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Phytosociological Study of Gelesho Dere Woodland in Kindo koysha District, Wolayta zone of SNNPR

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Abstract

This study was conducted on Gelesho Dere woodland in Kindo Koysha District, Wolayta Zone of SNNPR, and 367km southwest of Addis Ababa. Transect sampling method was used to collect vegetation data from 59 quadrats (25 m x 25 m). The sampling plots were placed at every 50m altitudinal drop along transect lines. To collect data for herbaceous plants, five 1 m x 1 m subplots were laid in each of the main plot, where four were at the corners and one at the center. The vegetation classification was performed using R software package. Shannon-Wiener Diversity Index was used to calculate species diversity, richness, and evenness. Sixty-five plant species in 54 genera and 31family were recorded from the sample plots. Fabaceae, Combretaceae, Euphorbiaceae, Rubiaceae, Rhaminaceae and Moraceae were the most dominant families with 12, 6, 4, 3 ,3 ,3, and 3 species, respectively. Three plant community types were recognized from the hierarchical cluster analysis. Gelesho Dere Woodland was compared with four other Woodlands. The results of this study indicated the presence of relatively high species diversity. To prevent the loss of this valuable woodland resource due to anthropogenically induced factors, sustainable protection and management of the woodlands is needed through the cooperative effort of all stakeholders

Keywords: Community, Floristic composition, Species diversity, Woodland

1. Introduction

Ethiopia is a country found in the horn of Africa between the geographical coordinates of 3^0 24' and $14^0$53' North and 32^0 42' and 48^0 12' East. According to [1], the total area of the land of the country is 1.12 million km^2. The country has different topographic land features such as mountains, deep gorges, low lands, valleys and flattened plateaus. These different topographic features assisted different types of flora and fauna that have been well adapted to their own geographical features and climatic conditions. The climate and topography of Ethiopia vary considerably and appear to have effects on the distribution of biological diversities. Thus, Ethiopia has considered a country having high biodiversity in Horn of Africa [2].

A large part of Ethiopia was believed to have been covered by forests and woodland vegetation in the past [3]. However, due to continuous massive deforestation made on it, the vegetation cover has been reduced through time to what it looks like at the present [4]. Different researchers have studied the vegetation of Ethiopia at different times [5, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16]. Based on the result of most of these studies, the various vegetation types of Ethiopia have been grouped into nine general categories for the purpose of developing the conservation strategy of Ethiopia. Recently a detailed vegetation map for Ethiopia has been published [17]. In this map, 12 vegetation types with 15 mapping units are recognized. The twelve vegetation types recognized are: 1. Desert and semi-desert scrubland; 2. Acacia-Commiphora woodland and bushland; 3. Wooded grassland of the Western Gambela region; 4. Combretum-Terminalia woodland and wooded grassland; 5. Dry evergreen Afromontane forest and grassland complex; 6. Moist evergreen Afromontane forest; 7. Transitional rain forest; 8. Ericaceous belt; 9. Afroalpine vegetation; 10. Riverine vegetation; 11. Freshwater lakes, lakeshores, marshes, swamps and floodplains vegetation, and 12. Salt-water lakes, lake shores, salt marshes and pan vegetation. From the 12 vegetation types mentioned above, the vegetation type of the forest under study is categorized under Acacia-Commiphora woodland and bushland.

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Woodland vegetation can be defined as lands covered by the open stand of trees with a canopy cover of more than 20 %, but never with interlocking crowns and usually with a field layer of grasses [18]. Based on height, woodland vegetation may not be differentiated from forest vegetation, but woodland vegetation never has densely interlocking crowns [19]. Woodlands are important sources of fuelwood and construction materials for the rural as well as for the urban community. Woodland vegetation was a good source of commercially important non timber forest products such as natural gums, myrrh, frankincense, and honey. In addition to these, woodland vegetation serves as habitat for large number of plant and animal species that are found in the area. Thus, attention should be given to the conservation and sustainable management of vegetation, especially for goods and services supplied by vegetation [20].

The coverage of each of the vegetation categories has been declining rapidly due to the anthropogenic impacts such as demand for land use for expansion of agriculture, overgrazing, illegal exploitation of forests and forest products [3, 21]. Extensive agricultural investment and expansion of road construction through vegetation are also becoming other causes of deforestation. Currently, increasing rates of drought, desertification, and shortage of food for both humans and animals are becoming serious problems that need attention [4]. These problems are directly related to the pressures exerted on vegetation by human beings, and thus need immediate solutions. Therefore, it is very important to study the current status of the woodland vegetation to identify the problems and threats associated with them and make useful recommendation that helps plan their future conservation and sustainable management. Hence, this study aimed to generate basic scientific information by identifying and documenting the floristic composition and community analysis of Gelesho Dere woodland in Kindo Koisha District.

2. Materials and methods

2.1. Descriptions of the Study Area

Kindo Koysha District is found in Wolayita Zone in Southern Ethiopia. The District is located at 367 km from the national capital city of Addis Ababa and 36km from the Wolayita Sodo. The study was conducted in sites known as Gelesho Dere woodlands that are found northeast of Bele town of kindo koysha district about 7km and 30km from Soddo, the central town of Wolayta zone. The total area of woodland is 366.25 ha. The Altitude of the vegetation of Gelesho Dere woodland ranges from 1300m to 1562asl with latitudes of $034^{0}06'72"$ to $034^{0}27'31"$ N and longitudes of $076^{0}34'81"$ to $076^{0}38'28"$E. The woreda covers the total area of 52623kms [22].

The dominant soil type and land use pattern of the woreda Clay (20%), Red (35%), Sandy (25%), Black(10%)and brown(10%) and Forestland(4957 ha), Agricultural land covers (37566 ha), grazing land(6922ha) fertile soil (338 ha) and infertile soil (695 ha) and finally the other soil types is (2145 ha) respectively [22].

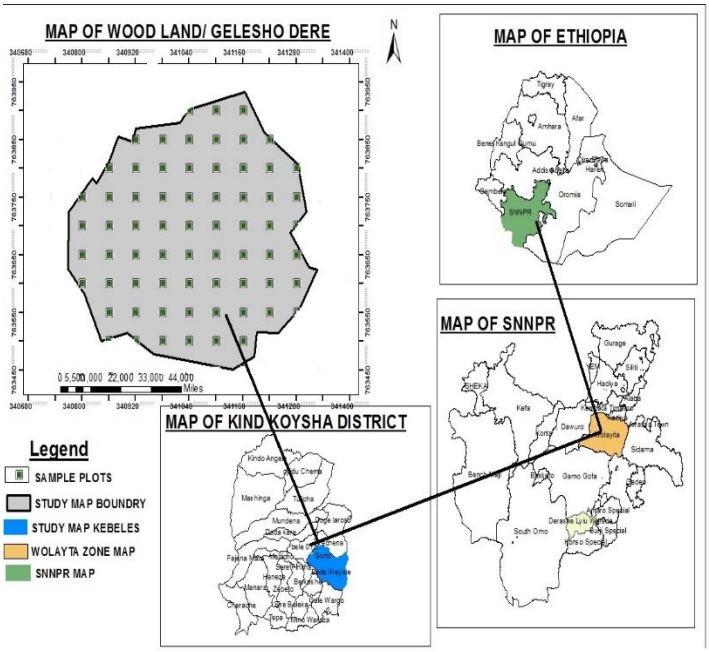


Figure 1. Map of kindokoysha district and study site

The climate of Gelesho Dere is considered to belong to the Arid (Kolla) agroecological zones of Ethiopia. According to the climate diagram below constructed based on the climate data of the nearest Gesuba station recorded from 2007–2018, the climate of Gelesho Dere woodland experiences a unimodal rainfall pattern (a regime of one rainy season), which extends between March and November [23]. However, unexpected showers may occur in all months of the year. According to the data from [23], the result of the analysis indicated that the mean annual temperature of the study area was 20.63^{0}C. The driest months were January, February, and December. The annual mean monthly minimum and maximum temperature of the study area were 11.92 and 29.440C respectively. The mean annual rainfall of the study area was 876 mm.

Kindo koysha District is generally characterized by rough topographic features. It has gorges, escarpments, mountains, and plateaus. The vegetation of Gelesho dere lies on a steep hill. The vegetation is found on the north and northwest facing parts of the escarpment (Fig 3). A perennial stream was flowing from the highlands into Gibe 3 River by crossing the District in east to west direction. The water from these streams provides services for drinking and washing.

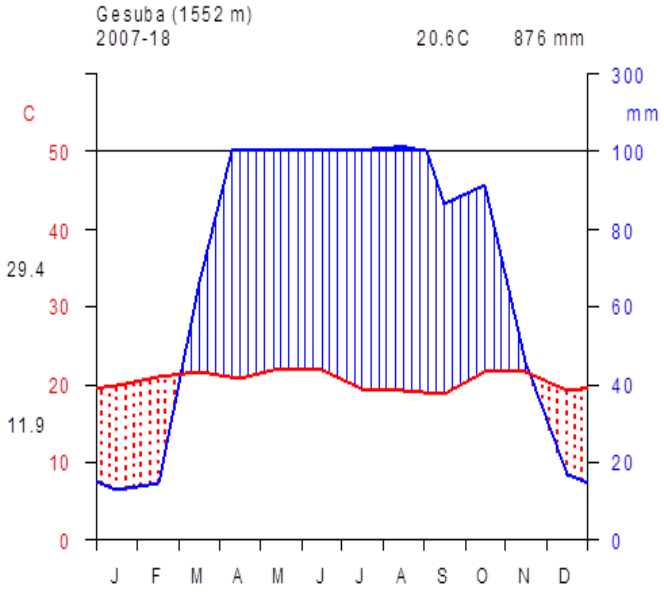


Figure 2 Climadogram for Gesuba station

2.2. Data collection and sampling method

The transect sampling method was used to collect vegetation data from 59 quadrats having a size of 25 m x 25 m. The sampling plots were placed at every 50m altitudinal drop along transect lines [24, 25]. After the highest altitude was recorded, one 25 m x 25 m quadrat was first taken at the peak of Gelesho Dere, and radiating transects were laid down from the top to the base of the mountain in four (N, W, S, and E) directions. The distance between each transect line was 400m. Each transect contained different numbers of plots depending on the length transect line. In addition, five 1 m x 1 m subplots, one at the four corners and one at the center of the 25 m x 25 m main plots were also laid to sample herbaceous plants.

In each of the quadrat, altitude was measured using Garmin 72 GPS (Geographical Position System) and aspect was determined using Suunnto Compass. Codes were given to aspects following [26] as: North=0; East=2; South=4; West=2.5; NW=1.25; SE=1.4; and SW=3.25. Ecological disturbances such as grazing and impacts of human beings (cutting, collecting firewood, producing charcoal and trampling) in the vegetation were noticed and recorded as present or absent in the sampled plots. Grazing intensity was estimated following [27, 28] as: 0= nil; 1= slight; 2= moderate and 3=heavy and the slope also was estimated as 1=(10-20%), 2=(20-40%), 3=(40-60%) and 4=(60-80%). The state of human interference (Disturbance) was estimated following [29, 30] codified using a 0-3 subjective scale to record the degree of the impacts (from cutting, fuelwood collection, charcoal production and sign of trampling) as: 0=nil; 1= low; 2= moderate; and 3=heavy.

Cover/abundance values for woody species were made and recorded in the field. The local name of each species, if present was recorded during the fieldwork. Specimens of all encountered woody and herbaceous plants were collected, pressed, dried and brought to the botany laboratory of Debre Berhan University, for taxonomic identification. The specimens were identified by comparing with authenticated specimens at DBU laboratory and also using the Flora of Ethiopia and Eritrea. Voucher specimens were kept at botany laboratory of Debre Berhan University.

Cover abundance data defined here as the proportion of area in a quadrat covered by every species recorded and gathered from each quadrat was converted to the 1-9 Braun- Blanquet scale, which was later modified by [31] as follows: (1) rare, generally one individual; (2) occasional, with less than 5% cover of the total; (3) abundant, with less than 5% cover of the total; (4) very abundant, with less than 5% cover of the total; (5) 5-12% covers of the total area; (6) 12-25% covers of the total area; (7) 25-50% covers of the total area; (8) 50-75% covers of the total area; and (9) 75-100% covers of the total area.

3.3. Data Analysis

The R software for Windows 3.6.1 version was used to analyze the vegetation data through the Agglomerative Hierarchical Classification technique. Euclidean distance and Ward's method were used for clustering the vegetation data [32]. An optimal number of clusters can be obtained with the help of an objective method. A sharp bend in the plot could be a good indication of the number of clusters in the data [32].
Shannon -Wiener Diversity Index was used to analyze the species diversity, species richness and evenness of the vegetation as:

$H = -\sum_{i=1}^{s} PilnPi$

Where, H: Shannon-Wiener Index S=the number of species

Pi: proportion of individual tree species or the abundance

ln: log base$_n$

The equitability or evenness of the species in each quadrat was computed using the formula:

Equitability (Evennss) $J = \frac{H'}{Hmax} = \frac{H'}{lns}$

Where J=Evenness

H'=Shannon-Wiener diversity index

H'$_{max}$ = Ins where s is the number of species

Sorenson's Similarity ratio was used to evaluate the similarity between the plant community types of the vegetation in the study area.

$Ss = \frac{2a}{2a+b+C}$

Where:

Ss = Sorensen's similarity coefficient

a = number of species common to both samples /communities/ study areas

b = number of species in sample,1

c = number of species in samole 2

The vegetation of Kindo Koysha District has been compared with four other relatively related woodlands studied at different times. The species richness oof these four woodlands was compared with that of Gelesho Dere to determine the phytogeographical impression of the study area. In this study, Redundancy Analysis (RDA) ordination was used in describing the pattern of plant communities along an environmental gradient since the preliminary analysis of the vegetation data using Detrended Correspondence Analysis (DCA) revealed that the longest axis of DCA for the dataset was less than 3 (= 2.22). RDA ordination was used since preliminary analysis of the vegetation data using DCA revealed a linear nature of the vegetation data set

The wastewater treatment system employed at Debre Berhan Dashen Brewery is UASB (up-flow anaerobic sludge blanket) with re-aeration system. A prerequisite for successful operation of a UASB system is the presence of well-settling (granular) sludge, which can stand the up-flow velocity of the wastewater and is retained in the reactor. In the UASB processes, the wastewater to be treated is introduced in the bottom of the reactor. The waste water flows upward through a sludge blanket which is made of biologically formed granules. Treatment occurs as wastewater contact with granules. The gases produced under anaerobic conditions mainly methane and carbon dioxide cause internal circulation, which helps in the formation maintenance of the biological granules. The free gas and the particles with the attached gas rise to the upper part of the reactor. The retention time in the UASB tank is 6 hours at average flow with volume of 700m^3.

3.Results

3.1 Floristic Composition of Gelesho Dere Wood Land

The study has shown that Gelesho Dere Woodland Vegetation has high species diversity in different growth forms (trees, shrubs, climbers, and herbs) (Appendix 1). Out of the total 65 plant species in 31 families and 54 genera recorded from the study area, trees, shrubs, herbs, and climbers comprise 73.85%, 12.31%, 9.23%and 4.62%, respectively (Fig. 4). Of all the families, Fabaceae, Combretaceae, Euphorbiaceae, Lamiaceae, Moraceae, Rhamnaceae, and Rubiaceae are the most dominant families represented by 12, 6,4,3,3,3, and 3 species and 8,2,4,3,1,2, and 3 genera, respectively. The next dominant families, Acanthaceae, Boraginaceae, Anacardiaceae, Capparidaceae, Sapindaceae, and Flacourtiaceae each represented 2 species and 2 genera of the total species (Table 1).

Other 18 families such as Alliaceae, Annonaceae, Balanitaceae, Apocynaceae, Ebenaceae, Tiliaceae, Myrsinaceae, Sapotaceae, Celastraceae, Sinopteraceae, Proteacea Polygonaceae, Polygalaceae, Malvaceae, Asteraceae, Solanaceae, Mussaceae and Myrtaceae were represented by one species and genera (Appendix 1). Out of the total plant species identified from the study area, *Acanthus sennii* is endemic to Ethiopia, confined to Ethiopia and Based on the IUCN Criteria of the level of threat, it was categorized under the category of near threatened (NT) [33].

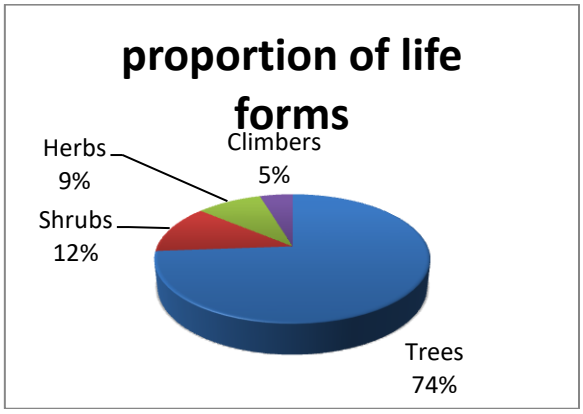


Figure 3. Life forms (habits) of Gelesho Dere woodland.

3. 2 Types of community

Three plant community types were identified from the hierarchical cluster analysis using R software for windows version 3.6.1. The community names of Gelesho Dere woodland were named after one or two species that had high cover-abundance value as indicated in the synoptic table. It also provided one way of summarizing our knowledge of vegetation types in the study area. Distribution of the three plant community types and altitudinal range was given in Table 2. The three community types in the Gelesho Dere woodland are discussed below.

Table 1. The Number of Genera, Species and Their Percentage

Family Name	Number of Genera	%	Number of Species	%
Acanthaceae	2	3.70	2	3.08
Alliaceae	1	1.85	1	1.54
Anacardiaceae	2	3.70	2	3.08
Annonaceae	1	1.85	1	1.54
Apocynaceae	1	1.85	1	1.54
Asteraceae	2	3.70	2	3.08
Balanitaceace	1	1.85	1	1.54
Boraginaceae	2	3.70	2	3.08
Capparidaceae	2	3.70	2	3.08
Celastraceae	1	1.85	1	1.54
Combretaceae	2	3.70	6	9.23
Ebenaceae	1	1.85	1	1.54
Euphorbiaceae	4	7.41	4	6.15
Fabaceae	8	14.81	12	18.46
Flacourtiaceae	2	3.70	2	3.08
Lamiaceae	3	5.56	3	4.62
Malvaceae	1	1.85	1	1.54
Mussaceae	1	1.85	1	1.54
Moraceae	1	1.85	3	4.62
Myrsinaceae	1	1.85	1	1.54
Myrtaceae	1	1.85	1	1.54
Polygalaceae	1	1.85	1	1.54
Polygonaceae	1	1.85	1	1.54
Proteaceae	1	1.85	1	1.54
Rhamnaceae	2	3.70	3	4.62
Rubiaceae	3	5.56	3	4.62
Sapindaceae	2	3.70	2	3.08
Sapotaceae	1	1.85	1	1.54
Sinopteridaceae	1	1.85	1	1.54
Solanaceae	1	1.85	1	1.54
Tiliaceae	1	1.85	1	1.54
Total				
31	54	100.00	65	100.00

Table 2. The ranges of altitude, quadrats, the number of communities and species

Community	Altitude	Number of plots	Quadrats	Number of species
C1	1330_1445	18	1,2,10,18,21,22,23,27,32,34,39,40,46,48,52,56,58,59	60
C2	1305_1539	17	11,12,13,17,20,28,29,30,37,41,42,44,45,47,49,54,55	47
C3	1312_1566	24	3,4,5,6,7,8,9,14,15,16,19,24,25,26,31,33,35,36,38,43,50,51,53,57	61

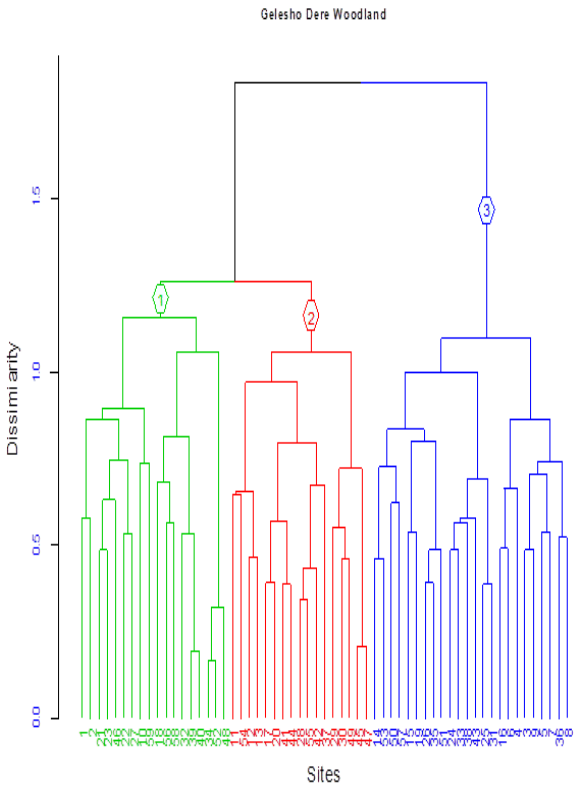


Figure 4. Dendogram of vegetation data from the hierarchial cluster analysis of the three plants communities in the Gelesho Dere woodland.

1. *Ficus sycomorus* _ *Combretum molle* community type I

This type of community was located between at the altitudinal ranges of 1330 _1445 m.a.s.l. There were 18 quadrats (30.51%) and the species richness was 60 (92.31%) in this community. *Ficus sycomorus* and *Combretum molle* were the dominant species in the tree layer. *Ficus vasta, Grewia bicolor, Rhus vulgaris, Piliostigma thonningii, Croton macrostachyus and Dovyalis abyssinica* were the associated species. The Characteristic species of community type I were listed as follows *Vernonia amygdalina, Vitex doniana, Vangueria madagascariensis, Terminalia brownii, Terminalia laxiflora, Solanum incanum, Sida tenuicarpa, Senna longiracemosa, Securidaca longepedunculata, Sapium ellipticum, Rothmannia urcelliformis, Rhoicissus revoilii, Capparis tomentosa, Capparis spinosa, Cleodendrum myricoides, Ehretia cymosa, Ficus vasta, Erythrina abyssinica, Gardenia ternifolia, Mussaenda arcuata, Ocimum urticifolium, Paulina pinnata, Phyllantus sepialis, and Piliostigma thonningii.*

2. *Balanites aegyptica _ Combretum collinium* community type II

This community was found between 1305_1539 m.a.s.l. The community consists of 17 quadrats (28.81%), and the species richness was 47 (72.31%). There was the least number of quadrats relatively compared to community one and two. The dominant species of this community were *Balanites aegyptica* and *Combretum collinium. Rumex abyssinica was the dominant herbs in this* community type. *Tamarindus indica, Onchoba spinosa, Acacia seyal, Terminalia laxiflora, Acacia tortilis, Abizia schimperiana, Acacia saligna, Hygrophil schulli, Cordia africana, Ozoroa insignis, Mumex abyssinica* and *Ziziphus abyssinica* were associated species in this community. The Characteristic species of this community were *Clutia abyssinica, Terminalia brownii, Rhoicissus revoilii* and *Ehretia cymosa*.

3. *Terminalia schimperiana_ Syzygium guineense* community type III

This type of community was found or distributed between at the altitudinal ranges of 1312_1547 m.a.s.l. The number of quadrats was 24(40.68%) and the numbers of species of this community was 61(93.85%). It had highest number of quadrats and altitude relatively compared to community two and one. *Terminalia schimperiana* and *Syzygium guineense* were the dominant tree species in which this community type was named (Table 3). *Acacia mellifera, Carissa spinarium, Dichrostachyus cinerea, Diospyros mespiliformis, Securidaca longepedunculata, Paulina pinnata, Combretum hereroense* and *Dodonaea angustifolia* were the

associated species of this community. Characteristic species of this community were *Rothmannia urcelliformis*, *Vernonia amygdalina*, *Gardenia ternifolia*, *Vitex doniana*, and *Erythrina abyssinica*.

Table 3. The synoptic cover value of plant species

Cluster number	C1	C 2	C 3
Cluster size	18	17	24
Combretum molle	**5.78**	2.76	1.75
Ficus sycomorus	**5.83**	1.94	0.88
Ficus vasta	4.22	2.53	0.00
Grewia bicolor	2.22	0.59	0.63
Croton macrostachyus	1.28	0.82	0.42
Dovyalis abyssinica	1.06	0.35	0.67
Piliostigma thonningii	1.44	0.00	0.21
Rhus vulgaris	1.56	0.47	1.08
Combretum collinium	1.11	**4.53**	1.38
Tamarindus indica	1.44	3.41	1.13
Acacia saline	1.61	2.06	0.92
Acacia seyal	2.72	2.82	0.75
Acacia tortilis	1.83	2.65	0.38
Albizia schimperiana	0.17	2.12	0.42
Balanites aegyptica	0.00	**5.41**	0.75
Cordia Africana	0.94	1.00	0.25
Onchoba spinosa	1.67	2.94	2.63
Ozoroa insignis	0.83	1.82	1.54
Rumex abyssinica	0.22	1.24	0.54
Terminalia laxiflora	0.50	2.53	2.29
Ziziphus abyssinica	0.28	1.29	0.38
Terminalia schimperiana	1.00	2.53	**6.08**
Combretum hereroense	2.11	1.24	4.63
Acacia mellifera	0.22	2.18	3.58
Carissa spinarium	1.61	0.76	2.92
Dichrostachyus cinerea	0.61	1.24	1.71
Diospros mespiliformis	1.44	1.24	1.54
Dodonaea angustifolia	1.94	2.18	3.25
Paulina pinnata	1.28	0.00	1.42
Securidaca longepedunculata	0.72	0.00	1.42
Syzygium guineense	1.67	2.18	**5.13**

reaching ≥1% in at least one community type.

3.3 Species richness, diversity, and evennness of the community

The Shannon – Wiener diversity index (H') was computed for each plant community types. The different values of H' for the communities reflect the difference in their species richness and evenness. Based on (table 4), the results of Shannon-Weiner diversity index and evenness indicated more or less similar species diversity and evenness among the identified plant communities. Community I is relatively more diversified one reaching a diversity index of 3.624 than Community two and three. Community two had relatively highest value of species evenness than community I and three. The diversity index value of community two was relatively the least diversified (3.437) and had least richnness than community one and two.

Table 4. Species richnness, Diversity index and evenness of plant community types of Gelesho Dere Woodland.

Communities	Species richness	Shannon Diversity index (H')	Shannon Evenness (H'/Hmax)
I	60	3.624085	0.885144
II	47	3.437985	0.892949
III	61	3.617049	0.879874

3.4 Sorenson's similarity for the communities

Calculating community similarity (what the communities have in common in terms of Species) helped us determine if we were compared individual plant species each other. There were many indices that done this, we would use sorenson's coefficient.Sorenson's coefficient given us a value between 0 and 1, the closer the value to 1, the more the communities have in common. Complete community overlap is equal to 1 and dissimilarity is equal to 0. The overall similarity coefficient ranges from 93-97% among all the communities (Table 5).

Table 5. Sorensen's similarity coefficient, percentage among the three communities.

Community	C1	C2	C3
Community 1	1		
Community 2	0.93	1	
Community 3	0.97	0.93	1

3.5 Phytogeographical comparison of vegetation of Gelesho Dere Woodland with other four woodlands

Gelesho Dere Woodland was compared with four other Woodlands in the country to see the distribution pattern of woody species in the study area and to determine the relative similarity in its woody species composition. Sire Beggo, Lake Abaya to Chencha, Gamo Gofa, and Gilgel Gibe III area. In the analysis of data from the four woodlands, Sorenson"s similarity index was used.

Distribution of plants at different areas compared was used to determine a similarity between different vegetation with respect to species richness, composition and the result from the comparison showed Gelesho Dere Woodland Vegetation has 29% similarity with Gilgel Gibe III woodland and 22% similarity with the woodland extending from Lake Abaya to Chencha highlands. The result of the comparison also indicated that Gelesho Dere Woodland Vegetation shares least similarity (13%) and 16% with the woodland vegetation around Gamo Gofa and Sire Beggo respectively (Table 6).

Distribution of woodlands of Gamo Gofa and Gilgel Gibe III area and Lake Abaya to Chencha highlands were found in the southern part of Ethiopia (Desalegn Wana and Zerihun Woldu, 2005) and that of Sire Beggo is found in Eastern Ethiopia.

3.6 Ordination

Redundancy Analysis (RDA) is a direct gradient analysis technique and known that PCA is unable to deal with nonlinear species responses to environment and produces an arc_shaped configuration of a single gradient. RDA is, therefore, a technique that can integrate regression principal component analysis.It can, therefore, be considered as the canonical version of principal component analysis. RDA ordination diagram normally is a biplot, but there are options to display` either the species or the sites or a combination of explanatory variables and species or sites or both [37]. Arrows pointing in roughly the same direction indicates a high positive correlation, arrows crossing at right angles indicate near-zero correlation, and those arrows pointing in roughly opposite directions indicate a high negative correlation [38].The first axis of RDA ordination can explain 29% of the variation while the second axis explains 26.9 of the variation in the vegetation data. The cumulative proportion of variation explained by the first three RDA axis was 74.11% (Table 7). This indicates that the proportion of variation explained by RDA axis declined towards the higher axis.

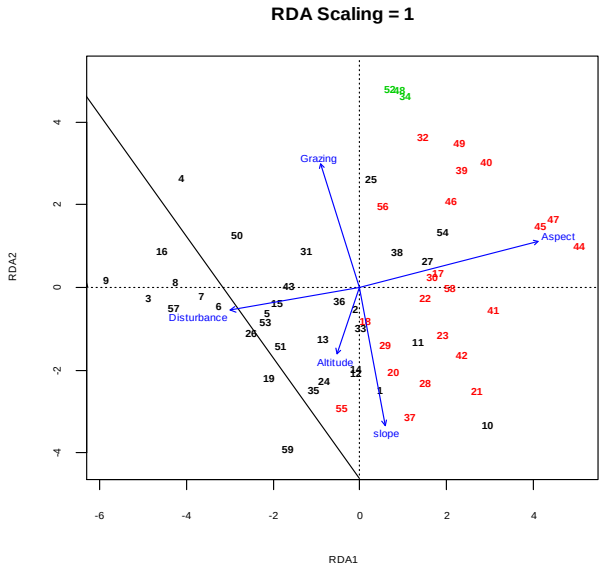
According to the ordination diagram observed in (Figure 6), the distribution of community three which has black color affected highly by the disturbance and altitude while community two that with red color is mostly affected by aspect. Community one has green and is mainly distributed along lower altitude and where the slope of the area is lower. So the vegetation of Gelesho Dere woodland could be affected by the degree of human impact, grazing, aspect and slope.

Table 6. Comparison of the vegetation of gelesho dere with other woodland vegetation studied in Ethiopia

Woodlands	Altitudinal range	a	b	C	Sc	Data source
Sire Beggo	1344-1907 m a.s.l.	20	45	165	0.16	[14]
Lake Abaya to Chencha	1177-2718 m a.s.l.	26	39	148	0.22	[34]
Gamo Gofa	600-1900 a.s.l.	13	52	203	0.13	[35]
Gilgel Gibe III area	703-828 m a.s.l.	22	43	64	0.29	[36]

Table 7. Ordination for environmental variables

	RDA1	RDA2	RDA3	RDA4	RDA5
Eigenvalue	5.882	5.4469	3.7036	2.8434	2.4077
Proportion Explained	0.290	0.2685	0.1826	0.1402	0.1187
Cumulative Proportion	0.290	0.5585	0.7411	0.8813	



1.0000

Figure 5. Impact of altitude, aspect, disturbance and grazing on gelesho dere woodland vegetation

4. Discussion

Floristic composition and community types

family Fabaceae was the dominant family in this study. The dominance of Fabaceae was reported from other vegetation studies in the woodlands of Ethiopia [35, 12, 14]. This may imply that the environmental conditions in these areas are more favorable to this family.

The three communities showed more or less similar species diversity and richness. The achievable reason for high species richness of community three may be altitudinal factor because intermediate altitude could be associated with optimal conditions of environmental factors that favor vegetation growth. The relatively highest species richness and diversity indices in community one and three may be due to fewer disturbances. The variability of each values between each community type could be difference in number of species, cover abundance values, degree of disturbance, the slope of the quadrats in the community and other related factors. Similar results were reported by [14]. Relatively the highest similarity was observed between community one and three **(**97%**)**, this may be due to existence of most quadrats near to each other that shows similar adaptation mechanisms and requirements for species occurring in these communities [34, 39]. The 93% similarity was observed between community one and three and community two and three with (93%**)**, this may be as result of different factors like anthropogenic impacts slope, grazing and related to the altitudinal drops on which most of the community categories or types were based.

Phytogeographic comparison

The vegetation of Kindo Koysha District was compared with four other related woodlands studied at different altitudes, areas and times. The species richness of these four woodlands was compared with that of Gelesho Dere Woodlands to determine the phytogeographical distribution of plants of the study area [40] (Table.8). Comparison of the species diversity of one woodland with other woodlands gives more or less a general distribution of the overall species diversity and phytogeographical similarity [41].

Dissimilarity (low species were shared) of Gelesho Dere woodlands with others could be due to differences in topographic variation, altitudinal drop, sample sizes and methods of the study, degree of anthropogenic impact, overgrazing and and factors of ecological climatic zones. But, the reason for the relative similarity shown between the woodlands and the vegetation under the study could be attributed to their conservation status and the same phytogeography. This conclusion is in line with the results given in Fisseha Adugna [36, 34].

Ordination

Community 3 was distributed in plots of higher altitudinal ranges and in highly disturbed plots in the study woodland. Altitudinal change leads to changes in humidity, temperature, soil type, and other factors that influence the growth and development of plants which in turn determine the patterns of vegetation distribution [42]. disturbance was also an important variable in determining the distribution of community three. Disturbance affects the distribution of plant community by hampering natural regeneration and seedling establishment [43]. Disturbance also favors the growth of herbaceous plant species by improving the availability of light condition in the ground layer as it widens the canopy gap and thus affects the distribution of communities with these species.

Conclusion

The results of this study indicated that the presence of relatively high species diversity. Shrubs and trees were the dominant growth forms while climbers and herbs scored the least proportion. From the total species, recorded *Acanthus sennii* was listed in the IUCN red data list under the Near threatened category. The vegetation was grouped into three different plant community types. These communities were arranged along different altitudinal range. The variation in species composition and diversity among plant communities could be attributed to different factors, such as altitude, slope, grazing, and anthropogenic activities play a major role. Dissimilarity (low species were shared) of Gelesho Dere Woodlands with others this could be due to differences in topographic variation, altitudinal drop, sample sizes and methods of the study, degree of anthropogenic impact, overgrazing and factors of ecological climatic zones. To prevent the loss of this valuable wood land resource due to anthropogenically induced factors, sustainable protection and management of the woodlands is needed through the cooperative effort of the government, NGO and the local community for reduction of tree cutting and production of charcoal.

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