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Research Article

Floristic Composition and Diversity of Vascular Plants in Remnant Patches of Arsi-Bale Massif of Oromia Regional State, Ethiopia

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This research was done in Arsi-Bale Massif remnant vegetation of southeast Ethiopia to investigate vascular plant diversity and endemism in forest patch, riverine, and grazing land-use types. A total of 126 quadrats, each with 900 m^2 (30 m × 30 m), were selected systematically along the altitudinal gradient. Shannon Weiner Diversity index and R Package 3.2 were applied to analyze species composition and diversity, whereas the similarity ratio among land use and other related vegetation was determined using Sorensen's index. From the study, 382 vascular plant species under 223 genera and 92 families were identified. The growth forms revealed that there were 118 woody (26 trees, 10 lianas, and 82 shrubs) and 239 herbaceous species of plant. Of these, 216, 165, and 154 species are shared by riverine, forest patch, and grazing land-use types, respectively. Asteraceae with 68 species was the most dominant family in the present study, followed by Poaceae, Lamiaceae, and Cyperaceae with 30, 21, and 13 species, respectively. Forty-four endemic species were documented in this study. According to the IUCN Red List, 22 species were not evaluated; 10 species were least concerned; 1 species was endangered; and 1 species was vulnerable, while 4 species have been categorized as not threatened. The highest similarity was observed between grazing and riverine land-use types; this may be due to the presence of many adjacent plots in both land use, associated mechanisms of adaptation, and requirements for species occurrence. Moreover, the floristic composition similarity of the study area in comparison with other vegetation types of Ethiopia shows variation (Ss = 0.223–0.526), maybe due to climatic variation, ecological distance, and disturbances. Generally, the total diversity and evenness of the studied remnant vegetation were 2.917 and 0.948, respectively. This lower diversity value clearly indicates that there are many human-induced factors deteriorating the plant species of the studied vegetation. Therefore, the concerned body of the government should work with local farmers to conserve the remaining plant species including many endemic species by developing appropriate conservation and management plans.

1. Introduction

Various forest of the tropics supports numerous living species constituting the biodiversity through webs of life. For example, as stated in Mukhopadhyay et al. [1], various life forms including humankind settled in and around the forests. However, many habitat disturbances cause the loss of forest elements in the tropical regions. Among those disturbances, the major threats to biodiversity are induced by habitat loss and fragmentation, and much of this are driven by agricultural activities [2]. Another study by Gibbs et al. [3] shows us the primary cause of the tropical forest in the 1980s and 1990s was agricultural expansion. As a result of these factors complex nature of the forest such as fragmentation of the forest landscape, the reduction of the forest population, the interruption of the dispersal and migration

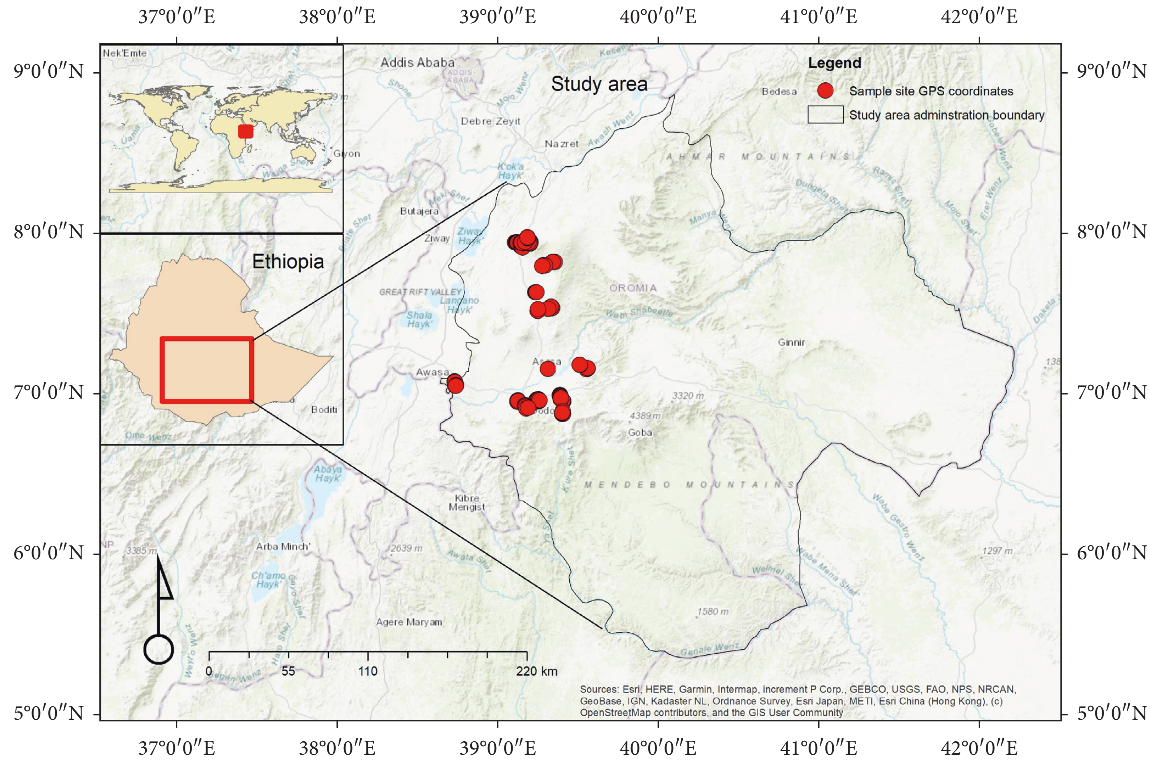

FIGURE 1: Map of the study sites (research location includes six districts: Kofele, Dodola, and Adaba from the east Arsi zone and Tijo, Sajure, and Bekoji from the west Arsi zone, which are distributed along the Arsi-Bale Massifs in southeastern Ethiopia).

patterns, inputs and outputs alteration in the ecosystem, and the previously isolated core habitats are exposed to other external conditions. Due to these reasons' erosion of biological diversity [4, 5]. These kinds of threats have similarly occurred in the highlands of Ethiopia. Thousands of years ago, Ethiopian highland agriculture developed largely inside the areas covered by dry evergreen Afromontane forest (DAF) complex and has been intensely utilized by man ever since, with the result that the bushland replaces most forests areas [6, 7].

In Ethiopia, the huge human population size associated with poverty has boosted the negative human impact on the forest resources [8]. According to Merga [9], the rural livelihood of 83% of the population in our country depends on renewable natural resources leaving high pressure on the forest resources. Moreover, the depletion and deterioration of the forest resources due to the large population size have resulted in the reduction of the product in the agricultural sector [9]. Due to continuous deforestation, nearly 141,000 ha (0.93%) of the forest cover of Ethiopia was eliminated every year [10]. Regardless of diminishing vegetation cover, Ethiopia contributes enormous biological diversity. This is due to vast geographic diversity such as high and rugged mountains, flat-topped plateaus and deep gorges, incised river valley, and rolling plains [11, 12].

Similarly, agricultural land expansions for cultivating wheat and barley have been employed in the remnant vegetation of Arsi-Bale Massifs, the study area [13]. These practices continue the clearance of small remnant patches of forest as well as minimize the remaining grazing area in the matrix of agricultural fields. This needs immediate conservation action to protect the remaining species of plants, animals, and the ecosystem in general. Therefore, the present study may help the conservationist and management planner by having information on floristic diversity and endemism along agricultural landscapes in Arsi-Bale Massifs.

2. Methodology

2.1. Description of the Study Area. The research was done in the fragmented agricultural landscape system of Arsi-Bale Massifs, which is located between 06° 52′ 27″ to 07° 58′ 19″ N latitude and 39° 06′ 26″ to 39° 44′ 24″ E longitude in southeast Ethiopia within Oromia Regional State (Figure 1). The study location lies between 2,318 m.a.s.l in Tulu kuche and 3,382 AMSL in Galama mountain. The topographic natures of the study sites include the plain lands of the pastures and agricultural fields, which are found on the border valleys, following the streams. The agricultural fields are distributed in the small patches of the forest, which are located on the top hills of the mountain peaks and at lower altitudes following streams or rivers [14].

The study area's annual mean temperature lies between 13°C and 16.8°C (Figures 2(a)–2(d)), and the annual precipitation was found to be 1,014 mm in Adaba to 1,117 mm in Bekoji (Figure 2(c)). The highest precipitation of wettest month (July) with 236 mm in Adaba and 235.47 mm in

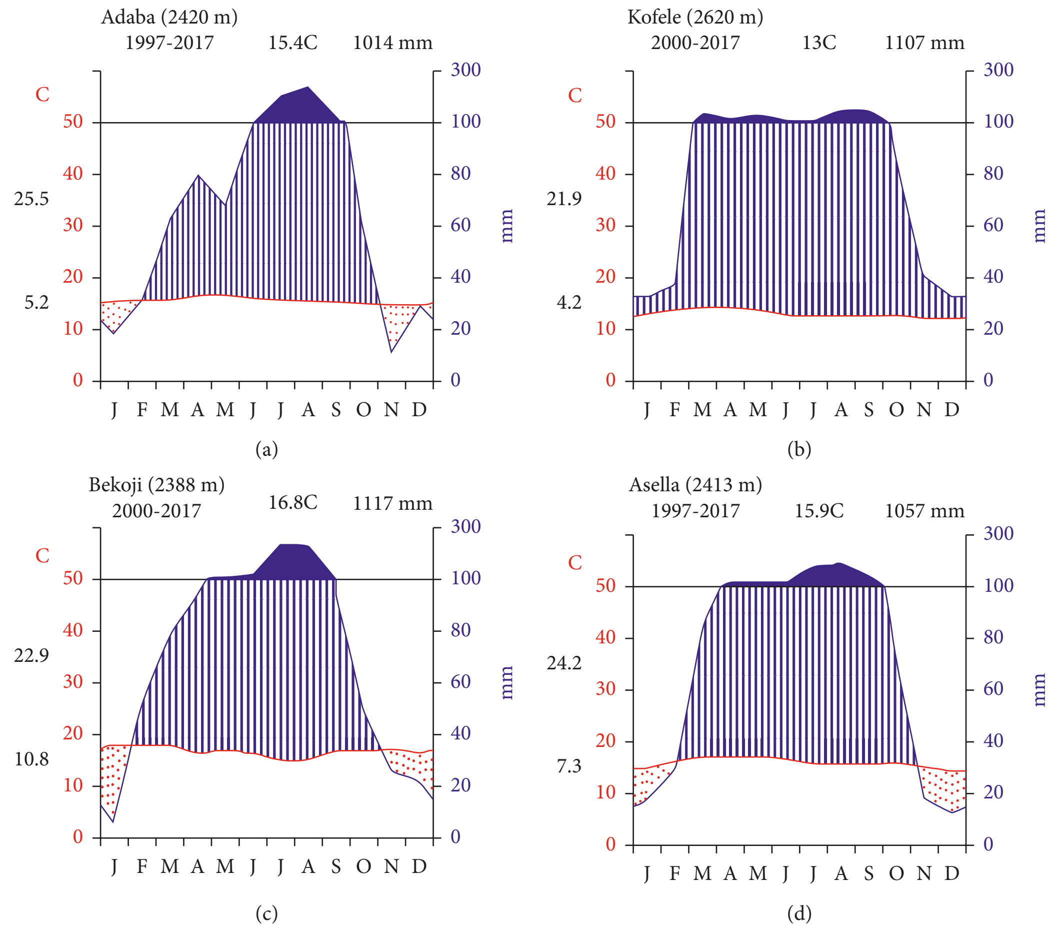

Figure 2: Climatic diagram of meteorological stations of the research sites (source: National Meteorological Service Agency [15].

Bekoji; while the driest month (January) is 6.06 mm in Bekoji. The months May to October are the rainiest months with high peaks in August, whilst November to February are the driest months of all the study districts except for Kofele, which is slightly different. The highest and lowest annual mean temperatures were documented in Adaba (Figure 2(a)) and Kofele (Figure 2(b)), respectively. In general, all the district vegetation of our study sites has variable altitudinal ranges with different climatic conditions.

2.2. Floristic Data Collection. A reconnaissance survey was conducted and observed in August 2015 to gather the baseline information, observe the land use vegetation distribution, get impressions of the study area conditions, and fix the best sampling sites, as well as to get the number of quadrants to be laid across the agricultural landscape and remnant patches of Arsi-Bale Massifs. The floristic data collection is mainly determined by the presence of the areas that were not ploughed beside the agricultural fields and depending on the presence of remnant patches of the forest. Accordingly, a total of 126 quadrats with 900 m^2 (30 m × 30 m) area were selected systematically along the altitudinal gradient. Finally, plant species were identified using different flora volumes of Ethiopia and Eritrea and by comparing with already existing plant species specimens in the National Herbarium of Ethiopia.

2.3. Data Analysis. Species richness and evenness are independent characteristics of biological communities that together constitute its diversity [16], in which the latter shows how evenly the individuals of the species are distributed in the community among the different species. On the other hand, the species richness index is very crucial in studying the taxonomic, structural, and ecological importance of a given habitat. Floristic richness, diversity, and evenness indices of Arsi-Bale Massifs along the three land-use types were done with R software (Version 3.2; [17]). Species diversity shows the product of species richness and evenness. Finally, the plant species endemism, rarity, and commonness were analyzed by species diversity indices [18] and described in the following sections.

2.4. Shannon Weiner Diversity Index. It is the most applicable index of diversity [19]. Shannon's index accounts for

Table 1: Floristic richness of the study districts (woredas) recorded of Arsi-Bale Massifs with species number in decreasing order.

Family	Number of genera	Proportion of genera	Species number	Proportion of species
Asteraceae	32	14.35	68	17.80
Poaceae	19	8.52	30	7.85
Lamiaceae	13	5.83	21	5.50
Cyperaceae	3	1.35	13	3.40
Apiaceae	7	3.14	11	2.88
Rosaceae	5	2.24	11	2.88
Fabaceae	6	2.69	10	2.62
Aspleniaceae	1	0.45	8	2.09
Scrophulariaceae	5	2.24	7	1.83
Solanaceae	3	1.35	7	1.83
Asclepiadaceae	5	2.24	6	1.57
Euphorbiaceae	4	1.79	6	1.57
Oleaceae	3	1.35	6	1.57
Rubiaceae	5	2.24	6	1.57
Crassulaceae	2	0.90	5	1.31
Malvaceae	4	1.79	5	1.31
Polygonaceae	3	1.35	5	1.31
Ranunculaceae	4	1.80	5	1.31
Urticaceae	4	1.80	5	1.31
79 others families	95	42.60	147	38.48
Total	223	100	382	100

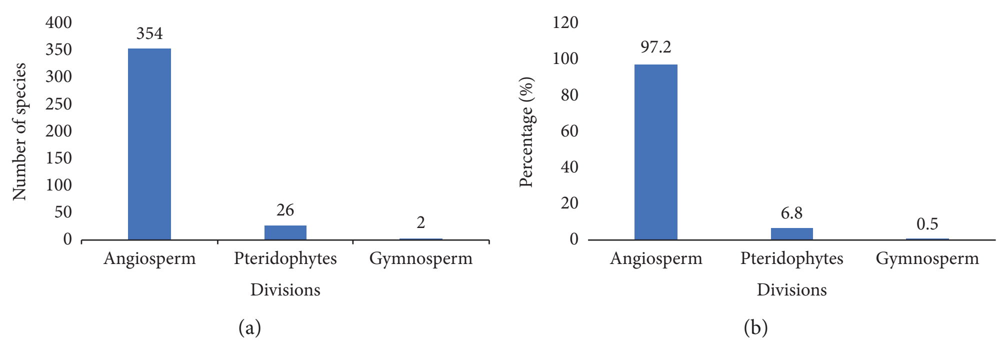

Figure 3: Percentage proportions (a) and number of species (b) of angiosperm, gymnosperm, and pteridophytes of the study area.

both the abundance and evenness of species present. The proportion of species relative to the total number of species (pi) is calculated and multiplied by the natural logarithm of this proportion (lnpi).

The Shannon diversity index (H′) is calculated as follows:

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

where *H*' is the Shannon–Weiner diversity index, *S* is the total number of species, *Pi* is the proportion of individuals or abundance of the i^{th} species as a proportion of total cover, and *ln* is the log base.

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

where *J* is the evenness and *H*'max is the lns.

Sorenson's similarity ratio was used to evaluate the similarity among the land use, the study vegetation, and seven other vegetation of Ethiopia on the basis of their species composition using the following formula:

$$Ss = \frac{2a}{2a + b + c}, \quad (3)$$

where *Ss* is Sorensen's similarity coefficient, *a* is the number of species common to both samples, *b* is the number of species in sample 1, and *c* is the number of species in sample 2. Finally, the species number, families, genera, and the percentage of growth forms were also done using MS Excel software.

2.5. Floristic Composition and Diversity. The vascular plant species composition, abundance, and diversity of the study districts of the remnant vegetation in Arsi-Bale Massifs were documented. There were 382 species of vascular plants belonging to 223 genera and 92 families (Table 1) within the altitudinal ranges between 2,318 and 3,882 m.a.s.l. In terms

Table 2: Comparison of Asteraceae dominance in different vegetation types of Ethiopia.

Study area	Authors and years	Asteraceae richness	Percentage Proportion	Species richness of study area	Study area coverage (ha)	Altitudinal ranges (m)
Arsi-Baale Massifs	Awoke, 2020	68	17.80	382	11.34	2,318–3,382
Gole natural forest	[35]	21	18.42	114	2.48	2,728–3,480
Sanka Meda forest, Arsi zone	[36]	21	15	139	2.8	2,578–2,650
Afromontane forest in Awi zone	[26]	18	8.49	212	6	1,830–2,660
Bale Mountain National Park	[37]	39	16.96	230	8.1	3,010–3,410
Belete moist evergreen forest	[38]	10	6.37	157	2.76	1,842–2,245
Chilimo forest	[24]	28	13	213	**	2,170–3,054
Gendo moist montane forest	Gemechu et al., 2015	24	14.3	168	2.88	2,183–2,300

of growth form, there were 118 woody (26 trees, 10 liana, and 82 shrub) and 239 herbaceous species of plants. angiosperms were represented by 354 (92.7%) species, pteridophyte by 26 (6.8%) species, and gymnosperms by 2 (0.5%) species of plants. This result showed that the highest proportion of species, genera, and families were accounted for by angiosperm groups (Figure 3). The remnant patches of studied vegetation have high species richness as compared with other similar studies such as dry Afromontane coniferous forest in the Bale Mountains with 113 species [20], Gedo forest in West Shawa with 130 species [21], Managesha Suba state forest in Central Shawa with 112 species [22], Desa'a and Hugumburda forest in the fragmented landscape of northern Ethiopia with 153 species [23], Chilimo forest in Central Ethiopia with 213 species [24], Wotagisho forest in Boloso Sore woreda with 51 species [25], evergreen Afromontane vegetation of Awi zone in Amhara region with 212 species [26], and Arero dry Afromontane forest of Borena zone with 81 species [8]. This may be due to the larger area coverage, habitat heterogeneity, high altitudinal gradient (i.e., six different districts were included in this study between the altitudinal ranges of 2,318–3,382 m with 11.34 ha area coverage) and microclimatic variations of the present study, even though there is high habitat fragmentation due to different factors, particularly agricultural expansion in the area. Beside habitat fragmentation and habitat loss, habitat diversity (or heterogeneity) [27–29] is the major determinant of species diversity and floristic composition and affects the distribution patterns in general. Additionally, the elevational difference [30], latitudinal [31], and humidity variations [32] affect the diversity of the species in the area. Hence, sustaining the variation of the habitat is a very important means of conserving species richness in habitats threatened by human activities [33, 34].

As presented in Table 1, the number of species, genera, and families with their percentages that were identified and documented from the remnant patches of the forest and farmlands in the agricultural landscape of Arsi-Bale Massifs of Oromia Regional State. The discussion is given below.

Among angiosperm, Asteraceae with 68 (17.8%) vascular plant species was the most dominant family followed by Poaceae, Lamiaceae, and Cyperaceae with 30 (7.85%), 21 (5.5%), and 13 (3.4%) species, respectively. On the other hand, Apiaceae, Rosaceae, Fabaceae, and Aspleniaceae with 11 (2.88%), 11 (2.88%), 10 (2.62%), and 8 (2.09%) species were followed by Scrophulariaceae and Solanaceae with 7 (1.83%) species each (Table 1). Moreover, among the families of pteridophytes, Aspleniaceae is the most dominant family accounting for the highest number of species (8 species), followed by Polypodiaceae and Sinopteridacea with 4 species each. *Juniperus procera* and *Podocarpus falcatus* were the two indigenous species representing gymnosperm in the study area.

Table 3: Top 10 species richest families of the study vegetation with increasing order of species.

Family	Species number	Percentage proportion
Scrophulariaceae	7	1.83
Solanaceae	7	1.83
Aspleniaceae	8	2.09
Fabaceae	10	2.62
Apiaceae	11	2.88
Rosaceae	11	2.88
Cyperaceae	13	3.40
Lamiaceae	21	5.50
Poaceae	30	7.85
Asteraceae	68	17.80
Total	189	49.48

Similar result reports are investigated in various researches by different researchers/scholars in different parts of Ethiopia as indicated in Table 2 which show the dominance of the Asteraceae family with the highest percentage of plant species among the Angiosperm families. Also, the present study identified Poaceae, Lamiaceae, and Cyperaceae as the other dominant families of the study districts of the study area. The family Lamiaceae has been reported as a dominant family by different authors [35, 36, 38, 39], whereas the dominance of Poaceae by Yineger et al. [37] and Kebede [21].

Moreover, the floristic richness of the studied Afromontane vegetation of the remnant patches in the agricultural landscape of Arsi-Bale Massifs of the study districts was described well with their species richest families (Table 3) and discussed clearly with previous similar studies of Afromontane and other vegetation types of Ethiopia, particularly dry evergreen Afromontane vegetation and grassland complexes. As shown in Table 3, from a total of 382 species, 189 species (49.48%) were accounted for by 10 species of richest families of the area (9 families from the Angiosperm group and 1 family from pteridophyte). Different findings [20, 24, 38, 40]; Kedir et al. [26] reported that

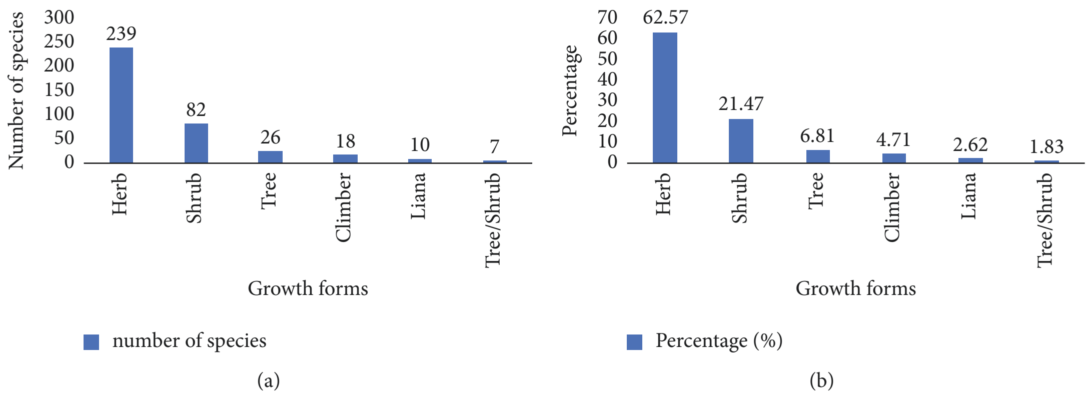

Figure 4: The growth forms of plants in Arsi-Bale Massifs of the study districts, including a number of species (a) and their percentage proportions (b).

Table 4: Floristic richness, evenness, and diversity of the three land-use types of the study area.

Land-use types	Number of plots	Species richness	Alpha diversity index (H')	Evenness index (J)
Forest patch	47	229	2.743	0.945
Riverine	48	267	3.018	0.951
Grazing	31	221	2.895	0.953
Total	126	382	2.917	0.948

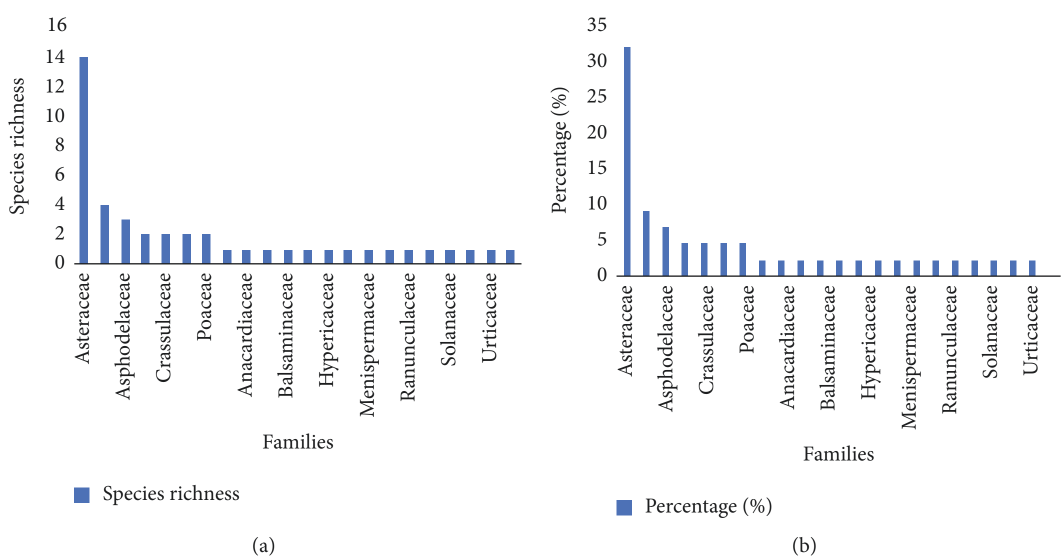

Figure 5: The percentage proportion (b) and species richness (a) of above-ground endemic plant species within the families.

the angiosperm groups were contributing more plant species than pteridophytes and gymnosperms in different vegetation types of Ethiopia. Similarly, our study identified 354 (92.67%) species of angiosperm belonging to 205 (91.93%) genera and 79 (85.87%) families.

Analysis of the growth form of vascular plant species identified different life forms such as tree, shrub, herb, liana, and climbers having various proportions (Figure 4). Herbs accounted for the highest percentage (62.5%) of life forms, while 21.47% and 8.61% were found to be shrubs and trees, respectively. The least proportion was observed for liana and climber (Figure 4). Similar studies reported the highest percentage of herbs than other life forms [8, 41, 42].

2.6. Vascular Plant Endemicity. There were 44 (11.52%) endemic plant species under 22 families and 37 genera were collected in this study. The family Asteraceae was the richest family with 14 (31.8%) species in endemicity followed by Lamiaceae and Asphodelaceae with 4 (9.01%) and 3 (6.82%)

Table 5: List of endemic species occurring in Arsi-Bale Massifs of the study districts with their IUCN threat categories.

No.	Scientific name	Family	Habitat	IUCN category
1	*Acanthus sennii* Chiov.	Acanthaceae	H	NT
2	*Alchemilla haumannii* Rothm.	Rosaceae	S	NE
3	*Bidens macroptera* (Sch. Bip. ex Chiov.) Mesfin	Asteraceae	H	NE
4	*Bothriocline schimperi* Oliv. and Hiern ex Benth.	Asteraceae	S	LC
5	*Clematis hirsuta* Perr. and Guill	Ranunculaceae	L	NE
6	*Cineraria sebaldii* Cufod.	Asteraceae	H	NE
7	*Cirsium schimperi* (Vatke) C. Jeffrey ex Cufod.	Asteraceae	H	LC
8	*Cissampelos pareira* L.	Menispermaceae	C	NE
9	*Crassocephalum macropappum* (Sch. Bip. ex A. Rich.) S. Moore	Asteraceae	H	LC
10	*Echinops ellenbeckii* O. Hoffm.	Asteraceae	S	EN
11	*Echinops longisetus* A. Rich.	Asteraceae	H /S	LC
12	*Erythrina brucei* Schweinf.	Fabaceae	T	LC
13	*Festuca macrophylla* Hochst. ex A. Rich.	Poaceae	H	NE
14	*Gladiolus longispathaceus* Cufod.	Iridaceae	H	NE
15	*Gomphocarpus purpurascens* A. Rich.	Asclepiadaceae	H	NE
16	*Helichrysum gofense* Cufod.	Asteraceae	H	NE
17	*Hypericum peplidifolium* A. Rich.	Hypericaceae	H	NE
18	*Impatiens rothii* Hook. f.	Balsaminaceae	H	LC
19	*Inula confertiflora* A. Rich.	Asteraceae	S	LC
20	*Jasminum stans* Pax	Oleaceae	S	NE
21	*Kalanchoe lanceolata* (Forssk.) Pers.	Crassulaceae	H	NE
21	*Kalanchoe lanceolate* (Forssk.) Pers.	Crassulaceae	H	NE
22	*Kalanchoe petitiana* A. Rich.	Crassulaceae	H	LC
23	*Kniphofia foliosa* Hochst.	Asphodelaceae	S	NE
24	*Kniphofia isoetifolia* Steud. ex Hochst.	Asphodelaceae	H	NE
25	*Kniphofia insignis* Rendle	Asphodelaceae	H	NE
26	*Leucas abyssinica* (Benth.) Briq.	Lamiaceae	S	LC
27	*Lippia adoensis* Hochst. ex Walp. Var. Adoensis	Verbenaceae	S	LC
28	*Lobelia rhynchopetalum* Hemsl.	Lobeliaceae	T	NE
29	*Lobelia scebelii* Chiov.	Lobeliaceae	H	NE
30	*Maytenus addat* (Loes.) Sebsibe	Celastraceae	T	NT
31	*Maytenus arbutifolia* (A. Rich.) Wilczek	Celastraceae	S	NE
32	*Mikaniopsis clematoides* (Sch. Bip. ex A. Rich.) Milne-Redh.	Asteraceae	L	LC
33	*Pennisetum humile Hochst.* ex A. Rich.	Poaceae	H	NE
34	*Phagnalon abyssinincum* Sch. Bip. ex A. Rich.	Asteraceae	H	LC
35	*Plectocephalus varians* (A. Rich.) C. Jeffrey ex Cufod.	Asteraceae	H	LC
36	*Pycnostachys abyssinica* Fresen	Lamiaceae	S	NT
37	*Rhus glutinosa* A. Rich.	Anacardiaceae	S	VU
38	*Satureja paradoxa* (Vatke) Engl. ex Seybold	Lamiaceae	H	NE
39	*Senecio myriocephalus* Sch. Bip. ex A. Rich.	Asteraceae	S	LC
40	*Senecio ochrocarpus* Oliv. and Hiern	Asteraceae	H	NE
41	*Solanum marginatum* L. f.	Solanaceae	S	LC
42	*Sparmania macrocarpa* Ulbr.	Tiliaceae	S	NT
43	*Thymus schimperi* Ronniger	Lamiaceae	H	LC
44	*Urtica simensis* Steudel	Urticaceae	H	NE

[a] indicates growth forms of the plants, H is the herb, T is the tree, S is the shrub, L is the liana, and C is the climber.

species, respectively (Table 4 and Figure 5). The family Celastraceae, Crassulaceae, Lobeliaceae, and Poaceae accounted for 2 species each (4.5%). On the other hand, families such as Acanthaceae, Anacardiaceae, Asclepiadaceae, Balsaminaceae, Fabaceae, Hypericaceae, Iridaceae, Menispermaceae, Oleaceae, Ranunculaceae, Rosaceae, Solanaceae, Tiliaceae, Urticaceae, and Verbenaceae were endemic species represented by only 1 species each (2.3%).

In terms of growth form, there are 20 woody (3 trees, 15 shrubs, and 2 lianas) species, 23 herbaceous species, and 1 climber endemic plant species with the highest proportion of herbs (52.27%) followed by shrubs (34.1%). From these, the highest proportion of herbs and shrubs are distributed in the family Asteraceae, whereas families Lamiaceae and Crassulaceaea are the other groups contributing a high number of growth forms of plant species. The remaining 19 families of endemic species of the study districts were contributing the least number of shrubs and herbs (Table 5).

Moreover, the work by Kelbessa et al. [43] and Vivero et al. [44] provided important evidence that contains the list

Table 6: Floristic composition similarity indices between the land-use types.

Land-use types	Forest patch	Riverine	Grazing
Forest patch	***		
Riverine	0.672	***	
Grazing	0.671	0.711	***

***indicates 100% similarity.

Table 7: Vascular plant species similarities between the present study area and other study areas in Ethiopia.

Areas	Richness	Altitude (m)	Study area	Authors
Study area (ABM)	382	2,318–3,382	1	Awoke et al., 2020
BMNP	230	3,010–3,410	0.375	[37]
BMF	157	1,300–3,000	0.223	[38]
CF	213	2,170–3,054	0.417	[24]
KARF	180	2,170–3,054	0.337	[39]
GDEMF	235	1,300–3,060	0.526	[21]
AF	162	1,700–2,370	0.155	[45]
AAMF	120	2,100–2,479	0.303	[46]

Note. ABM: Arsi-Bale Masssifs (present study area), BMNP: Bale Mountains National Park, BMF: Belete moist evergreen montane forest, CF: Chilimo forest, KARF: Komto Afromontane rain forest, GDEMF: Gedo dry evergreen montane forest, AF: Agama forest, and AAMF: Aba Asirat monastery forest.

of endemic plant species of Ethiopia and the level of threat to them. Accordingly, in the endemic species list of the present study and the level of threats of each plant species indicated in Table 5, one species was endangered (EN), and one species has been evaluated as vulnerable (VU), while four species have been categorized as not threatened (NT). The other twenty-two and ten were not evaluated (NE) and least concerned (LC), respectively.

2.7. Vascular Plant Diversity. The highest species richness was reported for Riverine followed by forest and grazing land-use types (Table 4). The Shannon–Weiner index and relative abundance of the study vegetation were 2.917 and 0.948, respectively. The Shannon–Weiner index values of riverine, grazing, and forest patch were H' = 3.018, H' = 2.895, and (H' = 2.743), respectively. The highest evenness index value of the study area was contributed by grazing land-use type, whereas the least was contributed by forest patch.

2.8. Floristic Composition Similarities between Land-Use Types. The floristic composition and their distribution among the land-use types in the study area show different similarity patterns (Table 6). The Sorenson similarities index in this study was generally strong ($Ss > 0.5$) [26]. The overall Sorenson similarities index ranges from 0.671 to 0.711 among all land-use types. The highest similarity was observed between grazing and riverine land-use types; this may be due to the presence of many adjacent plots in both land use, associated mechanisms of adaptation, and requirements for species occurrence. On the contrary, the lowest similarity was observed among grazing and forest patches of the study area, this may be due to various factors such as human-induced disturbances and physical factors such as soil, slope, aspect, microclimate, and that related to the altitudinal difference in which most of the classifications were based.

2.9. Floristic Similarities to Other Studied Vegetations of Ethiopia. The floristic composition of the present studied vegetation comparison with previous works in different parts of the country was done, and the comparison is presented in Table 7 that reveals the range of similarity indices. Its highest Shannon index value was observed for the Gedo dry evergreen montane forest [21] and Chilimo forest [24], followed by Bale Mountains National Park [37], Komto Afromontane rain forest [39], Aba Asirat montane forest [46], and Belete moist forest [38]. The least similarity was observed in Agama forest [45]. The present studied vegetation and other vegetation types listed in Table 7 may have different climatic conditions [47, 48], variations in disturbances [49, 50], and ecological distances [18]. These factors may cause the major important differences between the vegetation of the present study area and other study areas. In this study, in addition to agricultural expansion, exploitation of woody species for firewood and construction resolutions are the major factors that are threatening numerous plant species in the area. For instance, the Menagesha Suba and Jibat forests have been severely exploited for timber production and domestic consumption for firewood and construction purposes [49].

3. Conclusion

The remnant vegetation patches of Arsi-Bale Massifs in the agricultural matrix harbour various vascular plant species. In this study, 382 species of vascular plant belonging to 227 genera and 94 families were documented. Asteraceae was the most dominant family, followed by Poaceae and Lamiaceae. On the other hand, most of the families were species poor. For instance, 36 families contributed 1 species each. Arsi-Bale remnant patches are also important reservoirs for 44 endemic plant species.

The phytogeographical comparison revealed that the similarity between all land-use types was stronger ($JS > 0.67$);

however, the similarity ratio between the present study and other vegetation types of Ethiopia was weak (JS < 0.42) except for Gedo dry evergreen montane forest (JS = 0.53). Generally, the study area has low species diversity (H' = 2.917) and good relative abundance (J = 0.948). This may be due to habitat loss and fragmentation occurring by continuous agricultural expansion that increases the patch isolation and decreases the size of the remnant forest patches of the study area that support plant species population. The concerned body of the governments and nearby communities of the present study vegetation should work together to conserve the rare species and richest endemicity in these remnant patches (or microrefugia) of the agricultural matrix. [51–57]

Data Availability

The data supporting the findings of this study will be made available by the authors upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Supplementary Materials

The raw data used to support the findings of the present study were provided. The supplementary materials are the raw data that support the supplementary data such as figures and tables. Supplementary materials are provided for Figures 3, 4, and 5 and Tables 1, 3, and 4, and their descriptions are given with their respective captions. (*Supplementary Materials*)

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