Diversity of Indigenous Woody Species in Small Holder Farm Lands: Comparison across Different Agroecology and Land Use Types in Chilga and Dabat District, Northern Ethiopia.

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Abstract

Ethiopia is known for its massive expansion of plantations and woodlots, that are mainly of monocultures of the exotic tree species, Eucalyptus, which has still remained the pre-dominant tree components of plantations as well as farming systems in different parts of Ethiopian highlands, including the highlands in North Gondar. However, the status of indigenous/native tree species in these areas has become very limited, and is considered at risk. The current study was conducted in Chiliga and Dabat districts of North Gondar zone; it assessed (i) indigenous woody species diversity of farmlands in different agro-ecologies and farm land use categories, (ii) management and conservation practices carried out by farmers, and (iii) major constraints for enhancing on-farm integration of indigenous woody species. Primary data was obtained using such methods as, formal household survey, group discussion, observation and woody species inventory in two villages selected randomly from highland and mid highland for Dabat, and mid land and lowland for Chiliga district. A complete census of all woody individuals was conducted on all plots/parcels of 80 households. A total of 35 species were encountered in the farm lands of the studied area. Six of the total species was exotic, and constitute about 85% of the total abundance. The number of woody species per household increased with decreased agroecological gradient, and the largest value of stem number was found at the highland, followed by at mid highland, whereas least stem number was found in the lowland site. Likewise, the study found that home gardens host more diverse indigenous species than other land use types. Even though farm lands in the study areas were home to different indigenous woody species higher in number than exotic species, it was possible to confirm the already reported evidence that revealed exotic species have been remaining the pre-dominant tree components of the agricultural landscapes in different parts of Ethiopian highlands. However, the fact that remnant native tree individuals are currently growing with in the agricultural landscapes is an indication of the opportunity for integrating and managing native tree species through Agroforestry systems. The study concludes that there is a considerable possibilities of native and indigenous species to exist as an integral component of agricultural land use systems in Northern highlands where Eucalyptus expansion has remained the main focus of research and extension efforts.

Key words: Diversity, Eucalyptus, Exotic species, Farmland, Indigenous species, On-farm, Planting, Retaining

1. Introduction

Owing to the diverse climates, altitudes, topography, soil conditions and other ecological features, Ethiopia has diverse ecosystems, hosting a great diversity of flora and fauna resources. Afromontane vegetation is one of the country's diverse vegetation ecosystems. It is mainly distributed across the so-called 'Ethiopian highlands' which are defined as land areas above 1500 m and constitute about 44% of the country. These forests of the Ethiopian highlands have long been harboring diverse indigenous woody plant species that provide multiple goods and services. Despite the invaluable role, the resources have been subjected to intense deforestation and degradation for millennia as a result of the long history of overwhelming

population pressure in the highland areas, combined with sedentary agriculture, extensive cattle herding activities and socio-political instability (Eshetu, 2002; Ermias, 2011).

In an attempt to address the problem of deforestation and supplement the shortage of supply of products from natural forests, government initiated afforestation efforts in Ethiopia have been started long years ago- near the end of the nineteenth century (Bekele, 2003). Almost all state-initiated afforestation efforts were using Eucalyptus species as the main species for plantation. And, soon after the introduction and development of Eucalyptus tree plantation by the government, the practice has been expanded from state owned plantations to community woodlots and then to small holder farmers. Eucalyptus has then been reported to become an integral part of most of the Ethiopian farming system and one of the Ethiopian most important tree resources (Pohjonen and Pukkala, 1990).

The highlands of North Gondar zone- the current study area- is one of the areas in Ethiopia where largest concentration of Eucalyptus plantations and woodlots has been reported. As to the reports of Amare (2012), farmers in these highland areas have shown a strong interest in Eucalyptus farming in homesteads and farm boundaries. As a result, the species has been reported to become a dominant tree component of the farming systems. Following the widespread practice of Eucalyptus planting on the farm, scientific research and policy focuses regarding farmers' tree planting and management practices have mainly been concentrated on Eucalyptus species as compared to indigenous species. And, considerable attempts have been done to study different aspects of Eucalyptus including the trend, factors behind expansion, density of trees across agroecologies, land size categories, spatial pattern, and the like.

The current study argues that Eucalyptus is not the only species and Eucalyptus woodlots are not the only land use types incorporating trees. On the other hand, the attention for indigenous species has mainly been limited to the mere report of the rapid expansion of exotic tree species, the significant decline in the natural forests harboring indigenous species, and hence the loss of biodiversity and the associated benefits. However, except such tendency to stress the decline in the natural forest, little/no attention has been given for the status of indigenous species outside forested area, i.e. on the farm. In other words, the possibilities of native and indigenous species to exist as an integral component of agricultural land use systems have been overlooked. Given the increasing recognition of tree inclusion practice in agricultural landscapes with respect to the role in livelihood and biodiversity conservation, there have been a considerable scientific interest towards status, diversity, management and other aspects of on-farm tree species (e.g. Zebene, 2003; Tesfaye, 2005; Kindeya, 2004; Yeshanew, 1997). However, there exists little or no attempt to deal with such issues in the northern highlands where Eucalyptus expansion has remained the main focus of research and extension efforts.

The current study assessed (i) indigenous woody species diversity of farmlands in different agro-ecologies and farm land use categories, (ii) management and conservation practices carried out by farmers, and (iii) major constraints for enhancing on-farm integration of indigenous woody species.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted in two selected districts of the former North Gondar zone, focusing areas where high natural forest degradation and deforestation, and prevalent Eucalyptus expansion have been and are being prevailing. North Gondar zone is found in Amhara Region, north-western Ethiopia, located at latitudes from $12^0 39'66''$ to $12^0 42'45''$N, and longitudes from $37^0 26'99''$ and $37^0 28'42''$E. With an estimated area of 45, 944.6 km^2, altitude in this zone ranges from 500 m a.s.l. in the lowlands of *Quara* and *Adiarkay* districts to about 3000 m a.s.l. in the Semien Mountain national park. There exist different climatic types in North Gondar, owing to a varying amount, pattern and distribution of rainfall across the zone. In the mid and high lying areas of the zone- the focus of the current study, which includes, the central, southern and south eastern parts, the rainfall pattern is uni-modal and characterized by single maximum rainfall pattern with annual average amount ranges from 600 to 1165 mm per year. The mean annual temperature ranges from 12.9^{0}C to 26.4^{0}C.

Regarding the forest resources, it has been suggested that the numerous remnant natural forest patches and the climatic conditions prevailing in the highlands (particularly rainfall) suggest that by far most of the highland area was once covered by afromontane forests (Eshetu, 2009; Friis et al., 2011). But, these montane forests of the highlands have been subject to intense deforestation and degradation for millennia. Currently, available forests are found around monastery and church, and as fragmented and isolated patches in some areas of the highlands (Eshetu, 2009). In contrast to the already degraded natural forest and endangered native tree species, significant areas of the highlands have been covered with state, community and private plantation forests dominated by the exotic Eucalyptus species.

2.2. Sample Site and Household Selection

As mentioned above, North Gondar zone is comprised of areas with varying climatic, altitudinal and other environmental variables. The focus of the current study was those areas where high natural forest degradation and deforestation, and prevalent Eucalyptus expansion have been and are being prevailing. In order to select sample districts out of all highland districts, prior information was first collected from possible sources at regional and zonal level. Two stage procedures have then been followed, with the help of experts and informants to select sample sites. Accordingly, two districts were selected in the first stage: the districts were Dabat and Chilga, districts with high and low Eucalyptus cover, respectively. Then, two broad categories were set for each of the two districts based on altitude: highland and mid highland for Dabat, and mid land and lowland for Chiliga. After this, one peasant association (PA) was selected purposively in each category of each district, and then, two villages were selected randomly at each of the four PAs, hence, a total of eight villages were included in the current study. List of households at each village was taken from the administrative office and a total of 80 households, 10 households from each village, were selected randomly using systematic random sampling method (households included in the selection process were only those having one or more trees on the farm).

2.3. Method of Data Collection

Data was collected using farm / tree assessment, household interview and group discussion. For woody species assessment, households were requested to let us observe and survey all of their farm plots/parcels, and a complete census of all woody individuals was conducted on all plots/parcels. Five land use categories or niches in which the woody plants are grown were identified: homegarden (land use in and around a homestead), crop/cultivated fields (a plot far from home dominantly used for growing annual crops), boundary plantings (trees/shrubs in lines such as hedgerow, live fences, boundary), grazing lands (land allocated for private grazing purposes, but scattered trees can be found) and woodlots (land allocated for small-scale production of wood). For each niche, the area was measured and all species encountered in each farm were identified, counted and listed using local and scientific names. In addition, other supplementary information was collected using interview and observations, such as whether the tree is planted or retained; history of plantation (in the case of woodlots); age of the tree; the physical condition of the tree (e.g. coppiced, pollarded, pruned etc). All species were identified in the field with the help of expert informants and using field guide (Tesemma, 2007).

Household interview was used to obtain data regarding on-farm trees such as the major uses of each woody species grown in the farm; management and conservation practices, and their perception towards constraints. Besides household interview, one group discussion per village (made of up to ten members comprised of elders, village leaders and experts) was conducted so as to supplement the household data and to obtain additional information. The major tasks performed in the discussion included listing all woody species found in their village and the surrounding landscape, the major uses of each woody species, challenges and opportunities for on-farm tree integration.

2.4. Method of Data Analysis

The status of woody species in household's farms of the study areas were examined by computing the diversity, abundance and frequency values. Accordingly, woody species diversity was estimated by using species richness, Shannon diversity index and evenness index. Shannon index (Shannon, 1949) and Evenness measure (E) are the common tools used in plant diversity assessment studies. Shannon diversity index (H') and evenness index (E) were computed, respectively, as:

$$H' = \sum_{i=1}^{s}(Pi * lnPi) \qquad\qquad (1)$$

$$E = \frac{H'}{Hmax} = \frac{H'}{lnS} \qquad\qquad (2)$$

Where: *pi* is the proportion of individuals or the abundance of the ith species expressed as a proportion of the total, ln is the natural logarithm of this proportion, and *S* is the total number of species.

Two sets of abundance value were calculated in this study. (i) average abundance per plot, calculated as the sum of the number of stems of a species from all plots divided by the total number of plots, and (ii) relative abundance, calculated as the percentage of the abundance of each species divided by the total stem number of all species. Similarly, two sets of frequency were also computed: absolute frequency, which is the number of plots in which the species recorded; and relative frequency, the ratio of the absolute frequency of the species to the sum total of the frequency of all species.

The existence of statistical differences in number of all woody species, number of indigenous species, diversity indices, number of stems of all woody species and number of stems of indigenous species was tested by using one way ANOVA test for each of the four agroecologies and the five land uses. Mean comparison was done by using LSD test for those variables showing significant mean differences. The analysis was done using SPSS ver 16. Finally, management and conservation practices, and major constraints for integrating indigenous woody species in the farm were analyzed using frequency and percentage.

3. Results and Discussion
3.1. Overall woody species diversity and abundance on farmers' Land
A total of 35 species were encountered in the farm lands of the studied area. The list of woody species possessed by the households with their use types, relative frequencies and relative densities are given in Table 1. Six of the total species was exotic, and constitute about 85% of the total abundance. Eucalyptus species was the most abundant woody species; it accounted a significant share, 66.8%, of the total abundance (Table 1). Two indigenous woody species were the next most abundant species, namely, *Croton macrostachyus* and *Rhamnus prinoides*, with a relative abundance of 4.3 and 3.9%, respectively. The other exotic species, *Cupressus lusitanica*, was the fourth abundant, having 3.4% of relative abundance. Many of the most abundant species were also the most frequent one. For instance, *Eucalyptus*- the first most frequent species with 10.27% of relative frequency; *C. macrostachyus*- the second one with 8.4% of relative frequency; *C. lusitanica*- the third (7.7) and *R. prinoides* the fourth (7.6) frequent species.

Table 1 List of woody species and the respective relative abundance (RD), relative frequency (RF) and major uses utilized by farmers in the study districts

Species (family)	Origin*	RD (%)	RF (%)	Major Uses**
Eucalyptus globules Labill. (Myrtaceae)	E	66.58	10.27	Co, Fe, Fu, Tr, Ft, Sh
Croton macrostachyus Hochst. ex Delile (Euphorbiaceae)	I	4.31	8.4	Fe, Sc, Sh
Rhamnus prinoides L'Her. (Rhamnaceae)	I	3.96	7.6	Sh, Fd, Oth
Cupressus lusitanica Mill. (Cupressaceae)	E	3.42	7.73	Fe, Fu, Co, Sh, Ft, Tr
Cordia africana L. (Boraginaceae)	I	2.14	7.33	Tr, Fo, Fe, Fu, Sh, M
Acacia polyachanta (Fabaceae)	I	1.56	4.13	Fu, Ft, Sc, Hb
Acacia dicurrence Willd. (Fabaceae)	E	1.54	4.8	Co, Tr, Ft, Fe, Fu, Sh, Hb
Acacia melanoxylon R.Br. (Fabaceae)	E	1.33	3.07	Fu, Co, Sh, Fd, Tr, Hb, Ft
Maytenus arbutifolia (Celastraceae)	I	1.27	3.2	Fo, Ft, Fe, Fu, Me, Sh, Fd
Myrsine Africana L. (Myrsinaceae)	I	1.15	2.13	Co, Fo Fe, Fu
Flueggea virosa Guill. & Perr. (Euphorbiaceae)	I	1.08	2	Fe, Fo, Co, Fu

Ficus sur Forssk. (Moraceae)	I	1.04	3.47	Fo, Co, Sc, Sh, Fu, Fe
Malus sylvestris L. (Rosaceae)	E	0.96	2.53	Fo
Balanites aegyptiaca (L.). (Balanitaceae)	I	0.81	2.27	Fo, Fe, Fu, Sc
Acacia abyssinica Benth. (Fabaceae)	I	0.73	1.73	Fe, Fu, Sh, Fd, Co, Tr, Ft, Sc
Acanthus sennii Chiov. (Acanthaceae)	I	0.65	1.6	Fu, Fe, Ft
Anogeissus leiocarrpa	I	0.65	0.53	Fu, Fe, Ft
Syzygium guineense (Willd.) DC. (Myrtaceae)	I	0.65	2.13	Fo, M, Fe, Fu, Sh, Co
Dodonaea angustifolia L.f. (Sapindaceae)	I	0.6	2	Fe, Fd, Co, Ft, Fu, Sh
Dombeya torrid Bamps (Malvaceae)	I	0.6	1.33	Fe, Fu, Ft, Hb, Sh, Fd, Co
Olea europaea L. ssp. Cuspidate. (Oleaceae)	I	0.58	1.87	Fe, Co, Ft, Fu, Sh, Fd, Sc
Rosa abyssinica Lindley (Rosaceae)	I	0.58	3.2	Fe, Ft, Hb, Fo, Fu, Sh, Fd, Sc
Rumex nervosus Vahl. (Polygonaceae)	I	0.56	2.27	Fe, Fu, Sh, Fd, M, Sc
Clutia abyssinica Jaub. & Spach. (Euphorbiaceae)	I	0.54	2	Fe, Fu, Sh, Fd, Sc
Ficus sycomorus L. (Moraceae)	I	0.54	2	Fo, Co, Fe, Sc, Fd, Sh, Hb
Cytisus proliferus L.f. (Fabaceae)	E	0.37	1.2	Fe, Fu, Sh, Fd, Co, Ft, Hb
Solanecio gigas (Vatke) C.Jeffrey. (Asteraceae)	I	0.31	1.33	Fe, Sh, M, Hb, Sc
Tamarindus indica L. (Fabaceae)	I	0.29	1.47	Fo, Fe, Fu, Co, Sc
Ziziphus abyssinica Hoschst. (Rhamnaceae)	I	0.29	1.2	Fo, Fu, Fe
Carissa Spinarum L. (Apocynaceae)	I	0.21	1.47	Fo, Fe, M, Fu, Ft
Dovyalis abyssinica (A. Rich.) Warburg. (Flacourtiaceae)	I	0.15	0.4	Fo, Fu, Fe
Euphorbia abyssinica J.F. Gmel. (Euphorbiaceae)	I	0.15	0.93	Fe, Fu, Co, Tr, Ft
Table 1 – *continued*				
Juniperus procera Hochst. Ex Endl. (Cupressaceae)	I	0.15	1.07	Fe, Fu, Sh, Fd, Co, Tr, Ft
Terminalia laxiflora	I	0.15	0.8	Co, Ft, Ft, M
Diospyros abyssinica (Hiem) F. Wite (Ebenaceae)	I	0.1	0.53	Fu, Tr, Co, Sh, Fe, Fo

*Origin: I- Indigenous; E- Exotic. ****Major Uses:** Co, construction; Fd, fodder; Fe, fencing; Fo, Food; Ft, farm and household tools; Fu, fuel wood; Hb, honey bee; M, medicinal; Sc, soil and water conservation; Sh, shade; Tr, timber; Oth, important income source.

The average number of woody species per farm was 9.4 (ranging from 4 to 17 species) while the average number of stems was 283 trees (ranging from 16 to 701). When splitting the species and stem number based on origin, the average number of indigenous species was 6.6 and the number of stems was 43; whereas, that of exotics was 2.7 and 48.2, respectively. The overall Shannon and evenness value was 1.38 and 0.62, respectively. There are some important observations that should be focused here. Even though the farm land in the study areas were home to different indigenous woody species higher in number than exotic species, the abundance/density of the indigenous species in the farm was by far lower than that of exotic. This confirmed the already reported evidence that revealed exotic species have been remaining the pre-dominant tree components of the agricultural landscapes in different parts of Ethiopian highlands (Jagger and Pender, 2000; Eshetu, 2002; Amare, 2012). A recent study by Tefera et al. (2014) found that more than 85% of the individual trees encountered during the vegetation survey belonged to a single exotic tree species, *Eucalyptus*, and it had by far the greatest overall density (192 individuals/ha), while other species were much less dense, ranging from 0.2 to 10 individuals/ha. The result of diversity and evenness indices

supported the aforementioned findings on woody species density. The low value of this index (which usually ranges from 0 to 3.0) confirms our observation that woody plant diversity in farmlands is low despite the relatively high number of species occurring within the study areas. This indicates the extremely low densities of most woody species and the high relative abundance of *E. globules*.

3.2. On-farm woody species diversity and abundance across different agroecologies
3.2.1. Species diversity
The average number of species per household was significantly varied among the four agroecologies (p<0.00) with the highest recorded at mid land (11.85), followed by low land (10.15) and highland (8.15) (Table 2). Splitting the number of species based on origin, larger percentage of the total species was accounted by indigenous species at all agroecologies. Number and type of exotic species was more or less similar across the agroecologies. Among the total six exotic species, *Eucalyptus globulus, C. lustinica, Acacia dicurrence* and *A. melanoxylon* encountered at all agroecologies; whereas, *Malus sylvestris* at highland and mid highland, and *Cytisus proliferus* at the other two agroecologies. As a result, there was no significant difference in number of exotic species across agroecologies. Regarding indigenous species, the mean number of species per household varied across agroecologies in the order of: Mid land > lowland > highland > mid highland; which was statistically significant at p<0.05 (Table 2).

In terms of diversity indices, lowest mean Shannon value of 0.97 in mid highland and highest value of 1.78 in mid land was found. Mean variation among agroecologies was statistically significant (p<0.00). Similar trend was also found for Evenness values: highest at mid land (0.74) and lowest at mid highland (0.49), and such difference was statistically significant (p<0.00).

The number of woody species per household increased with decreased agroecological gradient, indicating that middle altitudes have favorable environmental conditions for plant growth compared to higher altitudes. This result is concurrent with some others who have found a declining trend of woody species richness with increased altitudinal gradients in multistrata agroforestry systems of the Southeastern Rift Valley (Negash et al. 2012) and in the Afromontane forest of the Bale Mountains of Ethiopia (Yirdaw et al. 2015).

Table 2 Mean number of woody species and stems per household across the four agroecologies

	Number of woody species			Number of woody stems		
	All	Indigenous	Exotic	All	Indigenous	Exotic
Highland	8.15[a]	5.35[a]	2.80	347.30[a]	30.40[a]	316.90[a]
	(0.40)	0.40	0.20	(46.02)	(2.29)	(46.73)
Mid highland	7.35[a]	4.70[a]	2.65	335.35[a]	22.55[a]	312.80[a]
	(0.41)	0.34	0.20	(35.05)	(2.24)	(34.21)
Mid land	11.85[b]	9.40[b]	2.45	230.30[b]	66.30[b]	164.00[b]
	(0.61)	0.57	0.20	(32.36)	(4.67)	(32.49)
Lowland	10.15[c]	6.95[c]	3.20	222.50[b]	53.25[c]	169.25[b]
	(0.39)	0.38	0.19	(31.02)	(5.28)	(33.17)
Overall	9.38	6.60	2.77	283.86	43.13	240.74
	(0.30)	0.29	0.10	(19.079)	(2.74)	(20.02)

Values in parenthesis are standard error of the mean
Means with different superscript letter within a column had a statistically significant difference at p<0.05

3.2.2. Number of stems
Similar to number of species, there exists variation in mean number of stems per household among agroecologies (Table 2). The largest value was found at highland (347stems), followed by at mid highland site (335 stems). Least density was that of lowland site (222 stems). However, the difference was not statistically significant. Splitting the number of stems based on origin, the highest number of stems of indigenous species was found at mid land (66 per household), and the least at mid highland (22.5 per household). This finding was inversed in the case of exotic species where the highland site had the highest stem number (317) whereas, the mid land had the least (164). Such differences in indigenous and exotic stem were statistically significant (p<0.00).

3.2.3. Abundant and frequent woody species

It was found that significant share of the total stem abundance was accounted by a single exotic species at all agroecology (Table 3). However, there was a variation across agroecology. For instance, though *Eucalyptus* was the first most abundant species at all agroecology, its relative abundance decreased from mid highland (79%), followed by highland (71%), to lowland (61%) and mid land (52%). This same species combined with the other commonly planted exotic tree species, i.e. *C. lusitanica*, account for about 82, 74.5, 65 and 56 % of the relative abundance of all woody species at mid highland, highland, lowland and mid land, respectively. On the other hand, the most abundant native woody species *R. prinoides*, *C. macrostachyus* and *Cordia africana* constituted 16.6% of the total abundance at mid land, whereas, their share was lower at the other agroecologies; 8.7 at LL, 8.5 at mid highland and 8.23% at highland agroecology (Table 3).

Similarly, *Eucalyptus* was the first most frequent species at three of the four agroecology; mid highland (13.6%), highland (12.3%) and lowland (8.8%), whereas, it was the second one at mid land. The first frequent species in this agroecology were rather indigenous species, i.e. *R. prinoides* and *C. africana*, each account for about 8.5 % of the total relative frequency (Table 3).

Table 3 Most abundant and frequent woody species across the four agroecologies

	Highland		Mid highland		Mid land		Lowland	
	RD	RF	RD	RF	RD	RF	RD	RF
Eucalyptus globules	70.99	12.27	78.69	13.61	51.5	8.02	61.26	8.87
Croton macrostachyus	3.33	6.75	3.28	11.56	7.61	8.02	3.2	7.88
Rhamnus prinoides	3.48	8.59	3.75	8.16	5.43	8.44	3.2	5.42
Acacia polyachanta	0	0	0	0	4.29	6.75	2.64	7.39
Cupressus lusitanica	3.19	9.2	3.02	8.16	3.89	6.75	3.77	7.39
Cordia africana	1.42	4.29	1.47	8.84	3.56	8.44	2.36	7.39
Acacia melanoxylon	0.21	1.23	0.2	0.68	2.83	3.38	2.64	5.91
Flueggea virosa	0	0	0	0	2.35	3.38	2.54	3.45
Malus sylvestris	2.13	5.52	1.34	6.8	0	0	0	0
Balanites aegyptiaca	0	0	0	0	1.62	2.95	2.07	4.93
Acacia dicurrence	1.99	6.13	2.01	6.8	0.57	1.69	1.41	5.91

RD- Relative Density; RF- Relative Frequency

3.3. Woody species diversity and abundance across different farm land use types
3.3.1. Number of indigenous and exotic woody species

As mentioned in the methodology part, five farm land use types were assessed in the current study (homegarden, crop lands, boundary plantings, small-scale woodlots and grazing lands). Based on the inventory result, these land use types showed a statistically significant difference in their woody species richness (p<0.000) with the highest recorded in homestead plots (5.8 species) followed by crop lands 3.2 species) and grazing lands (2.1 species) (Table 4). Only few species was found in boundary plantings and woodlots. The land use types did also show clear differences when species origin is considered (Table 4). The analysis revealed that homegarden was the only land use comprised of both exotic and indigenous species- though the latter was higher in number (mean 3.5 species) than the former (mean 2.3 species). The remaining four land use types were found to consist only of either exotic or indigenous species with few exceptions. For instance, grazing land use had no exotic species at all, so has crop land use except *A. melanoxylon* which was found in some occasions. Likewise, species found in woodlots were all exotic, except *Acanthus sennii* and *C. macrostachyus*. In boundary plantings, there were some indigenous species, and the average species per plot was 0.39.

Our results align with that of Tolera et al. (2008), who found that the woody plant species richness was much higher in home gardens than in adjacent crop fields. Homegardens have the highest woody plant diversity in part because homeowners feel a stronger sense of ownership, and plants in home gardens benefit from the direct care of household members. In particular, perennial plants in homegardens provide continued benefits by their long-term presence in close proximity to the family home. Such tendency in maintaining

or growing multipurpose species near and around homestead might be for the sake of easing management practices, and also to better make the farm protected from theft and other things such as wild animals and others' livestock.

3.3.2. Woody species diversity (diversity indices)

Species diversity of the five farm land use types was examined using Shannon and evenness indices. And, the analysis revealed that there was a significant difference among the land uses in the mean values of both indices (p<0.000 for both indices). Home gardens had the highest Shannon index value of 1.50 ± 0.05, followed by cropland and grazing land. Boundary planting and woodlots had lowest Shannon index. Similar pattern of variation was also found for Evenness values: highest in homegarden and crop lands, and lowest in boundary planting and woodlots.

Table 4 Mean number of woody species and stems per household in different farm land use types

	Homegarden	Crop land	Boundary	Grazing land	Woodlot
Number of all species	5.78a	3.18b	1.71c	2.04c	1.48c
	(0.22)	(0.11)	(0.10)	(0.19)	(0.08)
Number of Indigenous species	3.46a	3.16a	0.39b	2.04c	0.05*
	(0.23)	(0.11)	(0.07)	(0.19)	(0.03)
Number of exotic species	2.31a	0.01*	1.32b	-	1.43c
	(0.09)	(0.01)	(0.08)	-	(0.08)
Abundance of all species	39.35a	15.50b	125.74c	8.48ab	245.25c
	(1.91)	(0.85)	(12.16)	(0.60)	(22.05)
Abundance of Indigenous	18.45a	15.46a	7.74b	8.48b	0.35*
	(1.36)	(0.85)	(1.69)	(0.60)	(0.23)
Abundance of exotic species	20.900a	0.04*	118.0b	-	244.90b
	(1.33)	(0.04)	(12.23)	-	(22.01)

Values in parenthesis are standard error of the mean. Means with different superscript letter within a column had a statistically significant difference at p<0.05.
***variables are not included in mean comparison due to small/few observations**

3.3.3. Abundance of indigenous and exotic woody species

As with number and diversity of species, there was also variation among land uses in terms of number of all woody stems (*P<0.000*). The largest mean number of all woody stems per field was recorded in woodlots (245), followed by boundary plantings (126) and homegardens (39), whereas, the smallest was recorded in croplands and grazing lands, 16 and 9 stems per field, respectively (Table 4). When the mean stem number in each land use type was analyzed on the basis of species origin, the finding was like this: no exotic stems in grazing land; very few stems of exotic species in crop land (0.04); very few stems of indigenous species in woodlot (0.35); significantly higher number of stems of exotic than indigenous in boundary planting; and more or less comparable number of stems of indigenous (18.5) and exotic species (21) in homegardens. Further analysis of mean stem number among land use types and species origin revealed that there was statistically significant differences in mean stem number of indigenous (p<0.00) and exotic (p<0.00) species. In terms of indigenous species, the largest mean number of stems was recorded in crop land, followed by homegarden and grazing land, whereas, in terms of exotic species, woodlots (245) followed by boundary planting (118) and homegarden (21) (Table 4).

As indicated above, exotic species dominate woodlots and boundary planting, whereas, indigenous species dominate cropland and grazing lands. The commonly encountered exotic species of *Eucalyptus* was the most abundant species constituting 97.5 and 85.08% of the total abundance of woody species in woodlots and boundary planting, respectively (Table 5). Next most abundant species in these land uses were also exotics: *C. lusitanica* (2.15% in woodlots and 3.75% in boundary plantings) and *A. melanoxylon* (0.18% in woodlots and 3.37% in boundary plantings). On the other hand, both of the two indigenous species encountered in woodlots and seven of the nine encountered in boundary plantings had relative abundance value of less than 1%; the two indigenous species in boundary plantings, *Acanthus sennii* and *C. macrostachyus* had 2.21 and

1.35 % relative abundance. The current finding is similar with the study of Haile et al. (2017) in Central Ethiopia. They found that woodlots had the highest density of tree stems, and noted that the presence of higher exotic density in woodlots implied farmers' selectiveness in decisions about planting exotic trees in separate plots to minimize tree competition for resources such as light, water and nutrients (Duguma and Hager 2010; Agidie et al. 2013).

Table 5 Most abundant and frequent woody species in different farmland use types

	Homegarden		Crop land		Boundary		Grazing land		Woodlot	
	RD	RF	RD	RF	RD	RF	RD	RF	RD	RF
Eucalyptus globules	31.36	13.64	0	0	85.08	47.79	0	0	97.49	67.8
Flueggea virosa	0	0	3.33	3.15	0	0	26.28	17.65	0	0
Croton macrostachyus	5.57	6.93	22.33	21.65	1.35	2.65	8.03	3.92	0.04	1.69
Rhamnus prinoides	17.6	12.34	0	0	0.38	1.77	0	0	0	0
Cordia africana	7.84	11.69	3.17	5.51	0.19	0.88	0	0	0	0
Cupressus lusitanica	7.84	9.31	0	0	3.75	18.58	0	0	2.15	27.12
Acacia polyachanta	1.48	3.68	8	6.69	0	0	11.68	9.8	0	0
Ficus sur	0.35	0.65	6.5	8.66	0.77	1.77	2.19	3.92	0	0
Myrsine africana	0	0	7.67	5.91	0	0	10.22	3.92	0	0
Balanites aegyptiaca	0	0	6.17	5.91	0	0	3.65	5.88	0	0

RD- Relative Density; RF- Relative Frequency

The relative abundance of exotic species was relatively lower in homegarden land use type as compared with the two exotic-dominated land uses, i.e. woodlots and boundary planting. For instance, relative abundance of *Eucalyptus* in homegardens was 31.4%, which was significantly lower than the 97 and 85% found in woodlots and boundary planting (Table 5). On the other hand, the next most abundant species in homegardens were two indigenous species, namely, *R. prinoides* and *C.aAfricana*, constituting 17.6 and 7.84% of the total abundance. Regarding the indigenous-dominated land uses, the first most abundant species in cropland use was *C. macrostachyus* (22.3%) and that in grazing land uses was *Flueggea virosa* (26.3%) (Table 5). The other abundant species in crop land use were *Acacia polyachanta* (8.00%), *Myrsine africana* (7.67%) and *Maytenus arbutifolia* (7.5%); these species were also most abundant in grazing land use with relative abundance value of 11.68, 10.22 and 15.03%, respectively.

The finding regarding the widespread dominance of indigenous species in crop lands is consistent with the commonly reported trend in Ethiopia. Bishaw and Abdelkadir (2003) reported that dispersed trees grown in farmlands characterize a large part of the Ethiopian agricultural landscape. Likewsie, growing *Acacia albida* as a permanent tree crop, on farmlands with cereals, vegetables and coffee underneath or in between, and *Cordia Africana* intercropping with maize in the Harrarghe highlands and in Bako, respectively are some examples of this practice (Poschen, 1986). Some tree species are deliberately preserved as on-farm scattered trees from the original forest. For instance, Lemenih and Teketay (2006) observed that as a tradition, a few trees, mainly *Croton macrostachyus Del., Podocarpus falcatus Thunb., Celtis africana Burm f., Militia ferruginea Hochst.) Baker* and *Prunus africana (Hook. f.) Kalkam,* are deliberately preserved as on-farm scattered trees (parkland agroforestry) from the original forest in Munnesa.

3.4. On-farm woody plant management and conservation practices

The promising tradition of woody plant inclusion into the farmlands, as indicated above, was accomplished through retention of remnant or naturally regenerated plants and/or undertaking plantation activities. Out of the 35 species encountered in our samples, 10 were established through natural regeneration, 11 through planting and the remaining 14 were through both establishment modes. In terms of number of individuals, about 83% of the 5198 individuals were found to be established through planting while the remaining 17% were through natural regeneration. Regarding establishment mode of exotic and indigenous, all exotic species were found planted whereas, indigenous species were found retained or planted or both. Overall, farmers practice of retention and plantings varied across land use types. As shown in Table 6, retention of

indigenous species was observed in all of the surveyed crop land uses (100%) and in many of the grazing land uses (96%), whereas, planting practice was limited and observed in many homestead land uses (80%) and some of the crop land use types (68%).

Table 6 Percent of respondents practicing retention and planting in different land use type

	Retaining		Planting	
	Indigenous	Exotic	Indigenous	Exotic
Homegarden (N =80)	91.25	0	80	100
Crop land (N =80)	100	0	68.75	1.25
Boundary (N =65)	25.76	0	16.67	96.97
Grazing (N =25)	96	0	28	0
Woodlot (N =40)	5	0	0	100

The tradition of maintaining different woody species on the farm land was found to be accompanied by management practices carried out on the species so as to enhance and sustain its intended function. Tree management in this study refers to all activities/operations in handling the tree to harmonize their existence with crops and animals. Major management practices in the area include watering, pollarding, pruning, thinning, fertilizing and plant protection. Farmers are aware of the importance of the different tree management activities for optimizing tree crop interaction and to derive benefit such as fuel wood, fodder, and soil fertility improvement from tree management activities. For instance, pruning and pollarding are mainly practiced on trees on crop lands, and for different objectives such as reducing the effect on crops, getting fodder for animals, and obtaining fence and fuel wood.

3.5. Constraints for enhancing on-farm integration of indigenous woody species

Various constraints have been identified that could affect integration of woody plants in farmers' holdings. According to household respondents, major constraints include land shortage, limited extension service, low availability of seedlings for planting, drought/climate change, lack of natural regeneration, termite/disease and planting of introduced species (Figure 1).
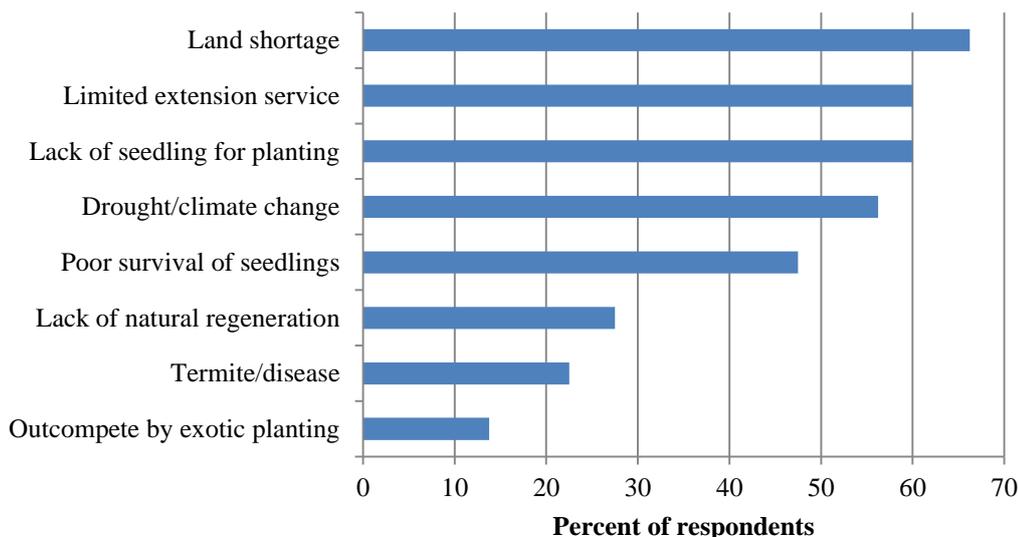

Figure 1. Major constraints for enhancing on-farm integration of indigenous woody species reported by respondents (*n = 80*)

4. Conclusion and Recommendation

The current situation in all study villages, that is on-farm integration and management of woody species, could be seen as an opportunity which promotes local peoples' interest in conservation and maintenance of such locally important species. The fact that remnant native tree individuals are currently growing with in the agricultural landscapes is an indication of the opportunity for integrating and managing native tree species through Agroforestry systems.

The study concludes that there is a considerable possibilities of native and indigenous species to exist as an integral component of agricultural land use systems in Northern highlands where Eucalyptus expansion has remained the main focus of research and extension efforts. The number of woody species per household increased with decreased agroecological gradient, and the largest value of stem number was found at the highland, followed by at mid highland, whereas least stem number was found in the lowland site. Likewise, the study concluded that homegardens host more diverse indigenous species than other land use types.

Even though farm lands in the study areas were home to different indigenous woody species higher in number than exotic species, it was possible to confirm the already reported evidence that revealed exotic species have been remaining the pre-dominant tree components of the agricultural landscapes in different parts of Ethiopian highlands, and such dominance of exotic tree species in farming landscapes may replace the native tree species in the long term. Based on the findings of the current study, the following points are recommended:

- Actions are necessary to prevent the rapid replacement of indigenous woody plant diversity by a monoculture of non-native trees.
- Future biodiversity conservation plans and programs should recognize the indigenous practices of on-farm tree/shrub retention and/or planting observed in the study sites, since these have a potential to be a buffer for the remaining forest resources.
- In order to enhance on-farm integration of indigenous woody species, it is important to:
  - Enhance availability and access to seedlings
  - Improve care and quality of seedlings to increase survival and performance on the farm
  - Enhance extension service and capacity building on tree management
  - Improve crop productivity so as to address the problem regarding crop land shortage
  - Develop and promote tree based income generation (like honey, fruit) so that tree integration will be attractive for farmers
  - Strengthen the protection of remnant forest patches which could serve as a seed and pollen source for plants growing outside forests

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