International Journal of Environmental Protection and Policy
2023; 11(3): 37-48
http://www.sciencepublishinggroup.com/j/ijepp
doi: 10.11648/j.ijepp.20231103.11
ISSN: 2330-7528 (Print); ISSN: 2330-7536 (Online)

Assessing the Extent of Tree Species Plantation across Different Land Use Types, in Case of Ale District, Ilu Aba Bor Zone, Southwest Ethiopia

Shifa Tahir Fogi

Department of Natural Resource Management, Ilu Aba Bor Zone, Agricultural Office, Oromia Bureau of Agriculture, Ministry of Agriculture, Addis Ababa, Ethiopia

Email address:
shifatahir97@gmail.com

To cite this article:
Shifa Tahir Fogi. Assessing the Extent of Tree Species Plantation across Different Land Use Types, in Case of Ale District, Ilu Aba Bor Zone, Southwest Ethiopia. *International Journal of Environmental Protection and Policy*. Vol. 11, No. 3, 2023, pp. 37-48.
doi: 10.11648/j.ijepp.20231103.11

Received: January 23, 2023; **Accepted**: May 22, 2023; **Published**: May 31, 2023

Abstract: Large-scale imports of exotic tree species are thought to be one of the main causes of worldwide environmental changes and alien forest plantations, putting many of our native forest ecosystems in danger. In comparison to the condition of native tree species, the status of alien tree plantings receives more attention from the community and encompasses many forms of land use. This study's goals were to evaluate the situation of plantings of exotic tree species across various land use categories. Purposive sampling was used in the data collection design. Plots of 20 m by 20 m, or 400 m^2 per grazing area, along the roadside, homestead, coffee farm, agricultural boundary, and woodlot were all used as locations for tree evaluation plots. The study's findings showed that there are 78% exotic tree species and 33.91% farmland on which individual families have planted exotic tree species in the Ale district plantation land use status. The tree basal areas are 24.69 m^2 ha^{-1} for exotic tree species and 15.88 m^2 ha^{-1} for native tree species, respectively. There were a lot of exotic tree plantings along the sides of the road, on the edges of agricultural land, and in wooded areas. In comparison to native trees, exotic tree species have been widely planted and now dominate most different forms of land use. Examples of these species are eucalyptus and *Grevillea robusta*. In order for policymakers to develop conservation and management strategies that can support the sustainability of indigenous tree species, the land use policy should be adopted or changed. The study area is not used for scientific research; there is a gap in the southwestern zone; and exotic tree species are widely planted through various forms of land usage.

Keywords: Different Land Use Types, Eucalyptus Tree Expansion, Extents of Exotic Tree Expansion, Tree Plantations, Native Tree Species

1. Introduction

1.1. Background and Justification

To preserve their total biodiversity, productivity, and sustainability under the heavy anthropogenic strain placed on many tropical forests, management measures are needed. An essential tool for determining a forest's sustainability, species conservation, and management of its ecosystems is an understanding of the composition and structure of its trees. Understanding the structure, species richness, and ecological traits of vegetation is essential for the long-term conservation of biodiversity [10]. Due to the introduction of foreign invasive plant species, many of our forest ecosystems are under danger [6]. Currently, non-native tree plantations make up 7% of the world's total forest area [8]. Significant disparities existed in the species varieties of native and exotic tree species, with the latter showing greater diversities than the former [10].

According to FAO [7], the world's total forest area is 4.06 billion hectares (ha), or 31% of the planet's land area. Despite the fact that forests are not regionally or globally distributed equally, this area corresponds to 0.52 hectares per person. One of Africa's oldest forest plantations is in Ethiopia. Next to Pinus and Cunninghamia, Eucalyptus is one of the most widely planted woody plants in the world [11].

A 12.296, 000-hectare area of Ethiopia is covered with trees, or 11.2% of the country, according to FAO [7], Forest Information Data. Ethiopia had planted forests covering 511,000 acres. Ethiopia lost 140,900 hectares, or 0.93%, on average between 1990 and 2010. 2,818,000 acres, or 18.6%, of Ethiopia's forest cover were lost.

Declines in species richness and abundance, seed bank variety, and natural regeneration are all adverse effects of alien tree species [16]. It's important to remember that agricultural development and demographic pressure are the main causes of these problems through overexploitation or poor management of forests, land, soil, and water. Eucalyptus is at the center of the debate pitting native species against exotic ones, which are accused of contributing to the loss of biodiversity and degradation of habitats and natural resources [12]. Five to ten different varieties of eucalyptus are frequently grown in Ethiopia for a variety of reasons. In Ethiopia's highlands, eucalyptus species are frequently incorporated into diverse farming methods, and their planting has produced substantial economic returns [5]. Environmentalists worry about this because of the potential harm to the eco-hydrological system. Foresters and the timber industry promote its growth because of its socioeconomic advantages. One of the nations where eucalyptus has dominated increases in forest development during the past century is Ethiopia [1, 9]. And their planting has produced substantial economic returns [5]. Environmentalists worry about this because of the potential harm to the eco-hydrological system. Foresters and the timber industry promote its growth because of the socioeconomic advantages. One of the nations where eucalyptus has dominated increases in forest development during the past century is Ethiopia [11, 9].

Monocultures or alien species, such as Eucalyptus globules, Eucalyptus *camaldulensis, Cupressus lustanica, Casuarina cunninghamiana, Pinus patula, Pinus radiata,* and *the indigenous species Junipers procera*, make up the majority of the forest plantations in Ethiopia. However, E. globule monocultures dominate Ethiopia's forest plantations, which are thought to make up roughly 90% of the nation's total plantation area [1, 17]. Eucalyptus was probably first planted in Ethiopia in 1894 or 1895 as a result of extensive deforestation for fuel around Addis Abeba [13]. Since then, eucalyptus has become particularly appealing due to a lack of fuel wood supply and the necessity for long-term economic benefits on farmers' properties. Eucalyptus is frequently cultivated on a farmer's parcel of agricultural land or along the edges of cropland. They also grow on marginal lands, and occasionally they are planted to help stabilize gullies in wet locations. In Ethiopia, eucalyptus is one of the rarest tree species [9]. The eucalyptus genus, which has more than 500 kinds of trees, is now the most widely planted one worldwide [15]. However, according to Jaleta [11], there are more than 700 different species of eucalyptus. According to Daba [4], the three largest nations that cultivate eucalyptus are China (170 million hectares), India (2.5 million hectares), and Brazil. (3.7 million Ha). There are over 800 species of eucalyptus, an evergreen flowering tree and shrub that is a member of the Myrtaceae family and subfamily Myrotideae [1, 9]. One of the reasons for the decline in native tree varieties is the development of exotic tree species. Patterns of tree diversity and composition have changed mostly as a result of the introduction and promotion of non-native tree species [14].

1.2. Statement of the Problem

The study area's natural forests are fast disappearing as a result of their conversion to alien tree species and careless and excessive exploitation brought on by rising human density. Exotic tree plantation development has a detrimental effect on species diversity and abundance, as well as the regrowth of native tree species through natural processes. This study comes to the conclusion that the current issue in the study area is that exotic tree species, like Eucalyptus spp. and *Grevillea robusta*, are more widely planted than native trees and dominates and the majority of the various landscapes, which is alarming for the sustainability of indigenous or native tree species. We expected that the variety of native tree species in the Ale district of the Ilu Aba Bor zone in southwest Ethiopia would be greatly impacted by the status of alien tree species, which is quickly growing relative to indigenous tree planting techniques across multiple land uses. This is supported by the fact that while the native tree species plantations are present in the study area, they are greatly outnumbered by the exotic tree species plantations. However, by discovering the answers to the issues, this discovery closes the gaps in the field of research. The objective of this paper is to compare the extent of exotic tree species composition with indigenous ones across different land use types in the study area.

1.3. Research Questions

What is the extent of exotic tree species plantations in comparison to indigenous tree species across various land use types?

1.4. Significance of the Study

When the extents of alien tree species and native tree plantings across various land use categories were examined, the study's relevance became clear. The strategies for balancing plantations of both exotic and native tree species are then noted for various interested bodies. After that, the community takes notice of and cares for plantings of indigenous tree species. To preserve the native tree species plantations, several stakeholders, including those involved in land management and usage, agriculture, and other relevant fields, are involved at various levels.

2. Materials and Methods

2.1. Description of the Study Area

2.1.1. Location

The study was conducted in the Ale district of the Ilubabor

zone, in Oromia National Regional State, southwest Ethiopia (Figure 1). Located south of Metu in the Illubabor Zone of the Oromia Region, this district has latitude of 8°00'00"N and a longitude of 35° 39' 59.99"E. The elevation of the district is 1400–2200 *m.a.l.* Ale is bounded on the east by the Didu Woreda, the west by Nono, the northwest by Halu, and the northeast by Metu. Gore of Ale woreda is one of the Ale towns. Rivers in Ale include the Moro Kala and Waffa, both parts of the drainage area of the Baro. High points include Mount Sidi. Coffee is an important cash crop in this woreda. Over 50 square kilometers are planted with this crop, 618 km from Addis Ababa. And two Sagi and Onga kebeles were selected from Ale district, where the sample data was collected [3].

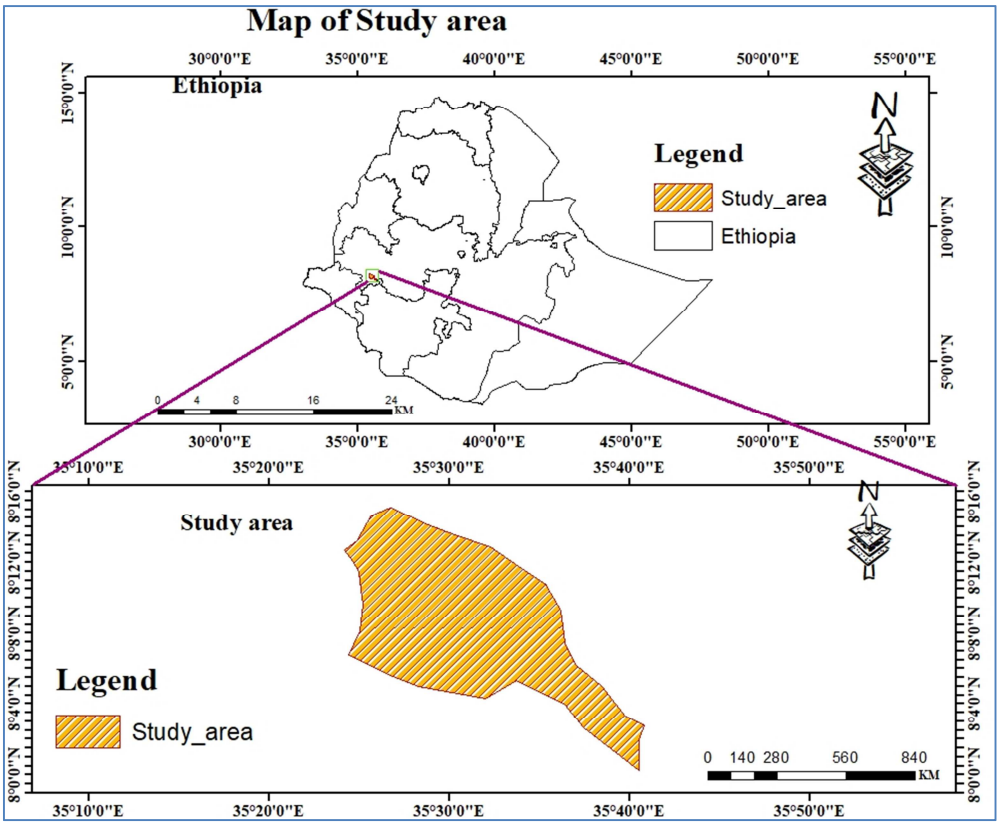


Figure 1. *Map of study area.*

2.1.2. Climate

Ale district has a tropical rainforest climate (AF) under the Koppen climate classification. It features a long annual wet season from March to December. The temperature is in a comfortable range, with the daily mean staying between 17°C and 25°C year-round and the amount of rainfall reaching the district minimum of 1500–1800 mm.

2.1.3. Population

Based on the 2017 projection conducted by the CSA, this Ilu Aba Bor Zone has a total population of 79,518 of whom 39,302 are men and 40,216 are women, and the total number of households in the Ale district is 9,985. The three largest ethnic groups reported in Ale woreda are the Oromo (85.55%), the Amhara (6.98%), and the Kafficho (3.98%); all other ethnic groups make up 3.49% of the population. Afan Oromo is spoken as a first language by 90.18%, 5.84% Amharic, and 2.26% Kafa; the remaining 1.72% speaks all other primary languages reported. The majority of the inhabitants professed Ethiopian Orthodox Christianity, with 56.55% of the population reporting they practiced that belief, while 34.7% of the population said they were Muslim, 6.49% were Protestant, and 1.41% was Catholic [3].

Land use system: Of the total land area in the Ale district, 76.77% is used for agriculture, 8.9% is for forestry, 2.74% is used for grazing, 6.95% is used for wetland, and 4.58% is used for other land use systems (see table 1). Exotic tree plantations make up 78% of plantations on forest land. Eucalyptus species are the most commonly planted tree species in these exotic tree plantations, with Grevillea robusta predominant the area.

2.2. Research Design

2.2.1. Sampling Design

An intentional sampling strategy was developed for this study based on the extent of the alien tree species extensively planted across diverse land use types in the study area. Ale was selected from the zone based on how extensively and broadly exotic tree species had been planted across multiple land uses, and Sagi and Onga, two peasant associations (PA), were selected from Ale rather than other districts. It was proposed to sample the vegetation using the best sampling

methods. As a result, a systematic sample approach was used for the data collection plan, using 3 plots per land use category among the 18 Sagi and 18 Onga peasant association plots. A total of 102 households owned 36 plots, each measuring 20 m by 20 m, or 400 m^2 (p_1, p_2, p_3). These plots were used to identify the different land use categories. These include the borders of agricultural property, homesteads, grazing areas, roadside trees, coffee farms, and woodlots. Key informants were gathered for one focus group discussion, and questionnaires were also created for each peasant association. The data was used to investigate the sizes of exotic tree species plantings across various land use classifications and techniques. Consequently, a systematic sample approach was used to obtain data.

2.2.2. Sample Size Determination

In terms of the sample size for tree assessment, a plot area was selected to compare the extent of exotic tree species plantation expansion and land use types. These land use types include farm land boundaries, homesteads, grazing land, roadside trees, coffee farms, and woodlots. Plots were established and measured at the start of an assessment. Three plots of 20 m x 20 m, or 400 m2, per selected land use type were laid.

2.3. Methods of Data Collection

2.3.1. Data Source

Data were gathered from households, focus groups, assessments of the tree species composition, observations of the woreda's plantation status, demographic information, and publications. To get relevant data from tree evaluations, data-gathering tools were created.

2.3.2. Evaluations of Tree Species Composition

The plots are Sagi kebele and Onga kebele; two of the 36 plots were diagonally distributed across each chosen land use category using a systematic sampling technique that was devised. The area of the designated kind of land use was calculated and finished. The composition of all tree species, including both native and exotic tree species found in the different land-use categories, was then recorded using data. Data was entered into the prepared sheet, and it listed the number of tree species, tree basal area, number of stems (density), diameter at breast height (DBH), and tree height. Following are the results of the evaluations of foreign and native tree species across various land uses:

The number of tree species, Tree height, diameter at breast height (DBH), number of stems (density), and basal area of the tree were measured and entered into the prepared spread sheet. Following are the results of the evaluations of foreign and native tree species across different land uses:

2.3.3. Tree Species Composition

Each plot's tree species composition was counted, and the data collected from the plots was accounted for or calculated per hectare. This was used to compare which species are significantly dominated in the selected land uses. These indicate the extent of species across different land use types.

2.3.4. Diameter at Breast Height (DBH)

The diameter at breast height (DBH) was measured outside the bark, at 1.3 m above the ground on the uphill side of the tree. The diameter, which is >10 cm, is measured using a tape meter and a caliper. The assessments of DBH ranged from 10 cm, 10–20 cm, 21–30 cm, 31–40 cm, 41–50 cm, and >50 cm for each of the 890 trees from the 36 plots, which are exotic and indigenous trees.

(i). Tree Height

Each tree height found in a plot was measured from the ground level to the tip of the tree, and clinometers were used to measure angles and allow the operator to determine the height of a tree. This parameter was calculated based on the volume of the tree per hectare or per plot across different land uses. The tree's height was calculated as Ht = (TR (%) - BR (%) /100 * horizontal distance (m), but the tree height was calculated based on the position of standing in line with up sloping ground tree height (tree top-reading + bottom reading) / 100 x horizontal distance from the tree standing) and on level ground tree height (tree-top reading / 100 * horizontal distance from the tree standing), and down sloping was performed if determined by a by clinometer.

(ii). Tree Basal Area (BA)

Tree basal area is often calculated to measure stand density and provide a basis for calculating stand volume. The area outline of a plant near the ground surface is measured through its diameter, which is usually at breast height (DBH). Generally used for trees, BA measurements are calculated based on measurements of tree diameters at breast height. Based on DBH measurements, the basal area was:

$$TBA = \pi\ (dbh/4)$$

Where: -
TBA = Tree basal area m2,
DBH = Diameter at breast height in m
Π = 3.14

(iii). Number of Trees

The number of trees was counted through direct counts of trees on a stand and measured in terms of trees per hectare. The tree density or stocking rate of a forest is described as the number of trees per plot, and the stocking rate (trees per ha) was calculated as trees per plot or plot per ha in different land use types.

2.4. Data Analysis

Descriptive statistics were used to analyses the collected data and express the numerical strength of the species in all land-use types. As well as the Shannon diversity index, a formula was selected. To compare species diversity for both exotic and indigenous tree species across land use type proportions, the Shannon-Wiener index (H`) was computed as:-

$$H' = \sum_{i=1}^{s} pi * lnpi$$

Where:

H`= Shannon-Wiener index

Pi = the proportion of individuals found in the species

S = the total number of specie

Finally, the area coverage of exotic tree species plantations in household landholding determination and the extent of exotic tree species plantation expansion compared across different land use types were analyzed through descriptive and inferential statistics. Following the measurement and quantification of all exotic and native tree scales in each plot, a tree inventory was displayed.

3. Results and Discussions

3.1. Tree Species Composition

The extent of exotic tree species plantations across different land use types was assessed in the Ale district. According to the data gathered, more exotic tree species were planted in the area than indigenous tree species. According to the assessment, approximately 23 tree species were counted from 36 plots (18 plots in Sagi kebele and 18 plots in Oga kebele), of which 7 are exotic and indigenous tree species belonging to 13 families. Fabaceae (five), Euphorbiaceae (four), Moraceae (three), and Others (one) are the most dominant families. The floristics and species dominate, as do their proportions. The most dominant tree species was the eucalyptus tree, extensively planted by 64% (pi = 0.64) with a total of 569 trees. The quantity (pi) is the proportion of individuals found in the species. A higher value of H indicates high species diversity in the sample.

The study revealed that the number of species and the species frequencies, 23 and 890, respectively, are proportional. The share of 795 exotic and indigenous tree species, which are 95 from six selected land use types, was determined, and where the proportion (pi) was determined, the exotic tree proportion of individuals found in the species is 0.89 (89%) and the indigenous tree proportion of individuals found in the species is also about 0.11 (11%). The Shannon Diversity Index (H) shows exotic tree species because the total number of individual frequencies is 795, the number of species is 7, Pi is 0.89, and the diversity of exotic tree species is 0.84. The total number of individual frequencies for indigenous tree species is (95), the number of species is (16), and Pi is (0.11). This indicates the extent of exotic tree species diversity is significantly greater than that of indigenous tree species.

Table 1. *Comparisons of exotic and indigenous tree species Shannon diversity Index.*

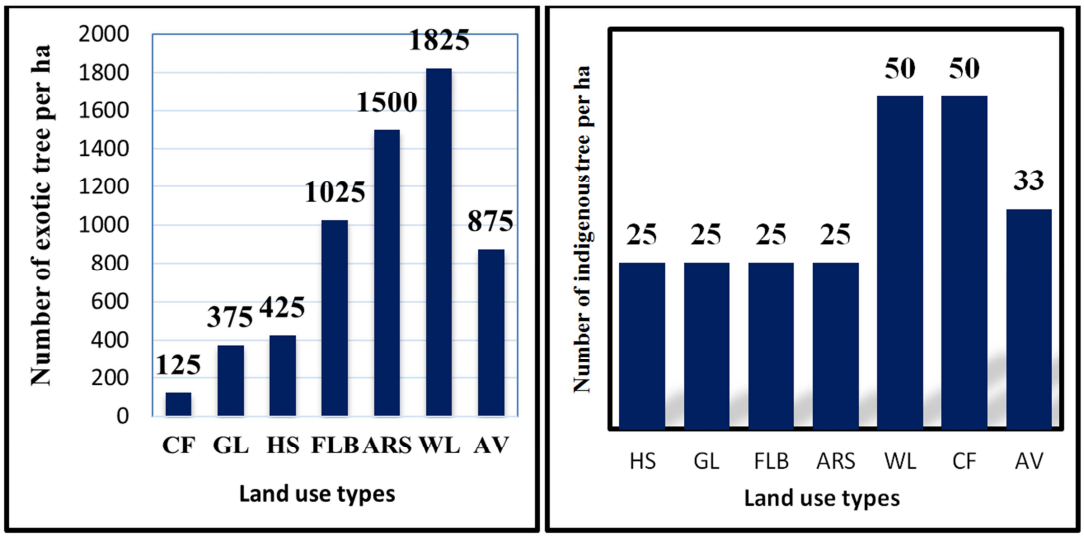
No	Name of tree spps	local Name	Family	types of Spps	Frequency	pi	ln(pi)	H=Σpi*ln(pi)
1	Sasbania sasban	sasbania	Fabaceae	E	31	0.03	-3.36	-0.12
2	Grevillia Robusta	Gravillaea	Proteaceae	E	173	0.19	-1.64	-0.32
3	Eucalyptus	Bargamo	Myrtaceae	E	569	0.64	-0.45	-0.29
4	persea americana	avocado	Lauraceae	E	6	0.01	-5	-0.03
5	Pinus Patula	shuwashuwe	Pinaceae	E	4	0	-5.4	-0.02
6	Cupress lusitatika	Yeferenj tid	Cupressaceae	E	10	0.01	-4.49	-0.05
7	Mangifera indica	Mango	Anacardiaceae	E	2	0	-6.1	-0.01
	Total Exotic tree species				795			0.84
8	Prunes Africana	Hoomii	Rosaceae	I	2	0	-6.1	-0.01
9	Albizia gummifera	Ambabessa	Fabceae	I	18	0.02	-3.9	-0.08
10	croton macrostachyus	Bakanisa	Euphorbiaceae	I	11	0.01	-4.39	-0.05
11	Cordia Africana	Wadessa	Boraginaceae	I	11	0.01	-4.39	-0.05
12	Vernonia amygdulina	Eebicha	Anacardiaceae	I	9	0.01	-4.59	-0.05
13	Supium ellipticus	Bosoka	Euphorbiaceae	I	10	0.01	-4.49	-0.05
14	Bersama abyssinica	Lolchisa	Melianthaceae	I	1	0	-6.79	-0.01
15	Bridelia micrantcha	Rigaraabaa	Euphorbiaceae	I	2	0	-6.1	-0.01
16	Ficus vasta	Kiltu	Moraceae	I	3	0	-5.69	-0.02
17	Millettia ferruginea	Sotalloo	Fabaceae	I	4	0	-5.4	-0.02
18	Acacia species	Sondii	Fabaceae	I	11	0.01	-4.39	-0.05
19	Leucaena leucocephala	Lukina	Fabaceae	I	5	0.01	-5.18	-0.03
20	Albizia grandibracteata	Alale	Moraceae	I	2	0	-6.1	-0.01
21	Ficus sycomorus	Harbuu	Moraceae	I	2	0	-6.1	-0.01
22	Olea welwitschii	Bahaa	Oleaceae	I	1	0	-6.79	-0.01
23	croton macrostachyus	Dogoma	Euphorbiaceae	I	3	0	-5.69	-0.02
	Total Indigenous species				95			0.48

Table 2: *Tree species composition.*

	N Statistics	Min Statistics	Max Statistic	Mean Statist ic	Std. Deviation Statistic	Variance Statistic
Tree species	23	1	569	38.70	120.85	14605.13
Valid N (list wise)	23					

3.2. Number of Tree Per Hectare

The number of trees and tree density per hectare were assessed across selected land use types in the study area. Among the recorded tree species, exotic tree species comprise a larger number of trees than native tree species. The highest number of exotic tree species per hectare was observed in the woodlot, along roadside boundaries, and on farmland boundaries. 1825, 1500, and 1025 were recorded, respectively. Furthermore, the highest density per hectare of native tree species was recorded on coffee farm land uses due to the fact that native tree species have a high canopy cover, create a conducive environment for coffee plantations and other biodiversity conservation efforts, and farmers prefer coffee shade trees such as *Albizia gummifera, Millettia ferruginea*, Acacia species, and others over exotic tree species. The average trees per ha-1 in exotic tree (879) and indigenous tree (33) species were calculated in the Ale district.



(Note: - FLB= Farm Land Boundary, ARS= Along Road Side, HS= Homestead, CF=Coffee Farm, WL = Wood Lot, GL = Grazing Land).

Figure 1. *Comparison of Exotic and Indigenous tree Number per hectare.*

In all land use types, plantations of exotic tree species were proportionally greater than those of indigenous tree species. Appendix Table 10 shows the relationship across different land uses and their correlation values, with a p-value of 0.722 (2-tailed) and the relationship between exotic and indigenous tree species being positively correlated.

3.3. Tree Basal Area

At grazing land (11.1 m2 ha-1), farmland boundaries (36.7 m^2 ha^{-1}), and coffee farms (6.13 m2 ha^{-1}), tree basal areas of exotic tree species were noted as being lower than those of native tree species because the native tree species found on these lands were mature or old, had high canopy cover, and the majority of their diameter at breast height (DBH) was > 50 cm. Native tree species are rare, especially in coffee areas, yet mature trees have high DBH and canopy coverings, and coffee plantations are genetically adapted to prefer shade. 0.08 m^2 ha^{-1} of the native tree species were found along a significant portion of the roadside land in the research area. Due to the exotic tree species, eucalyptus trees are often planted in this land use type. Farmers can easily move the products of their trees to the market or wherever else they need or want them to go since they have access to infrastructure. In general, there are a lot more plantations of exotic tree species. Table 8 below lists tree basal area per hectare across different land use categories. The average tree basal area of both native and exotic tree species is 24.69 m^2 per hectare.

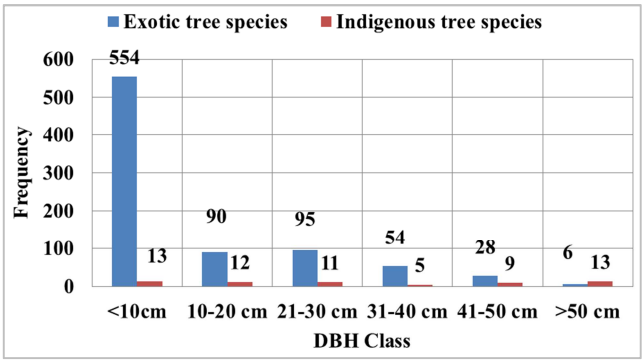


Figure 3. *The frequencies of trees per DBH classes.*

Table 3. *Tree basal area per hectare across different land use types.*

Land Use	BA m^2ha^{-1}	
	Exotic tree species	Indigenous tree species
Homestead	10.55	3.12
Grazing land	11.1	26.49
Woodlot	33.26	4.35
Along Road Side	50.38	0.08
Farm Land Boundary	36.75	41.17
Coffee Farm	6.13	20.08
Average	24.69	15.88

The exotic tree species are extensively planted across different land uses, which means the plantation rate in the Ale district is high. The commonly planted tree species in the study area are eucalyptus species, *Grevillea robusta,* etc., aggregated and expanded in the area. For predicting tree volume for different land uses, the tree's diameter worked as both a performance indicator for trees and a useful place to start. It means that there are six different classifications for the DBH. A breast height diameter of 10 cm for coppice, seedling, and sapling stages and frequencies of native and exotic tree species of 63 and 827, respectively, total 890 trees. The findings demonstrate that exotic tree species are more extensively coppiced than native trees and have a high probability of simply spreading across different land uses.

Figure 4. *Data collected from the field.*

4. Conclusion

This study revealed that the extents of exotic tree species plantations in the study area, as compared with indigenous tree species, are widely planted or cover different land uses, and one third of farmers` farm sizes are covered by exotic trees. This shows that it completes the diversity of other indigenous tree species. The Ale district land use profile shows 78% of exotic tree species plantations across different land use types, and exotic tree species cover 33.91% of farmland and individual household coverage in the Ale district.

The cumulative extent of exotic plantations poses risks to native forest diversity. Comparing the extent of exotic tree species composition with indigenous ones across different land use types by comparing trees per hectare of exotic and indigenous tree species (879 and 33, respectively), the tree basal area for exotic and indigenous tree species is $24.69 m^2 ha^{-1}$ and $15.88\ m^2 ha^{-1}$, respectively, across different land use types. The drawback of exotic tree species is that they complete the indigenous tree species plantation, due to the communities' focus on or preferences for planting the exotic trees and it also affect the diversity and structure of indigenous tree species.

So With the help of relevant organizations for plantations and policymakers, the land use policy should be established or revised in order to develop appropriate conservation and management plans that might support the sustainability of indigenous tree species. As well as Consider the best location for planting when choosing a plantation site, and make sure it is ecologically friendly and Responsible organizations should educate the community and extension workers about the benefits and drawbacks of exotic tree species, as well as how to take precautions. Further studies and research are required to determine "how to establish and balance exotic and native tree species in the future."

Acknowledgements

First and for most I would like to express my heartfelt thanks to my advisor Mr. Hirko Dibaba (*Assistant Professor*) and Dr. Tibebu Alemu (*Ph.D*), and Mr. Dareje Bekele (*Assistant Professor*). I really cannot put in to words how incredibly grateful they have done for me. They have provided me series of important professional advices and constructive comments to be successful in my work. I would like to express my profound gratitude to my wife Fanose Tekalign*)* for her great support by caring my children during absence of for my study, providing necessary materials and productive ideas for the smooth accomplishment of the research. I really thank her. I would like to express my profound gratitude to my friends/colleagues Amanel Indalew who supported and encouraged me and whom I shared all life burden throughout my study. My acknowledgement is also extended to Ilu Aba Bor zonal agricultural office, Ilu Aba Bor zone environmental protection Authority office, Ale district agricultural office staff and Sagi and Onga kebele Development Agents for their assistance during data collection. Finally, all things were made through God, I thank him.

Appendix

Area Coverage of Exotic Tree Species Plantations Determination of Household Landholdings

Table 4. *The Correlation of Tree Density across Different Land Uses.*

		Homestead	Grazing land	woodlot	Farmland boundary	Coffee Farm	Along road side	Average
Homestead	Pearson Correlation	1	1.000**	1.000**	1.000**	1.000**	1.000**	1.000**
	Sig. (2-tailed)		.	.	.	.	.	.
	N	2	2	2	2	2	2	2
Grazing land	Pearson Correlation	1.000**	1	1.000**	1.000**	1.000**	1.000**	1.000**
	Sig. (2-tailed)	.		.	.	.	.	.
	N	2	2	2	2	2	2	2
woodlot	Pearson Correlation	1.000**	1.000**	1	1.000**	1.000**	1.000**	1.000**
	Sig. (2-tailed)	.	.		.	.	.	.
	N	2	2	2	2	2	2	2
Farmland boundary	Pearson Correlation	1.000**	1.000**	1.000**	1	1.000**	1.000**	1.000**
	Sig. (2-tailed)	.	.	.		.	.	.
	N	2	2	2	2	2	2	2
Coffee Farm	Pearson Correlation	1.000**	1.000**	1.000**	1.000**	1	1.000**	1.000**
	Sig. (2-tailed)	.	.	.	.		.	.
	N	2	2	2	2	2	2	2
Along road side	Pearson Correlation	1.000**	1.000**	1.000**	1.000**	1.000**	1	1.000**
	Sig. (2-tailed)	.	.	.	.	.		.
	N	2	2	2	2	2	2	2
Average	Pearson Correlation	1.000**	1.000**	1.000**	1.000**	1.000**	1.000**	1
	Sig. (2-tailed)	.	.	.	.	.	.	
	N	2	2	2	2	2	2	2

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5. *Exotic tree species status of farmer's plant from their farm land size.*

Range of Farmland size (ha)	Average land (ha) size of Respondent	Respondent (Frequency)	Average Exotic plantation Farmland size ((ha) of Respondent	respondent (Frequency)	% of exotic plantation Farmland size (ha)
0.0625-1	0.9	69.0	0.4	69.0	43.54
1.1-3.5	2.3	10.0	0.9	10.0	37.8
3.6-6.5	4.2	11.0	1.5	11.0	36.6
>6.5	8.4	3.0	2.6	3.0	30.5
Grand total	15.8	93.0	5.3	93.0	33.9

Table 6. *Tree species.*

Paired Samples Test								
	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
one exotic tree per m^2 - one indigenous tree per m^2	-305.14	108.94	41.1	-405.9	-204.38	-7.4	6	.000

Table 7. *Number of Trees Species, its Frequency and proportion.*

Name of tree spps	local Name	Family	types of Spss	Frequencies per 36 plots	pi	ln(pi)	H=Σpi*ln(pi)
Gravillia Robusta	Gravillaea	Proteaceae	E	173	0.19	-1.64	-0.32
Eucalyptus	Bargamo	Myrtaceae	E	569	0.64	-0.45	-0.29
persea americana	avocado	Lauraceae	E	6	0.01	-5	-0.03
Pinus Patula	shuwashuwe	Pinaceae	E	4	0	-5.4	-0.02
Cupress lusitatika	Yeferenj tid	Cupressaceae	E	10	0.01	-4.49	-0.05
Mangifera indica	Mango	Anacardiaceae	E	2	0	-6.1	-0.01
Prunes africana	Hoomii	Rosaceae	I	2	0	-6.1	-0.01
Albizia gummifera	Ambabessa	Fabceae	I	18	0.02	-3.9	-0.08
croton macrostachyus	Bakanisa	Euphorbiaceae	I	11	0.01	-4.39	-0.05
Cordia africana	Wadessa	Boraginaceae	I	11	0.01	-4.39	-0.05
Vernonia amygdulina	Eebicha	Anacardiaceae	I	9	0.01	-4.59	-0.05
Supium ellipticus	Bosoka	Euphorbiaceae	I	10	0.01	-4.49	-0.05
Bersama abyssinica	Lolchisa	Melianthaceae	I	1	0	-6.79	-0.01
Bridelia micrantcha	Rigaraabaa	Euphorbiaceae	I	2	0	-6.1	-0.01
Ficus vasta	Kiltu	Moraceae	I	3	0	-5.69	-0.02
Millettia ferruginea	Sootalloo	Fabaceae	I	4	0	-5.4	-0.02
Acacia species	Sondii/Laaftoo	Fabaceae	I	11	0.01	-4.39	-0.05
Leucaena leucocephala	Lukina	Fabaceae	I	5	0.01	-5.18	-0.03
Albizia grandibracteata	Alale	Moraceae	I	2	0	-6.1	-0.01

Name of tree spps	local Name	Family	types of Spss	Frequencies per 36 plots	pi	ln(pi)	H=Σpi*ln(pi)
Ficus sycomorus	Harbuu	Moraceae	I	2	0	-6.1	-0.01
Olea welwitschii	Bahaa	Oleaceae	I	1	0	-6.79	-0.01
croton macrostachyus	Dogoma	Euphorbiaceae	I	3	0	-5.69	-0.02
Total Indigenous and Exotic tree species (N)				890			1.34

Table 8. *Case Summaries.*

Case summary			
	Name of tree species	Types of tree species	Trees per 36 plots
	Sasbania	*E*	31
	Gravillea	*E*	173
	Eucalypt	*E*	569
	persea a	*E*	6
	Pinus Patulla	*E*	4
	Juniperus procera	*E*	10
	Mangifer	*E*	2
	Prunes a	*I*	2
	Albizia	*I*	18
	croton m	*I*	11
	Cordia a	*I*	11
	Vernonia	*I*	9
	Supium e	*I*	10
	Bersama	*I*	1
	Bridelia	*I*	2
	Ficus va	*I*	3
	Milletti	*I*	4
	Acacia s	*I*	11
	Leucaena	*I*	5
	Albizia	*I*	2
	Ficus sy	*I*	2
	Olea wel	*I*	1
	croton m	*I*	3
N	23	*23*	23
Minimum	Acacia s	*E*	1
Maximum	Vernonia	*I*	569
First	Sasbania	*E*	31
Last	croton m	*I*	3
Mean			38.7
Median			5
Grouped Median			5
Std. Error of Mean			25.199
Sum			890
Range			568

Table 9. *The Tree Basal Area and Volume per Hectare.*

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Basal Area of exotic tree (ha-1) - Volume of exotic tree (m3ha-1)	-142.4	89.5	33.8	-225.2	-59.5	-4.2	6	.006
Basal Area of indigenous tree - Volume of indigenous tree	-46.52	42.5	16.1	-85.9	-7.14	-2.8	6	.028

Table 10. *Tree/Density per Hectare.*

	Types of tree spps	Onga							Sagi							Total						
		HS	GL	WL	FLB	CF	ARS	Total	HS	GL	WL	FLB	CF	ARS	Total	HS	GL	WL	FLB	CF	ARS	Total
Tree per plot	E	18	16	76	43	6	62	37	16	14	70	39	4	58	34	17	15	73	41	5	60	35
	I	1	1	3	1	2	1	10	1	1	1	1	2	1	1	1	1	2	1	2	1	5.6
Tree per Hectare	E	450	400	1900	1075	150	1550	921	400	350	1750	975	100	1450	838	425	375	1825	1025	125	1500	879
	I	25	25	75	25	50	25	38	25	25	25	25	50	25	29	25	25	50	25	50	25	33
One Tree per m^2	E	22	25	5	9	67	6	11	25	29	6	10	100	7	12	24	27	5	10	80	7	11

Table 11. *Tree Basal Area and Volume Assessment.*

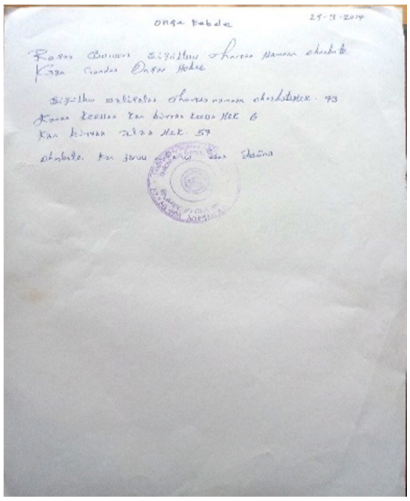
Kebele	land Use types	Exotic tree Spps								
		BA(m^2)		Volume			No Tree		N/SPPs	
		Per plot	per Ha	h(m)	Per plot	per Ha	Per plot	per Ha	per plot	per ha
	HS	0.1	3.5	11	1.5	16.2	43	1,075	5	4
	GL	0.8	19	14	10.6	111.7	18	450	2	3
	WL	0.5	12	12	5.8	60.5	65	1,625	1	3
Onga	ARS	0.9	21.3	15	12.8	133.9	67	1,722	1	3
	FLB	0.5	12	12	5.8	60.5	74	1,841	1	3
	CF	0.2	4.8	11	2.1	21.9	21	525	1	3
	Average	0.5	12.1	13	6.4	67.4	48	1,206	5	6
	HS	0.2	3.8	13	0.8	20.5	29	725	6	4
	GL	0.9	21.5	14	5.1	126.4	18	450	2	3
	WL	0.3	8	14	1.9	47	81	2,025	2	4
Sagi	ARS	0.6	14.5	15	3.7	91.4	83	2,070	2	3
	FLB	0.7	17.8	12	3.6	89.5	66	1,645	1	3
	CF	0.1	3	10	0.5	12.6	14	350	2	4
	Average	0.5	11.4	13	2.6	64.6	49	1,210	2.5	3.5
	HS	0.1	3.6	12	0.4	9.8	36	900	5.5	4
Average	GL	0.8	20.3	14	2.6	65.4	18	450	2	3
	WL	0.4	10	13	1.3	31.8	73	1,825	1.5	3.5

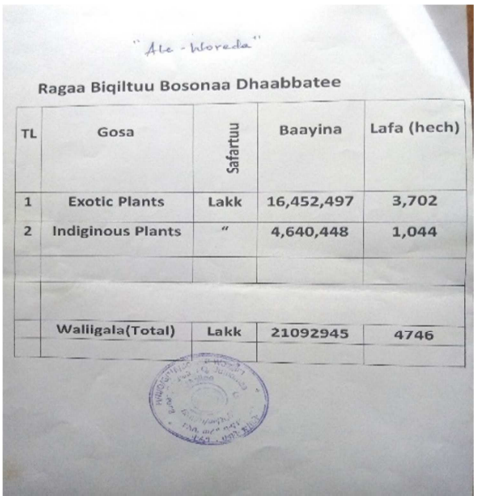
(Hint: -FLB= Farm Land Boundary, ARS= Along Road Side, HS= Homestead, CF=Coffee Farm, WL = Wood Lot, GL = Grazing Land, N/Spps= number of species).

Table 12. *Tree Basal Area and Volume Assessment of Indigenous Tree Species.*

Kebele	land Use types	Indigenous Tree Species								
		BA(m2)		Volume			No Tree		N/SPPs	
		BA(m2) /plot	BA/ha	height	Vol./plot	V/Ha	Per plot	per ha	per plot	per ha
	HS	0.1	1.5	9	0.2	5.7	8	200	2	5
	GL	0.5	13	11	2.3	58	3	75	3	3
	WL	0.1	1.5	11	0.2	5	5	125	2	2
Onga	ARS	0.2	4.5	11	0.9	23	1	25	1	6
	FLB	0.1	3	11	0.4	8.8	1	25	1	3
	CF	0.3	6.8	11	1.2	31	8	200	3	5
	Average	0.2	5	11	0.9	22	4	108	2	4
	HS	0	0.8	11	0.1	1.9	3	75	1	7
	GL	0.1	1.8	11	0.3	8.1	3	75	2	6
	WL	0.1	3	11	0.5	11	-	-	1	8
Sagi	ARS	0	0.3	11	0	0.7	-	-	-	11
	FLB	0.7	17	11	3.3	83	4	100	3	4
	CF	0.2	5.8	11	0.7	17	7	175	3	8
	Average	0.2	4.7	11	0.8	20	3	71	2	7
	HS	0	1.1	11	0.1	3.5	6	138	3	6
Average	GL	0.3	7.1	11	1.3	33	3	75	2	5
	WL	0.1	2.3	11	0.3	8	3	63	2	5

(Hint: -FLB= Farm Land Boundary, ARS= Along Road Side, HS= Homestead, CF=Coffee Farm, WL = Wood Lot, GL = Grazing Land, N/Sps= number of species).

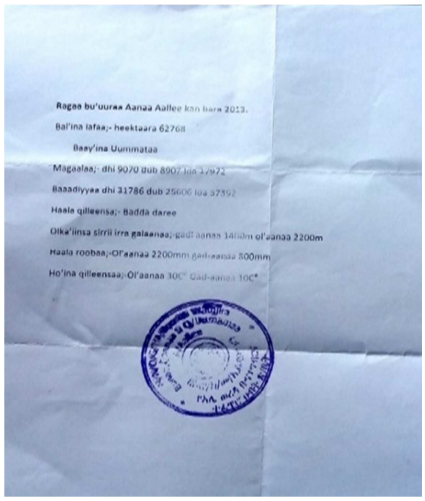




"Ale - Woreda"

Ragaa Biqiltuu Bosonaa Dhaabbatee

TL	Gosa	Safartuu	Baayina	Lafa (hech)
1	Exotic Plants	Lakk	16,452,497	3,702
2	Indiginous Plants	"	4,640,448	1,044
	Waliigala(Total)	Lakk	21092945	4746



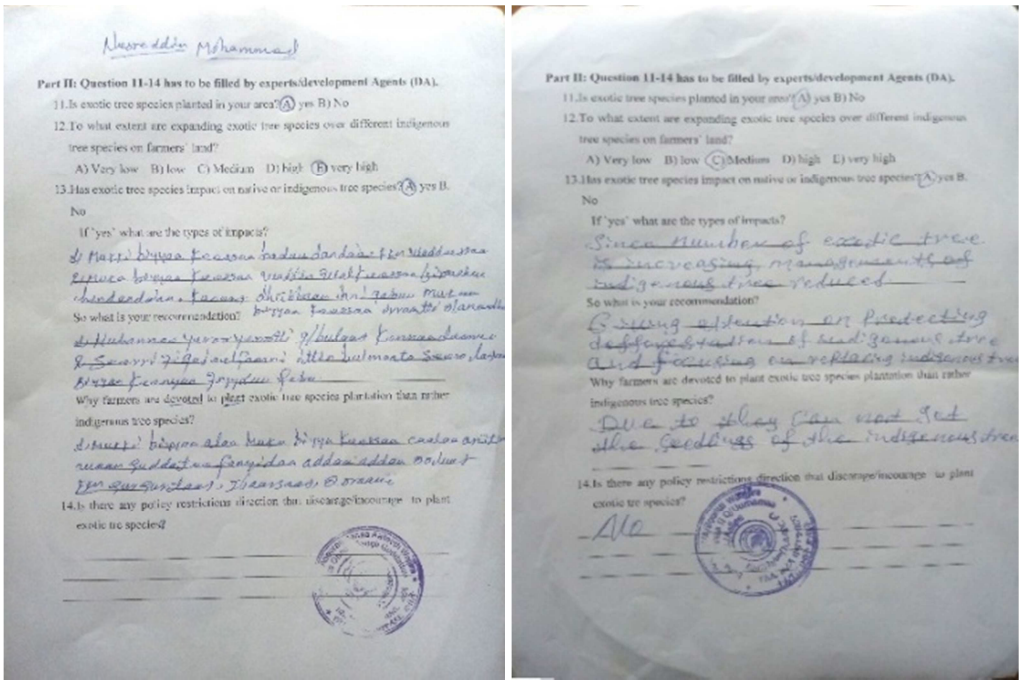


Figure 5. *Data collected from Ale district.*

Figure 6. *Data collected from Ale district.*

Figure 7. *Tree Assessment Tools.*

Table 13. *Area Coverage of Exotic Tree Species in Ale Land Use Data.*

no	location/PA	General plantation (ha)	Exotic tree plantation		Native tree plantation	
			Ha	%	Ha	%
1	Onga	73	67	91.8	6	8.2
2	Sagi	745	730	98.0	15	2.0
3	Ale district	4746	3702	78.0	1044	22.0

References

[1] Bayle, G. K., 2019. Ecological and social impacts of eucalyptus tree plantation on the environment. Journal of Biodiversity Conservation and Bio resource Management, 5 (1), pp. 93-104.

[2] Bekele, T. and Abebe, W., 2018. Indigenous woody species regeneration under the canopies of exotic tree plantations at Tore Forest, Gelana District, Southern Oromia, Ethiopia. Biodiversity Int J, 2 (1), p. 00034.

[3] CSA, 2017. Population projected data.

[4] Daba, M., 2016. The Eucalyptus Dilemma: The Pursuit for socio-economic benefit versus environmental impacts of Eucalyptus in Ethiopia. Journal of Natural Sciences Research, 6 (19), pp. 127- 137.

[5] Desalegn, T. et al. (2014) 'Land-use/land-cover (LULC) change and socioeconomic conditions of local community in the central highlands of Ethiopia', International Journal of Sustainable Development and World Ecology, 21 (5), pp. 406–413. Available at: https://doi.org/10.1080/13504509.2014.961181.

[6] Devine, K. and Fei, S., 2011. A review of impacts by invasive exotic plants on forest ecosystem services. In In: Fei, Songlin; Lhotka, John M.; Stringer, Jeffrey W.; Gottschalk, Kurt W.; Miller, Gary W., eds. Proceedings, 17th central hardwood forest conference; 2010 April 5-7; Lexington, KY; Gen. Tech. Rep. NRS- P-78.

[7] FAO (Food and Agriculture Organization of the United Nations), 2020. Global forest resources assessment. Main report. FAO Forestry Paper 163.

[8] FAO, 2009. Eucalyptus in East Africa: The Socio-economic and Environmental Issues. Addis Ababa.

[9] Haileab Z., 2010. Environmental and Socio-Economic Implications of Eucalyptus in Ethiopia https://Www.Researchgate.Net/Publication/260287131.

[10] Ifo, S. A., Moutsambote, J. M., Koubouana, F., Yoka, J., Ndzai, S. F., Bouetou- Kadilamio, L. N. O., Mampouya, H., Jourdain, C., Bocko, Y., Mantota, A. B. and Mbemba, M., 2016. Tree species diversity, richness, and similarity in intact and degraded forest in the tropical rainforest of the Congo Basin: case of the forest of Likouala in the Republic of Congo. International Journal of Forestry Research, 2016.

[11] Jaleta, D., Mbilinyi, B., Mahoo, H. and Lemenih, M., 2016. Evaluation of land use/land covers changes and Eucalyptus expansion in Meja watershed, Ethiopia. Journal of Geography, Environment and Earth Science International, 7 (3), pp. 1-12.

[12] Lawes, M. J. et al. (2021) 'Bark functional ecology and its influence on the distribution of Australian half-butt eucalypts', Austral Ecology, 46 (7), pp. 1097–1111. Available at: https://doi.org/10.1111/aec.13045

[13] Pankhurst, R., 1961. An introduction to the economic history of Ethiopia from early times to 1800. London: Lalibela House.

[14] Singh, S., Malik, Z. A. and Sharma, C. M., 2016. Tree species richness, diversity, and regeneration status in different oak (Quercus spp.) Dominated forests of Garhwal Himalaya, India. Journal of Asia- Pacific Biodiversity, 9 (3), pp. 293-300.

[15] Teketay, D., 2000. Facts and experiences on Eucalypts in Ethiopia and elsewhere: Ground for making life informed decisions. Walia, 2000 (21), pp. 25-46.

[16] Valduga, M. O., Zenni, R. D. and Vitule, J. R., 2016. Ecological impacts of non- native tree species plantations are broad and heterogeneous: a review of Brazilian.

[17] Zerga, B. and Berta, A., 2016. Preference, purpose, and pattern of Eucalyptus tree farming in Eza Wereda, Ethiopia. IJRIES, 3 (2), pp. 30-38.