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Review Article

The Status of Dry Evergreen Afromontane Forest Patches in Amhara National Regional State, Ethiopia

Getinet Masresha and Yirgalem Melkamu

Department of Biology, College of Natural and Computational Sciences, University of Gondar, P.O. Box. 196, Gondar, Ethiopia

Correspondence should be addressed to Getinet Masresha; danieloct9@gmail.com

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Ethiopian dry evergreen afromontane forests are primary biodiversity priority areas including many forest patches of Amhara Region. Natural vegetation of the region is now almost exclusively limited to sacred places, very few protected and less accessible areas. Despite different studies on the various dry evergreen afromontane forest patches of the region, there was not a review work on these forest patches at a regional level. Lack of comprehensive review work creates ambiguity to the understanding of the current status of the forest patches. Scientific information on these forest patches is important for future managerial intervention and sustainable utilization. Thus, the review was aimed to evaluate the status of dry evergreen afromontane forest patches of the Region. Each forest patch contained 15–156 plant species with a total of 525 species under 328 genera and 112 families. Asteraceae was the most species richest family followed by Fabaceae. Most patches harbored considerable number of endemic plant species with a total of 46 species within 44 genera and 26 families. Asteraceae was the most endemic species rich family. Most forest patches had high diversity. Diameter at breast height (DBH) and height class analyses of most forest patches revealed an inverted J-shape pattern. Mean basal area of the forest patches ranged from 1 m^2h^{-1} to 115.36 m^2h^{-1}. In most forest patches many number of species were put in low frequency classes. The forests had more seedlings and/or saplings than mature individuals. Although each patch had a rich source of biodiversity, it is influenced by severe anthropogenic disturbances. Therefore, appropriate managerial interventions are required.

1. Introduction

Globally, about 30 percent of the land was covered by forests which accounted for about 3,952 million hectares. However, gradually the coverage is declining from time to time at a rate of 12.9 million ha/year mainly as a result of different anthropogenic factors [1]. From this, Africa's forest cover is estimated to be 650 million ha, constituting 17 percent of the world's forests [1].

Ethiopia, as a result of its diverse physiogeographic features [2–5], is one of the east African countries endowed with rich biological resources [6]. This enabled the country to be one of the world's biodiversity hotspot [7] and one of the 12 Vavilov centers of crop genetic diversity [8, 9]. Its flora is very heterogeneous and has many endemic species. According to different authors [10–13], these plants are distributed under nine vegetation types or ecosystems. From these, Afromontane vegetation is one of the most species-rich ecosystems [5, 14]. The forests mostly occur in the high mountain regions [15] and are internationally recognized as the Eastern Afromontane Biodiversity Hotspot [5, 16].

Dry evergreen afromontane forests are one of the afromontane forests which have been set as one of the primary biodiversity priority areas in Ethiopia. Despite their high importance as a biodiversity hotspot, these forests are one of the most degraded forests and continuously shrinking mainly due to anthropogenic pressures [5]. According to Wassie et al. [17], the fragmentation and isolation of dry evergreen afromontane forests in northern Ethiopian highlands represent a particular case. Human population pressure coupled with the suitability of the forests for agricultural uses made these forests to be under severe land-use, which ultimately led to several fragmentations into patches [18, 19] especially in Amhara Region [17]. Although

different studies are made on many dry evergreen afromontane forest patches of Amhara Region, it is ambiguous to analyze floristic composition and status of those patches in the region for future managerial interventions since there was no review work conducted at a regional level on this vegetation type.

Different authors [20–22] underlined that in order to maintain the ecological equilibrium and to meet the forest resource requirements of the population and biodiversity conservation, scientific information on biodiversity and regeneration status are the bases. So, to conserve and maintain the remaining fragmented forest patches of the region, studying or reviewing the current status of the vegetation and understanding the environmental and anthropogenic factors leading to the loss of biodiversity are highly important. Thus, the objective of this work was to review the floristic composition, structure, species diversity and regeneration status of dry evergreen afromontane forest patches in Amhara National Regional State so as to recommend the possible solutions. To do this, fifteen research articles, three M.Sc. theses, two conference papers, one dissertation and one review article with a total of twenty-two studies on fifty-eight dry evergreen Afromontane forest patches in the region were reviewed. To identify endemic plant species,puplished volumes of Flora of Ethiopia and Eritrea were used.

2. Overview of Dry Evergreen Afromontane Forests and Grassland Complex of Ethiopia

Ethiopia is endowed with diverse ecosystems, the largest of which is afromontane vegetation (Figure 1). This vegetation is distributed in the mountain complexes of Ethiopian highlands that comprises over 50% of the African land areas covered by afromontane vegetation (Bekele, 1994). From this, dry evergreen afromontane forests and grassland complex form the largest part [23, 24]. Dry evergreen afromontane forest and grassland complex is a very complex vegetation type occurring roughly above 1500 m and below 3200 m in altitude, with average annual temperature and rainfall of 14–25 C° and 700–1100 mm, respectively, [12, 25]. But according to Lemenih and Frans [26], this vegetation type is located between 1,900 and up to 3,400 meters above sea level in the central, eastern, south-eastern, and northern highlands of the country. This difference might be occurred due to lose of representative vegetations in the lower boundaries as a result of different anthropogenic factors and slight climatic change within the reported time intervals. The majority of the Ethiopian population inhabits in this ecosystem and it represents a zone of sedentary cereal-based mixed agriculture for centuries.

The major species of this vegetation type are *Juniperus procera, Podocarpus falcatus, Prunus africana, Ekebergia capensis, Olea europaea* subsp. *cuspidata, Apodytes dimidiata, Allophylus abyssinica, Euphorbia ampliphylla, Olinia rochetiana, Myrsine melanophloeos, Dovyalis abyssinica, Myrsine africana,* and *Calpurnia aurea.* Friis [25] revealed that in such type of forests, the canopy is usually dominated by *Podocarpus falcatus*, *Juniperus procera*, and *Olea europaea* subsp. *cuspidata*. True lianas, epiphytes including *Peperomia*, ferns, and orchids are common. The ground cover is rich in ferns, grasses, sedges, and small herbaceous cotyledons. At the upper limits *Erica arborea*, *Hagenia abyssinica*, *Hypericum revolutum, Myrsine africana*, *Myrsine melanophloeos, Rosa abyssinica*, *Nuxia congesta,* and clumps of *Arundinaria alpina* are common.

The characteristic tree species in this vegetation type include *Olea europaea* subsp. *cuspidata*, *Juniperus procera,* and *Podocarpus falcatus*. The shrubs characterizing the vegetation include *Carissa spinarum* and *Dodonaea angustifolia* [12]. According to Kelbessa et al. [7], 120 threatened endemic plant species are known from Ethiopia, of which 35 occur in the dry evergreen afromontane forests and grassland complex of the country. Some of the threatened endemic plant species are *Acalypha marissima*, *Maytenus addata, Pentas concinna, Rubus aethiopicus,* and *Sedum epidendron* [7]. The forests of this vegetation is diminished due to human interference and replaced by grasslands in flatter areas with deep soil and by bushlands on steeper slopes with thin soil [26].

3. Review on the Status of Dry Evergreen Afromontane Forests and Grassland Complex in Amhara Region

Amhara is one of the 11 National Regional States of Ethiopia. It is located in the northwestern and north central part of the country between 8°45′ and 13°45′ North latitude and 36° 20′ and 40° 20′ East longitude (Figure 2). Its total land area is estimated about 170,000 square kilometers. Amhara borders Tigray Region in the North, Afar in the East, Oromiya in the South, Benishangul-Gumiz in the Southwest, and the country of Sudan in the west. Total population of the Amhara Region for mid-2008 was 20,136,000 with a fifty-fifty ratio of males and females and 3% population growth rate per year[27]. The topographical features of the region represent diversified elevations ranging from 700 meters to 4620 meters above sea level. Most of this is highland plateau above 1500 meters with rugged mountains, hills, plateaus, valleys, and gorges characterized by having dry evergreen Afromontane ecosystem type [17].

The dry evergreen afromontane ecosystem type of the region has relatively fertile soil and suitable climatic conditions. This made the region to have high population density and agriculture as the main economic activity. Land of the region, especially in the eastern part, has been cultivated for millennia with no variations, or improvements in the farming techniques. This accelerates the overexploitation of forest ecosystems and conversion of agricultural lands, bush lands, and grass lands [5]. At the present, forests are limited on religious (churches, monasteries, and mosques), inaccessible, and government protected areas [17].

The vegetation of Amhara National Regional State covers about 14% of the total area of the region, which is 21,783 km^2 [29] (Figure 3). Natural forest (dry evergreen Afromontane forest patches) of the region is now almost exclusively limited to inaccessible areas and sacred (religious) places [17, 30]. The

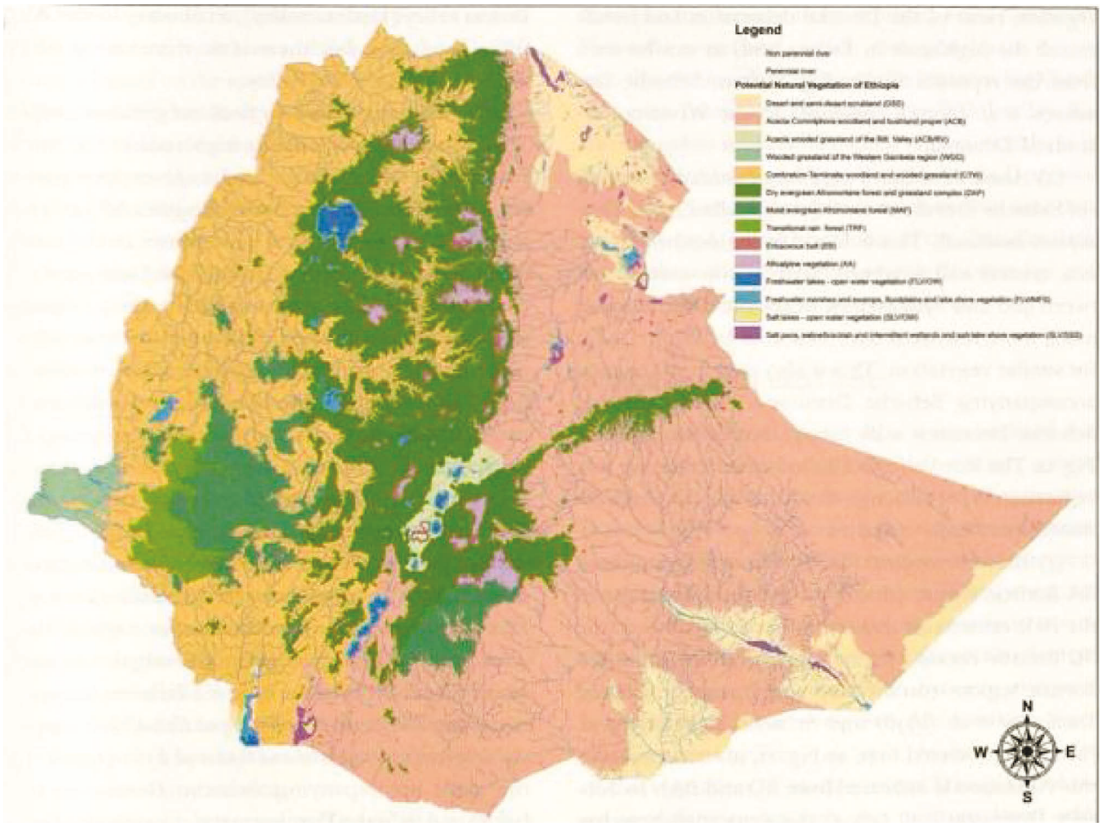

Figure 1: Vegetation map of Ethiopia (Source: [13]).

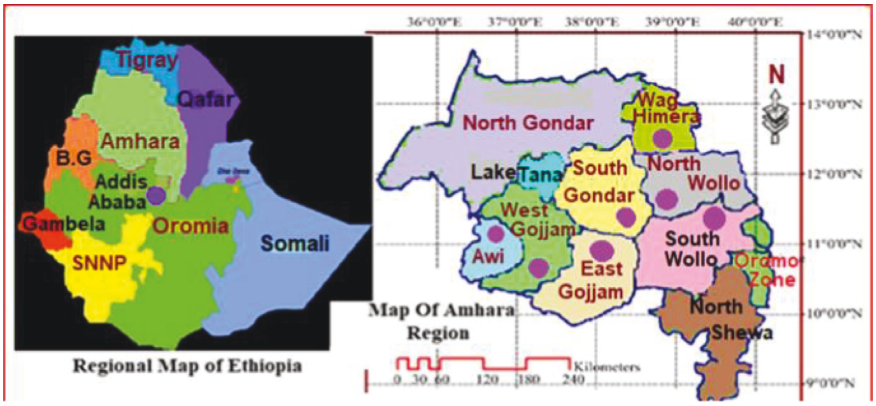

Figure 2: Map of Amhara Region (source: [28]).

report of Mulat [31] also revealed that the forest cover of the region is reduced to the level of patches and in some strips.

Currently, most of these forest patches are restricted largely on lands managed by followers of the Ethiopian Orthodox Church [32]. A recent inventory by Reynolds et al. [33] using high-resolution satellite imagery indicated the presence of more than 8000 church forests in the Amhara Region, ranging from <1 ha to over 100 ha in size. The floristic composition and structure of some of these patches of church forests were studied by different authors at different times. For instance, 28 church forests in the fragmented highlands of South Gondar Zone [17], Tara Gedam and Abebaye forests [34], Aba Asrat Monastery Forest [9], Tara Gedam Forest [35], Wanzaye [36] andYemrehane Kirstos Church Forest [37].

Beside the churches owned forests, other patches of forests are owned by the regional government. Some of the studied dry evergreen afromontane forest patches include the following: Yegof forest in South Wollo Zone [38, 39], Wof Washa forest in North Showa Zone [40], Alemsaga Forest in South Gondar Zone [2], Woynwuha Natural Forest in East Gojam Zone [41], Zerat Forest in North Showa Zone [42], Kurib forest in Awi Zone [43], Ylat Forest in North Wollo Zone [44], Amoro forest in West Gojam Zone [45], Zegie Peninsula Forest in north of lake Tana [46], Five forest paches (Apini, Bari, Dabkuli, Katasa, and Tsahare) in Awi

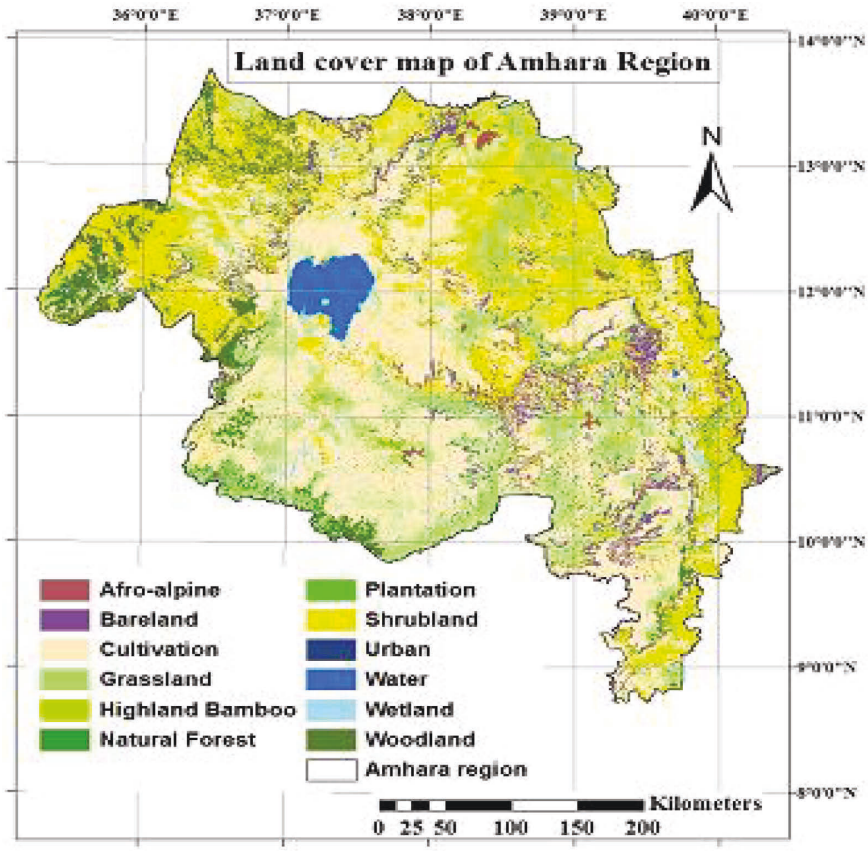

Figure 3: Land cover map of Amhara Region (Source: [50]).

Zone [47], and Gatira George's forest in North Wollo Zone [48].

These forest patches, however, are declining due to disturbances such as cutting, grazing, droughts, and fires occurring at increasing intensity and frequency [49]. In the region, it is difficult to conserve and manage the forests in proper way due to high population density with exception of churches and monasteries [31].

3.1. Floristic Composition of Forest Patches. From various studies, the dry evergreen afromontane forest patches of the region contained 525 plant species in 112 families and 328 genera (Appendix 1) including 41 climbers, 3 epiphytes, 194 herbs, 142 shrubs, 107 trees, and 39 trees/shrubs. The five most species rich families were Fabaceae (43), Asteraceae (42), Poaceae (23), Lamiaceae (21) and Euphorbiaceae (20). The dominance of Fabaceae and Asteraceae agreed with the report in Flora of Ethiopia and Eretria. The dominance of these families could be their high ecological adaptation invarious climates with efficient pollination and dispersal mechanisms [15]. But, at present, due to different anthropogenic factors, as described by different authors, forests are largely restricted to specific areas of the region.

As evidence, Wassie et al. [17] identified a total of 168 woody species (100 trees, 51 shrubs, and 17 liana species) representing 69 families in 28 church forests in the fragmented highlands of South Gondar Zone. Fifteen to seventy-eight species were encountered per church forest. Maximum number of species (78) was encountered from Wonkeshet and minimum (15) from Wonberoch church forest. The average number of species for all 28 church forests was 37. Berhanu [51] identified and documented a total of 212 plant species belonging to 169 genera and 79 families from six forest patches found in Awi Zone.

All the forest patches reviewed contain many and different floristic composition, even though herbaceous species were not considered in some patches such as Tara Gedam [34], Amoro [45], and Zengena [52] (Table 1).

3.1.1. Endemic Plant Species. Endemic taxa are those that are restricted to a particular geographic location and occurring nowhere else [56]. A total of 46 endemic plant species within 44 genera and 26 families were identified from different dry evergreen Afromontane forest patches of the Region (Table 2). The dominant family was Asteraceae represented by 10 species followed by Fabaceae, Lamiaceae, and Acanthaceae with 4, 4, and 3 endemic species, respectively. Liewise, at country level, Asteraceae and Fabaceae are found the most endemic species rich families in respective order [15, 51].

Highest endemism was observed at Zerat forest with a total of 17 species [42] followed by Yegof, Aba Asrat, and Alemsaga forests with 11, 8, and 7 species, respectively, which is inline with their species diversity (Table 1). Even if

Table 1: Floristic composition of plant species in the 27 selected forest patches of Amhara Region.

Forest patch	Woody species	Herbaceous species	Total no. of species	No. of families	Source
Tara gedam	120	—	120	57	[34, 35]
Abebaye	88	—	88		[34]
Aba asrat monastery	81	39	120	53	[9]
Ymrhane kirstose	39	—	39	29	[37]
Alemsaga	80	44	124	65	[2]
Woynwuha	69	—	69	41	[41]
Zerat	96	60	156	67	[42]
Ylat	50	10	60	41	[44]
Amoro	57	—	57	38	[45]
Kurib	39	—	39	26	[43]
Yegof	125 (3 epiphytes)	29	144	65	[38, 39]
Ambiqi	55	30	85		
Askunabo	64	44	108		
Bradi	62	48	110		[51]
Degera	56	21	77		
Khatasa	58	53	111		
Kidamaja	55	23	78		
Gatira georges	34	—	27	34	[48]
MugereZala	62	—	62	43	[53]
Kelta	36	—	36	29	
Chekaw	56	—	56	38	[54]
GoshWana	36	—	36	26	
Sesa maryiam	113	—	113	54	[55]
Wanzaye	49	—		29	[36]
Wof washa	62	—	62	40	[40]
Zegie peninsula	74	—	74	41	[46]
Zengena	50	—	50	31	[52]

Berhanu [51] identified twenty-three endemic species from six afromontane forests found in Awi Zone, each patch accounted for an average of four species. The lowest endemism was recorded at Yimrhane Kirstos and Woynwuha forests each represented by only one endemic species followed by Kurib and Zegie peninsula forests with two endemic species each. Yimrhane Kirstos and Kurib forest were endowed with the lowest species composition and this made similar level with respect to endemism (Table 1). In some forest patches such as Gemehat,Chekaw, Gosh, and Kelta forests [54] and Gatira Georges [48] forests, endemic species were totally absent (Table 2).

Generally, different dry evergreen afromontane forest patches of Amhara Region are endowed with various endemic species. Hence, greater conservation priority should be given to these forest patches so as to make them sources for different plant genetic resources to the country.

3.1.2. Floristic Diversity. Floristic description of vegetation involves the analysis of diversity and evenness. Species diversity is one of the most important indices used for evaluating the sustainability of forest community [43]. Species diversity is fundamentally multidimensional concept that includes species richness, abundance, and evenness [57], and can be analyzed by Shannon-Weiner diversity index.

The Shannon-Weiner diversity index varies between 1.5 and 3.5 and rarely exceeds 4.5. According to Kent and Cocker [58], Shannon-Weiner diversity is high when it is above 3.0, medium when it is between 2.0 and 3.0, low when it is smaller than 2.0. The species evenness value ranges between 0 and 1. Evenness value of 0 indicated that the area is dominated by single species and when it is 1, the species are evenly distributed in the area.

Depending on the above criteria, most forest patches indicated in Table 3 (Askunabo, Bradi, Chekaw, Degera, Kelta, Khatasa, Kidamaja, Wof Washa Wanzaye, Sesa Maryam, and Woynwuha forests) had high species diversity (H'>3.0). From these forest patches, Bradi forest was the most diverse followed by Wof Washa and Woynwuha forests, respectively. Some forests (Ambiqi, Ylat, YmrhaneKirstos, Tara Gedam, Gosh Wona, and Zegie Peninsula forests) had medium species diversity (2<H' < 3). Abebaye and Kurib forests were low in their species diversity (H'<2) and this could be attributed to the social and environmental factors [59].

The evenness analysis index showed that almost all forest patches listed in Table 3 except Abebaye and Zegie Peninsula forests were relatively high and this indicated that species were somewhat distributed evenly in the forests. Even if Kurib forest had the lowest species diversity, the species were distributed more evenly ($J = 0.91$) than other forest patches followed by Kelta ($J = 0.86$) and Sesa Maryam ($J = 0.85$) forests, respectively. Compared from the other forest patches, Abebaye forest had the least evenness ($J = 0.31$). From the review, it can be said that considerable number of forest patches were found to have high species diversity. This higher species diversity is thought to indicate a more complex, stable, and healthier community [2].

Table 2: Endemic species recorded at some selected DEAFP of Amhara Region.

Forest patch	Endemic species documented	Families with≥2 spp.	Authors
Aba asrat monastery forest	*Cynoglossum coeruleum, Echinops kebericho*, *Erythrina brucei, Gomphocarpus purpurascens, Kalanchoe petitiana*, *Lippia adoensis*, *Millettia ferruginea,* and *Solanecio gigas*	Fabaceae and asteraceae (2spp each)	[9]
Alemsaga forest	*Acanthus sennii*, *Lippia adoensis, Milletia ferruginea, Rhus glutinosa, Trifolium schimperi, Verbascum stelarum* and *Vipris dainielli*	Fabaceae (2 spp)	[2]
The six awi zone forest patches	*Acanthus sennii, Bothriocline schimperi, Brillantaisia grotanellii, Carum piovanii, Clematis longicauda, Crotalaria rosenii, Echinops kebericho, Erythrina brucei, Guizotia abyssinica, Justicia diclipteroides, Kalanchoe densiflora, Lippia adoensis, Maytenus addat, Millettia ferruginea, Otostegia tomentosa, Phyllanthus limmuensis, Polystachya caduca, Rhus glutinosa, Solanecio gigas, Tiliacora troupinii, Urtica simensis, Vepris dainellii,* and *Vernonia leopoldi*	Asteraceae (5spp), Acanthaceae (3spp), fabaceae (3spp)	[51]
Tara gedam and abebaye	*Maytenus serrata, Rhus glutinosa, Lippia adoensis, Clematis longicauda, Otostegia tomentosa,* and *Millettia ferruginea*		[34]
Zerat forest	*Mikaniopsis clematoides, Satureja paradoxa, Solanecio gigas, Rhus glutinosa, Urtica simensis, Kalanchoe petitiana, Inula confertiflora, Kniphofia foliosa, Cynoglossum coeruleum, Lippia adoensis, Thymus schimperi, Laggera tomentosa, Gladiolus balensis, Plectocephalus varians, Cineraria abyssinica, Crotalaria rosenii,* and *Becium grandiflorum*	Asteraceae (6spp), Lamiaceae (3spp)	[42]
Amoro forest	*Acanthus senni, Clamatis longicaudata, Laggera tomentosa* and *Solanecio gigas*	Asteraceae (2spp)	[45]
Kurib forest	*Erythrina brucie,* and *Solanecio gigas*		[43]
Ylat forest	*Acanthus sennii, Aloe pulcherrima, Anthoxanthuma ethopicum, Impatiens rothii, Inula confertiflora,* and *Millettia ferruginea*		[44]
Zegie peninsula	*Mellettia furruginea* and *Vepris danellii*		[46]
Yegof	*Acanthus sennii, Anthoxanthuma ethopicum, Laggera tomentosa, Maytenus addat, Millettia ferruginea, Rhus glutinosa, Robusa ethiopicus, Rytidosperma grandiflora,* and *Trifolium schimperi*	Poaceae (2spp)	[38]
YemrhaneKirstos	*Rhus glutinosa*		[37]
Gemehat	No endemism		[54]
Gatira	No endemism		[48]
Mugere-zala	*Inula confeptiflora, Lobelia rhynchopetalum, Ranunculus simensis,* and *Rhus glutinosa*		[53]
Woynwuha	*Rhus glutinosa*		[41]
Wanzaye	*Millettia ferruginea* and *Rhus glutinosa*		[36]
Zengena	*Acanthus sennii, Erythrina brucei,* and *Vernonia leopoldi*		[52]
Sesa maryam	*Erythrina brucei* and *Millettia ferruginea*	Fabaceae (2 spp)	[55]

3.2. Vegetation Structure

3.2.1. Diameter at Breast Height (DBH). DBH class analysis on many forest patches of Amhara Region was performed by different authors. For instance, the DBH class distribution of individuals in Alemsaga [2], Aba Asrat Monastery [9], Wof Washa [40], Sesa Maryam [55], Woynwuha [41], Zerat [42], Mugere Zala [53], and Amoro forests [45] showed inverted J-shape distribution. This is a general pattern of normal population structure where the majority of the species had the highest number of individuals at lower DBH classes with gradual decrease towards higher DBH classes. This suggests good reproduction potential of the vegetation. This could be attributed to high rate of regeneration but poor recruitment in the forest which might have been caused by selective logging of large sized individuals for different purposes [2, 4, 17].

Six forest patches (Ambiqi, Askunabo, Bradi, Kidamaja, Khatasa, and Degera) of Awi Zone showed interrupted inverted J-shape DBH distribution [51]. The Forest was classified into nine classes and all showed somewhat inverted J-shape distribution. But the higher DBH classes were slightly higher than the three classes just before them. This indicated that medium to slightly large sized plants which were easy to process were cut selectively than small sized and very large sized individuals, which might be difficult to process [45]. The same is true for Gatira George's church forest [48].

On the other hand, the work of Belay [43] at Kurib forest showed that DBH classes had zigzag type of distribution in which lower individuals were available in the first class and higher individuals at the second classes. This might be due to continuous disturbance by grazers or the effect of large sized individuals over the smaller once through shading or over

Table 3: Species richness, Shannon diversity (H′), and Evenness (*J*) of some selected forest patches of Amhara Region.

Forest Patch	Richness	Diversity		Sources
		H	*J*	
Ambiqi	85	2.91	0.73	
Askunabo	108	3.08	0.74	
Bradi	110	3.35	0.81	[51]
Degera	77	3.18	0.79	
Khatasa	111	3.18	0.78	
Kidamaja	78	3.24	0.81	
Kurib	39	1.86	0.91	[43]
Wanzaye	49	3.15	0.81	[36]
Sesa maryam	113	3.81	0.85	[55]
Tara gedam	111	2.98	0.65	[34]
Abebaye	88	1.31	0.31	
Wof washa	62	3.25	0.8	[40]
Woynwuha	69	3.24	0.76	[41]
Ylat	60	2.94	0.84	[44]
Ymrhane kirstos	39	2.88	0.79	[37]
Zegie peninsula	74	2.49	0.58	[46]
Kelta	36	3.1	0.86	[54]
Chekaw	56	3.3	0.81	
Gosh wona	36	2.78	0.8	

competition for nutrients. Tegegne [44] had got other variation in Ylat forest where most (97.15%) individual plants were distributed only in the first DBH class and some (2.85%) in the second but not any individual plant at the other classes. The forest had high regeneration ability but less recruitment indicating high pressure on the forest where large sized individuals were cut away or the area might be protected recently. Ayanaw and Dalle [37] brought still another result in Ymrhane Kirstose church forest that the general pattern of DBH class distribution had inverted bell-shape indicating good potential of reproduction and recruitment of the forest.

In addition, from 28 church forests in South Gondar Zone [17] eight forests were found to have inverse J-shaped pattern, six of them with U-shaped distributions, four of which with flat-shaped distribution and the remaining lacked defined pattern.

3.2.2. Height. Similar to DBH class, height class distribution analyses were conducted for some forest patches of the region. These analyses were used to understand the density of individuals at different height level. There was nearly similar height class distribution pattern on the forest patches with their DBH distribution in which higher number of individuals were distributed in the lower height class and vice versa. For instance, Woynwuha forest had an interrupted inverted J-shape height class distribution, which was similar to its DBH class distribution [41]. Likewise, Berhanu [51] reported a general inverted J-shape height class distribution from six forest patches in Awi Zone. For each of the six individual forest patches the author reported an interrupted inverted J-shape height class distribution pattern which was nearly similar to their DBH class distribution. This indicated that in all forest patches of Awi Zone, medium sized plants might be cut selectively. Similarly, Gedefaw and Soromessa [35] analyzed that Tara Gedam forest showed an interrupted inverted J-shape distribution. The height class analysis of Aba Asrat Monastery forest [9], Zerat forest [42], and Mugere Zala forest [53] all showed an inverted J-shape pattern similar to their DBH class distribution. This indicated that DBH and height both are important functions to understand the density of individual plants related to size. In addition, Wof Washa natural forest height class distribution showed nearly an inverted J-shape pattern [40]. It means that the forest had good regeneration status but selective logging concentrated on medium sized individuals.

Height class distribution of Yimrhane Kirstose Church forest showed a U-shaped distribution in which the density of individuals were the highest at the first (<5m) and at the last (≥20m) classes but lower at the middle classes [37]. Height class of Kurib forest had a zigzag pattern [43]. This might be resulted due to the presence of various environmental and anthropogenic factors that influence the normal vegetation of the forests [2].

3.2.3. Basal Area. Basal area provides the measure of the relative importance of the species than simple stem count [41]. Species with higher basal area could be considered as the most important species in vegetation [37]. The normal value of basal area in Africa is expected to be between 23 and 37 m^2/ha reported by [60]. Basal area of many dry evergreen afromontan forest patches (DEAFPs) of Amhara Region was analyzed by different researchers (Table 4).

Among these forest patches, Tara Gedam Monastery forest had the highest basal area (115.36 m^2h^{-1}) followed by Kurib forest (105.7 m^2h-^{1}) and Sesa Maryam forest (94.81 m^2h^{-1}), respectively, because these forests had old-aged big trees. Ylat forest had the lowest basal area (1 m^2h^-1) from all patches reviewed. The dominant species in this forest were shrubs rather than big trees that made basal area low. This might be resulted due to continuous logging of larger individuals in that area. In most of the forests, especially for those that had high basal area, the dominant species were nearly similar and all were big trees that made the patches to have high basal area (Table 4).

3.2.4. Frequency. Frequency is expressed as the proportion of plots in which a given species occurred in the sampled area. It gives an approximate indication for homogeneity and heterogeneity of vegetation [39, 43, 51]. High percentage of number of species in the lower frequency classes and lower percentage of number of species in the higher frequency classes indicate high degree of floristic heterogeneity [44].

Many dry evergreen afromontane forest patches of Amhara Region, Abebaye and Tara Gedam forests [34], Wof Washa natural forest [40], Woynwuha forest [41], Kurib forest [43], Yilat forest [44], Yegof forest [39], and Yimrhane Kirstose church forest [37], had high percentage of species in lower frequency classes and relatively low percentage of species in higher frequency classes. Similarly, pooled sample analysis of the six forest patches (Ambiqi, Askunabo, Bradi,

Table 4: Mean Basal area (BA) comparison of selected DEAFPs.

Forest Patch	BA ($m^2 h^{-1}$)	Five top dominant species in descending order	Authors
Ambiqi	57.4	*P. africana, A. gummifera, A. schimperiana, C. macrostachyus,* and *Celtis africana.*	
Askunabo	43	*A. gummifera, E. capensis, P. africana, D. kilimandscharica, A. schimperiana,* and *C. macrostachyus.*	
Bradi	37	*A. schimperiana, P. africana, E. capensis, A. gummifera,* and *V. dainellii.*	[51]
Dengera	34.5	*P. africana, A. dimidiata, C. africana, C. macrostachyus, R. urcelliformis,* and *A. schimperiana.*	
Khatasa	40.5	*A. dimidiata, J. procera, P. africana, C. oligocarpum,* and *N.congesta.*	
Kidamaja	35	*A.schimperiana, A. gummifera, V. dainellii, E. cymose,* and *D. steudneri.*	
Yimrhane kirstos	72	*J. procera, O. europaea, A. abyssinica, A. abyssinicus,* and *D. abyssinica*	[37]
Wanzaye	23.3	*F. sycomorus, F.vasta, S. kunthianum,* and *Cordia africana*	[36]
Gatira georges	7.84	*E. capensis, J. procera, O. europea, C. africana*, and *O. capenis*	[48]
Sesa maryam	94.81	*A. gummifera, C. macrostachyus, A. schimperiana, J. procera,* and *P. africana*	[55]
Wof washa	64.32	*J. procera*, *I. mitis, P. falcatus, M. arbutifolia,* and *H. abyssinica*	[40]
Alemsaga	75.37	*C. macrostachyus, N. congesta, A. schimperiana,* and *C. molle*	[2]
Abebaye	49.45	*F. vasta*, *A. lahai*, *C. Macrostachyus, A. pilispina*, and *S. ellipticum*	[34]
Tara gedam	115.36	*O. europaea, Schefflera abyssinica*, *A. gummifera, E. capensis*, *Ficus vasta,* and *A. dimidiata*	
Amoro	18.5	*S. abyssinica, P. africana,* and *A. dimidiata*	[45]
Yegof	15.85	*A. gummifera, M. salicifolia J. procera,* and *P. falcatus*	[39]
Kurib	105.7	*P. viridflorum, M. lanceolata*, *M. obscura, A. nilotica,* and *A. abyssinica*	[43]
Yilat	1	*O. ficus-indica, A. albida,* and *J. procera*	[44]
Woynwuha	20.03	*A. gummifera, O. europaea, C. macrostachyus, A. abyssinica,* and *C. edulis*	[41]

Dengera, Khatasa, and Kidamaja forests) of Awi Zone [51] and Amoro forest [45] showed high number of species at low frequency classes and low number of species at the higher classes. According to Lamprecht [60] these results revealed the presence of high degree of floristic heterogeneity in these forest patches whereas three remnant forests (Chekaw, Kelta, and Gosh wona) in North Wollo Zone had relatively equal number of species in both lower and higher frequency classes [54], which indicated that the forests had medium heterogeneity. From the above results it is possible to understand that most forest patches had good vegetation heterogeneity.

3.2.5. Density. The density of plants is expressed as the number of individuals per area sampled. It is the crucial parameter for sustainable forest management [43]. Different studies showed that DEAFPs of Amhara Region had great variation in their vegetation density (Table 5) and this might be resulted due to difference on climatic, edaphic, and anthropogenic factors at each forest patch [39]. Chekaw forest had the highest density followed by Kelta and Tara Gedam forests, respectively, but the lowest density was recorded in Kurib forest.

3.2.6. Regeneration Status. Composition and density of seedlings and saplings indicate the status of regeneration in a given vegetation [41]. Results of most DEAFPs of the region showed that the patches were in a good or fair regeneration statuses though sever disturbances were available. For example, in forests of Tara Gedam and Abebaye [34], Aba Asrat monastery [9], Wof Washa [40], Yilat [44], and Zegie Peninsula [46] density of seedlings

Table 5: Total density of some selected DEAFPs in Amhara region.

Forest patch	Total densityh^{-1}	Criteria	Source
Ambiqi	2437.5	Woody sp. with DBH≥2.5 cm	[51]
Degera	2340.6	Woody sp. with DBH≥2.5 cm	
Kidamaja	2179.5	Woody sp. with DBH≥2.5 cm	
Khatsa	2158.3	Woody sp. with DBH≥2.5 cm	
Bradi	2080.5	Woody sp. with DBH≥2.5 cm	
Askunabo	2059.5	Woody *s*. With DBH≥2.5 cm	
Chekaw	4938	Woody sp. with DBH >2 cm	[54]
Kelta	3032	Woody sp. with DBH >2 cm	
Gosh wona	2025	Woody sp. with DBH >2 cm	
Tara gedam	3001	All woody sp.	[34]
Abebaye	2850	All woody sp.	
Amoro	2860.5	Woody sp. with DBH≥2.5 cm	[45]
Yegof	1364.88	Woody sp. with DBH >2 cm	[39]
Gatira georges	1156	All woody sp.	[48]
Mugere zala	2340	All woody sp.	[53]
Kurib	152.53	Tree sp. with DBH >2.5 cm	[43]
Woynwuha	1991.68	Woody sp. with DBH >2 cm	[41]

were greater than saplings, and saplings were greater than mature individuals. All these showed that the forests had good regeneration status.

In Woynwuha forest, sapling density was higher than seedling, and seedling density was higher than mature plant [41]. In addition, a cumulative result of twenty-eight church forests in South Gondar indicated that the density of saplings was greater than seedlings [17]. This implied that the forests were at fair regeneration status. From those twenty-eight church forests, three forests had good regeneration status with high density of seedlings followed by saplings and mature plants, respectively. Eleven churches had more saplings followed by seedlings and mature plants, respectively. Thirteen church forests had more number of saplings followed by mature plants and seedlings, respectively, and this indicated that the forests were in poor status of regeneration. The remaining one church forest had saplings and adults but not seedlings. This forest was, thus, not regenerating as it lacked seedlings. Ayanaw and Dalle [37] showed that Yimrhane Kirstose church forest had more seedlings followed by mature plant than saplings, and this could be judged to have fair regeneration status.

4. Conclusion

Amhara National Regional State, as a result of its topographic features and altitudinal range, is largely characterized by dry evergreen afromontane forests and grassland complexes. This vegetation is highly threatened due to long history of anthropogenic disturbances converting it into patch forests restricted in inaccessible and protected areas. Floristic composition and vegetation structure of many of these patches are studied by many authors. Comparative review of these patches indicated that these patches are found in different status and though some of them are highly threatened, considerable number of them are still rich in species diversity and endemicity, good vegetation heterogeneity, normal inverted *J* shaped vegetation structure, and at good regeneration status. Thus, participatory forest management program should be implemented to enhance the awareness of local communities and make them to develop sense of ownership and responsibility for the proper management and conservation of the forest patches.

Data Availability

The data are available at the authors; some of the data are uploaded to the system as supplementary file (Appendix 1) and most of the data are deposited in the Library of University of Gondar. In addition, some of the data can also be accessed online in the form of articles.

Disclosure

The manuscript is part of a seminar paper by Yirgalem Melkamu.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Supplementary Materials

Appendix 1: List of plant species recorded by different authors at different DEAFPs of the region (Habit, E = epiphyte, H = herb, S = shrub, T = tree, and T/S = tree/shrub). (*Supplementary Materials*)

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