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Research Article

Woody Species Diversity across Agricultural Land Use in Dale Wabara District, West Oromia Region, Ethiopia

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Abstract

Sustainable farming practices have a potential for conserving biodiversity and also providing wood resources for local community in such it is a good solution to reduce deforestation and forest degradation. Different land uses encompass various types of biological diversity. This study was initiated to assess woody species diversity across different land use types in Dale Wabara district, West Oromia Region, Ethiopia. In three kebeles a total of 45 quadrates were laid on different land use types; 15 quadrates in each lowest administrative unit with three replications for each land use to get vegetation data by selecting households randomly. Plots size of 10 m × 10 m for woodlot, complete enumeration with about 900 m^2 plot size for homegarden, 20 m x 25 m for coffee farm, 40 m x 40 m for grazing land and 50 m × 50 m for crop fields was drown. Species richness, diversity, evenness, frequency and important value index were analyzed between land use types. The study result showed that a total of 50 woody species belonging to 27 families were identified from these three kebeles. Fabaceae was the most dominant family with 7 and 14% species followed by Moraceae with 4 and 8% species. From the total identified species 78% were trees and 22% shrubs. The result of one-way ANOVA showed that the diversity of woody species significantly vary across land use types ($F(4, 10) = 86.1$, $P < 0.001$). The highest species diversity was recorded in homegarden (H'=2.796) followed by grazing land (H'=2.624). In general, agroforestry practices have a role for biodiversity conservation. Therefore, trees on farm land needs due attention to maintain woody species diversity within the system by farmers in order to more augment biodiversity conservation.

Keywords: agroforestry practices, biodiversity, homegarden, land use types, woody species

1 Introduction

Attention and deliberate inclusion of trees in agricultural landscape has been a common practice among farmers for a very long time and the farming communities have played important roles in conserving crop and tree diversity (Oke and Jamala 2013). Tropical agricultural landscape including Ethiopia encompasses different land use types among which agroforestry practices are the major component. It is indicative of the complex, multi-layer structure of the natural forest with rich plant diversity and is shaped by deliberate planting or retention, and assisted regeneration of useful woody species (Kumar and Nair, 2004). [1]Agroforestry is a dynamic ecologically based natural resources management system through integration of trees on farms that diversifies agricultural landscapes and sustains production for increased social, economic, and environmental benefits for land users at all levels (ICRAF 2002). The concept of agroforestry puts woody perennials, including trees and shrubs as pillars for the system/practice (Mengistu and Asfaw 2016). It is growing/cultivation of trees and of non-tree crops or animals on the same piece of land which provides diverse output from the same land units. These land use types conserve different types of plant species in pieces of land and minimizes the impacts of communities in the natural forests (Mengistu and Asfaw 2016). It was credited as a sustainable farming practice that uses and conserves biodiversity and limits agricultural expansion into natural forests in Ethiopia (Khumalo et al. 2012). Different types of traditional agroforestry practices are found in different parts of the country. Some of the practices includes: coffee shade tree systems, scattered trees on the farm land, home gardens, woodlots, and trees on grazing lands (Asfaw 2003; Tesfaye 2005). Many woody species of trees are deliberately preserved, and their regeneration is assisted in the agricultural environment because of their specific use (Bishaw and Abdelkadir 2003). Meanwhile, different land uses encompass various types of biological diversity. Among several of them, woody species are one of the dominant types basically grown naturally or manually (Mengistu and Asfaw 2016).

Study of the biological structure of agroforestry systems indicated by the number and abundance of species helps to identify plant diversity to increase their abundance and productivity (Hamilton, 2005). For the purpose of determining the role that governments can play in achieving the essential solutions and conservation strategies for biodiversity, it is crucial to identify the diversity potential of woody species across different land use types. Such issue is important for conservation intervention in agro-ecosystems of the smallholder farmers in general and that of the land use systems in particular.

In Ethiopia, documentation of agroforestry practices are very limited and has been concentrated especially in southern parts of the country (Zebene 2003; Tesfaye 2005; Tesfaye et al. 2010; Mathewos et al. 2013; Bajigo and Tadesse 2015; Wari et al. 2019). Information on agroforestry practices across different land use types (mainly homegarden, shade tree-coffee farm, trees on grazing land, trees on crop fields and woodlot) and its potentials have not been evaluated in the western parts. Therefore, this study was intended to assess woody species diversity across land use types in agricultural landscapes of Dale Wabara district, West Oromia Region, Ethiopia to contribute to filling the existing gaps.

2 Materials and Methods

2.1 Description of study area

The study was conducted in Dale Wabara District, Kellem Wollega Zone West Ethiopia (Figure 1). The district is located in between 35°0'30" to 35°4'30"E and 8°53'0" to 8°59'0"N.

The study site is located at about 585 km from the capital city, Addis Ababa and has an altitude of 1850-2200 m.a.s.l. Nitosols is the major soil types of the study site. Agro-climatic zone of the study site is characterized to be wet Weina-Dega 98 % and moist Kola 2% with minimum annual temperature of 20ºC and maximum 25ºC with annual rain fall ranges from 1200–1800 mm

The dominant farming activities in the study area are mixed farming systems. Due to their wide range of uses, valuable trees like *Cordia africana*, *Albizia gummifera*, and *Eucalyptus camaldulensis* are included in farms through retention or planting by farmers in agroforestry systems, which is the normal method of using agricultural land. The most land use type on which woody plants grown by farmers of the district are: home-garden, crop field, grazing lands, coffee farm and woodlots are more common. The major economic activities are livestock rearing and crop production. Among crop production like, maize, millet, teff, sorghum, coffee and wheat are highly produced in the area and cows, sheep, oxen and goats are common livestock. Whereas coffee, livestock and teff are the main source of income which accounts about 32%, 20% and 16% respectively in the study area (Dale Wabara District Agricultural Office 2019)

2.2 Methods

2.2.1 Sampling technique for woody vegetation inventory

Multi-stage sampling techniques were followed, with the help of experts and informants to select sample *kebele*. In the first stage the Dale Wabara district was divided into different category based on percentage of agroforestry coverage. This is obtained from the total area of the district, the area covered by agroforestry and then converted to percentage. Accordingly, it was categorized as high, medium and low percent of agroforestry cover. In the second stage, three *kebeles* were selected randomly by assigning random number to every *kebeles* from each category. Then Foge Kombolcha from high, Dogano Bile from medium and Daye Gomi from low agroforestry coverage were selected. Plots for homegardens, crop fields, coffee farms, grazing land, and woodlots were set out in three chosen kebeles by randomly selecting five (5) households in Foge Kombolcha, seven (7) households in Dogano Bile and 8 (eight) households in Daye Gomi, totally 20 (twenty) households through allocating random number. Households were randomized for random selection of sample plot for inventory. Accordingly, 15 plots in each *kebeles* in three replications for each land use including homegarden were laid out and totally 45 plots in three *kebeles* following (Abreha and Gebrekidan 2014). The sample sizes per land use type were found to be sufficient according to the plot number-species accumulation curve done after data collection following (Bajigo and Tadesse 2015). This is mostly due to plant incorporated in agricultural land is identical in species component due to farmers intensive

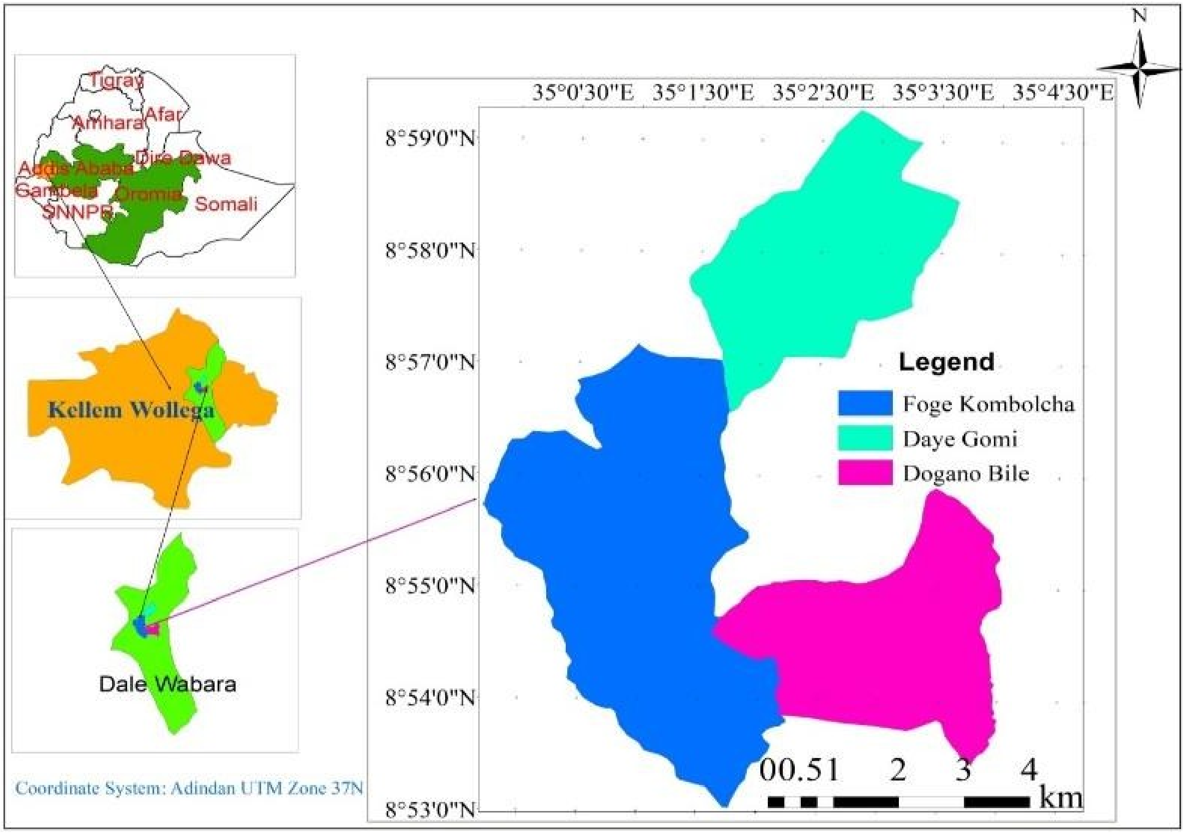

Figure 1: Map of the study area Agricultural activities of the study kebeles (Dale Wabara District Agricultural Office, 20019).

species preference to include in their farm land unlike that of natural forest which have heterogeneity in plant species requiring large sample size. Here the distribution of the five land use types among household is not equal. Therefore, for the replication of land use the number of household randomly selected for inventory was different. As a result, the number of plots inventoried from each household in each *Kebele* was variable. During inventory, when the 1st household has only three or two of the five different land use, for the left land use the next randomly selected household was used for inventory to have equal replication. It was interesting to note that, to reduce bias, farmers also replicated for each land uses.

A total of nine sample plots for each land use types including homegarden were surveyed with sample size of 10 m × 10 m for woodlots according to Senbeta et al. (2002) and Ponce- Hernandez et al. (2004), for homegarden a complete enumeration with about 30 m × 30 m (Tolera et al., 2008), 20 m x 25 m for coffee farm (Negawo and Beyene, 2017), 40 m x 40 m for grazing land following Nikiema (2005) and for crop fields 50 m × 50 m Tadesse et al. (2019) because of the low density of trees in crop field. A large sample plot area was used since it was less likely to get woody species from small plots in this land use (Tolera et al., 2008).

2.2.2 Woody species inventory

In each sample plot, local name, number of woody species, diameter at breast height (DBH) and tree height were collected. DBH and tree height of woody plants were measured by using diameter tape and clinometer, respectively. The data were collected from woody species with DBH greater than or equal to five centimeters ($\geq$ 5 cm) diameter at breast height (DBH at 1.3 m) and height $\geq$ 3m. This size was taken into account because of woody species less than this size is less available in agricultural land due to the fact that, farmers' intensive management to increase the land uses efficiency. With the help of a local Para taxonomist, species were identified using a guide book Flora of Ethiopia and Eritrea (Hedberg *et al*. 2004) and useful trees and shrubs for Ethiopia (Bekele 2007).

2.3 Data analysis

Inventory data were analyzed by Microsoft Excel and the outputs were used to determine population structures like basal area, importance value index (IVI) and frequency of woody species (Dibaba et al. 2014). The status of woody species in household's farms was examined by computing the diversity, species richness and evenness values. Accordingly, the following are the details of methods and steps used for analyzing the vegetation data.

The sum of all species encountered in each study area (through counting the total number of species) was used to determine the species richness of the study area (Giday et al. 2019).

Diversity was calculated by using the equation:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where, H' is Shannon index, S is species richness, and p_i is the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of the total.

Evenness was calculated as:

$$J' = \frac{H'}{\ln S}$$

Where, J' is evenness, H' is Shannon index, and S is species richness.

Frequency was calculated as:

$$\text{Frequency} = \frac{\text{Number of plots in which species occur}}{\text{Total number of plots}} \times 100$$

Basal area was computed for each woody species as:

$$BA = \pi \left(\frac{DBH}{2}\right)^2$$

Where, $\pi = 3.14$, BA is basal area (m^2), and DBH is diameter at breast height (cm).

Similarity Indices were computed by the following formula:

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

Where S_s is Sorensen similarity coefficient, a is the number of species common to both samples, b is the number of species distinctive in sample 1, and c is the number of species distinctive in sample 2.

Important Value Index was calculated as follows:

$$IVI(\%) = \text{Relative abundance} + \text{Relative dominance} + \text{Relative frequency}$$

Where:

$$\text{Relative abundance} = \frac{\text{Number of individuals of woody species}}{\text{Total number of woody individuals}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Dominance of woody species}}{\text{Total dominance of all woody species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of woody species}}{\text{Frequency of all woody species}} \times 100$$

2.4 Statistical Analysis

One-way ANOVA was used using R software version 3.5.3. Significant differences detected through ANOVA with $P < 0.05$ were investigated by comparison of means using Tukey's HSD test. During analysis woody species inventoried in each plots were converted to /ha to manage the variation in plot size of the land use types.

3 Results and discussion

3.1 Species composition

A total of 50 woody species belonging to 27 families were identified and recorded in the study area. Current study identified that *Croton macrostachyus, Albizia gummifera, Cordia africana, Vernonia amygdalina, Carica papaya*, *Grevillea robusta, Catha edulis, Eucalyptus camaldulensis, Cupressus lusitanica, Acacia lahai, Albizia schimperiana,* and *ficus vasta* were the most dominant species in the study site. Fabaceae was the dominant family represented by 7 species and it accounts (14%) following by Moraceae (8%), Euphorbiaceae, Myrtaceae and Bignoniaceae each account (6%). This result was in line with the result in Sub-Humid Lowlands of Ethiopia (Tadesse et al., 2019) and study in Wolayitta Zone of Ethiopia (Bajigo and Tadesse 2015) who reported that, Fabaceae family is the dominant family of the woody species recorded.

The results also revealed that, 37 (74%) of these species were indigenous while the remaining 13 species (26%) were exotic. This result is comparable with the result of Molla and Kewessa, (2015) who reported that from the identified species indigenous were the highest percent than exotic in traditional agroforestry practices of Dellomenna district, south eastern Ethiopia. Current study results showed that from the total 50 species, 39 (78%) were trees and 11 (22%) were shrubs which indicate that the largest portion of identified woody species were trees. This study was consistent with the study result of Wari et al. (2019), who reported that the identified woody species were dominated by trees.

Among recorded woody species, 23 species were found in homegarden, 16 in grazing land, 14 crop field, 18 in coffee farm and 4 in the woodlot. This indicates that, homegarden has got the highest woody plant species richness than other land use types in the overall study sites. Homegarden of Foge Komolcha has the highest woody species richness than other land use (16) followed by grazing lands of Foge Kombolcha (13) and Dogano Bile (12) when comparing species richness at kebele level. This is in line with the result of (Tolera et al. 2008; Fikir et al. 2018) who reported that, higher number of woody plant species found in homegardens than other land use types. However, the woody species richness of this land use is low as compared to Wari et al. (2019) in South western Ethiopia (39) and higher than (Mangistu and Asfaw 2016) in Dallo Mena Woredas of Bale zone South East Ethiopia.

From total woody species recorded in current study, four species were identified in woodlot which was much lower than other land uses in terms of species richness. This might be due to dominance of single species which affect the opportunity of other species occurrence. For instance, the intensity of light reaching the forest floor may differ in accordance with the density of crown cover, and this may influence understory plants colonization (Senbeta et al. 2002). The current study revealed that diversity of woody species varied from site to site. The variation could be due to differences in farm management, socioeconomic status, farmers' tree species preference and environmental factors. According to Schorth and Harvey (2007), different groups of species respond in different ways to various habitat types, management practices and landscape. Correspondingly, there were distinct differences in the level of species abundance and richness among the agroforestry types (Negash et al., 2012). Study in Southern Ethiopia shows that, due to the most important factors like local socioeconomic and physical conditions, there is variation in tree species richness on farm (Abebe et al. 2013). According to Tesfaye et al. (2014), there are more tree species in home compounds and fences than far away from homesteads due to day to day management and supervision by farmers. Results in Sub-humid lowlands of Ethiopia also indicate that, the accumulation of a greater number of species in homegardens compared to other land use is attributed to the planting preference of exotic species in homegardens (Tadesse et al., 2019). Similar to this results in South-East Ethiopia identified that, in the homegarden agroforestry practice, farmers manage both exotic and native trees/shrubs species (Mangistu and Asfaw 2016).

3.2 Similarity Indices

The similarities in woody species composition were compared among the land uses (Table 1). It measures the degree to which the species composition of different systems is alike (Guyassa et al. 2014). The highest similarity in woody species compositions (73.33%) was recorded between crop fields and grazing lands, while the lowest (18.18%) was between woodlots and coffee farms. Similar result with the result of Guyassa and Raj (2013) who identified that, the Sorensen coefficient of similarity estimated for crop land and grazing is greater as compared with others.

The relatively high similarity in woody species composition between grazing land and crop field could be due to the high number of common species found in both systems than other land use types. This is because of trees found in both systems were mostly composed from ruminants of forest species. The similarity index result of Dogano Bile and Foge Kombolcha sites were highest (64.61%) whereas it was lowest in Daye Gomi and Foge Kombolcha sites (55.17%) (Table 2). In homegarden-coffee farm, home- garden-woodlot, crop field-woodlot, grazing land-woodlot and coffee farm-woodlot this index were low comparing with others. This implies that, they have less overlapping species with each other which could be resulted from farmer's tree selection on different land uses for different purposes. This might be explained by the fact that farmers intensive species selection for different uses on different land use types might lead to low similarity index between land use types (Mengistu and Asfaw, 2016).

3.3 Woody species diversity

The Shannon diversity index across land use types were varied from 2.796 to 0.304 and species evenness varied from 0.946 to 0.219 (Table 3). It is important to note that during analysis woody species inventoried in each plots were converted to /ha to manage the variation in plot size of the land use types since Shannon diversity index is sensitive to different plot sizes.

The result of one-way ANOVA showed that the diversity of woody species significantly vary across land use types ($F(4,10) = 86.1$, $P < 0.001$) Figure 2). The highest species diversity was recorded in homegarden (H'=2.796) followed by grazing land (H'=2.624) and crop field (H'=2.163). Woodlot has the lowest Shannon index than other land use types. This result is in

line with study result in Wolayitta Zone indicating homegarden has the highest species diversity than other land use types (Bajigo and Tadesse, 2015). Evenness indices were highest in grazing land (j'= 0.946). It was interesting to note that despite grazing land has lower number of species than homegarden, it hosts evenly distributed species throughout its ecosystem. This contributed to high evenness index in this system.

The higher diversity indexes in homegarden could be due to difference in distribution of number of individuals and species richness as a result of variation in woody species efficiency, the difference in agroforestry practices, and planting site preference. This could be the case, because Shannon diversity index is usually associated with an increase in species richness (Abebe et al. 2010). According to Agidie et al. (2013), some farmers prefer to plant trees around their home to protect them from the livestock by family members. Studies in North Western Ethiopia indicated that the highest species diversity is due to the highest species richness (Giday et al. 2019). Even though the highest species evenness is also the case for the highest species diversity this may be not usually in where there is low number of species with evenly distributed in the system. According to Abebe et al. (2013), the composition, diversity and density of tree are influenced by physical and socioeconomic factors. Other findings also show, the higher woody species diversity around homesteads is due to the higher soil fertility from animal manure around this area contributes the higher performance of trees and shrubs (Felix et al., 2018; Giday et al. 2019) and also the daily follow up by farmers (Tesfaye et al. 2014).

Table 1: Similarity indexes of woody species among land use types. Sorensen similarity index in percent (%).

Land use type	Homegarden	Grazing land	Crop field	Coffee farm	Woodlot
Homegarden	-	-	-	-	-
Grazing land	42.72	-	-	-	-
Crop field	57.43	73.33	-	-	-
Coffee farm	38.28	43.53	43.05	-	18.18
Woodlot	34.78	20.00	33.33	-	-

Table 2: Percent of Sorenson similarity index in three sites

Site	Daye Gomi (%)	Dogano Bile (%)
Dogano Bile	64.4	-
Foge	-	-
Kombolcha	55.17	64.61

Comparing different land use types in terms of Shannon diversity indices, there was no statistically significance difference between homegarden and grazing land agroforestry practices in the study area. Variation was observed when comparing coffee farm with crop field, grazing land, homegarden, and comparing woodlot with crop field, grazing land and homegarden which was statistically significant ($p<0.001$). There was statistically significant difference ($p<0.05$) in diversity indices when comparing woodlot-coffee farm, grazing land- crop field and home-garden-crop field. Between woodlot and coffee farm, it was lowest at woodlot and highest in coffee farm, whereas between

grazing land-crop field and homegarden-crop field it was lowest in both comparisons at crop field. Results in Wolayitta Zone and Sub-humid lowlands of Ethiopia indicate, diversity index is significantly higher in homegarden than crop field (Bajigo and Tadesse 2015; Tadesse et al. 2019). This might be caused from farmer's continuous cultivation of crop field for crop production which affects the distribution of woody species across this system.

During comparisons, similar pattern of variation was also found for evenness values across different land use types. Comparing evenness indices of coffee farm with grazing land, home-garden and crop field it was highest in those land uses and lowest in coffee farm. The results also indicated that when comparing evenness indices of woodlot with crop field, grazing land, homegarden and coffee farm, it was lowest at woodlot than those land uses (j'= 0.219). These difference was statistically significant ($p<0.001$). However, comparing crop field with grazing land and home-garden, the evenness indices were highest in grazing land and homegarden and lowest in crop field which was statistically significant ($p<0.05$) and while there was no significant difference among home- garden and grazing land. The results were similar with the result of Fikir et al. (2018) who identified that, similar pattern of variation was also found for evenness values among land uses.

Comparing current study results at three kebele, as the result of Shannon diversity index shows, Foge Kombolcha was more diversified followed by Dogano Bile and Daye Gomi in homegarden agroforestry of study sites, where species evenness ranges between 0.974 and 0.896 (Table 4). The result was higher in both species diversity and evenness than home-garden of Gununo Watershed in Wolayitta zone (Bajigo and Tadesse, 2015) and in the South-central highlands of Ethiopia (Tolera et al. 2008) while lower in diversity index and higher in evenness index than study in East Shewa zone of Ethiopia (H'=3.05, j'= 0.34) (Yemenzwork 2014).

In grazing land, the highest diversity was recorded in Foge Kombolcha than Dogano Bile and Daye Gomi site with evenness index varying from 0.961 to 0.942. This result was higher in both species diversity and evenness index than result in Tigray region of Ethiopia (Guyassa and Raj 2013), when it was lower than the study result of South Western Ethiopia in species diversity and more or less higher than in evenness index (Wari et al., 2019).

The highest species diversity was recorded in the crop field of Daye Gomi than in Foge Kombolcha and Dogano Bile sites and evenness index of woody species ranged between 0.823 and 0.802. The result shows that, when comparing crop field with home-garden and grazing land, both index was low in this land use type. This could be resulted from very scattered and ununiformed (low evenness) distribution of species in this land use type (Guyassa and Raj 2013). Study in South-central highlands of Ethiopia indicate, Shannon diversity indices and evenness indices is higher in natural forest than crop fields and home-gardens due to the uniform distribution (high evenness) of species (Tolera et al. 2008). This result was higher in both Shannon diversity index and evenness index than study result in Tigray region of Ethiopia (Guyassa and Raj, 2013). However, it was lower in Shannon diversity index and higher evenness index in crop field of the South-central highlands of Ethiopia (Tolera et al. 2008) and Enda Mekhoni Wereda in Tigray region of North Ethiopia (Guyassa et al. 2014).

In Foge Kombolcha site, woody species diversity is higher than Dogano Bile and Daye Gomi while evenness index ranges from 0.352 to

0.271 in coffee farm land use type. The lowest species diversity in coffee farms in relation to other land use types may be explained in terms of uneven distribution of shade tree species and large percent domination of coffee shrubs in the study area. The result was in line with Wari et al. (2019) who reported that, single species (*Coffea arabica*) dominated the coffee farm and less shade tree species number. According to

Table 3: Woody species richness, diversity and evenness across land use types of study area

Land use type	Species richness	Species diversity (H')	Species evenness (j')
Crop field	14	2.163	0.819
Grazing land	16	2.624	0.946
Coffee farm	18	0.742	0.257
Homegarden	23	2.796	0.892
Woodlot	4	0.304	0.219

Table 4: Woody species richness, diversity, and evenness in three kebele sites

Land use	Site	Species richness (No.)	Species diversity (H')	Species evenness (j')
Crop field	Dogano Bile	7	1.580	0.802
Crop field	Foge Kombolcha	8	1.754	0.823
Crop field	Daye Gomi	10	1.889	0.821
Grazing land	Dogano Bile	12	2.388	0.961
Grazing land	Foge Kombolcha	13	2.428	0.944
Grazing land	Daye Gomi	9	2.071	0.942
Coffee farm	Dogano Bile	9	0.597	0.271
Coffee farm	Foge Kombolcha	7	0.684	0.352
Coffee farm	Daye Gomi	8	0.572	0.275
Homegarden	Dogano Bile	12	2.227	0.896
Homegarden	Foge Kombolcha	16	2.700	0.974
Homegarden	Daye Gomi	9	2.016	0.917
Woodlot	Dogano Bile	2	0.021	0.031
Woodlot	Foge Kombolcha	2	0.000	0.000
Woodlot	Daye Gomi	3	0.025	0.036

Mengistu and Asfaw (2016), due to farmer's activity to increase the land use efficiency like intensive thinning of other plant species in order to reduce competition from the coffee, lower species diversity is recorded from coffee farm agroforestry practices; and these activities might affect and limit the number of woody species grown in the system. Study in South East Ethiopia indicate that, in shade grown coffee agroforestry practice, about large percent of the practice are covered by coffee shrubs and other important shade tree species which are highly familiar and positive interaction with coffee plants are only found (Mengistu and Asfaw 2016). This result indicates higher diversity index and lower evenness index than study result in South East Ethiopia, while it was lower in both Shannon index than the result recorded in South West Ethiopia (Tadesse et al. 2014).

In relation to other site, relatively higher levels of diversity were recorded in woodlot of Daye Gomi followed by Dogano Bile while it was zero in Foge Kombolcha site. This result was similar with the result of Bajigo and Tadesse (2015) who reported that, since the woodlot is composed of single species, the diversity index was relatively zero. Species diversity index and evenness index were ranges between 0.025 to

0.000 and 0.036 to 0.000 respectively. The study result show that, the diversity index and evenness index of this land use type was lower in all sites than other land use types. This result was in agreement with those of Wari et al. (2019) who reported that, woodlots composed of some woody species, and the diversity index was relatively lower in all sites than other land use types. The same to this, current study identified woodlots are dominated by a single species mostly *Eucalypus* species and *Grevillea robusta* which was consistent with the result of (Bajigo and Tadesse, 2015) in Wolayitta zone of Ethiopia. Additionally, grazing land was more diversified followed by home-garden and crop field in Dogano Bile site. This result was in line with the study result of Wari et al. (2019), who reported that grazing land recorded highest species diversity than other land use system. Homegarden of Foge Kombolcha was more

diversified than other land use types in overall study site whereas species diversity of grazing land in each sites were higher than coffee farm, homegarden, woodlot and crop field except with Foge Kombolcha and Dogano Bile site homegarden.

Generally, this study showed that, species diversity and richness varies across different land uses. The land use types did also show clear differences when evenness indices are considered. This could be due to difference in topography, functions of species, nutrient and moisture availability, management activity and factors related to socioeconomic of the farmers. According to Nuberg et al. (2009), the variations of species diversity among different area is due to variation in topographic variables, moisture and nutrient availability. The study result in Southern Ethiopia showed that altitude have significant effects on total species richness, composition and diversity and identified that, diversity of tree decreases with increasing altitude. As altitude increase there is high rainfall and minimum temperature which restricts plant growth (Tefera et al., 2016). Similarly, result in South Eastern Rift Valley of Ethiopia indicate, the variation in species richness probably was due to differences in altitude and farmers' tree management practices. They report that, farmers in enset agroforestry give more emphasis to managing *Enset ventri-*

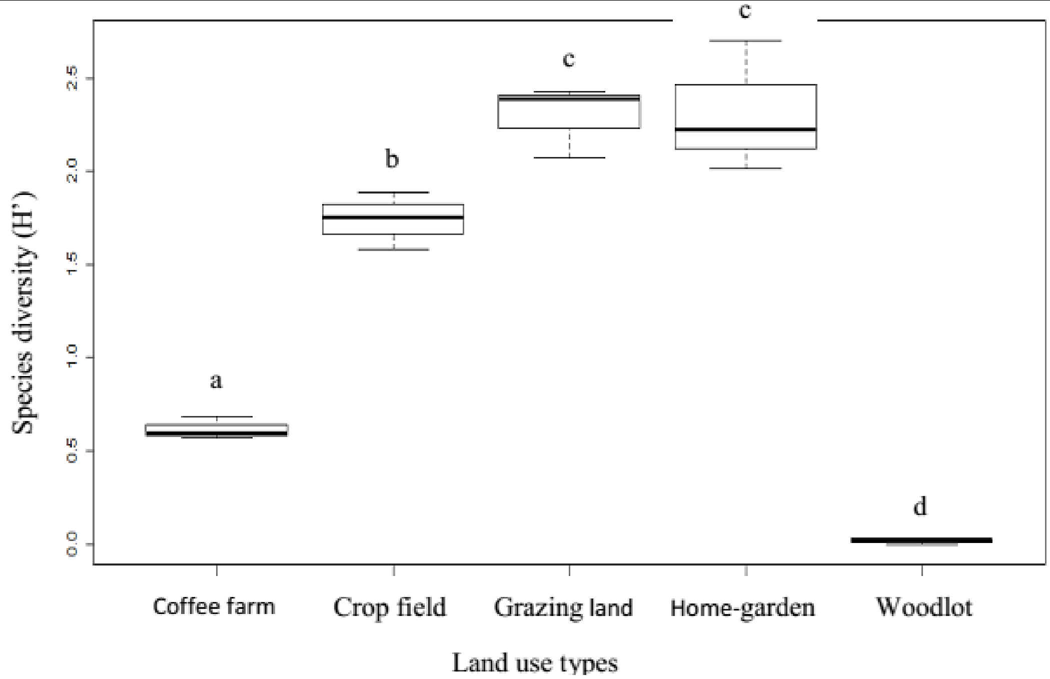

Figure 2: A boxplot showing the woody species diversity across land use types. The different small letters on boxplot indicate the significant differences in diversity among land use types.

Table 5: Woody species frequency class percentage in different land uses

Land use types	1 (0-20%)	2 (21-40%)	3 (41-60%)	4 (61-80%)	5 (81-100%)
Grazing land	6.25	62.5	18.75	12.5	-
Crop field	42.85	35.71	21.42	-	-
Coffee farm	66.67	16.66	5.55	-	11.01
Woodlot	67.7	15.5	-	16.86	-
Homegarden	34.78	34.71	21.75	8.76	-

cosum with native woody species. Due to this they practice thinning to create more space for growing this species (Negash *et al*. 2012).

High species diversity is often associated with important ecological services such as

nutrient cycling, soil and water conservation, and resilience under anthropogenic pressure (Jose, 2009). According to Faye et al. (2011), the most important functions of tree species are essential products like food, medicines, animal fodder, and fuel wood followed by environmental services which include soil fertility improvement, soil/water conservation, shade and sale products to generate revenue. Frequently existed woody species are fast growing, shade tree, tolerable for different managements and those provide different uses (Bajigo and Tadesse 2015). For instance, *Eucalyptus* is ranked higher than all other trees based on its growth performance, the availability of saplings at local extension offices, and its overall multi functionality (Tefera et al. 2014).

4 Structure of woody species Frequency

The current study showed that more percentage of woody species were frequently observed within frequency class '1' in crop field, coffee farm, woodlot and home-garden, whereas, frequency classes '2' in grazing land (Table 5). This result was in line with (Tefera et al., 2016; Wari et al., 2019) who reported that most of trees and shrubs species were recorded in the frequency class 'A'. The least number of species were recorded for frequency class 1 (6.25%), 3

(5.55%) and class 4 (8.76%) in grazing land, coffee farm and home-garden land use types, respectively.

The most frequently observed woody species in grazing land were *Acacia lahai* (66.66%) and *Croton macrostachyus* (55.05%) respectively; while *Terminalia laxiflora* (22.2%) was the least frequent in the overall study area. Where *A. lahai* (67.16%) and *Maesa lanceolate* (60.37%), in Foge Kombolcha; *A. lahai* (56.4%), *C. macrostachyus* (53.2%) and *Ficus vasta* (45.46%) were the most frequent species in Dogano Bile site. *Vernonia auriculifera* (71.3%) and *Buddleia polystachya* (64.21%) were the most frequented woody species in Daye Gomi grazing land. Most of these species were frequently cited in other grazing land (Wari et al., 2019). In homegarden the most frequently woody species were *Catha edulis* (77.32%) and *Carica papaya* (55.58%) where *Olea africana* (11.12%) was the least frequent in the overall study site. *Cupressus lusitanica* (72.6%) and *Grevillea robusta* (65.08%) in Foge Kombolcha site; *Citrus sinensis* (86.42%) and *Juniperus procera* (82.7%) in Dogano Bile site whereas in Daye Gomi site *C. edulis* (85.77%) and *Vernonia amygdalina* (78.04%) were the most frequently observed woody species in home-garden agroforestry system. Most of these woody species also frequently cited by (Mekonen et al., 2015; Tefera et al., 2016; Wari et al., 2019). In crop field, *Cordia africana* (55.63%), *Eucalyptus camaldulensis* and *V. amygdalina* both (44.57% each) were frequently observed in overall sites. Where in Dogano Bile site *C. macrostachyus* (66.45%) and *C. africana* (60.8%); while in Foge Kombolcha, *C. africana* (57.11%), *C. macrostachyus* (53.8%) and *E. camaldulensis* (48.62%), whereas in Daye Gomi site, *C. africana* (60.8%) and *V. amygdalina* (59.42%) were frequently found. These woody species frequently observed in another crop field. For instance, *A. gumifera and C. africana* in South western Ethiopia (Wari et al., 2019) and *C. macrostachyus* is the most frequent woody species encountered in crop fields of south central highlands of Ethiopia (Tolera et al., 2008). *C. macrostachyus, E. camaldulensis* and *V. amygdalina* were frequent woody species cited by Duguma and Hager (2010).

Coffea arabica (100%), *Albizia schimperiana* (57.53%), *V. auriculifera* (51%) and *C.africana* (48.03%) were the most frequently woody species encountered in coffee farms of the study area. Other studies in South East Ethiopia identified that *C. arabica* is the most frequently observed woody species in coffee farm (Mengistu and Asfaw, 2016). According to study result in Eastern Uganda, *C. africana* is the most frequent tree species encountered in coffee farm agroforestry system (Negawo and Beyene 2017). The only frequently observed woody species in class '5' and no species were recorded in frequency class '4' in this land use type. In woodlot, the most frequently observed woody species was *E. camaldulensis* in the study area. It was 66.67% frequency in the overall study sites, while 100% in Dogano Bile and Daye Gomi sites. *G. robusta* next to *E. camaldulensis* was the frequent woody species encountered during inventory with frequency of 33.33% in overall study sites and 100% in Foge Kombolcha site. Similar with the result of Wari et al. (2019) who reported that, *E. camaldulensis* was the most frequently observed species during the survey in woodlots. The frequency distribution of woody species on different land use types in the present study was variable. Study in South Eastern Ethiopia showed that, the frequency distribution of tree species on farms is variable (Molla and Kewessa 2015). This might be due to their values on land use types. As one would expect, tree species with a greater economic or ecological value or both were found to be frequently distributed across the farms (Molla and Kewessa, 2015).

4.1 Importance value index (IVI)

Importance value index (IVI) measures the overall importance of a species and gives an indication of the ecological success of a species in a particular area (Molla and Kewessa 2015). Species with high IVI is associated with the land uses and based on farmer's species preference which is linked with species market demand and service value. Especially in agroforestry practices, species with higher IVI are associated with framers species preference and product value (Mengistu and Asfaw, 2016). In this study the IVI showed that, *V. auriculifera, C. edulis, V. amygdalina* and *C. papaya* have high IVI due to their relatively high relative abundance 11.67%, 10.58%, 10% and 7.05%, respectively. *E. camaldulensis* (90.5%), *C. africana* (32.91%), *F. vasta* (23.6%) and *C. macrostachyus* (19.29%) have high relative dominance and hence contributed highest IVI value in the study area. According to Kent and Coker (1992), important value index indicates the extent of the dominance, occurrence and abundance of a given species in the current study indicated, the species with higher IVI were most important woody species in land use types of study area. For home-garden agroforestry practices the highest IVI value is covered by species which provide higher income for the farmers, while in the case of coffee agroforestry practice, about large percent of the practice were covered by coffee shrub and other important shade tree species which are highly familiar and positive interaction with coffee plants. Due to this in coffee farm *C. arabica* contributed the highest IVI because of its high relative frequency than shade tree. According to Mengistu and Asfaw (2016), in home-garden agroforestry practice, woody species with highest IVI are fruit tree species and other high market value species whereas, in shade grown coffee agroforestry practice woody species with the highest IVI are *C. arabica* and few other shade tree species.

This study identified that, *A. schimperiana* and *Acacia* species were most preferred woody species for coffee shades as they have thin and small leaves which allow an appropriate amount of light to reach the coffee trees. These results were in line with the result of Ango et al. (2014) who reported that, woody species with thin, small and elongated leaves are most preferred species as shade for coffee. Especially, *V. auriculifera* was preferred species during early establishment of coffee farm on treeless field until permanent shade tree species grown enough due to their fast growing habit in study area. Study results of Wari et al. (2019) also identified that, small trees and shrubs were used for shade when farmers convert other land uses and/or treeless field to coffee farm due to fast growing and soil fertility improvement. In crop field *C. africana*, *A. gumifera*, *C. macrostachyus* and others were the most important woody species found. During informant interview, they pointed out that, these tree species were incorporated for their multiple uses like nutrient cycling and crop protection besides to other economic uses. Study result of Agidie et al. (2013) in upper Blue Nile basin of Ethiopia showed, *C. africana* is preferable for timber, farm equipment and fodder while *C. macrostachyus* is useful for its fuel, fence, soil improvement and shade. They identified that, these species are widely found on farmlands, homesteads and farm boundary and has no any harmful effect to crops. According to Schroth et al. (2001), the incorporation of shade trees on crop field is frequently shown to positively affect and nutritional status through improved light regulation and nutrient cycling.

In homegarden agroforestry system *G. robusta, V. amygdalina, C. lusitanica, C. papaya and C. edulis* were the most important woody species recorded in this system. The current study identified that some of species were exotic, fruit trees and cash crops which have mostly economic value. This finding was in line with the result of

Table 6: The top five woody species with the highest IVI values in land use types

Land use types	Species name	IVI
Homegarden	*G. robusta*	19.27
Homegarden	*C. papaya*	19.17
Homegarden	*V. amygdalina*	18.04
Homegarden	*C. lusitanica*	17.53
Homegarden	*C. edulis*	16.85
Grazing land	*F. vasta*	34.26
Grazing land	*C. macrostachyus*	31.72
Grazing land	*Acacia species*	28.51
Grazing land	*V. amygdalina*	21.78
Grazing land	*M. lanceolate*	16.03
Crop field	*C. africana*	47.24
Crop field	*C. macrostachyus*	32.26
Crop field	*A. gummifera*	28.16
Crop field	*V. amygdalina*	19.74
Crop field	*E. camaldulensis*	13.41
Coffee farm	*C. Arabica*	52.64
Coffee farm	*A. schimperiana*	35.56
Coffee farm	*C. africana*	23.62
Coffee farm	*Acacia species*	11.17
Coffee farm	*V. auriculifera*	10.85
Woodlot	*E. camaldulensis*	134.46
Woodlot	*G. robusta*	54.30

Tolera et al. (2008) who reported, species occurred in homegarden were mostly exotic trees such as *Eucalyptus* and *Cupressus* spp., fruit trees and cash crops such as chat (*C. edulis*), which are all species of economic or nutritional importance for farmers. In woodlot land use type, *E. camaldulensis* and *G. robusta* were the most important woody species recorded in the study area. Other study in South Western Ethiopia showed that *E. camandulensis, C. lusitanica* and *G. robusta* were the most important woody species identified in woodlot land use type (Wari et al., 2019). *E. camaldulensis* was species dominating woodlots in the study area due to its multiuse like for pole, fencing, fire wood and market value. According to Agidie et al. (2013), farmers prefer *E. camaldulensis* for its multipurpose uses (poles, fuel and charcoal, construction and farm implements) and its contribution to income generation. Current study also revealed the most important woody species in grazing land were *F. vasta*, *C. macrostachyus, V. amygdalina, M. lanceolate* and *A. lahai*. Trees on grazing land play an interactive role in animal production by providing shade and fodder (Agidie et al., 2013). Especially key informant mentioned that, trees like *F. vasta, V. amygdalina, A. lahai and C. africana* were help as supplementary feed during dry months. According to Duguma and Hager (2010), *V. amygdalina* is the highly preferred species for animal feed.

4.2 Distribution of DBH and Height Classes

4.2.1 Density

The density of woody species was analyzed in the overall study sites. As the result indicates woodlots were higher than other land use types in number of woody plants per hectare (Table 7). Next to woodlot coffee farm and homegarden have higher woody plant density respectively.

4.2.2 Distribution of DBH

Distribution of all individuals in different DBH size classes was analyzed and classified into 5 classes as A (5-15cm), B (15.1-25cm), C (25.1- 35cm), D (35.1-45cm), E (45.1-55), F (>55cm). DBH class distribution of all individuals in different size class showed an inverted J-shape distribution in overall land use types of study area (Figure 3). This result was similar with the result of (Dibaba et al., 2014; Mengistu and Asfaw, 2016; Wari et al., 2019). Out of the total woody species, 49.03% were distributed in "A" diameter class and 25.6% were distributed in B diameter

classes. This indicates most of individual species have lowest DBH size in most of land use types. This might be due to farmer's tree selection, the tree characteristics, replacement of aged tree species by productive young and high resource competition within the system. Farmers were very sensitive for the land and very much selective for the tree species grown on their field. For instance in home-garden most of the trees grown were fruit trees which have small diameter. According to Mengistu and Asfaw (2016), due to farmers intensive tree selection most of trees grown in their field are fruit tree species which are not that much larger in diameter.

In case of coffee farm, the system is dominated by coffee shrubs and very limited individual of shade tree components. Due to selective thinning limited tree species are grown on the larger area without

Table 7: Density of woody plant in the study area

Study area	Homegarden	Grazing land	Crop field	Coffee farm	Woodlot
Site	1043.17	659.69	305.3	1971.52	6507
Dogano Bile	893	615	296	1021.7	4521.52
Foge Kombolcha	1103.64	519.3	401.4	2058	5641.61
Daye Gomi	962	502.17	187	1103	4031

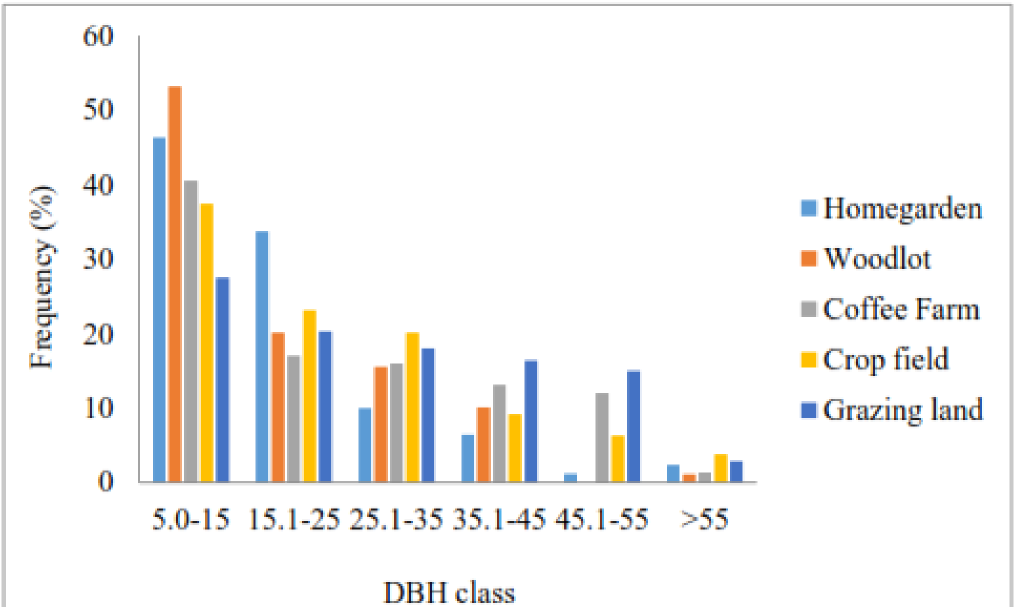

Figure 3: DBH class distribution of woody species in different land use type

competition for many years and results in higher DBH for few shade trees like *A. schimperiana, C. africana* and *Acacia* species in this system. Study result of Soto-Pinto et al. (2001) identified that, most of shade components were in the range of <20 cm DBH and most of the trees had height of ≤ 15m in coffee farms. Therefore, there was higher tree abundance at both the lower diameter and height classes in the system (Likassa and Gure, 2017). In grazing land there was more small sized and few large sized woody species found. In this system large sized tree species like *F. vasta, C. macrostachyus* and *Acacia* species were maintained specially to serve as shade during dry season. These species contributed highest DBH in this land use types. In case of woodlot, key informants explained, *Eucalyptus* were mostly planted in high densities for the requirement of straight poles which lead to resource competition and may results in low diameter.

5 Height classes distribution of woody species

From all system all individuals with ≥3 m height woody species identified during inventory and were categorized in to height classes. Based on the height, all species were classified into three height classes as 3 to 10 m lower height class, 10 to 17 m medium height class, and ≥17 m upper height class (Figure 4). The study results showed that woody species had highest frequency percentage of lower height class distribution across homegarden, coffee farm and crop field. This could be resulted from woody species management by farmers for different purposes.

According to Mengistu and Asfaw (2016), in homegarden and crop field in order to reduce shade and minimize light competition from the under growth plants the height of trees are managed repeatedly which affects height growth. Additionally, the majority of trees cultivated in this system were multi-purpose tree species whose height was controlled to collect wood for fence, house construction, farm equipment, animal feed, firewood, and also for sales. field while lowest species diversity was recorded in woodlot.

Generally, traditional agroforestry practices in which woody species integrated and managed with indigenous knowledge could be

potential for biodiversity conservation; and one option to address the problems of deforestation and related resource degradations in the current study area. The results of the present study confirm that, agroforestry practices can play a significant role in conservation of woody species diversity. Moreover, the presence of woody species in these systems may favor the survival of other organisms and hence contribute to wider conservation of biological diversity.

In order to manage integrated plant This result was in line with the result of Yakob et al. (2014). In case of coffee farm, the system was covered by very few shade trees and more coffee shrubs with small height in the study area. Woodlots were mostly dominated by

Figure 4: Height class distribution of woody species in different land use types.

higher heights. According to key informants, woody species produced in woodlots were mostly needed with sufficient heights for construction items like poles. This result was similar with the result of Wari et al. (2019) who reported that, woodlots are purposely required for woody products and it is dominated by higher height woody plants in overall study sites.

6 Conclusion and Recommendation

Farmers have got the tradition of integrating and managing woody species in different land use types. This could be seen as an opportunity which promotes local peoples interest in conservation and maintenance of such locally important species through agroforestry systems. They include woody plants into their farmlands through retention of remnant or naturally regenerated plants and/or undertaking plantation activities. In the present investigation, there was considerable significant variation in woody species diversities among different land use types of the study area. Accordingly, the study concluded that home-gardens host more diverse woody species followed by grazing land and crop

species on farmlands and sustain the existing woody species, it is necessary that more concrete efforts and interventions in conservation are required to retain woody species on farmlands to increase diversity. This is more important for improvement of the traditional agroforestry practices in which multi-purpose tree species are included for providing varies forest products and in doing so reducing pressures from existing forest besides to contributing to biodiversity conservation. Therefore, attention should be given to trees on farmlands and related land use types.

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Conflicts of interest

: We (the authors) declare that they have no conflicts of interest.

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