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ORIGINAL RESEARCH ARTICLE

Comparative Study on Floristic Composition, Structure and Regeneration Status of Woody Plants: the Case of Gond Teklehaymanot and Arsema Monastery Forests, Amhara Region, Ethiopia

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Abstract

A study was conducted in Gond Teklehaymanot and Arsema Monastery Forests, northwest Ethiopia with the objective of comparing the status of the two forests. Eight line transects spaced at 150m appart were laid on which plots were established at 150 m interval. A total of 40 plots (20m×20m) were sampled for each Monastery. In each plot, the identity, number and percent cover of all woody species were recorded. With in each main plot, five subplots (2m×2m) were established at each corner and center to facilitate collecting data for seedling and sapling. DBH was measured for trees and shrubs > 2.5 cm. Hierarchical cluster analysis was used to identify the community types. Shannon diversity and Sorenson similarity indices were used to compare the species diversity and similarity among the community types and the two forests respectively. Frequency, density, DBH, basal area and IVI were used to analyze the patterns of the vegetation structure. A total of 90 and 75 woody species were recorded at Gond and Arsema forests respectively. In both forests, Fabaceae was the dominant family. Four communities in Gond and 2 in Arsema were identified. Species richness, diversity and evenness varied among the plant communities and the forests. The total basal area of woody species for Gond Teklehaymanot forest was 35.63 while Arsema forest basal area was 9.16 m^2 ha^{-1}. Results from structure data revealed the two forests were largely composed of young woody species. Regeneration status of Gond and Aresema forests were found fair and good respectively. Structural and regeneration status data analysis indicated that some species need immediate attention for conservation for both forests.

Keywords: Evenness, plant community, richness, species diversity, species similarity

Introduction

Ethiopia has the fifth largest floral diversity in tropical Africa (Motuma *et al*., 2010). About 6,027 species of higher plants are estimated to exist in the country of which about 10% of plant species are estimated to be endemic (Ensermu and Sebsebe, 2014). However, the speedy depletion of floral resources (forests), as a result of anthropogenic activities, has brought significant decline in their biodiversity to the extent that some species are on the verge of local extinction (Alemayehu, 2002) and the rate of deforestation is aggravated in the northern Ethiopian highlands. Forest patches can be affected by various environmental factors (altitude, slope, and aspect) by influencing the patterns of tree species distribution (McEwan *et al*., 2011).

Monastery forests are among the few Ethiopian Afromontane forest patches left over deforestation (Jacob *et al*., 2014). The The sacred Monasteries of Ethiopian

Orthodox Church has long history of protecting and preserving indigenous flora (Alemayehu *et al*., 2010). The biodiversity found in the Monasteries are seen as sacred, with the trees symbolic of angels guarding the Monasteries. A biodiversity survey in monasteries and churches indicates that the Holy place serve as key refuge for the endangered plant and animal species (Ermilov *et al*., 2012). Various authors, Alemayehu *et al*., (2010), Haileab *et al*., (2010), Gojjam, (2013), Mohammed and Teshome (2014), studied the status and diversity of Church and Monastery forests in Ethiopia. The outcomes of these studies offer significant information on the regeneration status and structure of woody species, which is important to carry out appropriate conservation measures.

Gonde Teklehaymanot and Arsema Monastery Forests are important heritage priority areas which are not currently well managed. Basic scientific information regarding woody species composition, structural complexity and regeneration status necessary for the forest management and sustainable resource utilization are lacking for the two Monasteries Forests. Therefore, this work was initiated to compile and compare the floristic composition, structure and regeneration status of woody plants of the two forests so as to provide information on species diversity and community structure which is necessary for the forest management and sustainable resource utilization.

Materials and Methods

Study Area

The study was carried out in Gonde Tekelehaymanot and Arsema Monastery Forests (Fig. 1). The study areas are found in West Belesa (where Gonde Tekelehaymanot is located) and Gondar Zuriya (where Arsema Monastry is located) districts, Centeral Gondar Administrative Zone, Amhara National Regional State, Northwest Ethiopia. The distance from Gond Teklehaymanot to Arsema Monastery is 15 km.

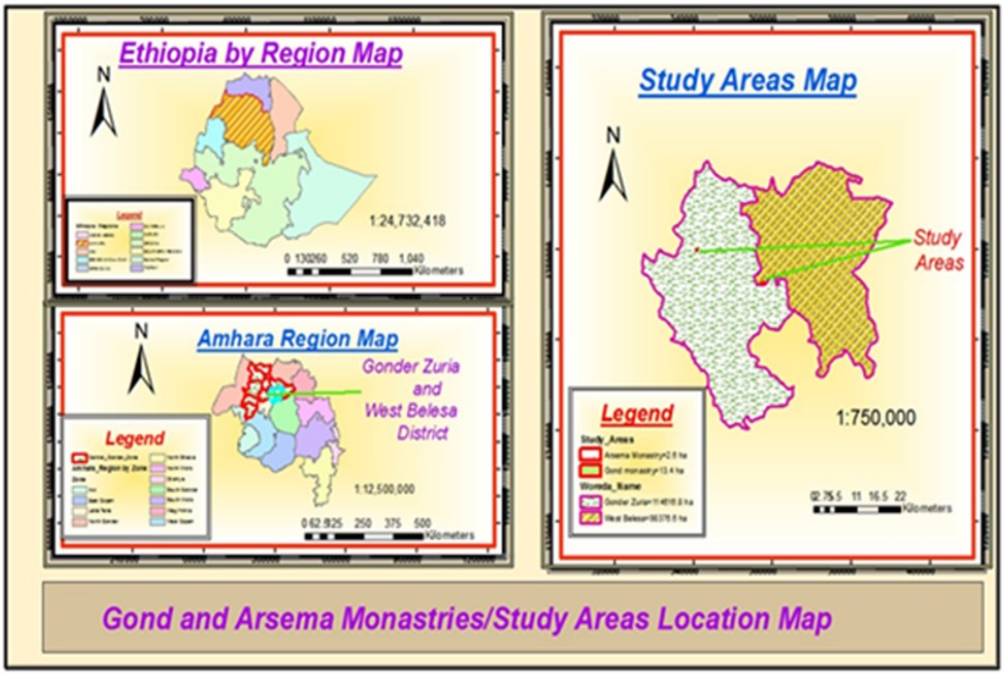

Figure 1. Map of the study areas

Gond Teklehaymanot Forest is located in altitude ranging from 2229-2478 m a.s.l with the geographical position ranging from 12°24'41"N to 12°25′04.7″N latitude and 37°41'31" to 37°41′42″E longitude. Arsema Monastery is located west of Gond Teklehaymanot and north of Makesgnit town, with altitude ranging between 2114 and 2275 m above sea level, and geographical position ranging from 12° 25'47"N–12°28'19″N latitude 37°31'55"E–37°32'04" longitude.

The agro-ecological map of the district showed that West Belesa agro-ecology is predominantly Kolla covering 59.8 %, followed by Woina Dega 38.7% and Dega 1.5%, while Gondar Zuria district agro-ecological zone shows 22% Dega and 78% Woina Dega. The Monasteries consist of chains of rugged mountains, flat and plane areas.

Meteorological data (from 2009 to 2018) obtained from National Meteorology Service Agency (Bahir Dar branch) indicated that the study areas obtained high rainfall between June and September and low rainfall from November to April. The mean annual rainfall of the area is 876 mm per year. The highest mean annual rainfall of the study areas within ten years was 291.8 mm recorded in July and the lowest mean annual rainfall was 0.2 mm recorded in January and February.

Mean annual temperature of the study areas were about 21°C, the lowest mean annual temperature over ten years was 12.1°C recorded in January whereas the highest mean annual temperature was 31.3°C recorded in April (Fig. 2).

According to the districts Agriculture Office (2016), the major soil types and their spatial coverage in the districts are Cambisol cover the area about 40.3% ha followed by Vertisol 32.3%ha, Luvisol covered the area about 9.9% ha, Nitosols 8.5% ha, Lithosols 5.7% ha and Rock surface covered 3.3% ha. According to West Belesa District of Agriculture Office (2016), it is mainly characterized by plateau with a share of 50%, mountains 40%, and hilly 10% of the total land of the District. Topography of the districts' area accompanied 65% flat land, 25% hill and 10% valley type. According to Mesfin Fenta (2017), Gondar Zuria's area covered 63% cropland, 14.8% grass land, 9.6% forest, 7.5% is taken by physical constructions, 2.6% is regarded as wilderness and 2.5% for others.

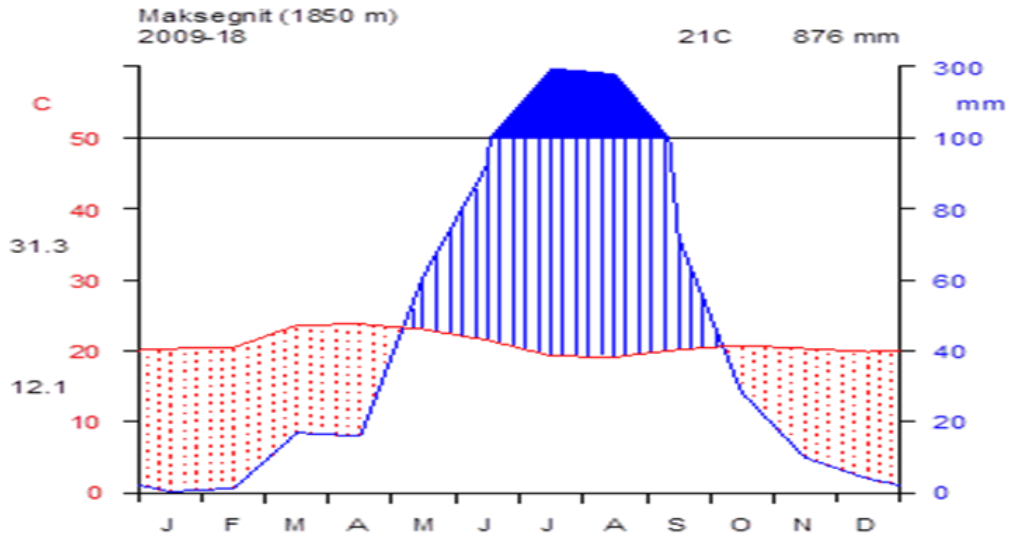

Figure 2. Climate diagram of Gondar Zuria

Based on the Central Statistical Agency of Ethiopia (CSA, 2007), West Belesa district had a total population of 179,118. From these total populations 89,201 (49.8%) were female and 89,917 (50.2%) were male. From this data record, 93.5% of populations were Orthodox followers and 6.5% were Muslims. In Gondar Zuria district, the total population was 224, 460 with 113,702 (50.6%) males and 110,758 (49.4%) females. Based on CSA projection (CSA, 2014), the majority of the inhabitants practiced Ethiopian Orthodox Christianity (94.8%), while 5.2% of the populations were Muslim. Based on the Central Statistical Agency of Ethiopia (CSA, 2007), West Belesa district had a total population of 179,118. From these total populations 89,201 (49.8%) were female and 89,917 (50.2%) were male. From this data record, 93.5% of populations were Orthodox followers and 6.5% were Muslims. In Gondar Zuria district, the total population was 224, 460 with 113,702 (50.6%) males and 110,758 (49.4%) females. Based on CSA projection (CSA, 2014), the majority of the inhabitants practiced Ethiopian Orthodox Christianity (94.8%), while 5.2% of the populations were Muslim.

According to West Belesa and Gondar Zuria Districts Agricultural Office (2019), the economies of the districts are mixed farming largely participated on crop production followed by livestock rearing. The local people are implicated in the collection of forest products; such as fuel wood and construction material for domestic consumption and income production. The major land use and land cover types observed in the districts were grazing land, forest and shrub land and the remaining are considered as a degraded. The major crops that are cultivated in the Districts include *Eragrostis teff*, *Zea mays*, *Sorghum bicolor*, *Cicer arietinum*, *Vicia faba* and *Triticum* spp. However, West Belesa district is among the chronically food insecure District in the region where the Food Security Program has been implemented since 2005.

Vegetation in the study area is largely dry evergreen afromontane forest and grassland complex. Gond Teklehaymanot forest covers 800 ha while Arsema monastery has forest coverage of 750 ha. Gond Teklehaymanot's forest is more of primary type characterized by *Olea europaea* subsp. *cuspidata*, *Myrsine africana*, *Juniperus procera*, *Acokanthera schimperi*, *Carissa spinarum*, *Rhus vulgaris*, *Pteroloblum stellautm*, *Calpurnia aurea*, *Pittosporium viridiflorum*, *Dombeya torrida*, *Grewia ferrugine* and *Dodonaea angustifolia*. The vegetation of Arsema Monastery is more of secondary type since the Monastery is relatively new and characterized by scattered patches of vegetation with *Combertum molle*, *Carissa spinarum*, *Erythrina abyssinica*, *Olea europaea* subsp.cuspidata, *Euphorbia candelabrum*, *Euclea racemosa* and others.

Method of Data Collection

Sampling design

To study on the status of Gond Teklehaymanot and Arsema Monastery Forests, eight parallel line transects spaced at 150 m intervals in each forest, were laid across the forests in west-east direction (Bullock, 1996). In each Forest, forty 20 m x 20 m plots were laid down systematically at 150 m distance intervals. Within each of the main plots, five 4 m^2 (2 m x 2 m) subplots were laid one at each corner and at the center to collect two sets of vegetation data (seedlings and saplings) as mentioned in Tadesse (2003).

Vegetation sampling

All trees and shrub species were recorded from the systematically established plots along each transect. Iindividual's of each species in every plot was counted. Cover abundance values of trees and shrubs was estimated following the modified 1–9 Braun-Blanquet scale as converted by van der Maarel (1979). Physiographic variables such as altitude, latitude, and longitude were recorded for each sampling plots using GPS. In each plot, trees and shrubs with DBH > 2.5 cm were measured and recorded for diameter at breast height (DBH) using diameter tape. In each plot, number of seedlings and saplings were recorded to determine the regeneration status. For regeneration status data collection, size classes

of woody species with a height up to 1m were considered as seedlings, height greater than 3m were considered as adult, and from 1-3m were considered as sapling (Singhal, 1996).

Data Analysis

Hierarchical cluster analysis was performed using the free statistical software R version 3.4.0 (R Development Core Team, 2017) to classify the vegetation into plant community types. Similarity ratio was used to determine the resemblance function and the Euclidian distance method to minimize the total within group mean square or residual squares (van Tongeren 1995). The community types which were identified from the cluster analysis was further refined in a synoptic table and species occurrences were summarized as a synoptic-cover abundance value. Dominant species of each community type was identified based on their synoptic values by which community types were named.

Species diversity was computed using Shannon-Wiener Index (Shannon and Wiener, 1949). $H' = -\sum_{i=1}^{S} PilnPi$

where; H' = the value of the Shannon-Weiner diversity index, S = number of species in the community, Pi = the proportion of individuals of the i^{th} species expressed as a proportion of total cover, ln = log bas10.

Evenness was analysed using the formula

$$J = \frac{H'}{H'max} = \frac{\sum_{i=1}^{S} PilnPi}{lns}$$

J = Evenness of species in sampling area, H'max = maximum value of diversity.

Species similarity of the two forests and the communities were compared by Sorensen's coefficient (Kent and Cooker, 1992).

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

where Ss is Sorensen's similarity coefficient, a is the number of species common to both study areas, b is the number of species in study area 1 only and C is the number of species in study area 2 only.

Density, frequency, DBH, basal area and importance value index (IVI) were used for the description of vegetation structure by the following formula;

$$\text{Relative density (RD)} = \frac{\text{Density of a species}}{\text{total density of all species}} \times 100$$

$$\text{Density(D)} = \frac{\text{Number of stem counted}}{\text{Sample area in hectar}}$$

$$\text{Frequency (F)} = \frac{\text{Total number of plots in which the species occur}}{\text{total number of plots studied}} \times 100$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of the species in stand}}{\text{Sum of the frequencies for all species in stand}} \times 100$$

Basal area (BA) = $\frac{\pi d^2}{4}$ where d refers diameter at breast height.

$$\text{Relative Dominance (RDO)} = \text{Relativebasal area} = \frac{\text{Dominance of species}}{\text{Total dominance of all species}} \times 100$$

$$\text{ImportanceValueIndex (IVI)} = \text{RD} + \text{RF} + \text{RDO}$$

Regeneration status of trees and shrubs for the two forests was analyzed and compared using density ratios between size classes (ratios between seedlings and saplings, and sapling and adults). According to Dhaulkhadi *et al.*(2008) and Chauhan *et al*. (2008), the regeneration status is in Good condition, if seedling is greater than sapling and adult (seedling > sapling >adults density); Fair regeneration, if seedling > sapling ≤ adults; poor regeneration, if a species survives only in the sapling stage, but has no seedlings (even though saplings may be <, >, or = mature); If a species is present only in an adult form, it is considered as not regenerating, new, if a species has no mature, but only sapling and/ or seedling stages.

Results and Discussion

Woody Species Composition

A total of 90 woody species representing 51 families were identified in Gond Teklehaymanot Monastery forest whereas 75 woody plant species were identified in Arsema forest distributed in 42 families. Of the total woody species recorded, in both study areas, trees, shrubs and climbers accounted for the highest number of species, 42.9%, 38.46%, 18.68% and 48%, 36, 16 in Gond and Arsema forests respectively.

In Gond Teklehaymanot Monastery forest *Fabaceae* was the dominant family (11 species) followed by *Oleaceae* (4 species). In Arsema Monastery forest, *Fabaceae* was the dominant species followed by *Euphorbiaceae* and *Oleaceae* (5 five species each). Thus, *Fabaceae* and *Oleaceae* are the species rich families in the two forests. The dominance of *Fabaceae* in species contribution is reported in several previous studies (Hailab *et al*., 2011; Molla, 2016; Mesifin *et al*., 2018). This might be due to the adaptation potential to wider agroecologies and dispersal mechanism efficiency of *Fabaceae* species.

The number of plant species from the forests of the two Monasteries are lower than some of the dry afromontane forests of Ethiopia, for instance Tara Gedam and Abebaye forests (Haileab *et al*., 2011), and Alemsaga Forest (Getinet *et al*.,2015), had relatively higher species composition compared to the present study. Contrary to Jibat Forest (Tamirat, 1994), Menagesha-Suba State Forest (Abate, 2007) and Yemrehane Kirstos Church Forest (Ayanaw and Gemedo, 2018) had lower species richness than Gond Teklehaymanot and Arsema Monastry forests. Species composition variation among these different forests might be attributed to altitudinal difference, size of the forests, anthropogenic activities and grazing.

Three endemic plant species, *Acanthus sennii* (shrub) and *Erythrina burcei* and *Millittia ferruginea* (trees) were identified at the study areas. *Acanthus sennii* was found in both forests whereas *Erythrina burcei* and *Millittia ferruginea* were found only in Gond Teklehaymanot Monastery. The three endemic species were also recorded from six Awi Zone forest patches (Abiyot, 2017) and two of them were identified in Alemsaga forest (Getinet *et al*., 2015). Compared to other previously studied dry evergreen afromontane forests (Haileab *et al*., 2011; Gojjam, 2013; Getinet *et al*., 2015), the forests of the two Monasteries have lower endemic species distribution. This might be attributed to the less habitat heterogeneity and size of the two forests which could contribute minimal isolation of the species.

Plant Community Types

Cluster analysis of vegetation data of Gond Teklehaymanot Monastery forest generated four community types. These were *Carrissa spinarum-Rhus vulgaris*, *Myrica salicifolia-Dombeya torida*, *Pittosporium viridiflorum-Ackokanthera shimperi* and *Juniperous procera-Schefflera Abyssinica* community types (Table 1).

Table 1. Communities with thier plots in Gond Teklehaymanot Monastery Forest

Communities	Plots found in communities	Richness	Diversity	Evenness	Elevation range (m)
C1	1, 2, 3, 4, 5, 6, 7,17, 18,20,21,40	60	3.61	0.88	2135 -2361
C2	8, 9, 12, 14, 15, 16, 19, 22, 23, 24,25, 26, 30, 37, 38	71	3.71	0.87	2317-2471
C3	10, 11, 31, 34, 35, 39	54	3.55	0.89	2314 -2488
C4	13, 27, 28, 29, 32, 33, 36	54	3.57	0.90	2354 -2446

Carrissa spinarum-Rhus vulgaris Community (C1)

Species in this community type were distributed between the altitudinal ranges of 2135 -2361 m a.s.l. The community contained 12 plots and 60 species (Table 1). Along with dominant species used to name the community, *Acalypha fruticosa*, *Calpurnia aurea*, *Maytenus arbutifolia* and *Clerodendrum myricoides* were dominant species in the shrub layer. *Grewia ferruginea* and *Acacia seyal* were the dominant tree species. *Jasmmium abyssinicum* and *Asparagus africanus* were the dominant climbers in the community (Table 2). The community is dominated by shrubs. Most of medium sized trees were removed by local communities for different purposes, such as construction, charcoal production, and fire wood and for preparation of agricultural materials (communication with monks during data collection).

Myrica salicifolia-Dombeya torida Community (C2)

Speciies in this community were mainly distributed in altitudinal ranges from 2317-2471 m a.s.l. It was represented by 15 plots (Table1) and 71 species. This community is the most diverse and contained the highest number of species which might be due to restricted disturbance since most of the plots were found around the church (Table 1). Apart from the dominant species used to name the community, *Albizia gummifera* was the dominant tree species. The dominant climber in the community was *Pterolloblum stellantum*. *Hibiscus macranthus*, *Euclea racemosa* and *Caparis tomentosa* were among the dominant species in the shrub layer (Table 2)

Pittosporium viridiflorum-Ackokanthera shimperi Community (C3)

This community was represented by 6 plots and 54 woody species distributed along the alititudinal ranges between 2314 and 2488 m a.s.l. The community was represented by least numbers of plots and species (Table 1). It was found on the uphill side of the mountanious area in which river is found and largely distributed in the western part of the monastery. The dominant tree species in this community was *salix sebserata* and *Croton macrostachyus*. *Ackokanthera shimperi* was the most dominant shrub in the community (Table 2).

Juniperous procera-Schefflera abyssinica Community (C4)

This community type was represented by 7 plots (Table1) and 54 woody plant species and located between the altitudinal ranges of 2354 and 2446 m a.s.l. In this community *Juniperus procera* was the dominant tree species and cover relatively large part of the area. *Allopphyllus abyssinicus* was the dominant tree species. The dominant species in the shrub layer was *Myrsine africana* (Table 2).

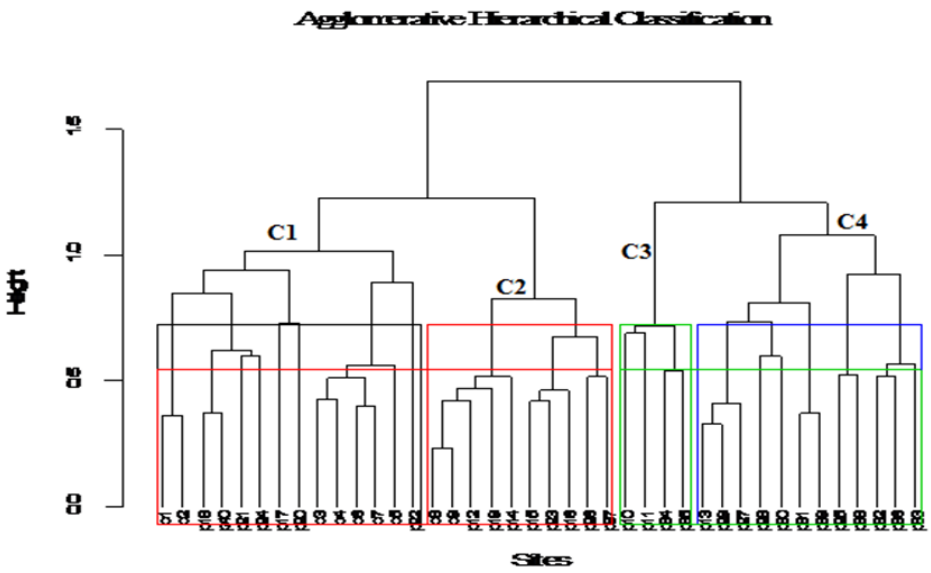

Figure 3. Dendrogram of vegetation data for Gond Teklehaymanot forest.

Table 2. Synoptic value for Gond Teklehaymanot species with the value>1(species used to name communities are in bold)

Species name	C1	C2	C3	C4
Carissa spinarum	5.17	2.33	1.67	3.43
Rhus vulgaris	3.67	3.07	0.00	1.43
Grewia ferruginea	2.83	1.67	0.00	2.00
Myrica salcifolia	0.00	5.40	0.67	2.29
Dombeya torrida	0.58	3.87	0.33	1.14
Pteroloblum stellautm	2.83	3.13	1.33	1.43
Acokanthera schimperi	2.25	2.40	4.00	2.71
Calpurnia aurea	2.58	1.80	0.17	1.57
Pittosporium viridiflorum	1.67	1.67	2.17	1.86
Capparis tomentosa	1.08	1.67	1.50	1.43
Maytenus arbutifolia	2.08	1.60	0.67	1.29
Jasminum abyssinicum	1.58	1.53	1.33	0.71
Dodonaea angustifolia	1.92	1.27	1.33	1.57
Schefflera abyssinica	0.67	1.00	1.33	3.00
Croton macrostachyus	0.17	1.00	1.83	1.00
Asparagus africanus	2.08	0.80	0.00	1.43
Juniperus procera	0.00	0.53	3.17	7.86
Acacia seyal	2.00	0.07	0.00	0.29

Species richness, evenness and diversity of plant communities in Gond Teklehaymanot Monastery forest

Diversity analysis of the vegetation data showed that the four communities had minimal varations in species richness, diversity and evenness (Table 1). Community C2 had the highest number of species (71) and diversity (3.71) whereas community 3 and 4 had relatively the least species richness (54 each) and diversity (3.55 and 3.57 respectively). The four communities showed nearly equivalent species evenness and had high or equitable distribution of individuals of each species (Table1). Community 4 had relatively highest species evenness (090) and community 2 was the least (087).

Species similarities among communities in Gond Teklehaymanot Monastery

Sorenson coefficient of similarity index among the 4 communities ranges from 0.61 to 0.8 (Table 3). The highest similarity was observed between community 4 and 1(80%) whereas the least similarity was between community 3 and 1. The similarities among other communities were intermediate between the mentioned ones. Topographic features, distance between communities, grazing, human disturbance and other environmental factors might contribute for differences and similarities in species composition among the community types.

Table 3. Sorensen's similarity coefficient of communities in Gond Teklehaymanot Forest.

Community	1	2	3	4
C1	1.00			
C2	0.76	1.00		
C3	0.61	0.74	1.00	
C4	0.8	0.79	0.7	1.00

Plant communities in Arsema Monastery Forest

The recognized community types in Arsema Monastery forest are briefly described below.

Table 4. Communities with their representative sites in Arsema Monastery forest.

Communities	Plots	Richness	H'	J	Elevation range (m)
C1	1, 3, 4, 5, 6, 7, 8,9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 23, 25, 26, 27, 28, 31, 38	70	3.79	3.89	2114-2275
C2	2, 21, 22, 24,29, 30, 32, 33, 34, 35, 36, 37, 39, 40	66	3.78	3.90	2123-2245

Acacia seyal-Allophylus abyssinicus (C1)

This type of community was found in altitudinal ranges between 2114-2275 m a.s.l. Species in this community were distributed in 26 plots. The dominant tree spesies in this community were *Allophyllus abyssinicus*, *Grewia ferruginea* and *Prunus africanus*. *Pterolloblum stellauutm was the* dominant climber species whereas *Acalypha fruticosa*, *Rhus vulgaries* and *Maythenus arbutifolia* were the dominant species in the shrub layer (Table 5). This community contained higher number of plots than community 2. Since plots comprising this community type were largely found at the edge of the forest it is highly encroached by

agricultural activities and grazing of the Monastery livestocks.

Euclea racemosa-Stereospermum kunthianum community (C2)

This community was found in an altitudinal range between 2123-2245 m a.s.l. This community comprised 14 plots and 66 woody plants. The dominant tree species in the community were *Olea europaea* sub spp. *cuspidata* and *Albizia gumifera*. *Euclea racemosa* and *Clerodendron myricoids* were dominant shrubs species in the community. The dominant climber in this community was *Jasminum grandiflorum* (Table 5). Plant community pattern of distribution is the manifestation of phiscal gradients (microhabitat, aspect, slope, soil heteroginity and elevation), biotic responses to physical gradients and historical disturbances (Tadess, 2003). In a similar manner, such factors may influence plant community formation of the study areas.

Species richness, evenness and diversity of plant communities in Arsema Monastery Forest

Diversity index analyses of vegetation data showed that the two communities had high species diversity. In relative terms, community 1 has higher species diversity and richness than community 2. On the contrary, evenness was higher in community 2 than community 1, though both communities had fairly distributed individuals of species (Table 4).

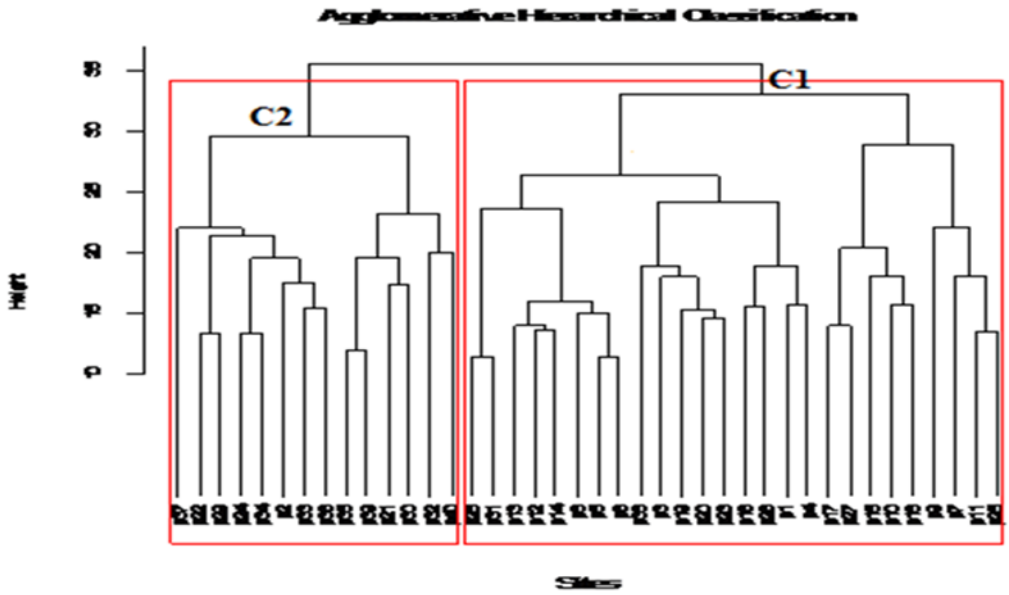

Figure 4. Dendrogram of vegetation data for Arsema Monastery forest.

Table 5. Synoptic cover abundance value for species with synoptic cover value > 1 **(**species used to name communities are in bold).

Species	C1	C2
Carissa spinarum	5.15	6.00
Pteroloblum stellautm	**5.15**	1.29
Acacia seyal	**5.12**	2.43
Caesalipinea spinosa	**3.96**	3.07
Allophylus abyssinicus	**3.12**	2.00
Rhus vulgaris	**3.08**	2.86
Grewia ferruginea	**2.85**	1.00
Acalypha fruticosa	**2.69**	2.14
Maytenus arbutifolia	**2.58**	2.07
Combertum molle	**2.35**	2.14
Prunus africana	**2.31**	1.07
Osyris quadripartita	**2.27**	1.86
Euclea racemosa	1.62	**3.50**
Stereospermum kunthianum	1.92	**3.07**
Olea europaea sub spp. *cuspidata*	1.73	**2.43**
Albizia gummifera	1.81	**1.79**
Nuxia congesta	0.92	**1.71**
Clerodendrum myricoides	1.12	**1.50**
Pittosporium viridiflorum	0.54	**1.43**
Clausena anisata	0.62	**1.29**
Jasminum grandiflorum	0.58	**1.21**

Similarity among the community types in Arsema Monastery Forest

Sorenson's similarity coefficient of the two communities was 0.9 (90%), which is higher than 0.5 indicating higher species similarity between the two communities.

Speciecies richiness and composition of Gond Teklehaymanot and Arsema Monastery forests

In comparison, Gond forest had higher species richness than Arsema. This might be arttibuted to size and successional stage of the forest species. Gond forest is relatively larger in size and aged forest which could contribute to its higher species richness. Sorensen's coefficient generated from the analysis of the two vegetation data indicated that the two sacred forests had greater species similarity (72%) which might be attributed to topographic characteristics and short distance between the two forests. Thirty-one species were found only in Gond Teklehaymanot whereas 15 species were only found in Arsema monastry. The rest species were common in both study areas. This slight difference in species composition might be slight differncec altitudine and anthropogenic activities.

Vegetation Structure

Frequency

In Gond Teklehymanot Forest, the most frequent species was *Olea europaea* sub spp. *cuspidata* (98%) followed by *Carissa spinarum* (83%), *Pteroloblum stelautum* and *Acokanthara schmperi* (70% each), *Albizia gumimifera* and *Euclea racemosa* (68% each) and *Rhus vulgaris* (65%). *Stereospermum kunthianum*, *Millettia ferruginea*, *Brucea antidysenterica*, *Prunnus africana*, *Buddleja davidii*, *Acanthus sennii*, *Erythrina brucei*,

Maesa lanceolata, and *Cordia africana* (with the frequency ranging from 0.03-0.05%) were among the least frequent species.

The most frequent woody species in Arsema Monastery forest was *Acacia seyal* (83%) followed by *Osiris quadripartite* (78%), The most frequent woody species in Arsema Monastery forest was *Acacia seyal* (83%) followed by *Osiris quadripartite* (78%), *Pteroloblum stelautum*, *Carisa spinarum* and *maytenus arbutifolia* (75% each) and *Combretum molle* (68%). *Gardenia ternifolia*, *Vitex doniana*, *Ficus sycomorus*, *Ficus sur* and *Prunnus africana* (3% each) followed by *Cordia africana*, *Jasminum abyssinicum*, *Helinus mystacinus* (5% each) were the least frequent woody species. *Pteroloblum stelautum* and *Carisa spinarum* were highly frequently species in both study areas.

The most frequent species in Gond Teklehymanot forest, *Olea europaea* sub spp. *cuspidata*, was reported in Yimrhane Kirstose forest as the second most frequent species (Amanuel and Gemedo, 2018). With regard to frequency classes, the numbers of species in the lower classes were higher than the number of species in the higher frequency classes. The higher frequency class in Arsema forest was represented by only 15 species (class 4 and class 5). The fifth frequency class contained only one species which accounted 83% frequency (*Acacia seyal*). The remaining species were represented on the first, second, and third frequency classes (Fig. 5).

The shape of the figure looks like interrupted inverted 'J' shape which represents higher number of species in the lower classes than that of the higher classes, and this showed heterogeneity of the vegetation. The variation in frequency between species might be attributed to habitat differences, habitat preferences among the species and species characteristics for adaptation. Such pattern of frequency distribution could reveal most species in the forest are less frequent. Similar result was reported in Abebaye and Tara Gedam forests (Haileab *et al*., 2011), Yegof forest (Mesfin *et al*., 2018) and Yimrhane Kirstose Church forest (Amanuel and Gemedo, 2018).

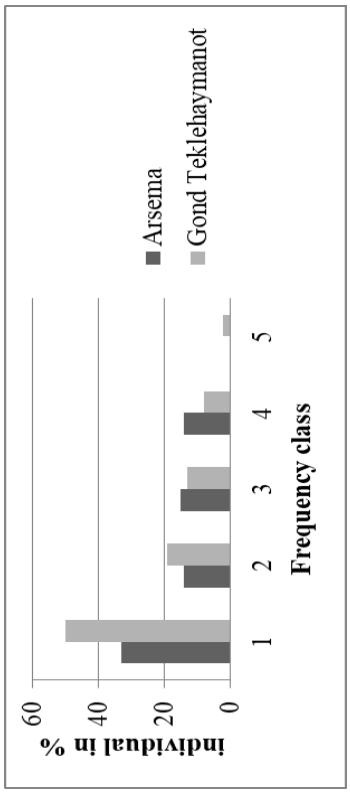

Figure 5. Frequency of woody species for Gond Teklehaymanot and Arsema Monastery Forests Frequency classes: 1=<20%, 2 = 11-40%, 3 = 41-60%, 4 = 61-80% and 5 = 81-100%

Density

The total densities of seedlings, saplings and adults in Gond Teklehaymanot Forest were 1298.75, 795.63 and 1422.5 ha^{-1}respectively whereas the total density of seedlings, saplings and adults in Arsema Forest were 1297, 942.5 and 843.75 ha^{-1} respectively.

In Gond Teklehaymanot Monastery Forest adults contributed 40.5% to the total forest density. *Olea europaea* sub spp. *cuspidata* contributed the largest individual ha^{-1} (11.03%) to the adult woody species density (1422.5 individual ha^{-1}) followed by *Acokanthera schimperi* (5.36%) whereas

Diospyros abyssinica, *Myrsine africana*, *Schinus molle*, *Ximenia Americana* and *Ziziphus spina-christi* accounted for the lowest density (0.04% each).

In Arsema Monastery Forest, *Carissa spinarum* contributed 11.04% individuals ha^{-1} followed by *Pteroloblum stellautm* (7.41% ha^{-1}) whereas *Cavratica gracilis*, *Ekeberja acapensis*, *Ficus sur*, *Ficus sycomorus, Ficus vasta* and *Gardenia ternifolia* contributed the least (0.07% ha^{-1} each). Such result reflected variability in abundance among the plant species that could arise from differences in anthropogenic activities, dispersal factors and environmental variables which suited differently for different species.

In the first class of Gond Teklehaymanot Monastery forest, there were 31 species which accounted for 34.06 % (Fig. 6) of the total adult woody species. Those adult woody species, with highest density were found in density class 7 which contained only 4 species. Species found in this class contributed 375 individuals ha^{-1}.

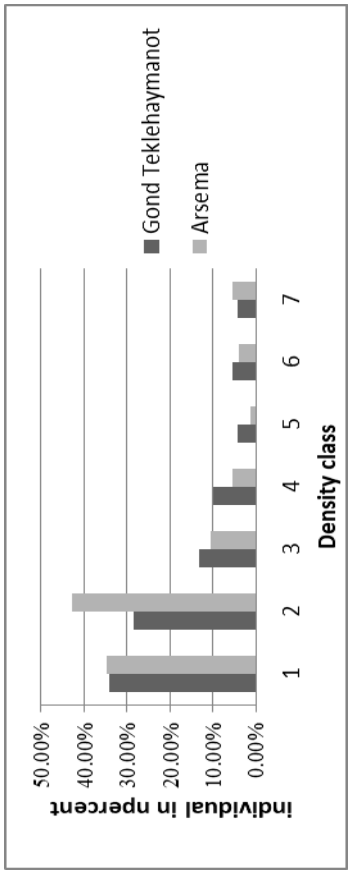

Figure 6. Density distributions of matured woody species for both study areas

In Arsema Monastery Forest, the highest density of matured woody plants was observed in class seven which accounted for 18.44% (Fig. 6) and contributed by only two species whereas class six contained three species with density of 136.87 ha^{-1}. Adult woody plant species in density class five was represented by 1 species. In both studies forests the trend of species distribution over the density classes showed decreasing order from the lower to the higher density classes. Such pattern of distribution was also reported in similar previous studies such as Motuma *et al.* (2010), Haileab *et al*., 2011), Getinet *et al* (2015) and Mesfin *et al*. (2018). This trend of distribution could mean most species contribute small number of individuations to the vegetation.

Diameter at breast height

In Gond Teklehaymanot forest, *Carissa spinarum*, *Rhus vulgaris* and *Acokanthera schimperi* contributed higher number of individuals for the lower DBH classes whereas *Olea europaea* sub spp. *cuspidata*, *Schefflera abyssinica*, *Myrica salicifolia*, *Ekeberja capensis*, *Ficus sur* and *Juniperus procera* contributed for the higher DBH classes. Most woody species were distributed in the first and second DBH classes in both study areas indicating that the forests are composed of young trees and shrubby species (Fig. 8).

The general pattern of DBH class distribution of Gond Teklehaymanot and Arsema Monasteries forests showed an inverted 'J' shaped distribution. Inverted 'J' shape suggests satisfactory reproduction but poor recruitment (Simon and Girma, 2004) and considered to be with stable population structure. Similar results were observed in, Dello Menna (Motuma *et al*., 2010), Sesa Mariam Monastery (Birhanu Wolde *et al*., 2015), Alemsaga (Getinet *et al*., 2015) and Yimrhane Kirstose Church forest (Amanuel and Gemedo, 2018). This general structure of the vegetation showed that medium and slightly large sized individuals might be detached by the local community (Birhanu *et*

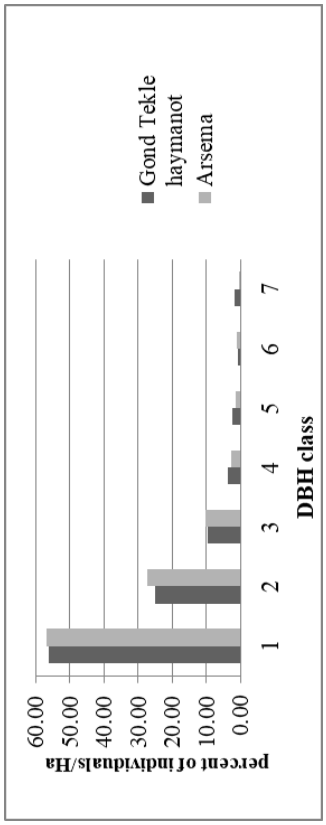

Figure 7. DBH classes of the two study Forests DBH classes 2.5-10cm =1, 10.01-20=2, 20.01-30 =3, 30.01-40 =4, 40.01-50 =5, 50.01-60 = 6, >60 =7

al., 2016) or the areas might be protected in recent times where the species are in earlier successional stages.

Population structure

In Gond Teklehaymanot, seven patterns of population structures were revealed (Fig. 8A-G). The first pattern was bell-shaped distribution formed by species with higher number of individuals in the middle DBH classes. Species such as *Ficus vasta* and *Acassiya abessinica* (Fig. 8G) were characterized by this distribution. This pattern might happen due to trampling of young stages and selective cutting of aged individuals for different purposes. The second pattern was seen on *Hypericum quartinianum* (Fig. 8A) which showed broken inverted J-shaped diameter class distribution. This showed that there might be selective cutting of the species for different purposes like fuel wood. The third pattern was represented by inverted 'J' shape, in this pattern, representative species showed high density in the lower DBH classes and decreases in the higher DBH classes. This type of pattern is considered as the normal population structure and was represented by *Albizia gummifera* (Fig. 8B). The fourth population structure showed Zigzag pattern. *Juniperous procera* exhibited this type of distribution pattern (Fig. 8C). Inturuption of some stages, in this patten, might be the life strategy of the species to adapt the climatic and ecological condition of its natural environment. The fifth pattern was represented by *Olea Europeae* subsp *cuspidata* and *Schefflera abyssinica* (Fig. 8D) with interrupted inverted 'J' shape types of distribution.

In such pattern, the density of all individuals in the first group partially decreased with increase DBH up to some points and then increases with increasing DBH in the second group. The pattern continues to decrease with increasing DBH and finally ends with increasing density as DBH increases. Selective removal of some individuals at different stages of development might result this pattern. The sixth pattern consists of those species that occur only in the first and second DBH classes, but absent in the rest DBH classes. *Combretum molle* (Fig. 8E) was the representative of this structure. This might be due to selective cutting of trees in the middle and higher DBH class. In addition, some species, by their nature, do not grow into large diameter size. The seventh pattern was species only found in the middle DBH classes. This type of pattern mainly occurred in *Cordia africana* (Fig. 8F). This pattern might appear due to the current increase trampling of young stages and selective removal of matured ones.

In Arsema Monastery Forest, though similar in population structure with Gond Teklehaymanot Forest, most of the species were shrubby and small sized trees. In this Forest 5 population patterns were observed.

The first pattern was inverted 'J' shape. *Acacia seyal* and *Stereospermum kunthianum* were the representatives of this structure (Fig. 9C). The second pattern was bell shape. *Acacia abyssinica* represented this type of structure (Fig. 9A).

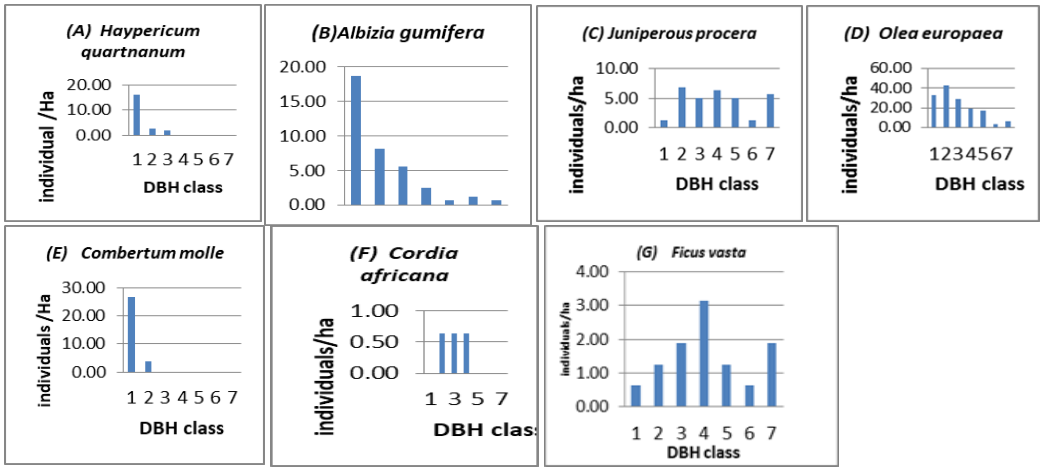

Figure 8. Population structure of selected species in Gond Teklehaymanot Monastery.

The third pattern represents species in the first and higher DBH classes were missed, but in the second and third DBH classes individuals were present. The representative of this pattern was *Allophylus abyssinicus* (Fig. 9B).The fourth pattern was represented by broken inverted 'J' shape. In this population structure, an individual in the first class were higher but progressively decreased to the middle classes and finally missed in the higher classes. *Carissa spinarum* (Fig. 9E) was the representative of this DBH class. The fifth structure was species found in the first and second class but in the middle and higher classes completely deficient. *Croton macrostachyus* (Fig. 9D) was the representative of this structure.

In general, the vegetation structures of the study areas were hampered due to cattle grazing and different anthropogenic activities. Gond Teklehaymanot, relatively, had large sized trees, though trees were removed for different purposes such as selective cutting for construction or firewood which are common practices in the study areas. In contrast, Arsema Monastery forest had immature vegetation and most of the plant species were found in young tree stages or shrubby.

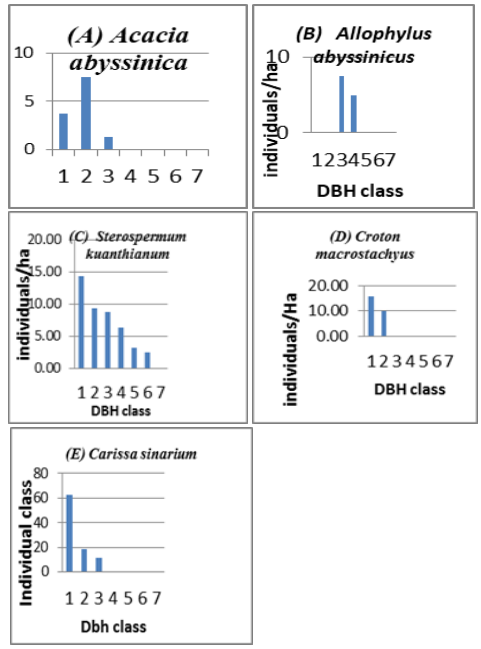

Figure 9. Population structure of selected species in Arsema forest

As mentioned, in the study forests, different species appear with different structural pattern which could be resulted from the effects of different factors. Inverted J shape distribution indicates health regeneration of the species. Such pattern was also reported by Feyera *et al*. (2007), Motuma *et al*. (2010)

and Getinet *et al*. (2015). J shape pattern rveals poor reproduction and weak regeneration. This pattern was also reported in the studies of Feyera *et al* (2007) and Getinet *et al*. (2015). Gauss type or bell shap distribution is a pattern with poor reproduction and recruitment which could arise due to removal of seed breaning individuals. Feyera *et al*. (2007) and Hailab et al (2011) are among the workers who reported such pattern of distribution. The zigzag pattern is a pattern which showed irregular distribution of individuals in the DBH classes. Getinet et al. (2015).

Basal area

The total basal area of woody species (DBH > 2.5 cm) in Gond Teklehaymanot and Arsema Monastery forests were 35.63 and 9.16 m^2ha^{-1} respectively. In Gond Teklehaymanot forest, the most important woody species with respect to basal area was *Olea europea* sub spp. *cuspidata* (9.99 m^2ha^{-1}) followed by *Juniperus procera* (4.06 m^2ha^{-1}) (Table 6).

Table 6. Basal area of selected species in Gond Teklehaymanot Monastery forest

Plant Species	Basal area (m^2ha^{-1})	Percentage (%
Olea europea sub spp. *cuspidata*	9.99	28.03
Juniperus procera	4.06	11.4
Schefflera abyssinica	2.93	8.21
Salix sebserata	3.43	6.02
Albizia gummifera	1.84	5.16
Ekebergia capensis	1.43	3.99
Erythrina brucei	1.28	3.58
Ficus sur	1.28	3.58
Allophylus abyssinicus	0.88	1.28

In Arsema Monastery forest, *Erythrina abyssinica (*0.91 m^2 ha^{-1} or 9.89%) and *Euphorbia candelabrum* (0.89 m^2 h^{-1} or 9.75%) contributed larger proportions to the total basal areas (Table 7). The reason for variation in basal area is the presence of older-more aged and big trees in Gond Teklehaymanot Forest than Arsema monastery Forest. Basal area is a better measure of the relative importance of the species rather than simple stem count (Derege, 2006). For that matter, species with the largest basal area are considered as the most important woody species in the study area. Spesies like *Olea europaea* sub spp. *cuspidata,* which has higher BA, are the most important woody species in the area.

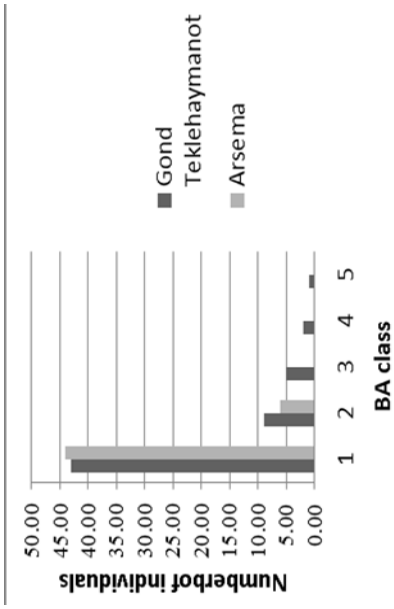

Figure 8. Basal area of Gond Teklehaymanot and Arsema Monastery forests

Table 7: Basal area of selected species in Arsema Monastery forest

Plant species	Basal area	Percentage
Erythrina abyssinica	0.91	9.89
Euphorbia candelabrum	0.89	9.75
Olea europaea	0.73	7.91
Caesalpina spinosa	0.61	6.62
Acacia seyal	0.53	5.80
Ekebergia capensis	0.51	5.59
Acacia brevispica	0.41	4.23
Stereospermum kunthianum	0.39	4.23
Carissa spinarum	0.29	3.14

In Gond Teklehaymanot, about 57% of the total basal area was distributed in the lower diameter classes (Fig. 10) whereas in Arsema Monastry Forest, almost all spesies was found in the firist and second BA classes. From the result, it can be said that basal area does not depend on the number of species rather on the size of the species, because plant species that contained lower density had higher basal area. For instance; *Scheffler aabyssinica*, *Ficus sur* and *Ekeberja capensis* had lower density but they had higher basal area. This revealed that species with the highest basal area do not necessarily have the highest density, indicating size difference between species (Gemedo and Amanuel, 2018). The study Forests had smaller basal areas than Tara Gedam, Abebaye, Manna, Sese, Alemsaga and Yemirihane Kiristos basal areas. However, Gond Teklehaymanot had higher basal area than Jimma, Yegof, Amoro, and Woynwuha basal areas (Table 8). This might be due to the dominance of smaller sized tree species and shrubs in the studied areas which can be related to the age of establishment.

Table 8. Basal area Comparison of Gond and Arsema Monastery forests with other forests

Study area	Basal area (m^2ha^{-1})	Source
Gond Teklehaymanot	35.63	Current study
Tara Gedam	111.36	Haileab *et al.* (2011)
Arsema	9.16	Curreent study
Abebaye	49.43	Haileab *et al.* (2011)
Alemsaga	75.37	Getinet *et al.* (2015)
Yimrhane Kirstos	72	Amanuel and Gemedo (2018)
Yegof	15.85	Mesfin *et al.* (2018).

Important Value Index

In Gond Teklehaymanot Monastery Forest, *Olea europea* sub spp. *cuspidata* emerged as the most important species with an index value of 40.04, followed by *Juniperus procera* (14.69). *Ziziphus spina-christi* (0.19), *Ficus thonningii* (0.21), *Calotropis procera* (0.23), *Stereospermum kunthianum* (0.35) and *Justicia schimperiana* (0.41) were species with lower IVI (Table 9). Important value index is used to compare the ecological significance of species (Lamprecht, 1989) in which high IVI value indicates that the species sociological structure in the community is high. Accordingly, species with higher value of IVI were identified as important and most dominant of a particular vegetationt (Simon Shibru and Girma Balcha, 2004). In addition, IVI shows the treat status of the species where a species with higher IVI are not endangerd and needs regular monitoring only whereas species with lower IVI are at risk of local extiniction which need immediate conservation measures. This justification might not work for naturally rare species which could happen due to their extreme habitat spesficity.

Table 9. IVI of ten woody species of Gond Teklehaymanot Monastery.

Species name	**RD**	**RF**	**RDO**	**IVI**
Olea europaea sub spp. cuspidata	7.06	4.95	28	40.02
Juniperus procera	1.37	1.92	11.40	14.69
Acokanthera schimperi	5.75	3.54	2.05	11.34
Albizia gumifera	2	3.44	5.16	10.60
Schefflera abyssinica	0.63	1.41	8.21	10.26
Rhus vulgaries	4.21	3.28	1.7	9.19
Myrica salcifolia	3.84	2.78	2.39	9.00
Pittosporium viridiflorum	3.55	2.78	2.19	8.52
Dombeya torrida	3.51	3.18	1.81	8.50
Carrissaspinarum	2.64	4.19	1.03	7.87

Table 10. B**asal area** of selected woody species in Arsema Monastery forest.

Species	**RD**	**RF**	**RDO**	**IVI**
Maytenus arbutifolia	10.6	3.59	0.20	14.46
Acacia seyal	4.5	3.98	5.8	14.33
Erythrina abyssinica	0.9	2.39	9.89	13.26
Ceasalpinia spinosa	2.18	3.5	6.62	12.30
Olea europaea	1.25	2.63	7.91	11.8
Pteroloblum stellautm	7.65	3.59	0	11.24
Carrissa spinarum	4.73	3.59	3.14	11.46
Euphorbia candelabrum	0.64	0.14	9.75	10.53
Stereospermum kunthianum	2.95	3.02	4.23	10.19
Osyris quadripartita	4.81	3.74	1.5	10.05

In Arsema Monastery forest, the highest IVI value was recorded in *Maytenus arbutifolia* (14.46). Accordingly, 10 species in decreasing IVI values are listed in table 10. These spesies were the most ecologically significance plants whereas species which were found in the lower rank of IVI were *Hibiscus macranthus*, *Diplolaphium africanum*, *Calotropis procera*, *Vitex doniana* and *Gardenia ternifolia* which need special conservation priorities.

Regeneration Status

In Gond Teklehaymanot, a total 1298.75 seedlings ha^{-1}, 795.63 saplings ha^{-1}, and 1422.5 adults ha^{-1} were found whereas in Arsema Monastery a total 1297.5 seedlings ha^{-1}, 942.5 sapling ha^{-1}, and 843.75 adults ha^{-1} were encountered.

In Gond Teklehymanot Forest, species contributed for higher desity were *Pteroloblum stelautum*, *Maytenus arbutifolia*, *Calpurniaaurea*, *Acokathra schimperi* and *Myrcine Africana.* In Arsema Monastery forest, *Pteroloblum stelautum*, *maytenus arbutifolia* and *Cassia singueana* contributed the largest proportions of the total number of seedlings. In Gond Teklehaymanot forest *Rhus vulgaris*, *Capparis tomentosa*and *Calpurnia aurea* were woody species contributed higher number of saplings. Similarly, *Combretum molle*, *Osyris quadripartita* and *Acacia seyal* contributed higher number of saplings for Arsema Monastery forest.

In Gond Teklehaymanot Monastrey forest, *Olea europaea* and *Acokanthera schimperi* contributed higher density of adult whereas *Carissa spinarum* and *Pteroloblum stellautm* contributed higher density of adults for Arsema Monastrey Forest. In Gond Teklehaymanot, *Erythrina abyssinica*, *ficus thonninggi*, *Lannea fruticosa*, *Schefflera abyssinica* and *Ziziphus spina-christi* survived only at matured stages whereas in Arsema, *Ekebergia capensis*, *Erythrina abyssinica*, *Euphorbia candelabrum*, *Ficus sur*, *Ficus sycomorus*, *Ficus vasta*, and *Vitex doniana* were species without juveniles. These species are at risk of local extinction and needs priority in conservation measures.

Successful regeneration of a species is determined by the survival of seedlings which are sensitive stages needed for long-term sustainability of forests (Malik and Bhatt, 2016). Gond Teklehaymanot Monastry forest was in fair regeneration status (where seedlings >saplings < adults) whereas Arsema Forest was in good regeneration status (Seedlings >saplings >adults). The reason for fair regeneration status might be amputation of medium sized trees/shrubs for fire wood. Some species only survives at seedling stage others only survived at sapling and few species were found only at matured stages. Based on the above information plants which are found only in seedling stages are at good regeneration status and needs monitoring management. Species found without seedling or represented by few seedlings should get the first priority for conservation. Species with out matured stage needs applying different conservation measures.

Conclusion and Recommendations

Conclusion

Results of this study revealed that the two monastery forests harbor good number of woody plant species serving as *in-situ* conservation sites. Structural data analysis indicated that the forests are largely composed of young tree and shrubby species indicating that the forests are not aged or disturbed. Result from regeneration status data showed that the forests are at least in fair regeneration status. IVI and regeneration status results indicated that there are some species with few or no juveniles and/or few numbers of adult individuals that need immediate conservation measures.

Recommendations

Based on the current findings, the following points were recommended for future consideration of the sacred forests.

- Species under low IVI values and in poor regeneration status needs special priorities for conservation measures.

- Participatory forest management programme should be implemented to aware and encourage the communities to plantindigenous and suitable exotic tree species in the agroforestry systems in order to reduce the pressure on the natural forests.
- Detail study on the seed bank, mechanisms of the survival and recruitment of seedlings of tree species in the forest patches, influence of environmental and disturbance factors need to be considered for more comprehensive sympathetic of the ecosystem.

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Appendix: List of plant species collected in the study Forests

Scintific name	Familly	H	Gond	Arsema
Acacia abyssinica subspp. Abyssinica.	Fabaceae	T	*	*
Acacia brevispica Harms.	Fabaceae	T	*	*
Acacia lahaisteud Hochst. Ex. Benth.	Fabaceae	T	_	*
*Acacia nilotica (*L.) Willd	Fabaceae	T	*	*
Acacia seyal Del.	Fabaceae	T	*	*
Acalypha fruticosa (A.D.C) F. wheat.	Euphorbiaceae	S	*	*
Acanthus sennii Chiov.	Acanthaceae	S	*	*
Acokanthera schimperi (A.DC.) Schweinf.	Apocynaceae	S	*	_
Agave sisalina	Astraceae	TS	_	*
Albizia gummifera (J.F. Gmel.) C.A.Sm.	Fabaceae	T	*	*
Allophylus abyssinicus (Hochst.)	Sapindaceae	T	*	*
Arundo donax L.	Poaceae	S	*	_
Asparagus africanus Lam.	Asparagaceae	C	*	*
Bersama abyssinica Fresen.	Melianthaceae	T	*	*
Bridelia micrantha (Hochst.) Brain.	Euphorbiaceae	T	_	*
Brucea antidysenterica Swiss. Chard.	Simaroubaceae	S	*	_
Buddleja davidii Franch.	Loganiaceae	T	*	_
Buddleja polystachya Fresen.	Loganiaceae	T	*	*
Caesalpinia spinosa (Mol.) Ktz.	Rhamnaceae	T	_	*
Calotropis procera L.	Asclepiadaceae	S	*	*
Calpurnia aurea (Ait.) Benth.	Fabaceae	S	*	*
Capparis tomentosa Lam.	Capparidaceae	T	*	*
Carissa spinarum L.	Apocynaceae	S	*	*
Cassia singueana (Del.)	Fabaceae	S	*	*
Cavratica gracilis (Guill. & Perr.) Suesseng	Vitaceae	C	*	*
Clausena anisata (Willd.) Benth.	Rutaceae	S	*	*
Clematis hirsutum Perr. & Guill.	Ranunculaceae	C	*	*
Clematis simensis Fresen.	Ranunculaceae	C	*	*
Clerodendrum myricoides (Hochst.) Vatke.	Lamiaceae	S	*	*
Clutia lanceolata Forssk.	Euphorbiaceae	S	*	*
Combretum molle R.Br.ex.G. Don	Combretaceae	T	*	*
Commelina africana	Commelinaceae	S	*	_
Cordia Africana Lam.	Boraginaceae	T	*	*
Croton macrostachyus Del.	Euphorbiaceae	T	*	*
Dichrostachys cinerea Wigt & Am	Fabaceae	T	*	*
Dioscorea prahensilis Benth	Dioscoreaceae	C	*	_
*Diospyros abyssinica (*Hiem) F. Wite.	Ebenaceae	T	*	*
Diplolaphium africanum Fresen.	Apacieae	S	_	*
Dodonaea angustifolia L. f	Sapindaceae	S	*	*
Dombeya torrida (J.F. Gmel.) P. Bamps	Sterculiaceae	T	*	_
Dovyalis abyssinica (A. Rich.) Warb.	Flacourtiaceae	S	*	_
Drege arubicunda Schum.	Asclepiadaceae	C	*	_

Appendix Continued

Scintific name	Familly	H	Gond	Arsema
Ekebergia capensis Spamn.	Meliaceae	T	*	*
Embelia schimperi Vatke.	Myrsinaceae	S	*	_
Erythrina abyssinica Lam. ex DC.	Fabaceae	T	_	*
Erythrina brucei Schweinf.	Fabaceae	T	*	_
Eucalyptus camaldulensis Dehnh.	Myrtaceae	T	*	*
Euclea racemosa Hiern.	Ebenacea	S	*	*
Euphorbia candelabrum Kotschy.	Euphorbiaceae	T	_	*
Euphorbia tirucalii L.	Euphorbiaceae	S	_	*
Ficus carica L.	Moraceae	S	*	_
Ficus sur Forssk.	Moraceae	T	*	*
Ficus sycomorus L.	Moraceae	T	_	*
Ficus thonningii Blume.	Moraceae	T	*	_
Ficus vasta Forssk.	Moraceae	T	_	*
Gardenia ternifolia Schumach. &Thonn.	Rubiaceae	T	_	*
Gladiolus candidus L.	Araceae	C	_	*
Grewia ferruginea Hochst.ex A. Rich.	Tiliaceae	T	*	*
Helinus mystacinus (Ait.) E. Mey. ex Steud.e	Rhamnaceae	C	*	*
Heteromorpha arborescens (Spreng.) Cham. &Schldl.	Apiaceae	T	*	_
Hibiscus macranthus Hochst. ex A. Rich.	Malvaceae	S	*	*
Hypericum quartinianum A. Rich	Hypericaceae	T	*	*
Jasminum abyssinicum Hochest. Ex DC.	Oleaceae	C	*	*
Jasminum grandiflorum L.	Oleaceae	C	*	*
Juniperus procera Hochst ex. Engl.	Cuppressaceae	T	*	_
*Justicia schimperiana (*Hochst. ex Nees) T. Anders.	Acanthaceae	S	*	*
Kanahia laniflora (Forssk.) R. Br.	Asclepiadaceae	S	*	_
Lannea fruticosa (Hochst. ex A. Rich) Engl	Anacardiaceae	T	*	*
Maesa lanceolata Forssk.	Myrsinaceae	S	*	_
Maytenus arbutifolia (A. Rich.) Wilczek.	Celastraceae	C	*	*
Millettia ferruginea (Hochst.) Back	Fabaceae	T	*	_
Momordica foetida Schumach.	Cucurbitaceae	C	*	_
Myrica salcifolia Hochst. ex A. Rich.	Myricaceae	T	*	_
Myrsine Africana L.	Myrsinaceae	S	*	*
Nuxia congesta R.Br. ex Fresen.	Loganiaceae	T	*	_
Ocimum urticifolium Koth.	Lamiaceae	S	*	*
Olea europaea subsp. cuspidata L.	Oleacea	T	*	*
Opuntia ficus-indica (L.) Miller.	Cactaceae	T	*	_
Osyris quadripartite Decn.	Santalaceae	T	*	*
Otostegia integrifolia Benth.	Lamiaceae	S	*	*
Pentas lanceolata (Forssk.) Defl.	Aloaceae	S	*	*
Phytolacca dodecandra L'Herit.	Phytolaccaceae	C	*	*
Pittosporium viridiflorum sims.	Pittosporaceae	T	*	*
Prunus Africana (Hook. F.) Kalkm.	Rosaceae	T	*	*

Appendix Continued

Scintific name	Familly	H	Gond	Arsema
Psydrax schimperiana Subsp.schimperiana.	Rubiaceae	T	*	_
Pteroloblum stellautm (Forssk.) Brenan	Fabaceae	C	*	*
Rhamnus prinoides L'Herit.	Rhamnaceae	S	*	_
Rhus vulgaris Meikle (get)	Anacardiaceae	T/S	*	*
Rosa abyssinica Lindley.	Rosaceae	S	*	*
Rumex nervosus Vhal.	Polygonaceae	S	*	*
Salix sebserata		T	*	_
Schefflera abyssinica (Hochst. ex A. Rich.	Araliaceae	T	*	_
Schinu smolle L.	Anacardiaceae	T	*	_
Senna alata L.	Fabaceae	S	_	*
Solanum marginatum L.f.	Solanaceae	S	_	*
Steganotaenia araliacea Hochst. ex A. Rich.	Apiaceae	S	*	_
Stereospermum kunthianum Cham.	Bignonaceae	T	*	*
Syzygium guineense (Willd.) DC.	Myrtaceae	T	*	_
Urera hypselodendron (Hochst.) ex A. Rich.	Utricaceae	C	*	*
Vernonia amygdalina Del.	Astraceae	S	*	*
Vernonia myriantha Hook.f.	Astraceae	S	*	_
Vitex doniana Sweet.	Lamiaceae	T	_	*
Ximenia Americana L.	Olacaceae	T	*	*
Zehneria scabra (Linn. f.) Sond.)	Cucurbitaceae	C	*	*
Ziziphus spina-christi (L.) Desf.	Rhamnaceae	S	*	_

Presence of the species is indicated by *, while absence is indicated by _, H= habit, T = Tree, S = Shrub, c = climber, Gond=Gond Teklehaymanot