Heliyon 10 (2024) e35258

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

The status of plant diversity in different land use types of agricultural landscape of west Oromia, Ethiopia

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ARTICLE INFO

Keywords:
Dry afromontane
Degradation
Matrix land
Refugia
Species richness
Vegetation

ABSTRACT

Understanding how land use types embedded in agricultural landscapes support forest biodiversity is critical, especially during this period of continuing fragmentation and habitat losses in natural ecosystems. Here, we explored the floristic species composition with respect to land use types in the agroecosystem of west Oromia, Ethiopia. For this, a systematic sampling method was employed to collect floristic data from 122 main quadrats and 610 sub-quadrats, following transects laid out with a 1500-m interval. The main quadrats were arranged on transects with an 800-m interval to assess woody species, and five sub-quadrats (i.e., four at the corners and one at the center) were taken within each main plot to assess herbaceous plants. Accordingly, the floristics were assessed with respect to the identified five land use types, including crop land, forest, grazing land, home gardens, and riverine. We used a one-way ANOVA to test the difference in species diversity among the land use types. Adonis 2 and indval functions were used to describe the species composition and indicator species in relation to the land use types. Moreover, NMDS was applied to visualize the associations of the species composition with environmental variables in ordination space. A total of 285 plant species belonging to 220 genera and 89 families were recorded. Our results showed significant differences in species diversity, dissimilarity in species composition, and species indicator values among the land use types. These results indicate that the potentiality of the land use types in supporting plant diversity is significantly different; for example, species diversity and abundances were higher in grazing lands and home gardens when compared with other land use types. Overall, our findings suggest that conservation strategies in agricultural landscapes should take into account the differences in capacity for supporting biodiversity among land use types when planning.

1. Introduction

Plant biodiversity has faced a serious degradation problem because of the declining extent of vegetation cover and its qualities from time to time [1–3]. The decline of vegetation in extent and quality could enhance the increasing loss of suitable habitats that can support biological diversities in their natural ecosystem settings [4–6]. Deforestation is the cause of the loss of suitable habitats that can support a wide range of different groups of organisms in the vegetation of natural and semi-natural ecosystems [7–9].

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https://doi.org/10.1016/j.heliyon.2024.e35258
Received 30 January 2023; Received in revised form 23 July 2024; Accepted 25 July 2024
Available online 26 July 2024

Agricultural land expansion is the main driving factor for the destruction of vegetation and, hence, the loss of habitats for plant biodiversity [10–12]. The agricultural land expansion facilitated through deforestation could lead to the formation of variegated landscapes with mosaics of semi-natural vegetation intermixed with agricultural farm lands [13–16]. This gradual vegetation degradation could result in the formation of semi-natural habitat forms identified as crop land, fragmented forest patches, grazing land, home gardens, and riverine/stream habitats, which are in general known as land use types.

This implies that vegetation studies can be conducted in such landscapes with fragmented forest patches intermixed with other land use forms [17,18]. For example, the diversity of trees and shrubs in fragmented patch forests distributed in agricultural landscapes may show a variation in abundance and richness, as explained in the study [19]. Similarly, plant species that may be absent in the surrounding intact forest could be abundant in nearby agricultural matrix land that is intermixed with mosaics of various fragmented forest patches [20].

Similarly, the strips of riverine vegetation and trees found scattered in farm lands are explained as good indicative remnant marks in agricultural landscapes [21,22]. Patches of shrubs found scattered on the margins of farm lands can also be considered part of vegetation and contribute to the study of the diversity of plant species in agricultural landscapes [20,23]. This indicates that studying plant diversity in agricultural landscapes can contribute to generating a sort of knowledge that attributes biodiversity conservation aspects to such landscapes [24–26].

Similarly, deforestation practiced for a long period could bring considerable changes to the extent of vegetation cover and its qualities at different corners of Ethiopia [27]. Increasing farmer demand for agricultural land, settlements, and intensive state farm expansions practiced in the country were the main causes for the destruction of vegetation cover in wide areas of the country [28–30]. Most previous studies done on vegetation in Ethiopia focused on dense forests and explained the status and changes brought on them due to impacts from anthropogenic pressure [31–33]. The studies could also explain gradual changes that could bring forested areas to fragmented patches intermixed with different land use types that can be explained as agricultural landscapes.

So, conducting vegetation studies in agricultural landscapes is paramount to understanding the diversity of plant species among different land use types. Furthermore, having an understanding of plant species diversity and richness in various land use variables can initiate insights on biodiversity conservation for potential management plans. In west Oromia, where agricultural activities have been widely practiced and could bring considered changes to the land feature for long periods, we intended to conduct a vegetation study in the agricultural landscape, comprising various land use types such as crop land, forest, grazing land, home gardens, and riverine. Here, we hypothesized that there were significant differences in plant species composition and species diversity among different land use types in agricultural landscapes in west Oromia. To test the hypothesis, we analyzed sample vegetation data collected within each of the five land use types in Gudeya Bila District.

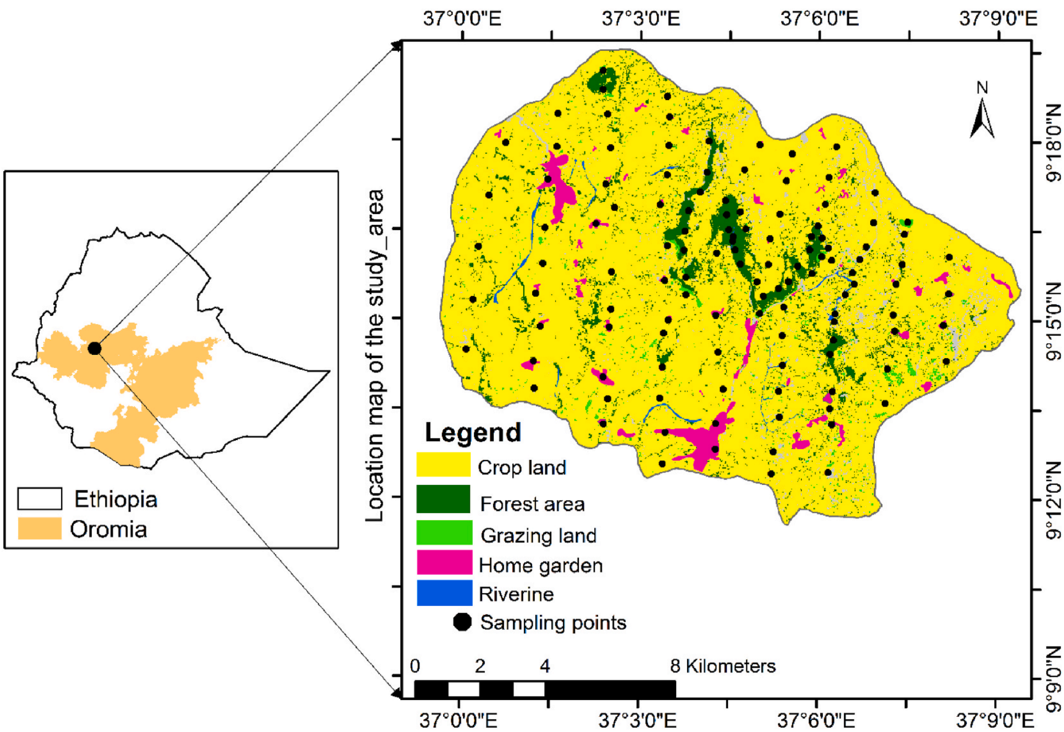

Fig. 1. The map of the study area shown in relation to the Oromia region and Ethiopia.

2. Materials and methods

2.1. Study area

The study was conducted in Gudeya Bila District, which is situated in west Oromia Region, Ethiopia, between the geographical coordinates of 9°11′33″–9°19′40″ N and 37°0′05″–37°9′24″ E (Fig. 1). The topography of the study area is characterized by a flat land platform, undulating ups and bottoms, rocky hills, and belts of escarpments with steady slopes directing towards the Gibe basin. The study area extends within the altitudinal range of 1970–2899 m.a.s.l. The main soil types in the study area are nitosols and vertisols [34]. The area receives rainfall in a unimodal pattern [35], where the annual average ranges between 1400 and 2000 mm [36]. The vegetation types of the study area belong to the Combretum-Terminalia woodland and Dry evergreen afromontane forest and grassland complex [37]. The agricultural landscape of the study area is heterogeneous and composed of fragmented forest patches, crop land, grassland, grazing land, shrub lands and built-up areas.

2.2. Study design

Taking into account our previous knowledge of vegetation fragmentation and ecological degradation around the study area, we selected agricultural landscape to study plant species diversity in different land use types. Firstly, we observed the satellite images in Google Earth to identify the landscape that encompasses different land use structures such as crop land, forest patches grazing land, riverine area, and home garden (Fig. 1). The total area of the study landscape is 164.3787 km^2. Secondly, we laid out parallel transects with a 1500 m interval in the study landscape. On each transect, quadrats of different sizes were arranged with an 800 m interval, and the coordinates of each plot were recorded with a hand-held GPS. Accordingly, to assess woody species, 50 m × 50 m main quadrats were used for crop land, grazing land, and home gardens; for forest and riverine, 20 m × 20 m and 10 m × 50 m were used, respectively. Similarly, five 2 m × 2 m smaller quadrats laid out within the main quadrats (four at the corners and one at the center) were used to assess the data of herbaceous plants. In total, 122 main quadrats and 610 sub-quadrats were used to collect floristic data.

2.3. Data collection

From each main quadrat and subquadrat, trees, shrubs, and herbaceous floristic species were assessed, and the number of stems of shrubs and trees was recorded for the land use types encountered on transects. Here, five land use types, such as forest, riverine, grazing crop land, and home garden, were identified during the assessment. Along with this, the topographic aspect, altitude, and slope of each plot were recorded using a hand-held GPS. Plant specimens were collected, pressed, dried, and transported to the national herbarium of Addis Ababa University for later identification at the species level.

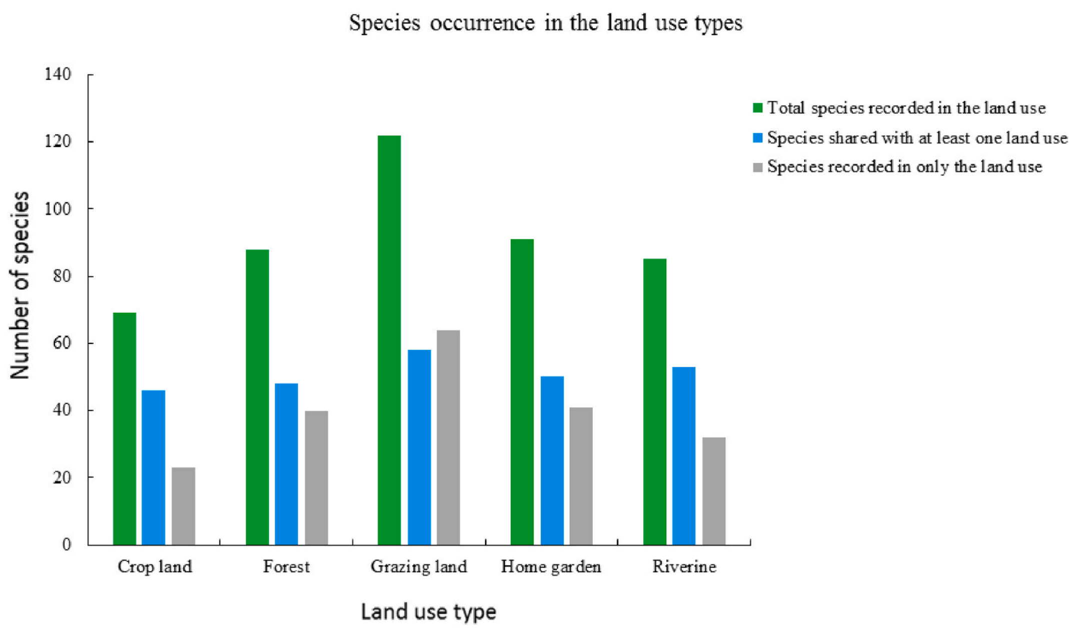

Fig. 2. The bar graph showing the shared and unique and total species richness with respect to the land us types.

2.4. Data analysis

The species richness, Shannon-Weier diversity index, and the number of stems of trees/shrubs were compared for each plot, and a one-way ANOVA was used to test for differences among the five land use types. After we found the significance difference, we executed the multiple comparisons of the means using the Tukey Honest Significance Difference (Tukey's HSD) with Bonferroni adjusted p-values within the multcomp package. The dissimilarity in species composition among the land use types and the indicator species values were analyzed by employing the Adonis2 function with 999 permutations. Adonis2 is a permutational multivariate analysis of variance (MNOVA) used for partitioning distance matrices among sources of variations among samples by measuring the dissimilarity with the Bray-Curtis distance method. To identify the characteristic and commonly occurring species in relation to the land use types, the indicator species analysis was carried out using indval functions within the labdsv package. Moreover, non-metric multidimensional scaling ordination (NMDS) was applied using the Bray-Curtis distance method to visualize the species composition along with the environmental variables in the ordination space. All statistical analyses were performed using the R statistical computing environment (version 4.2.1., R Core Team 2022).

Table 1
Indicator species showing the diversity of the land use types with significant statistical value ($p < 0.05$).

Species	Crop land	Forest	Grazing land	Homegarden	Riverine	p-values
Caesalpinia decapetala	0.000	0.000	0.000	**0.266**	0.000	**0.001**
Celtis africana	0.054	0.164	0.042	0.001	**0.315**	**0.001**
Coffea arabica	0.000	0.000	0.000	**0.345**	0.040	**0.001**
Dracaena steudneri	0.000	0.006	0.000	0.000	**0.233**	**0.001**
Ficus vasta	**0.268**	0.000	0.000	0.000	0.000	**0.001**
Hypoestes forskaolii	0.000	**0.400**	0.000	0.000	0.000	**0.001**
Justicia schimperiana	0.000	0.000	0.002	**0.318**	0.000	**0.001**
Musa paradisiaca	0.000	0.000	0.000	**0.233**	0.000	**0.001**
Phytolacca dodecandra	0.000	0.000	0.000	0.001	**0.250**	**0.001**
Vangueria apiculata	0.000	0.000	0.000	0.000	**0.266**	**0.001**
Allophylus abyssinicus	0.000	**0.217**	0.000	0.000	0.036	**0.002**
Carissa spinarum	0.000	**0.241**	0.017	0.000	0.105	**0.002**
Millettia ferruginea	0.000	0.046	0.000	0.000	**0.230**	**0.002**
Apodytes dimidiata	0.023	**0.204**	0.021	0.001	0.000	**0.003**
Cordia africana	**0.260**	0.050	0.020	0.120	0.030	**0.003**
Erythrococca abyssinica	0.000	0.000	**0.187**	0.000	0.000	**0.003**
Ricinus communis	0.000	0.000	0.000	**0.200**	0.000	**0.003**
Teclea nobilis	0.000	**0.180**	0.000	0.000	0.037	**0.003**
Catha edulis	0.000	0.000	0.000	**0.200**	0.000	**0.004**
Vernonia myriantha	0.008	**0.290**	0.102	0.013	0.050	**0.004**
Vernonia amygdalina	0.000	0.004	0.002	**0.220**	0.127	**0.005**
Adiantum poiretii	0.000	**0.150**	0.000	0.000	0.000	**0.006**
Hygrophila schulli	0.002	0.000	**0.165**	0.000	0.000	**0.007**
Mangifera indica	0.000	0.000	0.000	**0.166**	0.000	**0.007**
Solanecio gigas	0.000	0.000	**0.187**	0.000	0.000	**0.007**
Dombeya torrida	0.000	**0.150**	0.000	0.000	0.000	**0.008**
Ficus sur	0.015	0.178	0.032	0.000	**0.244**	**0.009**
Vepris dainellii	0.000	**0.150**	0.000	0.000	0.000	**0.010**
Rhamnus prinoides	0.000	0.000	0.000	**0.177**	0.044	**0.011**
Plectranthus punctatus	0.000	0.000	0.000	0.000	**0.133**	**0.012**
Urera hypselodendron	0.000	0.000	0.000	0.000	**0.133**	**0.013**
Ensete ventricosum	0.000	0.000	0.000	**0.166**	0.000	**0.014**
Erythrina brucei	0.000	0.006	**0.157**	0.001	0.064	**0.015**
Calpurnia aurea	0.044	**0.257**	0.103	0.113	0.027	**0.016**
Persea americana	0.000	0.000	0.000	**0.133**	0.000	**0.016**
Rumex abyssinica	0.000	0.000	0.000	0.000	**0.133**	**0.016**
Eucalyptus camaldulensis	0.113	0.000	0.000	**0.178**	0.000	**0.020**
Schefflera abyssinica	0.014	**0.143**	0.000	0.002	0.000	**0.020**
Maesa lanceolata	0.000	**0.163**	0.012	0.000	0.013	**0.022**
Desmodium repandum	0.000	0.000	0.000	0.000	**0.133**	**0.024**
Rosa abyssinica	0.000	**0.124**	0.010	0.000	0.000	**0.024**
Tapinanthus heteromorphus	0.057	0.118	**0.185**	0.000	0.000	**0.024**
Hypericum quartinianum	0.000	**0.110**	0.016	0.000	0.000	**0.025**
Mikaniopsis clematoides	0.000	0.000	**0.125**	0.000	0.000	**0.027**
Rumex nervosus	0.000	0.000	**0.120**	0.000	0.000	**0.027**
Laggera crispata	0.000	0.000	**0.125**	0.000	0.000	**0.037**
Rubus apetalus	0.000	0.000	0.014	0.000	**0.101**	**0.038**
Solanum aculeatissom	0.000	0.000	**0.125**	0.000	0.000	**0.039**
Achyranthes aspera	**0.122**	0.000	0.000	0.005	0.000	**0.044**
Salix mucronata	0.000	0.000	0.000	0.006	**0.106**	**0.049**

3. Results

3.1. Species composition

A total of 285 plant species belonging to 220 genera and 89 families were recorded in the study area (Appendix 1). From the families recorded, 11.24 % were represented by more than five species, and this has contributed to 48.07 % of the total species. From these, Asteraceae, Fabaceae, Poaceae, Lamiaceae, and Solanaceae are the top five families. About 47.2 % of each of the recorded families is represented only by one species. For example, those species include Apodytes dimidiata (Icacinaceae), Celtis africana (Ulmaceae), Combretum paniculatum (Combretaceae), Grewia ferruginea (Tiliaceae), and Pittosporum viridiflorum (Pittosporaceae).

From the total species, grazing land shares the highest proportion (20.35 %), followed by riverine (18.60 %), home garden (17.54 %), forest (16.84 %), and crop land (16.14 %) with other land use types (Fig. 2). However, the unique species for each land use type is higher for grazing land (22.46 %), followed by home gardens (14.39 %), and crop land (8.07 %).

The species composition was significantly dissimilar among the land use types (Adonis2, $p < 0.001$). This dissimilarity was clearly indicated by the significant differences in indicator species values among the land use types (Table 1). Accordingly, Ficus vasta, Cordia africana and *Achyranthes aspera* are common in crop land; Hypoestes forskaolii, Vernonia myriantha, Calpurnia aurea, Carissa spinarum, Allophylus abyssinicus, Apodytes dimidiata and Teclea nobilis in forest land use; Erythrococca abyssinica, Tapinanthus heteromorphus, Hygrophila schulli and Erythrina brucei in grazing land; Coffea arabica, Justicia schimperiana, Caesalpinia decapetala, Musa paradisiaca, Vernonia amygdalina, Catha edulis in home gardens; and Celtis africana, Vangueria apiculata, Phytolacca dodecandra, Ficus sur, Dracaena steudneri and Millettia ferruginea were the indicator species in riverine land use types (Table 1).

The NMDS analysis indicated that the species composition in forest, riverine and grazing land has relatively more association with aspect, slope and altitude gradients as compared crop land, and home garden (Fig. 3).

3.1.1. Species diversity

The result of the one-way ANOVA showed that species richness and stem abundance significantly vary among the land use types ($P < 0.05$). The mean species richness was highest in grazing land (7.63 ± 0.82), followed by riverine (5.67 ± 1.1), forest (4.40 ± 1.23), home garden (3.03 ± 0.67) and crop land (1.68 ± 1.11). However, the Shannon-Weiner diversity is higher for forest land use (2.99) but lower for the home garden (1.06); (Fig. 4). The species stem density per hectare is higher in grazing land and forest when compared with the other land use types (Fig. 5).

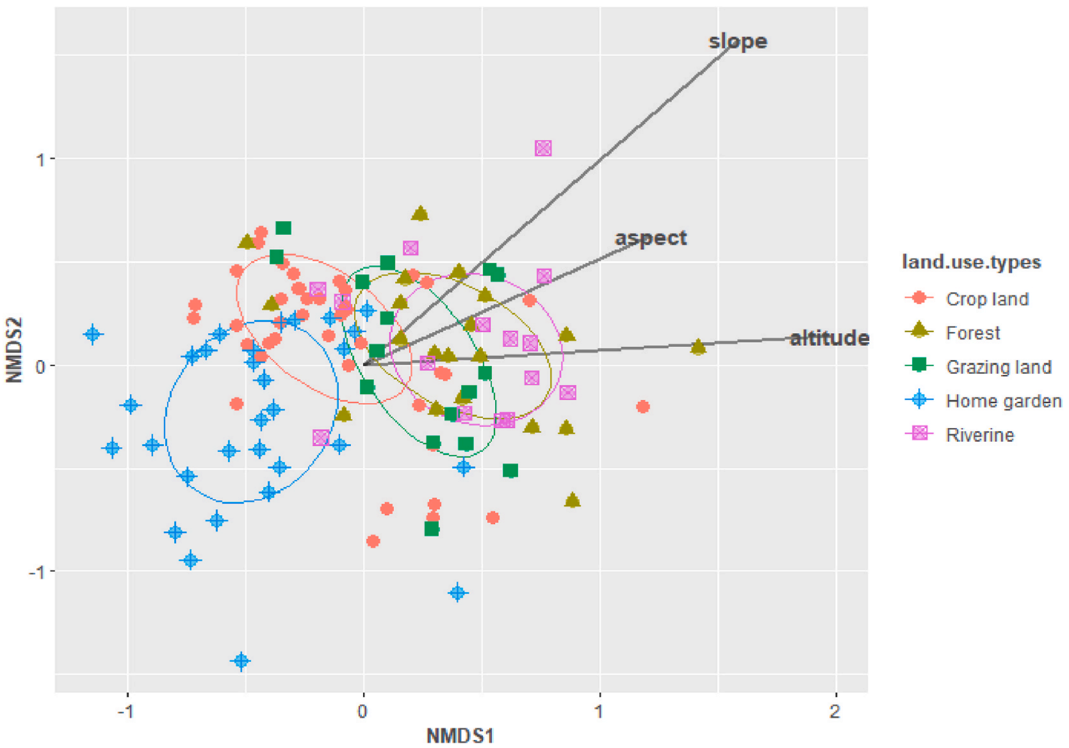

Fig. 3. A non-metric multidimensional scaling (NMDS) plot of the data set by land use types with the aspect, altitude, and slope showing the species dissimilarity composition among the different land use types in the study area.

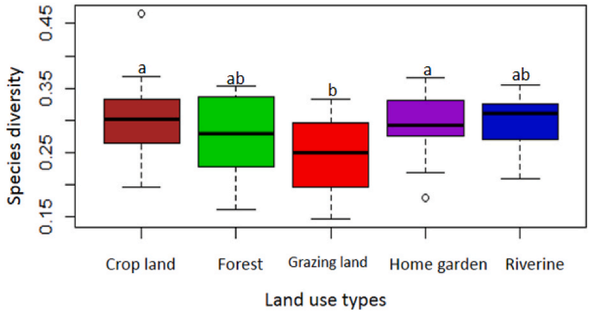

Fig. 4. The boxplot showing the species diversity across the land use types (using square root of species diversity). The difference in the lowercase letters on the boxplots shows significant differences in species diversity among the land use types (P < 0.05).

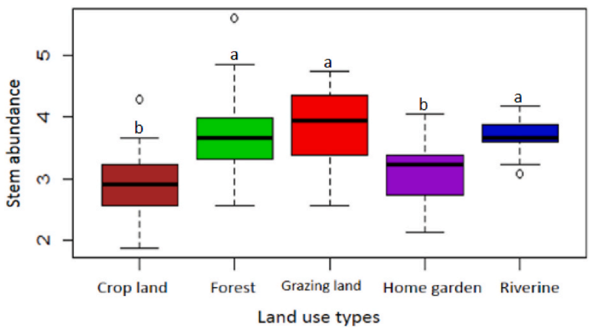

Fig. 5. The boxplot showing the abundance of woody stem across the land use types (using square root of species stem abundance). The difference in the lowercase letters on the boxplots shows significant differences in woody stem abundance among the land use types (P < 0.05).

4. Discussions

In agricultural landscapes, different land use systems have emerged as a result of habitat loss and forest fragmentation, which are the main factors contributing to the decline of natural ecosystems. It is crucial to investigate how a variety of plant species are supported by such diverse land use systems embedded in agricultural landscapes. To do this, we evaluated and analyzed the floristic composition, species diversity, species richness, woody stem abundance, and indicator species for diverse plant species across a range of land use systems in the agricultural landscape of west Oromia. The overall findings of the study are consistent with data compiled on the flora of Ethiopia and Eritrea since the Asteraceae, Fabaceae, and Poaceae families consist of the most prevalent species in the agroecosystem (Appendix I). Their dominant position could perhaps be due to efficient pollination and successful seed dispersal mechanisms that might have contributed to their adaptation to spread over a wide range of ecological conditions [38,39]. Contrarily, families like Icacinaceae, Ulmaceae, Combretaceae, Tiliaceae, and Pittosporaceae, which are represented by only species, may be lost from the area because of environmental impacts like human overexploitation.

The proportions of total species shared and unique within each land use type may explain the association among the land use types (Fig. 2). In grazing land, 22.46 % of the total species that were unique to the land use type could contribute to the extent of dissimilarity it has from the other land use types. Similarly, the lowest value evaluated for the proportion of species unique to crop land (8.07 %) indicated that its dissimilarity with the other land use types is lower. On the contrary, the highest and lowest proportions of species shared by grazing land (20.35 %) and crop land (16.14 %), respectively, could contribute to the similarity the various land use types have in common. The higher proportion of species found in grazing land (20.35 %) and riverine (18.60 %) compared to other land use types indicated that they are playing important roles in conserving plant species diversities in the landscape.

Despite the land use types that are making this important contribution, most tree species like Albizia schimperiana, Celtis africana, Cordia africana and Vachellia abyssinica were found standing without representative seedlings in the crop land, grazing land, and home garden. The highest proportion of species occurrence only in the grazing land contributes to the highest records of herbaceous plants obtained from the land use type than in the others.

The output of species dissimilarity analysis indicated that the contribution of species composition to the variation of land use types was based on the contribution of indicator species (Table 1). The fact that Hypoestes forskaolii, Vernoni amyriantha, Calpurnia aurea, Carissa spinarum, Allophylus abyssinicus, Apodytes dimidiata and Teclea nobilis species contributed to the dissimilarity of the forest indicates that these species have higher occurrence records in the forest than the rest of the land use types. Similarly, the species Erythrococca abyssinica, Solanecio gigas, Hygrophila schulli and Erythrina brucei in the grazing land and Ficus vasta, Cordia africana and *Achyranthes aspera* in the crop land showed the dissimilarity of the land use types due to their higher occurrence proportions.

Focusing on the home garden, Coffea arabica, Musa paradisiaca, Catha edulis, Rhamnu sprinoides, Mangifera indica, Ensete ventricosum and Persea americana played an important role in the variation of land use types in species composition. Here, the dissimilarity of species composition played a role in the variation and could be contributed to by a human-assisted conservation intervention because of the economic significance of the species.

Conversely, species such as Vangueria apiculata, Ficus sur, Dracaena steudneri, Millettia ferruginea, and Salix mucronata played a role in land use variation in the riverine area. The species contribution to this dissimilarity in the riverine area could be due to their affinity to survive in wetland d environments. Land use cover change can contribute to the variation of species composition observed among the land use types due to anthropogenic impacts exerted on land features when utilizing them for different purposes [40,41].

The NMDS ordination analysis indicated that altitude and slope determined the distributions of plant species in the forest, grazing land, and riverine, while their influences were slightly moderate on those distributed in the crop land and home garden (Fig. 3). On the other hand, despite aspects that seem to have a contribution to influence the species distribution in the forest, grazing land, and riverine, their influence is low as compared with the altitude and slope (Fig. 3). This aspect could have little influence on the plant species distribution in the study landscape because Ethiopia is located in a tropical region where sunlight is almost fully available in all directions [42]. In the landscape, the highest species diversity index (i.e., with greater equitability) achieved by the forest (2.99) and crop land (1.86) allowed them to be more stable in species composition. Conversely, grazing land, the most species-rich land use type (7.63 ± 0.82), achieved a lower value of the species diversity index (1.53) and a lower value of equitability. This may be due to the fact that plant species found in the forest are comparatively less exposed to destruction and due to the contribution of remnant standing shade trees left in the crop land for a long time [43,44]. Moreover, grazing land and home garden land use types consisting of 122 and 91 species, respectively, comprise the most species-rich positions in the landscape and can be explained as semi-natural potential refugia for implementing species conservation management practices [45,46]. In general, the variations observed in the distribution patterns of species richness and stem abundance among the different land use types (Figs. 4 and 5) may be attributed to selective cuttings exerted on some woody species [47–49] by local communities for different purposes. However, as our objective did not include seeing the regeneration status of the vegetation, this study has focused only on species composition and diversity aspects. So, not making an assessment of the regeneration status of the plant species recorded in the land use habitats is a limitation of the study, and thus interested researchers can fill the potential gap.

5. Conclusion

A landscape comprising different land use management units utilized for crop cultivation, cattle grazing, human settlement, and traditionally conserving fragmented forest patches can be considered an agricultural landscape. Such land use types can support a vast number of biological diversities and thus play important roles in maintaining the overall well-being of local ecosystems. Based on the results of our study, it is clear that a variety of plant species are distributed across different land use patterns identified in the agricultural landscape. The fact that the grazing land and home garden took the most species-rich position indicated that these human-modified habitats can be considered as potential refugia for conserving important plant species. Additionally, despite some economically important plant species being managed in some home gardens, they are lacking in most home gardens of the local community. Moreover, remnant patch forests found in the study landscape are still experiencing serious degradation and thus need close conservation management attention. Therefore, plant biodiversity conservationists should pay close attention to the roles played by land use types in conserving diverse plant species in agroecosystems and incorporate conservation strategies into their plans for their further implementation. In conclusion, studying the regeneration status, soil seed bank, and carbon sequestration are future potential research areas in the ecological area.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Data availability statement

The data used in the study will be made available on request from the corresponding author.

CRediT authorship contribution statement

Zerihun Tadesse: Validation, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Sileshi Nemomissa:** Supervision, Methodology, Conceptualization. **Debissa Lemessa:** Supervision, Software, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We express our gratitude to Addis Ababa University and Wollega University for their financial support. We thank the Gudeya Bila District Administration and local communities for allowing us to collect data. Our thanks also go to Shitaye Deti, Kemal Mustefa, and Habtamu Getachew for their full assistance during the data collection.

Appendix 1. List of plant species recorded from the study landscape in Gudeya Bila District: crop land (Cl), fragmented forest (Fr), grazing land (Gl), home garden (Hg) and riverine (Rv)

No	Species	Family	Land use types					Coll. code
1	*Acanthus eminens* C.B.Clarke	Acanthaceae					Rv	ZT176
2	*Acanthus polystachius* Delile	Amaranthaceae	Cl	Fr	Gl		Rv	ZT001
3	*Achyranthes aspera* L.	Amarantaceae	Cl			Hg		ZT145
4	*Adiantum poiretii* Wikstr.	Adiantaceae		Fr				ZT148
5	*Aeschynomene schimperi* Hochst. exA. Rich.	Fabaceae				Hg		ZT149
6	*Agave sisenara* Perrine ex Engl.	Aloaceae	Cl			Hg		ZT158
7	*Ageratum conyzoides* L.	Asteraceae				Hg		ZT159
8	*Albizia schimperiana* Oliv.	Fabaceae	Cl	Fr	Gl	Hg	Rv	ZT004
9	*Allophylus abyssinicus* (Hochst.) Radlk.	Sapindaceae		Fr			Rv	ZT006
10	*Alcea roseus* L.	Malvaceae				Hg		ZT003
11	*Amaranthus spinosus* L.	Amaranthaceae				Hg	Rv	ZT002
12	*Amorphophallus abyssinicus* (A. Rich.) N.E. Sr.	Araceae					Rv	ZT011
13	*Amphicarpa africana* (Hook. f.) Harms	Fabaceae		Fr				ZT089
14	*Anagalis arvensis* L.	Primulaceae		Fr				ZT239
15	*Andropogon abyssinicus* Fresen.	Poaceae	Cl			Hg		ZT173
16	*Anethum graveolens* L.	Apiaceae			Gl			ZT223
17	*Apodytes dimidiata* E. Mey. ex Am	Icacinaceae	Cl	Fr	Gl	Hg		ZT224
18	*Argemone mexicana* L	Solanaceae	Cl		Gl			ZT241
19	*Arisaema schimperiana* Schott	Araceae					Rv	ZT016
20	*Arundinaria alpina* K.Schum.	Poaceae	Cl					ZT123
21	*Arundo donax* L.	Poaceae				Hg		ZT187
22	*Asparagus africanus* Lam.	Asparagaceae		Fr				ZT210
23	*Bartsia trixago* L.	Scrophulariaceae			Gl			ZT268
24	*Berkheya spekeana* Oliv.	Asteraceae	Cl					ZT042
25	*Bersama abyssinica* Fresen.	Melianthaceae		Fr	Gl	Hg	Rv	ZT069
26	*Bidens biternata* (Lour.) Merr. & Sherfft	Asteraceae				Hg		ZT012
27	*Bidens pilosa* L.	Asteraceae				Hg		ZT019
28	*Bidens prestinaria* (Sch, Bip.) Cufod.	Asteraceae				Hg		ZT240
29	*Bougainvillea spectabilis* Witld.	Nyctaginaceae				Hg		ZT206
30	*Brucea antidysenterica* J.F.Mill.	Simaroubaceae		Fr	Gl	Hg	Rv	ZT101
31	*Buddleja cordata* B.K.	Loganiaceae		Fr				ZT204
32	*Buddleja polystachya* Fresen.	Loganiaceae	Cl	Fr	Gl	Hg	Rv	ZT264
33	*Caesalpinia decapetala* (Roth) Alston	Fabaceae				Hg		ZT022
34	*Callistemon citrinus* (Curtis) Skeels	Myrtaceae				Hg		ZT007
35	*Callistemon salignus*(Sm.) Sweet	Myrtaceae				Hg		ZT024
36	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	Cl	Fr	Gl	Hg	Rv	ZT026
37	*Canarina abyssinica* Engl.	Campanulaceae		Fr				ZT027
38	*Capparis tomentosa* Lam.	Capparidaceae	Cl	Fr	Gl	Hg	Rv	ZT028
39	*Capsella bursa-pastoris* (L.) Medic.	Brassicaceae	Cl					ZT040
40	*Carduus nyassanus* (S. Moore) R.E. Fries	Asteraceae	Cl					ZT051
41	*Carica papaya* L.	Caricaceae				Hg		ZT052
42	*Carissa spinarum* L.	Apocynaceae		Fr	Gl	Hg	Rv	ZT053
43	*Casimiroa edulis* La Llave	Rutaceae				Hg		ZT071
44	*Cassipourea malosana* (Baker) Alston	Rhizophoraceae		Fr				ZT074
45	*Catha edulis* (Vahl) Forssk. a Endl.	Celastraceae				Hg		ZT075
46	*Caylusea abyssinica* (Fresen.) Fisch. & Mey.	Resedaceae	Cl		Gl	Hg		ZT076
47	*Celtis africana* Burm.f.	Ulmaceae	Cl	Fr	Gl	Hg	Rv	ZT077
48	*Chenopodium album* L.	Chenopodiaceae			Gl			ZT078
49	*Chenopodium ambrosioides* L.	Chenopodiaceae	Cl					ZT079
50	*Chionanthus mildbraedii* (Gilg & Schel/enb.) Stearn	Oleaceae					Rv	ZT093
51	*Cinenaria deltoidea* Sond.	Asteraceae					Rv	ZT103
52	*Cirsium englerainum* O.	Asteraceae			Gl			ZT104
53	*Cirsium schimperi* (Vatke) C. Jeffrey ex Cufod.	Asteraceae	Cl					ZT124
54	*Citrus limon* (L.) Bunnf.	Rutaceae				Hg		ZT125
55	*Citrus medica* L.	Rutaceae				Hg		ZT131
56	*Citrus sinensis* (L.) Osb.	Rutaceae				Hg		ZT136
57	*Clausena anisata* (Willd). Benth.	Rutaceae	Cl	Fr				ZT137
58	*Clematis longicauda* Steud.ex A. Rich.	Ranunculaceae		Fr	Gl	Hg	Rv	ZT139

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No	Species	Family	Land use types					Coll. code
59	*Clematis sinensis* Fresen.	Rununculaceae					Rv	ZT153
60	*Clerodendron myricoides* (Hochst.) Vatke	Lamiaceae			Gl			ZT163
61	*Clutia abyssinica* Jaub. &- Spach.	Euphorbiaceae		Fr				ZT165
62	*Coffea arabica* L.	Rubiaceae				Hg	Rv	ZT177
63	*Combretum paniculatum* Vent.	Combretaceae		Fr	Gl	Hg	Rv	ZT250
64	*Commelina africana* L.	Commelinaceae		Fr				ZT257
65	*Commelina bengalensis* L.	Commelinaceae		Fr			Rv	ZT258
66	*Commelina diffusa* Burm.f.	Commelinaceae			Gl			ZT279
67	*Commelina subulata* Roth	Commelinaceae			Gl			ZT280
68	*Gomphocarpus fruticosus* (L.) Ait. f.	Apocynaceae			Gl			ZT281
69	*Convolvulus kilimandschari* Engl.	Convolvulaceae				Hg		ZT282
70	*Conyza stricta* Willd.	Asteraceae	Cl		Gl	Hg		ZT283
71	*Copressus lustanica* Mill.	Cupressaceae	Cl			Hg		ZT284
72	*Cordia africana* L.	Boraginaceae	Cl	Fr	Gl	Hg	Rv	ZT285
73	*Cotula abyssinica* Sch. Bip. exA. Rich.	Asteraceae		Fr				ZT150
74	*Crassocephalum crepidioides* (Benth.) S. Moore	Asteraceae	Cl					ZT151
75	*Crassocephalum macropappum* (Sch. Bip. ex A. Rich.) S. Moore	Asteraceae	Cl					ZT155
76	*Crassocephalum rubens* (Juss. ex Jacq.) S. Moore	Asteraceae			Gl		Rv	ZT259
77	*Crepis rueppel* Sch. Bip.	Asteraceae	Cl		Gl			ZT262
78	*Crepis tenerrima* (Seh. Hip. ex A. Rich.) R. E. Fries.	Asteraceae			Gl			ZT073
79	*Crotalaria emarginella* Vatke	Fabaceae					Rv	ZT086
80	*Crotalaria incana* L.	Fabaceae			Gl			ZT105
81	*Croton macrostachyus* Del.	Euphorbiaceae	Cl	Fr	Gl	Hg	Rv	ZT141
82	*Cyanotis caespitosa* Kot1lchy & Peyr.	Commelinaceae			Gl			ZT265
83	*Cyathula cylinderica* Moq.	Amaranthaceae					Rv	ZT045
84	*Cynodon aethiopicus* Clayton & Harlan	Poaceae			Gl			ZT039
85	*Cynodon dactylon* (L.) Pers.	Poaceae			Gl			ZT037
86	*Cynodon nlemfuensis* Vanderyst	Poaceae			Gl			ZT038
87	*Cynoglossum coeruleum* Hochst. exA.DC. in DC.	Boraginaceae			Gl			ZT226
88	*Cyperus mundtii* (Nees) Kunth	Cyperaceae		Fr				ZT041
89	*Cyperus triceps* Endl	Cyperaceae		Fr				ZT273
90	*Dalbergia lactea* Vatke	Fabaceae		Fr				ZT143
91	*Datura stramonium* L.	Solanaceae	Cl					ZT144
92	*Desmodium repandum* (Vahl) DC.	Fabaceae					Rv	ZT174
93	*Dicrocephala integrifolia* (L.f) Kuntze	Asteraceae	Cl		Gl			ZT175
94	*Digitalia ternata* (A. Rich.) Staf	Poaceae			Gl			ZT048
95	*Digitalia velutina* (Forssk.) P.Beauv	Poaceae			Gl			ZT049
96	*Dodonaea angustifolia* L. f.	Sapindaceae		Fr				ZT063
97	*Dolichos sericeus* E. Mey.	Fabaceae			Gl			ZT064
98	*Dombeya torrida* (G.F. Gmel.) P. Bamps	Sterculiaceae		Fr				ZT065
99	*Dovyalis abyssinica* (A. Rich.) Warb.	Flacourtiaceae		Fr				ZT066
100	*Dracaena steudneri* Engl.	Dracaenaceae		Fr			Rv	ZT067
101	*Dregea schimperi* (Decne.) Bullock	Asclepiadaceae			Gl			ZT068
102	*Drynaria volkensii* Hieron.	Polypodiaceae		Fr				ZT070
103	*Echinops giganteus* A. Rich.	Asteraceae			Gl			ZT160
104	*Echinops macrochaetus* Fresen.	Asteraceae			Gl			ZT161
105	*Ehretia cymosa* Thonn.	Boraginaceae	Cl			Hg	Rv	ZT162
106	*Ekebergia capensis* Sparrm.	Meliaceae	Cl	Fr	Gl	Hg	Rv	ZT171
107	*Eleusine floccifolia* (Forssk.) Spreng.	Poaceae			Gl			ZT072
108	*Embelia schimperi* Vatke	Myrsinaceae					Rv	ZT157
109	*Englerina woodfordioides* (Schweinf.)M. Gilbert	Loranthaceae	Cl	Fr	Gl	Hg	Rv	ZT087
110	*Ensete ventricosum* (Welw.) Cheesman	Musaceae				Hg		ZT088
111	*Erythrina brucei* Schweinf.	Fabaceae		Fr	Gl	Hg	Rv	ZT100
112	*Erythrococca abyssinica* Pax	Euphorbiaceae			Gl			ZT061
113	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae	Cl			Hg		ZT082
114	*Eucalyptus globulus* (F.Muell.) J.B.Kirkp.	Mytaceae	Cl			Hg		ZT112
115	*Euphorbia ampliphylla* Pax	Euphorbiaceae		Fr		Hg	Rv	ZT115
116	*Euphorbia buchananii* Pax	Euphorbiaceae				Hg		ZT116
117	*Euphorbia cotinifolia* L.	Euphorbiaceae				Hg		ZT117
118	*Ficus mucuso* Ficalho.	Moraceae					Rv	ZT225
119	*Ficus sur* Forssk.	Moraceae	Cl	Fr	Gl	Hg	Rv	ZT269
120	*Ficus thonningii* Blume	Moraceae	Cl		Gl	Hg	Rv	ZT270
121	*Ficus vasta* Forssk.	Moraceae	Cl					ZT005
122	*Flacourtia indica* (Burm.f.) Merr	Flacourtiaceae		Fr			Rv	ZT008
123	*Foeniculum vulgare* Miller	Apiaceae	Cl					ZT013
124	*Galinsoga parviflora* Cav.	Asteraceae			Gl			ZT033
125	*Galinsoga quadriradiata* Ruiz & Pavon	Asteraceae			Gl			ZT036
126	*Galium spurium* L.	Runiaceae			Gl			ZT080
127	*Gardenia ternifolia* Schumach. &Thonn.	Rubiaceae	Cl					ZT081
128	*Geranium arabicum* Forssk.	Geranaceae			Gl			ZT090

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No	Species	Family	Land use types					Coll. code
129	*Girardinia bullosa* (Steudel) Wedd.	Urticaceae			Gl			ZT092
130	*Girardinia diversifolia (*Link) Friis	Urticaceae			Gl			ZT097
131	*Gnaphalium rubriflorum* Hilliard	Asteraceae		Fr				ZT111
132	*Gnidia glauca* (Fresen.) Gilg	Thymelaeaceae		Fr				ZT152
133	*Gradiolus muriclae* Kelway	Iridaceaea			Gl			ZT167
134	*Grevillea robusta* A. Cunn. ex R. Br.	Gravelliaceae				Hg		ZT178
135	*Grewia ferruginea* Hochst.ex A. Rich.	Tiliaceae	Cl	Fr	Gl	Hg		ZT220
136	*Guizotia scabra* (Vis.) Chiov.	Asteraceae			Gl			ZT244
137	*Guizotia schimperi* Sch. Bip. ex Walp.	Asteraceae			Gl			ZT245
138	*Hagenia abyssinica* (Broce) I.F. Gmel.	Rosaceae	Cl					ZT246
139	*Haplocarpha schimperi* (Sch. Rip.) Beauv.	Asteraceae	Cl					ZT247
140	*Helinus mystacinus* (Ait.) E. Mey. ex Steud.	Rhamnaceae					Rv	ZT272
141	*Heliotropium zeylanicum* (Burm f.) Lam.	Boraginaceae	Cl					ZT275
142	*Hibiscus vitifolius* L.	Malvaceae					Rv	ZT099
143	*Hippocratea africana* (Willd.) Loes.	Celastraceae					Rv	ZT122
144	*Hippocratea goetezi* Loes.	Celastraceae	Cl					ZT128
145	*Hygrophila schulli* (Hamilt.) M.R. & S.M	Acanthaceae	Cl		Gl			ZT198
146	*Hyparrhenia anthistirioides* (Hochst. ex A. Rich)	Poaceae					Rv	ZT134
147	*Hypericum quartinianum* A. Rich.	Guttiferae		Fr	Gl			ZT147
148	*Hypoestes forskaolii* (Vahl) R. Br.	Acanthaceae		Fr				ZT219
149	*Hypoestes triflora* (Forssk.) Roem & Schult.	Acanthaceae					Rv	ZT017
150	*Impatiens hocshtetteri* Warb.	Balsaminaceae		Fr				ZT133
151	*Impatiens rothii* Hook. F	Balsaminaceae		Fr				ZT060
152	*Indigofera arrecta* Hochst. exA. Rich.	Fabaceae					Rv	ZT154
153	*Inula confertiflora* A.Rich.	Asteraceae			Gl			ZT168
154	*Isodon schimperi* (Vatke) J.K. Morton	Lamiaceae			Gl			ZT169
155	*Jacaranda mimosifolia* D. Don	Bignonaceae				Hg		ZT185
156	*Jasminum abyssinicum* Hochst. ex DC.	Oleaceae					Rv	ZT186
157	*Juniperus procera* Hochst. ex Endl.	Cupressaceae				Hg		ZT214
158	*Justicia diclipteroide* Lindau	Acanthaceae					Rv	ZT215
159	*Justicia schimperiana* (Hochst. ex Nees) T.	Acanthaceae			Gl	Hg		ZT237
160	*Kalanchoe densiflora* Rolfe	Crassulaceae			Gl			ZT256
161	*Kalanchoe petitiana* A. Rich.	Crassulaceae			Gl			ZT238
162	*Lagenaria abyssinica* (Hookf.) C. Jeffrey	Cucurbitaceae			Gl		Rv	ZT205
163	*Laggera crispata* (Vahl) Hepper & Wood	Asteraceae			Gl			ZT031
164	*Lantana camara* L.	Verbenaceae				Hg		ZT032
165	*Launaea cornuta* (Hochst. ex Oliv. & Hiem) C. Jeffrey	Asteraceae			Gl			ZT184
166	*Lepidotrichilia volkensii* (Gilrke) Leroy	Meliaceae		Fr				ZT109
167	*Leucaena leucocephala (*Lam.] De Wit	Fabaceae			Gl	Hg		ZT207
168	*Leucas deflexa* Hook.f.	Lamiaceae			Gl			ZT266
169	*Leucas martinicensis* (Jacq.) R. Br.	Lamiaceae			Gl			ZT010
170	*Lippia adoensis* Hochst. ex Walp	Verbenaceae			Gl			ZT142
171	*Luffa cylinderica* (L.)M J. Roem	Cucurbitaceae				Hg		ZT196
172	*Maesa lanceolata* Forssk.	Myrsinaceae	Cl	Fr	Gl	Hg	Rv	ZT197
173	*Mangifera indica* L.	Anacardiaceae				Hg		ZT248
174	*Maytenus arbutifolia* (A.Rich.) Wilczek	Celastraceae	Cl	Fr	Gl			ZT106
175	*Maytenus gracilipes* (Welw. ex Oliv.) Exell	Celastraceae	Cl	Fr	Gl		Rv	ZT166
176	*Melia azederach* L.	Meliaceae				Hg		ZT025
177	*Mikaniopsis clematoides* (Sch. Bip. ex A. Rich.)	Asteraceae			Gl			ZT261
178	*Millettia ferruginea* (Hochst.) Bak.	Fabaceae		Fr			Rv	ZT118
179	*Morus alba* L.	Rosaceae				Hg		ZT119
180	*Musa paradisiaca* L.	Musaceae				Hg		ZT120
181	*Myrica salicifolia* A.Rich.	Myricaceae		Fr	Gl	Hg		ZT121
182	*Nicandra physaloide* (L.) Gaertn.	Solanaceae	Cl	Fr				ZT110
183	*Nicotiana tabacum* L.	Solanaceae				Hg		ZT180
184	*Nuxia congesta* R.Br. ex Fresen.	Loganiaceae		Fr	Gl			ZT181
185	*Ocimum lamiifolium* Hochst. ex. Benth.	Lamiaceae		Fr				ZT108
186	*Ocimum urticifolium* Roth.	Lamiaceae			Gl			ZT172
187	*Oenanthe procumbens* (Wolff) Norman	Apiaceae	Cl				Rv	ZT034
188	*Olea capensis* subspecies macrocarpa (C.H. Wright) Verdc.	Oleaceae		Fr				ZT035
189	*Olea europaea* subspecies *cuspidata* (Wall.ex G.Don) Cif.	Oleaceae	Cl		Gl	Hg		ZT113
190	*Olinia rochetiana* A.Juss.	Oliniaceae	Cl					ZT263
191	*Oplismenus hirtellus* (L.) P. Beauv.	Poaceae			Gl		Rv	ZT114
192	*Orobanchae minor* Smit	Orobanchaceae			Gl	Hg		ZT029
193	*Osyris quadripartita* Decne	Santalaceae		Fr				ZT050
194	*Panicum monticola* Hook.f.	Poaceae		Fr				ZT156
195	*Pavetta abyssinica* Fresen.	Rubiaceae		Fr				ZT188
196	*Pavonia burchellii* (DC.) Dyer	Malvaceae		Fr				ZT189
197	*Pavonia urens* Cav.	Malvaceae				Hg	Rv	ZT242
198	*Pelargonium multibracteatum* Hochst. exA. Rich.	Geraniaceae				Hg		ZT190

(*continued on next page*)

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No	Species	Family	Land use types					Coll. code
199	*Pennisetum clandestinum* Chiov.	Poaceae			Gl			ZT232
200	*Pennisetum schimperi* A. Rich.	Poaceae			Gl			ZT233
201	*Pennisetum sphacelatum* (Nees) Th. Dur.	Poaceae			Gl			ZT271
202	*Pennisetum thunbergii* Kunth	Poaceae			Gl			ZT192
203	*Periploca linearifolia* Quart.-Dill. & A. Rich.	Asclepiadaceae		Fr				ZT211
204	*Persicaria decipiens* (R. Br.) K.L. Wilson	Polygonaceae	Cl			Hg		ZT209
205	*Persea americana* Mill.	Lauraceae				Hg		ZT212
206	*Phoenix reclinata* Jacq.	Arecaceae					Rv	ZT213
207	*Phragmanthera macrosolen* (A. Rich.] M. Gilbert	Loranthaceae	Cl					ZT015
208	*Physalis peruviana* L.	Solanaceae			Gl			ZT020
209	*Phytolacca dodecandra* L'Herit.	Phytolaccaceae				Hg	Rv	ZT021
210	*Pimpinella oreophila* Hook. J	Apiaceae					Rv	ZT083
211	*Pinus radiata* D. Don	Pinaceae				Hg		ZT084
212	*Pittosporum viridiflorum* Sims	Pittosporaceae	Cl		Gl		Rv	ZT085
213	*Plantago lanceolata* L.	Plantaginaceae	Cl					ZT094
214	*Platostoma roundifolia* (Briq.) AJ. Paton	Lamiaceae					Rv	ZT095
215	*Plectranthus punctatus* (L.f.) L'H'er.	Lamiaceae					Rv	ZT107
216	*Podocarpus falcatus* (Thunb.) R.B. ex. Mirb.	Podocarpaceae	Cl	Fr	Gl	Hg	Rv	ZT146
217	*Pouteria adolfi-friederici* (Engl.) Baehni	Sapotaceae					Rv	ZT191
218	*Prunus africana* (Hook.f.) Kalkm.	Rosaceae	Cl	Fr	Gl	Hg	Rv	ZT194
219	*Pteridium aqulinium* (L.) Kuhn	Hypolepidaceae					Rv	ZT199
220	*Pterolobium stellantum* (Forssk.) Brenan	Fabaceae		Fr	Gl			ZT200
221	*Rhamnus prinoides* L'Herit.	Rhamnaceae				Hg	Rv	ZT201
222	*Rhiocissus tridentata* (L. f.) Wild & Drummond	Vitaceae			Gl		Rv	ZT202
223	*Rhus glutinosa* A.Rich.	Anacardiaceae		Fr				ZT249
224	*Rhus natalensis* Krauss	Anacardiaceae		Fr				ZT260
225	*Ricinus communis* L.	Euphorbiaceae				Hg		ZT216
226	*Ritchiea albersi* Gilg	Capparidaceae	Cl		Gl			ZT203
227	*Rosa abyssinica* Lindley	Rosaceae		Fr	Gl			ZT234
228	*Rothmannia urcelliformis* (Hiem) Robyns	Rubiaceae					Rv	ZT102
229	*Rubia cordifolia* L.	Rubiaceae					Rv	ZT014
230	*Rubus apetalus* Poir.	Rosaceae			Gl		Rv	ZT058
231	*Rubus steudneri* Schweinf.	Rosaceae			Gl		Rv	ZT046
232	*Rumex abyssinica* Jacq.	Polygonaceae					Rv	ZT140
233	*Rumex nepalensis* Spreng.	Polygonaceae			Gl			ZT221
234	*Rumex nervosus* Vahl	Polygonaceae			Gl			ZT243
235	*Rytigynia neglecta* (Hiern) Robyns	Rubiaceae		Fr	Gl		Rv	ZT044
236	*Salix mucronata* Thunb. (S. subserrata Willd)	Salicaceae				Hg	Rv	ZT138
237	*Salvia nilotica* Jacq.	Lamiaceae			Gl			ZT179
238	*Satureja paradoxa* (Vatke) Engl. ex Seybold	Lamiaceae			Gl			ZT218
239	*Scadoxus multiflorus* (Martyn) Raf'.	Amaryllidaceae			Gl		Rv	ZT227
240	*Schefflera abyssinica* (Hochst. ex A. Rich.)	Araliaceae	Cl	Fr		Hg		ZT230
241	*Schinus molle* L.	Anacardiaceae				Hg		ZT231
242	*Schrebera alata* (Hochst.) Welw.	Oleaceae			Gl			ZT062
243	*Scutia myrtina* (Burm. f.) Kurz	Rhamnaceae					Rv	ZT127
244	*Senna didymobotrya* (Fresen.) Irwin& Bameby	Fabaceae			Gl			ZT195
245	*Senna petersiana* (Bolle) Lock	Fabaceae				Hg	Rv	ZT228
246	*Senna septemterioles* (Viv.) Irwin & Bameby	Fabaceae				Hg		ZT229
247	*Sesbania sesban (*L) Merr	Fabaceae				Hg		ZT235
248	*Sida rhombifolia* L.	Malvaceae			Gl			ZT276
249	*Snowdenia polystachya* (Fresen.) Pilg.	Poaceae				Hg		ZT126
250	*Solanecio gigas* Boulos ex Humbert	Asteraceae			Gl			ZT059
251	*Solanum aculeatissom* Jacq.	Solanaceae			Gl			ZT043
252	*Solanum anguivi* Lam.	Solanaceae	Cl	Fr	Gl	Hg	Rv	ZT054
253	*Solanum marginatum* L.f.	Solanaceae			Gl			ZT055
254	*Solanum nigrum* L.	Solanaceae			Gl			ZT056
255	*Discopodium penninervium* Hochst.	Solanaceae			Gl			ZT057
256	*Solenostemon autrani* (Briq.) J.K. Morton	Lamiaceae	Cl					ZT267
257	*Sonchus oleraceus* L.	Asteraceae	Cl					ZT277
258	*Sonchus schweinfurthii* Olivo & Hiem	Asteraceae	Cl					ZT236
259	*Spathodea campanulata* P. Beauv.	Bignoniaceae				Hg		ZT193
260	*Sporobolus africanus* (Poir.) Robyns & Tourny	Poaceae	Cl					ZT009
261	*Stephania abyssinica* (Dillon & A. Rich.) Walp.	Menispermaceae		Fr				ZT096
262	*Stereospermum kunthianum* Cham.	Bignoniaceae		Fr				ZT217
263	*Syzygium guineense* (Willd.) DC.	Myrtaceae	Cl	Fr	Gl			ZT023
264	*Tacazzea conferta* N.E. Br.	Asclepiadaceae		Fr				ZT278
265	*Tagestes minuta* L.	Asteraceae		Fr	Gl		Rv	ZT030
266	*Tapinanthus heteromorphus* (A. Rich.] Danser	Loranthaceae	Cl	Fr	Gl			ZT018
267	*Teclea nobilis* Del.	Rutaceae		Fr			Rv	ZT091
268	*Torilis arvensis (*Hudson) Link	Apiaceae					Rv	ZT182

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No	Species	Family	Land use types					Coll. code
269	*Tragia brevipes* Pax	Euphorbiaceae					Rv	ZT183
270	*Tragia doryodes* AI. Gilbert	Euphorbiaceae		Fr				ZT208
271	*Tridactyle filifolia* (Schltr.) Schltr	Orchidaceae			Gl			ZT251
272	*Trifolium rueppellianum* Fresen.	Fabaceae			Gl			ZT252
273	*Uebelinia abyssinica* Hochst.	Caryophyllaceae				Hg		ZT253
274	*Urera hypselodendron* (A.Rich) Wedd.	Urticaceae					Rv	ZT254
275	*Vachellia abyssinica* (Hochst. ex Benth.) Kyal. & Boatwr.	Fabaceae	Cl	Fr	Gl	Hg	Rv	ZT255
276	*Vangueria apiculata* K. Schum.	Rubiaceae					Rv	ZT098
277	*Vepris dainellii*(Pichi-Serm.) Kokwaro	Rutaceae		Fr				ZT132
278	*Verbsacum sinaiticum* Benth.	Scrophulariaceae			Gl			ZT135
279	*Vernonia amygdalina* Del.	Asteraceae	Cl	Fr	Gl	Hg	Rv	ZT047
280	*Vernonia bipontini* Vatke	Asteraceae		Fr				ZT129
281	*Vernonia brachycalyx* O. Hoffm.	Asteraceae		Fr				ZT130
282	*Vernonia hymenolepsi* A. Rich.	Asteraceae		Fr				ZT274
283	*Vernonia leopoldi* (Sch. Bip. ex Walp.) Vatke	Asteraceae		Fr	Gl			ZT164
284	*Vernonia myriantha* Hook.f.	Asteraceae	Cl	Fr	Gl	Hg	Rv	ZT170
285	*Vernonia thomsoniana* Olivo & Hiern ex Oliv.	Asteraceae			Gl			ZT222

References

[1] I.C.G. Vieira, P.d. Toledo, J.d. Silva, H. Higuchi, Deforestation and threats to the biodiversity of Amazonia, Braz. J. Biol. 68 (2008) 949–956.
[2] S. Chakravarty, S. Ghosh, C. Suresh, A. Dey, G. Shukla, Deforestation: causes, effects and control strategies, Global perspectives on sustainable forest management 1 (2012) 1–26.
[3] R. Ray, M. Chandran, T. Ramachandra, Biodiversity and ecological assessments of Indian sacred groves, J. For. Res. 25 (2014) 21–28.
[4] J. Fischer, D.B. Lindenmayer, Landscape modification and habitat fragmentation: a synthesis, Global Ecol. Biogeogr. 16 (2007) 265–280.
[5] X. Giam, C.J. Bradshaw, H.T. Tan, N.S. Sodhi, Future habitat loss and the conservation of plant biodiversity, Biol. Conserv. 143 (2010) 1594–1602.
[6] C.S. Mantyka-pringle, T.G. Martin, J.R. Rhodes, Interactions between climate and habitat loss effects on biodiversity: a systematic review and meta-analysis, Global Change Biol. 18 (2012) 1239–1252.
[7] M. Zhumanova, C. Mönnig, C. Hergarten, D. Darr, N. Wrage-Mönnig, Assessment of vegetation degradation in mountainous pastures of the Western Tien-Shan, Kyrgyzstan, using eMODIS NDVI, Ecol. Indicat. 95 (2018) 527–543.
[8] B.J. Zoungrana, C. Conrad, M. Thiel, L.K. Amekudzi, E.D. Da, MODIS NDVI trends and fractional land cover change for improved assessments of vegetation degradation in Burkina Faso, West Africa, J. Arid Environ. 153 (2018) 66–75.
[9] W. Mengist, T. Soromessa, G.L. Feyisa, Landscape change effects on habitat quality in a forest biosphere reserve: implications for the conservation of native habitats, J. Clean. Prod. 329 (2021) 129778.
[10] X. Giam, Global biodiversity loss from tropical deforestation, Proc. Natl. Acad. Sci. USA 114 (2017) 5775–5777.
[11] T. Decaens, M.B. Martins, A. Feijoo, J. Oszwald, S. Dolédec, J. Mathieu, X. Arnaud de Sartre, D. Bonilla, G.G. Brown, Cuellar, Y.A. Criollo, Biodiversity loss along a gradient of deforestation in Amazonian agricultural landscapes, Conserv. Biol. 32 (2018) 1380–1391.
[12] E.O. Acheampong, C.J. Macgregor, S. Sloan, J. Sayer, Deforestation is driven by agricultural expansion in Ghana's forest reserves, Scientific African 5 (2019) e00146.
[13] D.D. Daye, Fragmented Forests in South-West Ethiopia: Impacts of Land-Use Change on Plant Species Composition and Priorities for Future Conservation, Bangor University, United Kingdom, 2012.
[14] A.A. Mitiku, Afromontane Avian Assemblages and Land Use in the Bale Mountains of Ethiopia: Patterns, Processes and Conservation Implications, University of Pretoria, 2013.
[15] R.K. Peet, D.W. Roberts, Classification of natural and semi-natural vegetation, Vegetation ecology (2013) 28–70.
[16] Y. Malhi, T.A. Gardner, G.R. Goldsmith, M.R. Silman, P. Zelazowski, Tropical forests in the anthropocene, Annu. Rev. Environ. Resour. 39 (2014) 125–159.
[17] J. Southworth, D. Munroe, H. Nagendra, Land cover change and landscape fragmentation—comparing the utility of continuous and discrete analyses for a western Honduras region, Agric. Ecosyst. Environ. 101 (2004) 185–205.
[18] J. Hartter, J. Southworth, Dwindling resources and fragmentation of landscapes around parks: wetlands and forest patches around Kibale National Park, Uganda, Landsc. Ecol. 24 (2009) 643–656.
[19] H. Adal, Z. Asfaw, A Pragmatic Comparison of Smallholder Farmers' Perceptions and Attitudes towards Integration of Trees in Farmed Landscapes in North Eastern Ethiopia, 2016.
[20] D.B. Lindenmayer, J.F. Franklin, Conserving Forest Biodiversity: a Comprehensive Multiscaled Approach, Island press, 2002.
[21] P. Angelstam, P. Bergman, Assessing actual landscapes for the maintenance of forest biodiversity: a pilot study using forest management data, Ecol. Bull. (2004) 413–425.
[22] T. Plieninger, C. Schleyer, M. Mantel, P. Hostert, Is there a forest transition outside forests? Trajectories of farm trees and effects on ecosystem services in an agricultural landscape in Eastern Germany, Land Use Pol. 29 (2012) 233–243.
[23] W.S. Keeton, S.M. Crow, Sustainable forest management alternatives for the Carpathian Mountain region: providing a broad array of ecosystem services, in: Ecological Economics and Sustainable Forest Management: Developing a Trans-disciplinary Approach for the Carpathian Mountains, 2009, pp. 109–126.
[24] D. Sharpe, G. Guntenspergen, C. Dunn, L. Leitner, F. Stearns, Vegetation dynamics in a southern Wisconsin agricultural landscape, in: Landscape Heterogeneity and Disturbance, Springer, 1987, pp. 137–155.
[25] S. Lameire, M. Hermy, O. Honnay, Two decades of change in the ground vegetation of a mixed deciduous forest in an agricultural landscape, J. Veg. Sci. 11 (2000) 695–704.
[26] M.C. Anderson, J.M. Norman, W.P. Kustas, F. Li, J.H. Prueger, J.R. Mecikalski, Effects of vegetation clumping on two–source model estimates of surface energy fluxes from an agricultural landscape during SMACEX, J. Hydrometeorol. 6 (2005) 892–909.
[27] B. Bishaw, Deforestation and land degradation in the Ethiopian highlands: a strategy for physical recovery, NE Afr. Stud. (2001) 7–25.
[28] G. Chimdesa, The political economy of deforestation and forest degradation in Ethiopia, J. Resour. Dev. Manag. 29 (2017) 38–43.
[29] K. Getahun, J. Poesen, A. Van Rompaey, Impacts of resettlement programs on deforestation of moist evergreen Afromontane forests in Southwest Ethiopia, Mt. Res. Dev. 37 (2017) 474–486.
[30] A. Abera, T. Yirgu, A. Uncha, Impact of resettlement scheme on vegetation cover and its implications on conservation in Chewaka district of Ethiopia, Environmental Systems Research 9 (2020) 1–17.

[31] A. Fetene, T. Bekele, M. Lemenih, Diversity of Non-timber forest products (NTFPs) and their source species in Menagesha Suba Forest, Ethiop. J. Biol. Sci. 9 (2010) 11–34.
[32] G. Woldegeorgis, T. Wube, A survey on mammals of the Yayu forest in Southwest Ethiopia, Sinet 35 (2012) 135–138.
[33] M.A. Tesfaye, O. Gardi, T. Bekele, J. Blaser, Temporal variation of ecosystem carbon pools along altitudinal gradient and slope: the case of Chilimo dry afromontane natural forest, Central Highlands of Ethiopia, Journal of Ecology and Environment 43 (2019) 1–22.
[34] A. Engdawork, Characterization and Classification of the Major Agricultural Soils in Cascape Intervention Woredas in the Central Highlands of Oromia Region, CASCAPE–Addis Ababa University, 2015.
[35] E.J. Sieben, S.P. Khubeka, S. Sithole, N.M. Job, D.C. Kotze, The classification of wetlands: integration of top-down and bottom-up approaches and their significance for ecosystem service determination, Wetl. Ecol. Manag. 26 (2018) 441–458.
[36] T.T. Edosa, T. Kebede, Z. Shumeta, Analysis of price efficiency of smallholder farmers in maize production in Gudeya Bila district, Oromia national regional state, Ethiopia: stochastic, dual cost approach, International Journal of Contemporary Research and Review 10 (2019) 21480–21487.
[37] I. Friis, Demissew S., P. Van Breugel, Atlas of the potential vegetation of Ethiopia, Det Kongelige Danske Videnskabernes, Selskab (2010) 307.
[38] E. Kelbessa, T. Soromessa, Interfaces of regeneration, structure, diversity and uses of some plant species in Bonga Forest: a reservoir for wild coffee gene pool, Sinet 31 (2008) 121–134.
[39] A. Kremer, O. Ronce, J.J. Robledo-Arnuncio, F. Guillaume, G. Bohrer, R. Nathan, J.R. Bridle, R. Gomulkiewicz, E.K. Klein, K. Ritland, Long-distance gene flow and adaptation of forest trees to rapid climate change, Ecol. Lett. 15 (2012) 378–392.
[40] L.N. Trinh, J.W. Watson, N.N. Hue, N.N. De, N. Minh, P. Chu, B.R. Sthapit, P.B. Eyzaguirre, Agrobiodiversity conservation and development in Vietnamese home gardens, Agric. Ecosyst. Environ. 97 (2003) 317–344.
[41] C.N. Weiner, M. Werner, K.E. Linsenmair, N. Blüthgen, Land use intensity in grasslands: changes in biodiversity, species composition and specialisation in flower visitor networks, Basic Appl. Ecol. 12 (2011) 292–299.
[42] J.A. Gallardo-Cruz, E.A. Pérez-García, J.A. Meave, β-Diversity and vegetation structure as influenced by slope aspect and altitude in a seasonally dry tropical landscape, Landsc. Ecol. 24 (2009) 473–482.
[43] J.A. Danquah, A. Pappinen, Analyses of socioeconomic factors influencing on-farm conservation of remnant forest tree species: evidence from Ghana, Journal of Economics and Behavioral Studies 5 (2013) 588–602.
[44] D.G. Dastidar, S. Basu, C. Venkatraman, P. Chaudhuri, P.N. Raj, Remnant vegetation in farmland-its significance in ethnobotany and local ecosystem, Plant Science Today 9 (4) (2022) 900–908.
[45] G. Baiamonte, G. Domina, F. Raimondo, G. Bazan, Agricultural landscapes and biodiversity conservation: a case study in Sicily (Italy), Biodivers. Conserv. 24 (2015) 3201–3216.
[46] R. Duflot, S. Aviron, A. Ernoult, L. Fahrig, F. Burel, Reconsidering the role of 'semi-natural habitat' in agricultural landscape biodiversity: a case study, Ecol. Res. 30 (2015) 75–83.
[47] H. Rendón-Carmona, A. Martínez-Yrízar, P. Balvanera, D. Pérez-Salicrup, Selective cutting of woody species in a Mexican tropical dry forest: incompatibility between use and conservation, For. Ecol. Manag. 257 (2009) 567–579.
[48] Y. Paillet, L. Bergès, J. Hjältén, P. Ódor, C. Avon, M. Bernhardt-Römermann, R.J. Bijlsma, L. De Bruyn, M. Fuhr, U. Grandin, Biodiversity differences between managed and unmanaged forests: meta-analysis of species richness in Europe, Conserv. Biol. 24 (2010) 101–112.
[49] L. Birhanu, T. Bekele, S. Demissew, Woody species composition and structure of Amoro forest in west Gojjam zone, north western Ethiopia, J. Ecol. Nat. Environ. 10 (2018) 53–64.