The third pattern was represented by a single species of *Acacia gerrardii* (Figure 5(c)). This pattern indicates the presence of the lowest density in the lower DBH classes with

TABLE 1: Species composition and diversity.

Woodland type	Number of species	Number of genera	Number of families
Free grazed woodland	446	14	4
Protected woodland	641	17	7

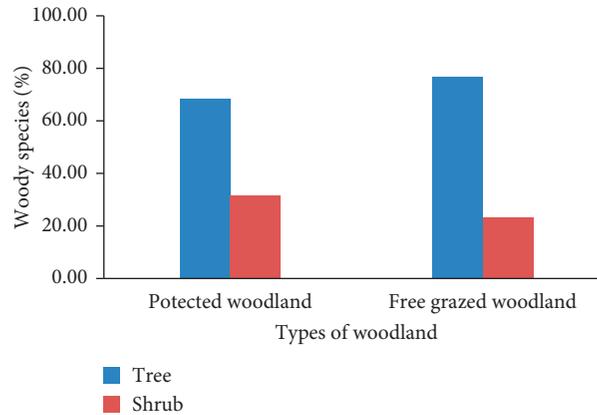


FIGURE 2: Floristic composition of protected and free grazed woodland.

TABLE 2: Mean diversity indices and richness of woody species in protected and free grazed woodland.

Types of woodland	Shannon	Evenness	Simpson	Species richness
Free grazed woodland	1.69 ± 0.77 ^b	0.74 ^a ± 0.25	0.86 ^a ± 0.25	7.28 ^a ± 3.23
Protected woodland	2.26 ± 0.67 ^a	0.51 ^b ± 0.21	0.82 ^a ± 0.21	8.63 ^b ± 4.23
Grand mean	1.97 ± 0.72	0.62 ± 0.23	0.73 ± 0.23	7.96 ± 5.52

Different superscript small letters indicate there is significant variation between the two woodland categories (F test, $P < 0.05$) with Shannon, evenness, and richness of woodland.

TABLE 3: Stand structure of protected and free grazed woodland (mean ± SE).

Stand characters	Free grazed woodland	Protected woodland	Overall mean	P value
Mean dbh (cm)	53.2 ± 7 ^a	67.3 ± 9 ^b	60.25 ± 8	0.036
Mean diameter branch	0.15 ± 2 ^a	0.28.1 ± 3 ^a	0.43 ± 1.5	0.23
Mean height (m)	6.7 ± 2 ^a	8.2 ± 1 ^a	7.45 ± 1.5	0.41
Mean crown ratio	33.2 ± 4.1 ^b	42.63 ± 4.02 ^b	37.9 ± 4.02	0.003
Mean crown diameter	5.4 ± 1 ^a	6.7 ± 2 ^b	6.02 ± 1.5	0.001
Density ha ⁻¹	317.24 ± 52.6 ^a	346.53 ± 57.3 ^b	331.9 ± 54.95	0.002
Basal area (m ² ha ⁻¹)	3.1 ± 1 ^a	4.2 ± 2 ^b	3.45 ± 1.5	0.0024
Volume (m ³ ha ⁻¹)	235.17 ± 12.3 ^a	355.06 ± 23.6 ^b	295.12 ± 17.95	0.01
Canopy cover	6.4 ± 1 ^a	7.3 ± 2 ^b	6.85 ± 1.5	0.0006

Different superscript small letters indicate there is significant variation among the two woodland categories (F test, $P < 0.05$) with stand structure between woodlands.

a gradual increase in density towards the bigger classes. It represents a J-shaped curve and it suggests there is not good reproduction and less sustainability (Figure 6).

4. Discussion

4.1. Species Composition and Diversity. In the present study, we found that the species composition differed between the protected woodland site and the free grazed woodland site. This difference in species composition might be associated with differences in grazing time and regeneration characteristics of individual tree and soil characteristics between

the two sites [26]. The results from analyzed data showed that Fabaceae and Balanitaceae are the most dominant species in Giraba Korke Adii kebele woodland. *Vachellia tortilis* in free grazed woodland declined as a result of illegal cutting and collecting for fuelwood and *Vachellia gerrardii* found were highly declined in both woodlands as a result of less regeneration, illegal cutting, and harvest for fuelwood during mourning time in kebele. Those dominant species were gradually replaced with other species year to year, especially with *Dichrostachys cinerea*. Such changes in species composition have also been observed elsewhere, particularly in relation to uncontrolled grazing [26].

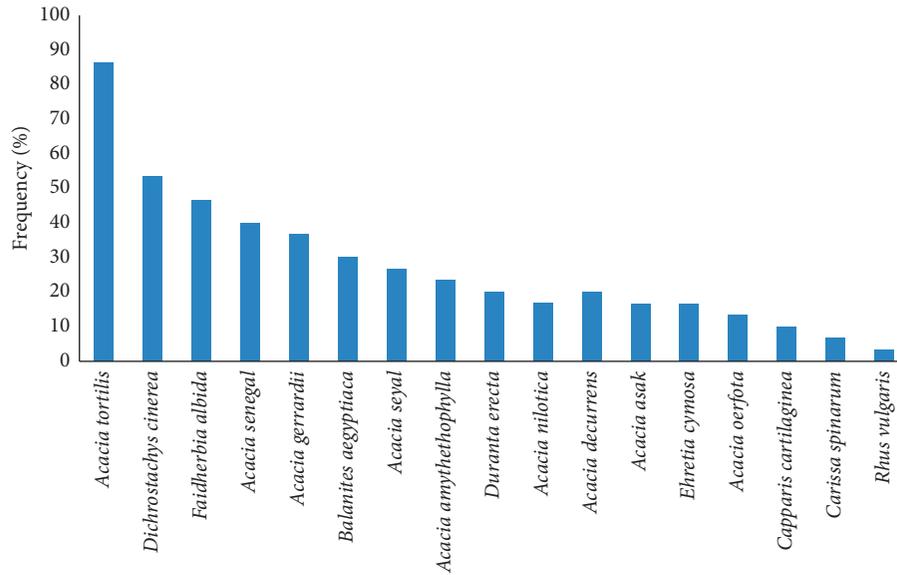


FIGURE 3: Frequency of occurrence of woody species in protected woodland.

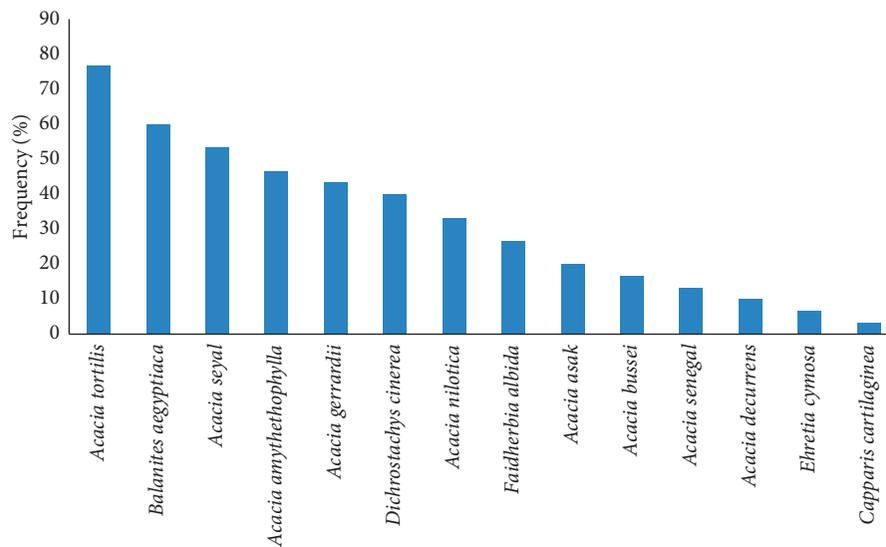


FIGURE 4: Frequency of occurrences of woody species in free grazed woodland.

TABLE 4: Summary of IVI of woody species in free grazed woodland in descending order.

Species name	Family	Free grazed woodland			IVI
		RF	RDO	RD	
Acacia tortilis	Fabaceae	23.71134	95.76186	43.6377	163.1109
Acacia gerrardii	Fabaceae	9.278351	0.900861	8.067473	18.24668
Dichrostachys cinerea	Fabaceae	7.216495	0.613333	9.717638	17.54747
Acacia amythethophylla	Fabaceae	8.247423	1.086908	6.784012	16.11834
Balanites aegyptiaca	Fabaceae	11.34021	0.058752	4.033737	15.43269
Acacia seyal	Fabaceae	9.278351	0.428176	2.383572	12.0901
Faidherbia albida	Fabaceae	6.185567	0.009614	4.950495	11.14568
Acacia senegal	Fabaceae	4.123711	0.605321	6.233957	10.96299
Acacia nilotica	Fabaceae	6.185567	0.089018	4.583792	10.85838
Acacia asak	Fabaceae	4.123711	0.011572	2.383572	6.518855
Acacia decurrens	Fabaceae	3.092784	0.05982	2.933627	6.08623
Acacia brevispica	Fabaceae	4.123711	0.000935	1.283462	5.408108
Ehretia cymosa	Boraginaceae	2.061856	0.373875	2.566923	5.002654
Capparis cartilaginea	Capparidaceae	1.030928	1.87E - 06	0.550055	1.580985
Total		100	100	100	300

RF = relative frequency; RDO = relative dominance; RD = relative density; IVI = important value index.

TABLE 5: Summary of IVI value of woody species in protected woodland in descending order.

Scientific name	Family name	Protected woodland			
		RF	RDO	RD	IVI
<i>Acacia tortilis</i>	Fabaceae	9.79021	85.84028	31.7161	127.346
<i>Dichrostachys cinerea</i>	Fabaceae	13.28671	7.31238	15.0730	35.6721
<i>Acacia gerrardii</i>	Fabaceae	7.692308	4.029025	10.5197	22.2410
<i>Acacia senegal</i>	Fabaceae	8.391608	0.453416	6.12341	14.9684
<i>Balanites aegyptiaca</i>	Balanitaceae	7.692308	0.774535	6.59444	15.0612
<i>Faidherbia albida</i>	Fabaceae	9.090909	0.288647	5.6523	15.0319
<i>Acacia seyal</i>	Fabaceae	6.993007	0.087556	4.08227	11.1628
<i>Acacia amythethophylla</i>	Fabaceae	5.594406	0.215523	4.39629	10.2062
<i>Acacia nilotica</i>	Fabaceae	5.594406	0.090202	3.92526	9.60987
<i>Acacia decurrens</i>	Fabaceae	4.195804	0.881976	3.45423	8.53201
<i>Duranta erecta</i>	Verbenaceae	5.594406	0.01355	2.04113	7.64909
<i>Acacia asak</i>	Fabaceae	3.496503	0.003656	1.88412	5.38428
<i>Ehretia cymosa</i>	Boraginaceae	3.496503	0.002021	1.41309	4.91161
<i>Carissa spinarum</i>	Apocynaceae	2.797203	0.000625	0.94206	3.73989
<i>Acacia oerfota</i>	Fabaceae	2.797203	0.000337	0.94206	3.73960
<i>Capparis cartilaginea</i>	Capparidaceae	2.797203	0.001243	0.78505	3.58349
<i>Rhus vulgaris</i>	Anacardiaceae	0.699301	0.000962	0.62804	1.32830
Total		100	100	100	300

RF = relative frequency; RDO = relative dominance; RD = relative density; IVI = important value index.

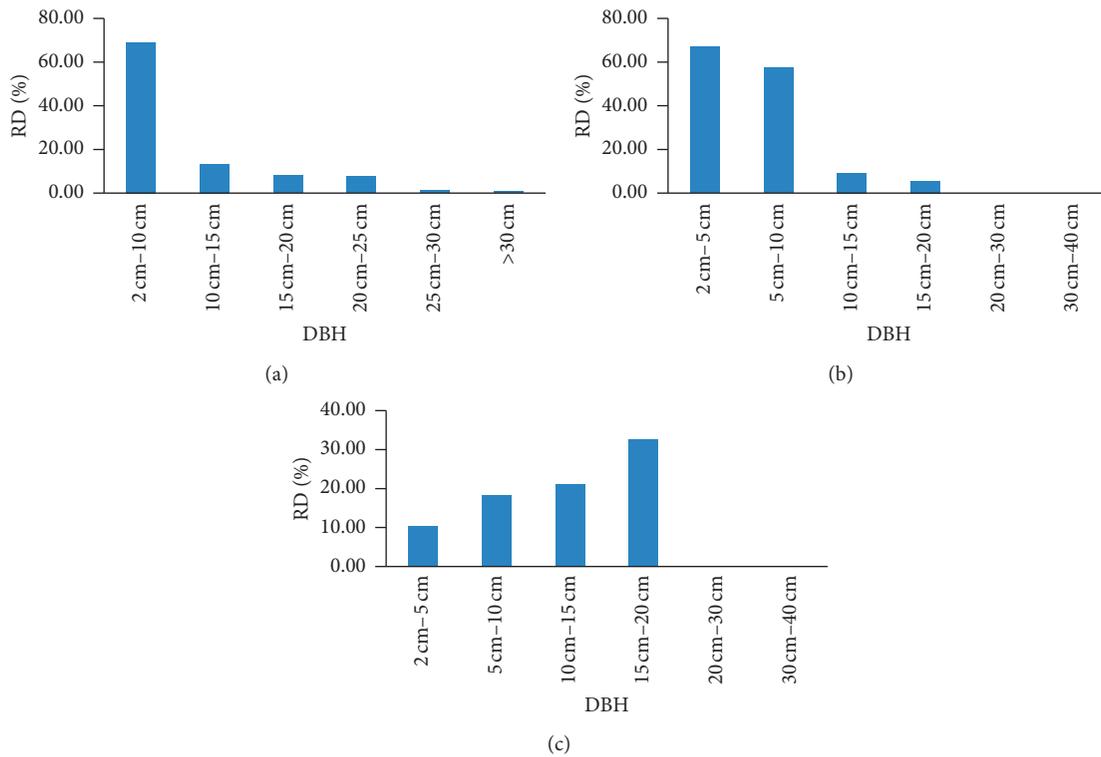


FIGURE 5: DBH class distribution of some important woody species in free grazed woodland. 0 = <2 cm; 1 = 2-5 cm; 2 = 5-10 cm; 3 = 10-15 cm; 4 = 15-20 cm; 5 = 20-25 cm; 6 = 25-30 cm; 7 = >30 cm. (a) *Acacia tortilis* in free grazed woodland. (b) *Dichrostachys cinerea* in free grazed woodland. (c) *Acacia gerrardii* in free grazed woodland.

4.2. *Species Diversity, Evenness, and Richness.* The overall diversity of woody plants was much higher in protected woodland ($H' = 2.28$) than free grazed woodland ($H' = 1.692$), which may be a consequence of the high species richness in protected woodland. It has been noted that the

value of obtained empirical data usually falls between 1.5 and 3.5. This implies that the diversity of woody species at free grazed woodland falls at the lowest value of the diversity range. Cattle intervention and woodcutting during weeding and mourning may be responsible for the considerable

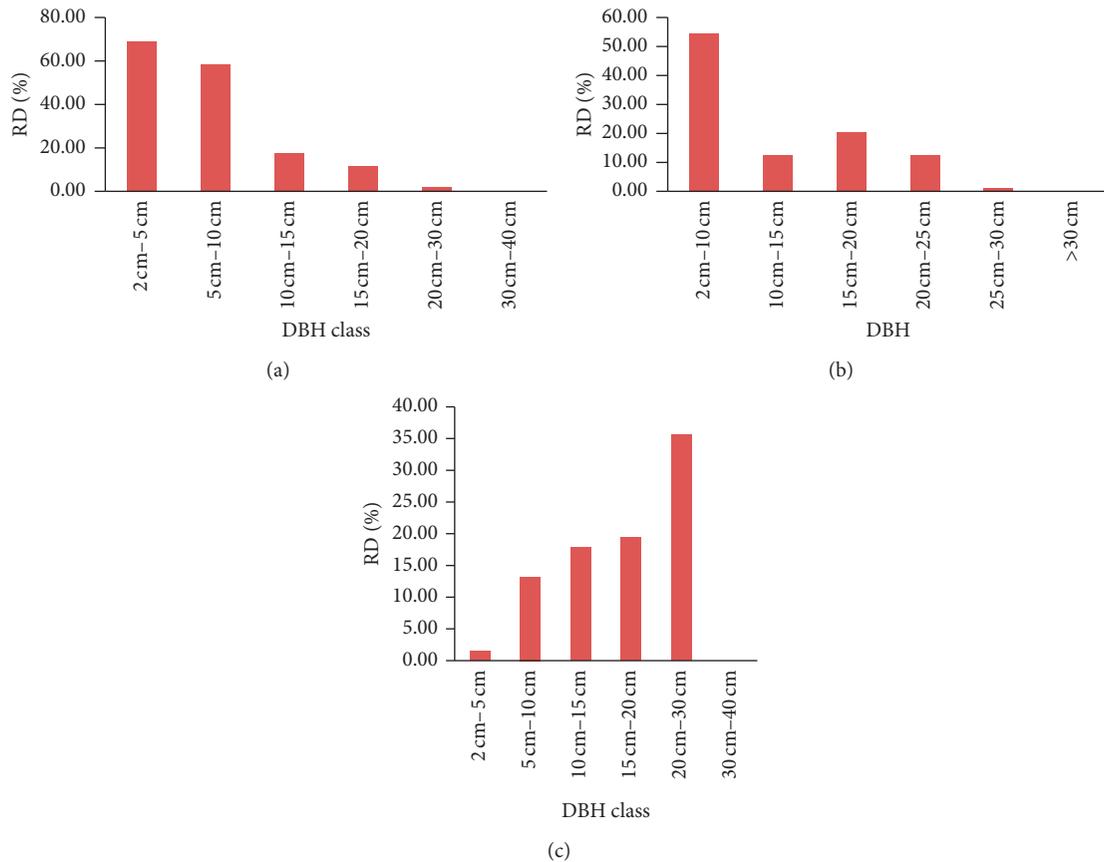


FIGURE 6: DBH class distribution of some important woody species in protected woodlands. 0 = <2 cm; 1 = 2–5 cm; 2 = 5–10 cm; 3 = 10–15 cm; 4 = 15–20 cm; 5 = 20–25 cm; 6 = 25–30 cm; 7 = >30 cm. (a) *Acacia tortilis* in PW. (b) *Dichrostachys cinerea*. (c) *Acacia gerrardii*.

floristic variations (richness of species, genera, and families and overall diversity) between the two sites.

4.3. Population Structure and Important Value Index.

Based on the assessment of diameter class distributions, the population structure patterns of the woody species recorded from protected and free grazed were categorized into six groups. *Vachellia tortilis* and *Dichrostachys cinerea* species in the protected woodland show inverted J-shaped distribution, which is widely acknowledged to indicate stable population structure, naturally replacing individuals of all age categories together with seedlings and saplings [27]. The results of the size distribution of protected woodland showed a similar trend, which was also reported from the semiarid areas of northern Ethiopia [28, 29]. This indicates a good status of regeneration and stable population of the vegetation in Dugda Woreda with good opportunity for sustainable management. On the other hand, the result of the size distribution of free grazed woodland does not exhibit inverse J-shaped. Tree density is expressed as the number of trees per unit area and it is a crucial parameter for sustainable woodland management. The total density of all woody species was found to be 317.24 and 346.53 stems ha⁻¹ at free grazed woodland and protected woodland use, respectively (Table 2). The total basal area of the woody plant was

3.1 ± 1 m²/ha in free grazed woodland and 4.2 ± 2 m²/ha in protected woodland (Table 2). Importance value index (IVI) is a good measure for summarizing vegetation characteristics of a given habitat and is useful to compare the ecological significance of species and for conservation practices. *Vachellia tortilis*, *Vachellia gerrardii*, *Dichrostachys cinerea*, and *Vachellia amythetophylla* at free grazed woodland and *Vachellia tortilis*, *Dichrostachys cinerea*, *Vachellia gerrardii*, and *Senegalia senegal* at protected woodland can be considered the most ecologically important woody species with IVI values based on the contributed high values of density, frequency, and dominance. It is interesting to note that *Vachellia tortilis* was recorded among the most ecologically important woody species at both study sites.

5. Conclusion

The Dugda Woreda woodland has a small number of woody species bound with small diversity. The woodland was dominated by woody species, which was dominated by the Fabaceae family. The renewal of species through regeneration was weak; the vulnerability of young plants slowed down the sustainability of woody species. However, human pressures on the majority of the species are represented by woody cuts during death mourning for fuelwood, overgrazing in free grazed woodland and camel intervention are considered as

ecological and environmental problems, contributing to the degradation of the diversity in Dugda Woreda woodland.

The present study has provided valuable information on woody species diversity, structure, and sustainability status of woody plants in the protected and free grazed woodland that would be used as an input for effective conservation of the area. The variation in population structure and regeneration status of the park indicates the long-time past disturbance of individual species and the whole resources of the park.

The importance value index (IVI) values revealed that there is poor regeneration status in woodland due to the activities of human disturbance variables, particularly livestock browsing and grazing and human-induced fire following extensive cultivation and tradition and expansion of agriculture. These factors lead to a decline in the density of seedling and sapling of common tree species, which are economically and ecologically important in the woodland.

Data Availability

In this manuscript, the vegetation-enumerated data used to support the findings of this study are included within the article.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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