Status and Management of Indigenous Tree Species and Their Determinant Factors across Landuse Types in Three Selected Districts of Jimma Zone, Southwest Ethiopia

By

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DEDICATION

This thesis is dedicated to my family for nursing me with affections and love; and their dedicated partnership for success through my life.

STATEMENT OF THE AUTHOR

I, the undersigned, declare that this thesis is my original work and is not submitted to any institution elsewhere for the award of any academic degree, diploma or certificate and all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree in Natural Resources Management (specialization of Forest and Nature Management) at Jimma University, College of Agriculture and Veterinary Medicine and is deposited at the University library to be made available to borrowers under the rules of the library.

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BIOGRAPHICAL SKETCH

Habte Wendime Gemechu was born at Elamu Malole kebele, Hababo Guduru Woreda, Horro Guduru Wollega zone on June 04, 1985. He attended his Elementary, Junior Secondary, and High School education at Kenate Biya Elementary School, Embabo Junior Secondary and Fincha High School, respectively. Then after, he joined Maichew ATVET (Agricultural Technical Vocational and Educational Training) College in 2003 and graduated on 2005 with a Diploma in Natural Resources.

He served as an extension agent and supervisor at Hababo Guduru Agriculture and Natural Resource Office; he attended the distance education while serving as extension agent and graduated with BSc. in Agricultural Economics from Yardstick International College of Distance and Open Learning (YICDOL) in 2010. By using the opportunity of Oromia National Regional State for extension agents, he joined Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) in 2011 and graduated in 2012 with BSc. degree in Natural Resources management (NRM) with very great distinction. After graduation again he served as supervisor and Woreda experts on the positions of coordinator of supply and credit management of agricultural inputs; coordinator of cooperative development and deputy head of cooperative promotion office of Hababo Guduru Woreda.

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ACRONYM AND ABBREVIATIONS

ANOVA	Analysis of Variance
ANRO	Agriculture and Natural Resource Office
BOPED	Bureau of Planning and Economic Development
DAs	Development Agents
EBI	Ethiopian Biodiversity Institute
FAO	Food and Agriculture Organizations
HHs	Household Heads
HSD	Honestly Significant Difference
IAS	Invasive Alien Species
MPTS	Multipurpose Trees and Shrubs
NABU	Nature and Biodiversity Union
NGOs	Non-government Organizations
NRM	Natural Resources Management
NTFPs	Non-Timber Forest Products
ORG	Oromia Regional Government
PAs	Peasant Associations
SNNPR	Southern Nations, Nationalities and Peoples Region
SWC	Soil and Water Conservation

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ABSTRACT

In Ethiopia, even though indigenous trees are ecologically more valuable than exotics they are reducing in their abundance and diversity and their multipurpose benefits getting off and replaced by exotic tree species due to more economic value of exotic trees. The aim of this study was thus to assess the status and understand the factors affecting management of indigenous tree species in Mana, Kersa and Seka Chekorsa Districts of Jimma Zone, Southwest Ethiopia. These districts were selected following multi-stage sampling technique. From each district, five PAs were selected based on the level of tree planting practices. A total of 136 households were selected for questionnaire survey and from these 50% (68 each households with all landuse types) were selected randomly and a total of 340 plots were taken for tree species assessment from different landuse types. A total of 44 tree species (33 indigenous and 11 exotic) belonging to 29 families were identified and recorded. Fabaceae was the dominant family with 7 trees species followed by Moraceae with four. The diversities and density of indigenous tree species were higher on farm (H'=2.459) and in farm boundary (460.1 stems per hectare) respectively when compared with other landuse types. The farming communities of the study area plant/retain tree species across landuse types. Accordingly, from 33 indigenous tree species identified, 3 species were planted and/or retained and 30 were retained. Management of tree species showed highly significant difference by gender (x^2=16.9, df =1, p<0.001), landholding size (x^2=23.455, df =4, p<0.001) and among landuse types (x^2=35.333, df =4, p<0.001). The result of the questionnaire survey indicated that factors such as, high economic interest (97.1%), agricultural expansion (64.7%), lack of knowledge on tending (90.4%) and access to seed sources and other planting methods for indigenous tree species (63.2%) were the major threatening factors that constrained management of indigenous tree species. Beside this, twenty indigenous tree species were identified as at risk from the study area including Podocarpus falcatus, Hagenia abyssinica, Pouteria adolfi-friedericii that were ranked from one to three. Altogether, efforts such as awareness creation, forest extension works focusing on indigenous tree planting and management, promoting agroforestry practices, producing and supplying enough seedlings, improving institutional frame work and enforcement of existing laws regarding indigenous tree species are of prime importance to scale up planting and management of indigenous tree species and correspondingly restore ecosystems and the associated services.

***Keywords**: Farming community; Indigenous tree species; Exotic tree species; Tree species selection; Landuse type*

1. INTRODUCTION

1.1.Background and justification

Increasing population of the Ethiopia has resulted in extensive forest clearing for agricultural use, overgrazing, and unwise exploitation of existing trees (indigenous) from forests for fuel wood, fodder and construction materials (Matousa *et al.,* 2013). In most, agricultural land expansion in the country is changing rapidly in most rural landscapes of the country and leads to unwise exploitation of trees, indigenous, for their multipurpose functions. Because of this the country is facing rapid deforestation and degradation of land resources (Bishaw, 2001) and the number of these trees are reducing and majority of them had low abundance.

According to Bishaw (2001), tree plantation was started at large as natural resources management (NRM) strategies to overcome deforestation and land degradation problems as well as to provide the people with food, fuel wood, and fodder on sustainable basis. Implementing agroforestry and social forestry in the rural areas where subsistence farming is practiced, expansion of plantation forestry on uncultivated and sloping lands and conservation of the remaining natural forests to conserve species were proposed methods to implement tree plantation strategies, especially in Ethiopian highlands.

Tree planting and management is a natural resource management (NRM) technology (Jagger and Pender, 2000). In Ethiopia it is an old age practice especially in the form of traditional agroforestry that can be intervened as maintaining trees on crop lands for their usefulness providing multiple products (Achalu *et.al,* 2003; Abebe *et al.,* 2010; Birhane, 2014). The people of the country cultivate indigenous tree species in the form of agroforestry for provision of livelihood support functions among rural communities as source of food, charcoal production, timber production, house construction, fuel-wood and farm implement (Robi and Edris, 2017; Solomon and Moon, 2018) and also for the existence of other living organisms (Amare *et al.,* 2019).

In Ethiopia, households of different agro-ecological settings plant various tree/shrub species in quite small numbers in which fruit trees are grown within the homegardens and indigenous tree species are grown along farm and/or farm plot boundaries, where exotic tree species are grown

widely separated from crop fields and also maintain naturally regenerated tree species within hedgerows or outside crop fields (Achalu *et al.*, 2003).

Even though the number and type of species retained is differed, there is a tradition of retaining woody species during conversion of forest land to agricultural land and to settlement areas. In this regard *Millettia ferruginea, Vernonia amygdalina, Ficus sur, Croton macrostachyus and Sapium ellipticum* are the most frequently retained tree species than others (especially in Southwest). The reasons for retaining different woody species depend on the tangible uses and services that they render to the household such as; fuel wood, shade, construction, beehive stand, fence and boundary, agricultural implements, soil fertility, beehive making, source of income (Yakob *et al.*, 2014).

According to Yakob *et al*., (2014), many native species, such as *Cordia africana, Millettia ferruginia* and *Albizia gummifera* are planted and retained dominantly as a basic components of homegarden structure because of their roles in providing shade and soil fertility, wood and other products. Even though planting of scattered trees on cropland is not common, deliberate leaving of naturally grown matured trees and shrubs are common on cropland for their beneficial effect on soil fertility and contribution to wood production (Alebachew, 2012).

On the other hand, *Eucalyptus species, Juniperus procera* and *Cupressus lusitanica* are the most undesirable species on croplands primarily for their intense competition with food crops, drying up of the soil (Achalu *et al.*, 2003) and hence planted as small plantation of woodlots (Alebachew, 2012). Deliberate protection and management of the naturally grown trees on grazing land is also a common practice because naturally grown trees on grazing lands have several benefits such as, construction, wood, medicinal value, good odor and firewood (Alebachew, 2012).

Farmers employ different management practices for tree species either planted or retained on different landuse types depending on different benefits obtained from the system, the effect of these managements on tree products and sustainable land management, to reduce and reclaim degraded lands (Madalcho and Tefera, 2016). For instance, the farming community manages woody species which are either planted or retained in homegardens by applying common management practices such as thinning, pruning, fertilizing, watering, protection, coppicing and lopping, fencing to protect from damage by animals (Yakob *et al.*, 2014).

However, tree growing by smallholder farmers has been constrained by a wide range of factors, which vary according to households' characteristics (family size, age and educational level), suitability of tree species for various purposes and the environment in which they are grown, market drivers and policy variables (McGinty *et al.*, 2008).

Although farmers have always incorporated trees in their farming systems; but since the onset of technological advancement (i.e. using chemical fertilizers) (Parc, 1992); undermines the natural fertilizers from indigenous trees and their role, and finally trees became a neglected factor in agriculture, is one of the major problem affecting the density and diversity of indigenous trees in farming communities in Ethiopia (Solomon and Moon, 2018). This implies that the value of indigenous trees and their multipurpose benefit is getting off and being replaced by exotic species.

Expansion of planting exotic tree species such as *Eucalyptus species*, *Pinus patula* and *Cupressus lusitanica* (started by government since the early 1970s and continued by small holder farmers) captured interest of the people for their fast growth, easily establishment and maximum yield, scaffold, transmission pole and timber. But expanding their distribution are changing the structure and composition of native plant communities (Tererai *et al*., 2013). The native species also on extinction (Pereira *et al.*, 2012) and many of the species are in danger of extinction. This is not only because of rapid conversion of forest to agricultural land and over-grazing (Bekele, 2007; Hundera, 2010; Bogale *et al.*, 2017) but also due to limited knowledge about propagation and field establishment of indigenous tree species (Tafesse, 2007).

1.2. Statement of the problem

In selecting species for plantation, it is often best to choose the ones that are already growing in the area (indigenous species), since these are adapted to the environment and able to regenerate naturally (Tafesse, 2007). The choice of tree species to plant usually varies with individual farmer tree knowledge, interest and land size but may also depend on other factors such as species compatibility with crops, duration to harvesting and the value of end products (Lengkeek and Carsan, 2004).

In Ethiopia, it is suggested that conserving, propagating and developing indigenous trees are extremely important (Negash, 2010) and planting them helps to reverse the accelerated loss of

natural forests (Belude, 2007); because they have several important biological attributes over exotic in which their presence in natural stands in a given area can give a clue to undertake possible plantation activities (Evans, 1992); since they are adapted to the environment and are already integral part of an ecological niche. They are less susceptible to serious damage from diseases and pests because predators, viruses, climatic factors are already present (Negash, 2007) and ecologically more valuable than exotics for the conservation of native flora and fauna as well as for the conservation of water.

However, people are planting more economically useful trees without considering their ecological values, hence there seems less and less preference for indigenous tree species; but there is no evidence that proves or disproves this assumption. Therefore, the present study attempts to understand the status and factors that determine management of indigenous tree species in the study area.

1.3. Significance of the study

The finding of this study on status and management of indigenous tree species will provide basic information on diversity, appropriate landuse types for each tree species and traditional management practices applied for indigenous tree species for their existence and valuable uses. This helps to understand their current status and identify remedial action needed to improve their management and conservation status. This in turn contributes to the national policies and strategies to encourage the sustainable management of indigenous tree species.

1.4. Research questions

1. Do planting and management status vary between indigenous and exotic tree species across landuse types?
2. What are the traditional management practices undertaken for indigenous tree species?
3. What are the factors affecting planting and management of indigenous tree species?

1.5. Objectives

1.5.1. General objective

- To assess the status and understand determinant factors affecting management of indigenous tree species across landuse types in three selected Districts of Jimma Zone, Southwest Ethiopia

1.5.2. Specific objectives

- To assess the tree species composition and diversity across different landuse types;
- To study the traditional management practices of indigenous tree species in different landuse types;
- To examine the factors affecting the diversity and management of indigenous tree species.

1.6. Hypothesis

- Indigenous tree species diversity vary across landuse types of three selected Districts of Jimma Zone, Southwest Ethiopia

2. LITERATURE REVIEW

2.1. Tree planting in Ethiopia

Ethiopia has a long history of tree planting activities. Even though, afforestation started in the early 1400s by the order of King Zera-Yakob (1434-1468), modern tree planting using introduced tree species (mainly Australian *Eucalyptus*) started in 1895 to alleviate the shortage of firewood and construction wood in the capital city, Addis Ababa (Dessei, 2019). During the *Dergue* regime (1974-1991), rapid expansion of large scale and community plantations occurred which resulted in the establishment of large scale plantations mainly for supplying the huge demand for wood products in Ethiopia (Yitebitu *et al*., 2010). The community woodlots were the other implemented as centrally managed afforestation schemes and the private sector was not encouraged to plant trees due to land tenure policy (Holden *et al.*, 2003).

Planting trees at upper-storey in homegarden, woodlots and farm boundary for purposes of environmental regeneration, for poles, for marking a farm boundary are common and mostly *Eucalyptus species* are selected due to their fast growth and coppicing ability (Birhane, 2014). Planting fast growing small trees and shrubs to serve as mulch and green manure for the crops, growing chosen trees, shrubs or herbaceous plants in areas where soil fertility is poor are other practices. Planting selected trees or shrubs on earth structures for combining physical soil conservation structures and also as live-fences that used as barriers of closely spaced trees or shrubs and to protect crops or structures against livestock and human interference are another purposes of tree planting in Ethiopia.

According to FAO (2010) tree plantation practices in Ethiopia, mainly of exotic tree species with *Eucalyptus*, covering the largest area of hardwood plantations, has now been seen by many households as socially acceptable. This is due to their ability to ensure the sustainability of the resource base and improve their socio economic wellbeing by providing range of benefits to rural communities, including fuel wood, fodder and wood for building and daily uses, as well as environmental and amenity benefits.

2.2. Uses of indigenous tree species in Ethiopia

Plantations can be defined as a forest crop or stand raised artificially either by sowing or planting (Yirdaw, 1996). They are forest stands established artificially by afforestation on land that previously did not carry forests, or by reforestation of land, which has carried forest within the last 50 years. This is done by renewal of essentially the same tree as before or regenerating an existing forest by enrichment through planting tree seedlings (Evans, 1982; FAO, 1993).

Forest trees and shrubs are the major suppliers of energy and wood based products of national consumption in Ethiopia (EBI, 2012). Trees have multiple roles in rural livelihoods, where they provide significant economic and ecological benefits (Gebreegziabher *et al.,* 2010). Therefore, planting trees is seen as an alternative livelihood strategy, particularly in drier areas of Ethiopia where drought is frequent, soils are very poor, and use of fertilizers and improved seeds is risky and less profitable (Pender *et al.,* 2006).

Tree planting has significantly contributed to the production of non-timber forest products (NTFPs), such as honey and beeswax production. Harvesting honey and beeswax from forests has been a long-time, indigenous tradition in Ethiopia (Hartmann, 2004). It could substantially enhance the production of these NTFPs and the country's role in the export market; it also provides food; construction materials for traditional farm implements, houses, and household furniture; medicine; and fodder for animals.

Table 1. Uses of some indigenous tree species in Ethiopia

No	Name of the tree		Uses			References
	Scientific	Local name	Timber products benefits*	Non-timber benefits**	Non market benefits***	
1	*Acacia albida*	Laaftoo (Or)	Fuel, furniture	Food, fodder, medicines	Shade, wind break, SWC	EBI, 2012; NABU, 2016
2	*Albizia gummifera*	Muka arbaa (Or)	Timber, fuel,	Food, fodder, medicines	shade, ornamental, N_2-fxation, soil conservation	Bekele, 2007; EBI, 2012
3	*Boswellia paprifera*	Yetigre etan zaf (Am)		gum and resin		Bekele, 2007; EBI, 2012
4	*Cordia africana*	Waddeessa (Or)	Timber, Internal construction (household furniture)	Food, fodder, medicine	SWC, soil fertility, biodiversity conservation, cultural, aesthetic, shade	Abebe *et al*. 2010; Bekele, 2007; IBC, 2012; Abate *et al.*, 2018
5	*Croton macrostachyus*	Bakkanniisa (Or)		medicine, bee forage	SWC	Bekele, 2007; EBI, 2012; Abate *et al.*, 2018
6	*Ekebergia capensis*	Somboo (Or)			SWC, Shade	Bekele, 2007; EBI, 2012
7	*Ficus sur*	Harbuu (Or)		Food, medicine	SWC	Guinand and Lemessa, 2000; Faleyimu and Oluwalana, 2008; Bekalo *et al*.2009; Getahun 2011; Abate *et al.*, 2018
8	*Hagenia abyssinica*	Kosso (Am)	Timber,	Medicine	SWC, aesthetic	Bekele, 2007; EBI, 2012
9	*Juniperus procera*	Gaattiraa (Or)			Aesthetic, biodiversity conservation	Bekele, 2007; EBI, 2012; Abate *et al.*, 2018
10	*Millettia ferruginea*	Birbira (Am)	Timber, construction (tools)	Fodder (for ruminants), Medicine	Coffee shade, SWC	Bekele, 2007; EBI, 2012;
11	*Podocarpus falcatus*	Birbirsa (Or)	Timber, poles,	Medicine	SWC, cultural, aesthetic, shade, nourishment	Bekele, 2007; Tafesse, 2007; EBI, 2012

					for birds and small mammals	
12	*Prunus africana*	Hoomii (Or)	Timber, fuel, poles,	Medicine, bee forage	SWC, shade, wind break	Bekele, 2007; EBI, 2012
13	*Tamarindus indica*	Roka (Am)	Timber, charcoal, Firewood, pole,	Food, Fodder, medicine	SWC, soil fertility, biodiversity conservation, shade, wind break, aesthetic	Bekele, 2007; EBI, 2012
14	*Bersama abyssinica*	Lolchiisaa (Or)	Firewood,	Medicine, bee forage	Live fence	Bekele, 2007

NB: Am-Amharic language; Or-Afaan Oromoo language

*Timber benefits- poles, fuel wood, benefits from branches, sticks and leaves for fodder, and charcoal production

**Non-timber benefits- medicines, tannin and resin, and honey and beeswax

***Non market benefits- include windbreak or shelterbelt values, ornamental values, shade and a variety of values associated with the environmental services.

2.3. Site preference and tree species selection for planting

The practice of purposefully retaining trees on cropland has been described as a traditional agro-silvicultural practice (Jamala *et al*., 2013). Such practice is common throughout the tropics and it involves managing of indigenous multipurpose tree species by retaining in crop fields and around homesteads usually found dispersed irregularly for a variety of services (Amare *et al.,* 2018). Likewise, in Ethiopia the deliberate retaining of naturally regenerating trees on farmlands by smallholders for provision and ecosystem services is widely practiced (Iiyama *et al.,* 2017; Amare *et al*., 2018).

A pattern or a combination of patterns may exist in a given landuse system, depending on whether the farming system is extensive, protection against livestock is difficult, trees have a beneficial positive impact on neighboring crops, or trees are cash crops (Abiyu *et al.,* 2016). Small-holder farmers collect and plant seedlings or sow seeds of various trees for their own use or for sale. For instance, in central and south western part of the country, farmers grow germ-plasms of agroforestry trees in rows, in patches as woodlots, or scattered on farmlands, farm boundaries, and pasture lands mostly *Acacia albida, Arundinaria alpina, Acacia abyssinica, Acacia tortillis, Croton macrostachys, Albizia gummifera* and *Cordia africana* (EBI, 2012*).*

According to Achalu *et al.,* (2003) indigenous tree species such as *Cordia africana* is intentionally planted in fewer numbers for its superior quality wood for construction purposes; and *Juniperus procera* is disliked tree species among farmers mainly for their drying up effects on the soil and intense competition with crops; whereas leguminous species like *Milletia ferruginia, Albizia gummifera* and *Erythrina abyssinica* are mostly managed by retaining naturally regenerated seedlings either in grazing lands, along hedges, or rarely in crop fields.

2.3.1. Homegardens

Homegarden agroforestry is the landuse system involving deliberate management of multipurpose trees and/or shrubs in intimate association with annual and/or perennial agricultural crops and invariably livestock within the compounds of individual houses, the whole tree-crop animal unit being intensively managed by family labor and it is an indigenous practice (Abebe *et*

al., 2010) since the best designers and managers of traditional agroforestry practices have been the farmers themselves.

According to Yakob *et al*., (2014), woody species are very important part of homegardens that contributes to the livelihoods diversification and they are managed to provide shade for coffee and variety of commercially valuable spices as well as for livestock; to supply rural communities with fuel wood and timber; to provide other products such as fodder, human and livestock medicine, food and they serve as bee forage; and to play important ecological roles which could contribute to sustainability of agricultural systems.

2.3.2. On farm

The practice of growing and maintenances of scattered trees on cropland may be based on protection and management of selected matured trees already on the site (Rocheleau *et al.,* 1988). Even though planting of trees scattered on cropland is not common, deliberate leaving of naturally grown matured trees and shrubs are common and farmers classified naturally existing trees on cropland in three categories. The first category includes those species that have beneficial effect on soil fertility such as *Croton macrostachyus, Acacia abyssinica, Olea africana, Cordia africana, Celtis africana, Gliricidia sepium, Psydrax schimperiana, Ficus sycomorus, Sesbania sesbain, Maytenus senegalensis,* and *Albizia scimperiana*; second category includes those species that have adverse effect on adjacent crops such as *Eucalyptus camaldulensis, Rhus glutinosa, Psydrax schimperiana***,** *Olinia schimperiana***,** *Dodonea angustifolia, Cupressus lusitanica* and *Euphorbia triculai, Eucalyptus globulus* and *Juniperus procera;* and the third category includes those species that contribute to wood production without any clear adverse effect on adjacent crops such as *Adhatodea schimperiana* (Alebachew, 2012).

Trees planted on farm are appreciated for their role in meeting domestic wood requirements, provision of income and enhancing soil biophysical conditions. Indigenous timber species such as *Cordia africana,* are further appreciated for their soil improvement roles amongst other functions such as water catchment protection and certain cultural values (Achalu *et al.,* 2003; Carsan, 2007)**.** For instance, *Ficus thonningii, Croton macrostachyus, Cordia africana* and *Olea*

europaea are retained because they have beneficial effects through increasing soil fertility, reducing soil erosion and using as shade on the neighboring crops (Teklay *et al.* 2006). Mixing tree and agricultural crop on smallholder farms is therefore an interdependent practice which seems to play a key role in securing many smallholder livelihoods (Lengkeek and Carsan, 2004).

2.3.3. Woodlots

A woodlot is a small plantation established or kept to produce firewood, poles, posts or other small round wood (Alebachew, 2012). For instance, *Eucalyptus camaldulensis, Eucalyptus globulus* and *Acacia decurrens* are planted in compact blocks in woodlots (Abiyu *et al.*, 2016). Woodlot are dominated mostly by single species and are important for income, fire wood, construction material (Endale *et al.*, 2017).

2.3.4. Farm boundary

Living fences are the most common practices in rural landscapes of Ethiopian. Farmers have certain criteria in selecting tree/shrub species as living fence; they prefer those species that coppice easily, that are thorny, more leafy and dense crown (Alebachew, 2012); and the mostly used tree species for this are *Dombeya torrida, Buddleja polystacha, Commiphora habessinica, Allophllus abyssinicus, Vernonia amygdalina, Eucalyptus globulus, Myrica salicifolia, Cupressus lusitanica, Chamaecytisus palmensis, Olea africana, Adhatodea schimperiana, Millittia ferruginea, Euphorbia tricuali, Ricinus communis, Eucalyptus camaldulensis, Dovyalis abyssinica, Celtis africana, Sesbania sesban, Acacia species, Cordia africana, Podocarpus glaciliar, Psydrax schimperiana, Croton macrostachys, Albizia schimperiana,* and *Entada abyssinica* are common living fences. On the other hand, *E. tirucalli, E. camaldulensis* and *F. thonningii* are planted as live fences for protection against livestock which have free range grazing (Abiyu *et al.*, 2016).

A variant of boundary planting which is commonly practiced by farmers in Ethiopia is biomass transfer. The biomass transfer technology involves the growing of trees/shrubs along boundaries or contours on farms or the collection of the same from off-farm niches such as roadsides and applying the leaves on field at planting time (Birhane, 2014).

2.3.5. Grazing lands

The production of woody plants combined with pasture or rangeland is often referred to as silvo-pastoral system. Leguminous species like *Millettia ferruginia, Albizia gummifera* and *Erythrina abyssinica* are mostly managed by retaining naturally regenerated seedlings either in grazing lands, along hedges, or rarely in crop fields. Indigenous species like *Juniperus procera* are intentionally planted in fewer numbers for its superior quality wood for construction purposes (Achalu *et al.,* 2003).

According to Alebachew (2012) the major tree species naturally grown on grazing lands are *Comberetum molle, Buddleja polystacha, Myrica salicifolia, Allophyllus abyssinicus, Cupressus lusitanica, Podocarpus glaciliar, Olea africana, Pygeum africana, Maytenus senegalensis, Rhus glutinosa, Dombeya torrida, Olinia rochetiana, Leonotis ocymifolia, Acacia abyssinica, Croton macrostachys, Euclea schimperi, Psydrax schimperiana, Carissa edulis* and *Cordia africana.*

2.4. Constraints for planting of indigenous tree species

The future composition of forests depends on potential reproduction and recruitment as regeneration status of tree species within a forest stand in space and time (Eilu and Obua, 2005); and the patterns of regeneration is important because it will ultimately determine the floristic composition of the remnant and the successful regeneration of woody tree species is mainly depend on a function of their ability to initiate new seedlings, the survival ability and growth of seedlings and saplings. The knowledge of regeneration and population structure of a plant community is a prerequisite to understand the overall structure and function of any ecosystem (Singh *et al*., 2016), whereas understanding woody species diversity and socioeconomic factors causing devastation of natural forests ecosystem is crucial in the management of the remnant forest ecosystems (Yakob and Fekadu, 2016).

2.4.1. Knowledge gap on seed biology

Propagations of many indigenous tree species from seeds had been difficult due to lack of precise knowledge on their seed biology and germination physiology; because many native plant species have developed survival strategies through evolutionary processes for millions of years

(Legesse, 1995). The germination physiology of seeds of several indigenous tree species must be reached at certain level of maturity for the successful germination of the seeds to produce the required amount of seedlings for mass propagation of forest trees. Seed physiological maturities are also important for the planning of collection, since mature seeds have a higher germination rate (Silva *et al.,* 2008). For instance, in *Podocarpus falcatus* fruit commenced when at least 60-70% of them become yellow to get high quality viable seeds (Negash, 1995). Additionally, changing the colour of fruits from green to a usually bright and conspicuous red, orange, yellow and becomes soft; and simultaneously the pulp usually loosens easily from the seed, fruits develop a strong odour of fragrance that attracts seed dispersals are the signs that show seed maturation (Schmidt, 2000).

On-farm planting of indigenous tree species is constrained by lack of seedlings, shortage of land, and long gestation periods (Achalu *et al.*, 2003) and mostly naturally regenerated seedlings and cutting are used as a source of planting material for indigenous woody species which can be acquired from both garden of farmers and natural forest (Yakob *et al.*, 2014). On the other hand, the extension services given for farmers not sufficiently promoting integration of leguminous MPTS species in the existing landuse system due to lack of adequate training in agroforestry innovations and species selection for various ecological regions and management objectives. Moreover, extension agents are often entrusted with a mandate that is far beyond their physical and technical capabilities and seedlings are raised without matching the supply with the needs of the farmers and without sensitizing them to the use and functions of the trees (Achalu *et al.*, 2003).

2.4.2. Climatic and environmental factors

Forest can be affected by different environmental factors such as altitude, slope, and aspect by affecting the patterns of tree species distribution (Yitebitu *et. al.*, 2010)**.** Insects, pathogens and livestock, as well as climate variability and random disturbances such as fire have significant impacts on herbaceous and woody plants species. The resistance of a tree species to destructive elements, as well as climatic shocks and events, significantly influences the rate of seedling survival and therefore the risk associated with investing scarce resources in planting a particular

species (Jagger and Pender, 2000). Climate change related recurrent drought has impacted natural regeneration of forest (EBI, 2012).

Seed germination of indigenous tree species also affected by their ability to adopt the local environmental conditions. For instance, *Croton macrostachyus* and *Cordia africana* are pioneer species whose seeds germinate and establish under canopy gaps soon after disturbance (Bekalo *et al*., 2002); whereas *Podocarpus falcatus*, *Prunus africana*, *Pouteria adolfi-friederici* and *Syzygium guineense* are shade tolerant species whose seeds germinate and establish in shaded under story of forests.

The density value of seedling and saplings are considered as an indicator of regeneration potential of the species in which the presence of good regeneration indicates the suitability of a species to the environment and management of natural forests largely depends on successful natural regeneration of valuable species (Islam *et al*., 2016), which occur when the trees establish and develop as part of the stand.

2.4.3. Biotic factors

Poor biotic potential of tree species which either affect the fruiting or seed germination or successful conversion of seedling to sapling stage are the major factor that affect the regeneration of indigenous tree species (Bogale *et al.*, 2017). The invasiveness of exotic trees may restrict the germination and growth of indigenous tree species, for instance, *Eucalyptus* affect by its allelopathic property over other native species (Solomon and Moon, 2018).

IASs are all categories of living organisms (plants, mammals and insects) which comprise the most common types in terrestrial environments and they are non-native or exotic organisms that occur outside their adaptive ranges and dispersal ranges that have the ability to establish themselves, invade, compete natives species directly competing for resource such as: food and breeding sites; indirectly by altering habitat and modify hydrology, nutrient cycling and other ecosystem processes and take over the new environment (Shiferaw *et al*., 2018). They have unique characteristics over the native ones; they do not need special environmental requirement for seed germination, they have rapid seedling growth and produce seeds for longer period of time as long as environmental condition permit, they are also highly tolerant to climatic and

edaphic variations and have an ability to compete and drive off other species from their habitat and they can reproduce sexually and asexually.

Invasive species are a serious impediment to the conservation and sustainable use of global, regional, and local plant species diversity with significant undesirable impact on the goods and services provided by ecosystems. Among the invasive species *Lantana camara* is one of the most invasive alien species in Ethiopia that severely affects the health and regeneration of the woody plant species; in which its distribution is very high and it is a highly aggressive exotic species or environmental weed in many countries that has significantly adverse effect on vegetation biodiversity (Getahun, 2010).

The other effect of invasiveness of exotic trees is the ignorance of indigenous tree species by the local communities and dominance of IAS (Invasive Alien Species) over the indigenous/native tree of the community (Feyera *et al.*, 2002; Tafesse, 2007). For instance, *Prosopis juliflora* are threatening endemic plant species in Afar Region of Ethiopia, such as *Acacia prasinata*, *Boswellia ogadensis*, *Euphorbia doeloensis*, *Eucalyptus ogadensis* and *Indigo ferakelleri* (Shiferaw *et al*., 2018). Among 35 invasive alien species threat the biodiversity of the Ethiopia, the major IAS that affects native tree species are listed below (Table 3).

Table 2. Major invasive alien species (IAS) that affects native tree species

No.	IAS	Origin	Impacts (Specific to native species)
1	*Parthenium hystarophorus*	Mexico	• Allelophatic and rapid replacement (Pandey and Dubey, 1989)
2	*Prosopis juliflora*	Mexico and Caribbean	• Allelochemicals that inhibit the germination and spread of other plant species (Essa *et al.*, 2006)
3	*Lantana camara*	South and Central America	• Allelophatic (Ahmed *et al.*, 2007) • Competing soil nutrients (Dobhal *et al.*, 2010) • Altering micro environment (Rosacia *et al*., 2004)
4	*Senna didymobotrya*	Africa	• Impede growth and regeneration of native plants by forming dense impenetrable thickets (Tamiru, 2017)

2.4.4. Anthropogenic factors

Human impacts restrict the distribution of species and population sizes and modify the demography of many tropical forest plants (Derero *et al.*, 2011*).* The natural forest cover of the country has been diminishing over times due to various human induced pressures such as rapid

population growth, extensive forest clearing for cultivation, overgrazing and exploitation of forests for fuel wood and construction materials without replanting (Kebebew and Demissie, 2010; Solomon and Moon, 2018); and alter the future structure and composition of the forest (Bogale *et al.,* 2017); selective harvesting, conversion of natural forests to plantations or fragmentation are expected to affect genetic structures differently (Derero *et al.,* 2011).

The disappearance of many plant species due to human activities is depleting the world's genetic resources and is putting man's heritage of biodiversity under serious threat. Today, most areas across eastern Africa certainly need more trees because people have cut down too many trees without putting effective replanting programs in place (Moir *et al*., 2007).

2.4.4.1. Deforestation and forest fragmentation

High and rapid population growth beyond the carrying capacity of the national economy is continually adding pressure to an already declining forest resource base. Declining standard of livelihood or poverty of the farming communities and their close dependence on forests have led to clearing/burning of the forest resources for subsistent farming, cutting of trees/shrubs for fuel wood and charcoal production (both for consumption and sale) (Mohammed, 2011**)**.

Deforestation in Ethiopia is increasing at alarming rate and the rate of afforestation was very negligible in light of the very high rate of clearing for fuel, expanding agricultural land, for construction, urban development purposes; and lack of awareness creation for the communities have contribution for deforestation (Andoshe, 2011**)**. The intensive logging practice seriously damages the structure and composition of natural woody plant species and leading to the declining of forest diversity that pose a serious threat to and regeneration status of biodiversity in general and plant species in particular (Mebrat and Gashaw, 2013) .

Over harvesting (unsustainable harvesting) of mature tree by people for different purposes influenced the regeneration of indigenous tree species and the capacity of the species to maintain its wild population is significantly reduced (Robi and Edris, 2017). Similarly, increasing demand and rise in market value of forest products such as office and household furniture resulted in selective harvesting pressure on some forest trees particularly indigenous species such as *Cordia africana* and *Hagenia abyssinica* (EBI, 2012). For instance, high demand of *Cordia africana* has

caused a rapid depletion of the species and the tree is now proclaimed as one of the most endangered tree species of Ethiopia (Alemayehu *et al*., 2016); *Podocarpus falcatus* is classified as a high class soft wood, thus encouraging its selective removal from the forest. Overexploitation of the seed bearing female or male trees of it can reduce their genetic diversity, as well as abundance, thus resulting in local extinction (Tafesse, 2007).

2.4.4.2. Expansion of planting exotic tree species

Forest plantations can foster the regeneration of native woody species under their canopy and catalyze the subsequent succession processes (Getachew and Abiyot, 2006). The practice of farmland agroforestry is declining in many agricultural landscapes in Ethiopia due to increase in fuel wood demand and degradation of nearby forests (Onyekwelu *et al*. 2015), agricultural intensification, the increasing popularity of exotic tree species which generate larger economic benefits for farmers (Teshome, 2009). The establishment of woodlots and plantations (especially fast growing exotic species such as *Eucalyptus*) to satisfy demand for forest produce has long been advocated as a strategy for relieving pressure on indigenous forest and woodland (Jagger and Pender, 2000).

Many exotic tree species (non-native species) plantation, especially *Eucalyptus*, *Cupressus* and *Pinus* to counteract the ongoing destruction of natural forest and to alleviate the shortage of fuel wood and construction materials (such as *Eucalyptus* species) specifically around the high lands of Ethiopia, it become dominant and also enormously supporting development in Ethiopia (Desalegn and Tadesse, 2010; Solomon and Moon, 2018). *Eucalyptus* changes the structure and composition of native plant communities (Tererai *et al*., 2013), cause the extinction of species (Pereira *et al.,* 2012) either by their allelopathic effect, invasion or reducing or weakening the attention of the local people that is given to the native species which are known by their values for food, traditional medicine, enhancement of soil fertility, conservation of soil, regulation of the microclimate and soil moisture. This changes the interests of society and making them to neglect the management of indigenous species (Solomon and Moon, 2018).

3. MATERIALS AND METHODS

3.1. Description of the study area

3.1.1. Location and Topography

The study was conducted in Mana, Kersa and Seka Chekorsa Districts of Jimma Zone of Oromia National Regional State, Southwest Ethiopia (Figure 1). Jimma zone is located at 356 km from capital city of the country, Addis Ababa and it has 21 districts. The zone is located between $7^{o}13'$ – $8^{o}56'$N latitudes and $35^{o}49'$E –$37^{o}38'$E longitudes with an estimated area of 19,506.24 km^2 and between altitude ranges of 880 to 3340 meters above sea level (ORG, 2003). The topography includes mountains, dissected plateau, hills, plains, valleys and gorges. There are several perennial rivers and intermittent streams.

The study sites (districts) are located between $7^{o}45'$N-$36^{o}45'$E, $7^{o}45'$N-$37^{o}05'$E and $7^{o}30'$N-$36^{o}05'$E; as well as their altitude ranges between 1470-2610 meters above sea level, 1740-2660 meters above sea level and 1580-2560 meters above sea level for Mana, Kersa and Seka Chekorsa respectively (ANRO, 2020).

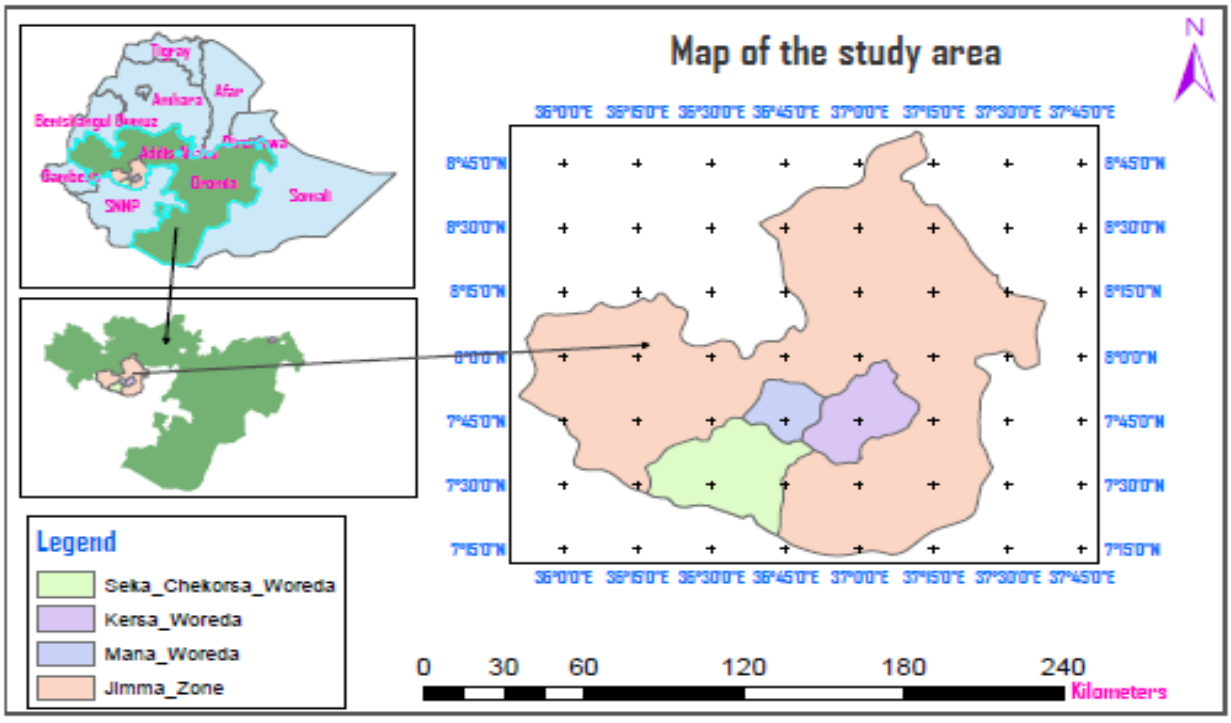


Figure 1. Map of the study area

3.1.2. Vegetation type and climatic condition

High forest, woodland, riverine, shrubs and bush, and man-made forests are all found in the zone. The Zone is classified into three agro-climatic zones: Kolla (14.9% - lowlands); Woina-dega (64.4% -mid-highlands); Dega (20.5% - highland). The average temperature of the zone is 15^{o}c and rainfall variation across the whole zone is between 1200 and 2400 mm per year, with a long rainy season from February/March to October/November (ORG, 2003).

3.1.3. Population

According to the 2007 national population and housing census, the zone has a total population of 2,486,155, of whom 1,250,527 (50.3%) are men and 1,235,628 (49.7%) are women, of which 88.7% are rural residents and 11.3% are urban residents.

Table 3. Demographic data of the study areas

District	Total Household size	Total population					
		Rural			Urban		
		Male	Female	Total	Male	Female	Total
Mana	29,848	72,493	69,789	142,282	2,205	2,188	4,393
Kersa	32,958	80,901	79,064	159,965	2,678	2,748	5,426
Seka Chekorsa	41,844	101,303	99,764	201,067	3,455	3,574	7,029
Total	104,650	254,697	248,617	503,314	8,338	8,510	16,848

(Source: District ADNRO, 2019)

3.1.4. Farming system

Almost 49.6% of the zone total area devoted to cultivation (Nigussie and Kissi, 2012). According to Jimma zone Agriculture and Natural Resource Office (ANRO), (2019), the landuse in this zone are 45.6% arable or cultivable, 9.03% pasture, 24.4% forest, 3.1% swampy, 10.7% covered by coffee and the remaining 7.2% is the land used for community services (construction, religious, offices, market area including unusable (Table 4).

Table 4 The landuse pattern of the Jimma Zone

No.	Landuse type	Area (ha)	Percent
1	Arable land	834,534	45.6
2	Forest land	445,190	24.4
3	Grazing land	164,888	9
4	Wetland/swampy	55,616	3.1
5	Coffee land	196,251	10.7
6	Others	131,848	7.2
	Total	1,828,327	100

Dystric Nitosol, Orthic Acrisols, Chromic and Pellic Vertisols are the major soil types found in Jimma zone (BOPED, 2000). For the study sites Nitosols and Orthic Acrisols are dominant in Mana (ORG, 2003), Orthic Acrisols and Pellic Vertisols are dominant in Kersa (BOPED, 2000) and Nitisols and cambsoil are dominant in Seka Chekorsa (FAO, 1994).

The zone is one of the major coffee growing areas of Oromia region and major crops grown, in addition to coffee, are maize, teff, sorghum, barley, pulses (beans and peas), root crops (enset-false banana and potato) and fruits. Teff and honey production are another sources of cash after coffee. *Enset* is a strategic crop substantially contributing to the food security of the zone and it receives good rains, ranging from 1,200 – 2,800 mm per annum (Lemessa, 2000).

3.2. Research Design

3.2.1. Sampling Design

A multi-stage sampling system was employed for this study: firstly, three districts Mana, Kersa and Seka Chekorsa were selected from the zone based on the extent of tree planting practices. Secondly, five peasant associations (PAs) were selected from each district including Somodo, Meti, Buture, Gudeta Bula and Baballa Karra from Mana district; Merewa, Gelo, Kitimbile, Babo and Bala Wajo from Kersa district; and Buyo Kechema, Kusaro, Dabo Gibe, Gibe Boso and Ushane Koche from Seka Chekorsa. In total, 15 PAs were selected based on the level of tree planting practices and information obtained from Agricultural and Natural Resources offices of their respective districts. At the final stage, sample households were determined proportionally based on the number of households of the PAs and they were selected randomly and interviewed with prepared questionnaires to collect data on the purpose of planting trees, planting site selection and tree management activities.

3.2.2. Sampling size

The sample size of the households that were used for the study was determined using the following formula (Yamane, 1967).

$$n = \frac{z^2 p(1-p)N}{e^2(N-1) + p(1-p)z^2}$$

Where,

n=required sample size

N= total households

z = the table value of chi-square for 1 degree of freedom with desired confidence level (95%)

p = an estimate of the household proportion

e= the degree of accuracy expressed as proportion (5%)

Therefore, by using the above formula the sample size of household heads for the study were calculated following the above formula and finally determined for each PAs based on their total HHs (Table 5).

$$n = \frac{(1.96)^2 * 0.1 * 0.9 * 11488}{(0.05)^2 * (11488-1) + 0.1 * 0.9 * (1.96)^2} \approx 136 \text{ (Total sampled HHs)}$$

Regarding tree species assessment it was difficult to undertake tree species assessment for all sampled household heads due to time and budget constraints. Therefore, from sampled household heads 50% (68 HHs) with all landuse types (homegarden, on farm, woodlot, grazing land and farm boundary) were selected randomly. Then, for each PAs the landuse types were determined proportionally based on their total household heads and the trees on their landuse types were assessed.

Table 5. The sample sizes determination

District	No	PAs	Total HHs	Sample size/landuse type*					
				HHs	HG	OF	WL	GL	FB
Mana	1	Somodo	1,208	14	7	7	7	7	7
	2	Meti	926	11	6	6	6	6	6
	3	Buture	932	11	6	6	6	6	6
	4	Gudeta Bula	508	6	3	3	3	3	3

	5	Baballa Karra	1,594	19	9	9	9	9	9
Kersa	1	Merewa	781	9	4	4	4	4	4
	2	Babo	619	7	4	4	4	4	4
	3	Kitimbile	523	6	3	3	3	3	3
	4	Gelo	489	6	3	3	3	3	3
	5	Bala Wajo	591	7	4	4	4	4	4
Seka Chekorsa	1	Buyo Kechema	1,045	13	6	6	6	6	6
	2	Kusaro	382	5	2	2	2	2	2
	3	Dabo Gibe	457	5	3	3	3	3	3
	4	Gibe Boso	592	7	3	3	3	3	3
	5	Ushane Koche	841	10	5	5	5	5	5
		Total	11,488	136	68	68	68	68	68

* HG= homegarden, OF= on farm, WL= woodlot, GL= grazing land, FB= farm boundary

3.3. Data collection

For this study both primary and secondary data were used. Primary data were collected from household (HHs) interview and tree species assessment, while secondary data were also used from publications and Agricultural and Natural Resources office of the Jimma zone and respective districts.

3.3.1. Household questionnaire survey

The semi-structured questionnaire was used to interview 136 households. This was conducted to get better information on the interest and purpose of planting trees, tree species selection and appropriate traditional management practices undertaken for each tree species across different landuse types by farming community and factors affecting the management of tree species, especially indigenous trees. The information used to describe species richness, density, tree and site selection, tree management practices and factors affecting management of tree species across landuse types.

3.3.2. Tree species assessment

Before the actual tree assessment was executed, a reconnaissance survey was conducted so as to get an overview of understanding about the households' tree planting practices and associated landuse types in which these trees grown by households. Accordingly, the trees assessment was undertaken in five landuse types, such as homegarden, on farm, farm boundary, grazing lands and woodlots for each 68 households. Here after the areas of specified landuse type were

measured, complete inventory was carried to record all tree species (exotic and indigenous) found in that landuse type.

The tree data recorded were number of tree species and number of stems for each tree species that were used in diversity analysis and density (stems/hectare) calculation for both indigenous and exotic tree species. The origin and socio-economic uses, establishment mode (retained/planted), and traditional tree management practices were also recorded to identify the interest of farming community of the area to plant/retain across different landuse types. For the trees species that could not be identified in the field, specimens were collected and taxonomic descriptions including the local names for the tree species were identified by asking DAs and the local people.

3.4. Data analysis

First, data collected from the field were entered and organized in Microsoft Excel and checked to clear out errors. The tree species data from different landuse types were computed per hectare since the areas of landuse types vary and hence to bring to the variables to the comparable level prior starting analysis. Descriptive statistics (density) was used to analyze the collected data and to express the numerical strength of species in all landuse types. To compare species diversity for both indigenous and exotic tree species across landuse types a Shannon-Weiner diversity index (H′) was computed as:

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

where, H′=Shannon-Weiner diversity index

p_i= the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of the total,

ln= the natural logarithm of the proportion, and

s=the total number of species

The variation in the square root transformed data of number of tree species and number of stems, and Shannon species diversity index among landuse types were tested using one-way ANOVA. Here species richness and stem number were transformed before analysis since they are count data and hence to replace the value of each data with its square root in order to meet the

assumption of ANOVA. After it was found that the number of tree species, trees stem number and species diversity significantly differs among these landuse types, multiple comparisons for the means (mean separation) was computed using Tukey's Honestly Significant Difference (HSD) with Bonferroni post hoc test for p-value adjustments.

Similarly, chi-square test was performed to identify the association between household socio-economic characteristics and management of tree species. The socio-economic characteristics of household heads were grouped in different classes such as gender (male/female), age (20-30, 31-40, 41-50, 51-60 and >60 years), marital status (single, married, widowed and divorced), educational status (illiterate, read and write, 1-8 grades, and 9-12 grades), landholding size (<0.5, 0.5-1.5, 1.5-2.5, 2.5-3.5 and >3.5 hectares), family size (0-2, 3-5, 6-8 and >8 members) and landuse types (homegarden, on farm, woodlot, grazing land and farm boundary). The management of tree species also grouped into planting and retaining in different landuse types. Species richness, Shannon-Weiner Diversity Index (H') and the associations between household characteristics and tree species management were carried out using R software program (version 3.6.2.).

4. RESULT AND DISCUSSION

4.1. Tree species composition

Overall a total of 44 tree species belonging to 28 families were identified from all landuse types and recorded as indigenous and exotic tree species (Appendix I). Accordingly, 33 tree species were indigenous which belong to 21 families, whereas 11 were exotic from 9 families. While Fabaceae and Myrtaceae families comprised both indigenous and exotic tree species, others families consisted of either indigenous or exotic species. The dominant family was Fabaceae comprised of 7 (15.9%) species followed by Moraceae 4 (9.1%) species, and other families such as Boraginaceae, Euphorbiceae and Rosaceae had equal number of species (i.e., 2 (4.5%) each). For fifteen families each only one indigenous tree species was recorded, while only one exotic tree species was found for 6 families each. The current finding is in line with Wari *et al.*, (2019) as Fabaceae is the dominant family representing most tree species around Jimma town.

4.2. Species richness and density across landuse types

The 34 number of tree species was recorded from on farm landuse type (coffee farm and crop field) and this number is maximum when compared with that of homegarden (i.e., 26 species), farm boundary (12), grazing land (11) and woodlot (3 species) landuse type (Figure.2).

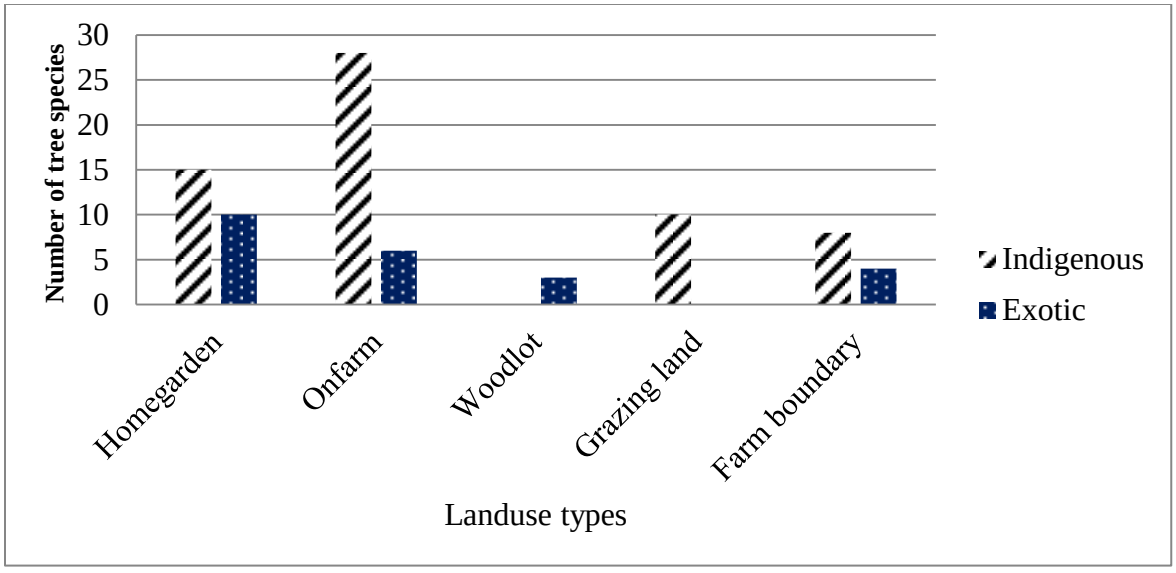


Figure 2. Number of tree species across different landuse types

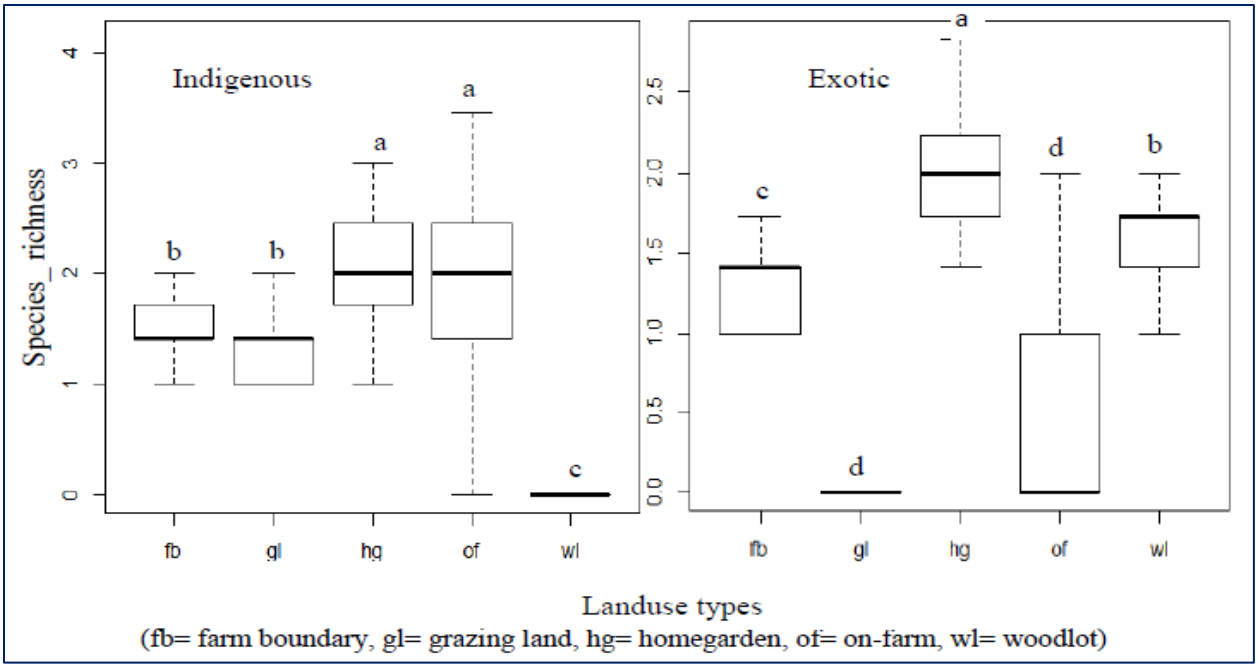
In terms of the indigenous tree species richness, it is also on farm landuse type from which maximum number (28) was recorded when compared with homegarden (15), grazing land (10), farm boundary (8) and woodlot (0). However in terms of the exotic tree species richness the maximum number was recorded in homegarden (10) followed by on farm (6), farm boundary (4) and woodlot (3).

Most landuse types of the study area comprised of both exotic and indigenous species (Figure 2) with exception of woodlot and grazing land which comprises only exotic and indigenous respectively. The total highest mean species were recorded on farm (0.5 species) followed by homegarden (0.37 species) whereas woodlot (0.04 species) which is the least (Table 6). The result of the current study not in line with the findings of Fikir *et al*., (2018) who studied at Chilga and Dabat Districts of Northern Gonder, that states homegarden has the highest tree species richness and Wari *et al*., (2019) who studied around Jimma town on woody species and reported the highest diversity in the grazing land than other landuse types. This is due to the target population of the study in which they focus woody species whereas the current study focuses on tree species.

Table 6. Mean of species richness and stem numbers across different landuse types

Origin	Homegarden	On farm	Woodlot	Grazing land	Farm boundary
Mean of all species richness	0.37±0.37	0.5±0.42	0.04±0.09	0.15±0.15	0.18±0.15
Indigenous species richness	0.22±0.27	0.41±0.37	0.0±0.0[c]	0.15±0.15	0.12±0.12
Total density	224±39.2	53.2±11.6	2,455.7±543.8	15.5±3.5	311.8±35.1
Indigenous density	84.2±20.3	37.9±6.9	0.0±0.0	54.1±4.5	147.8±14.6

The tree species richness significantly differs among the landuse types for both indigenous and exotic tree species ($p<0.00$). The highest tree species for indigenous were recorded in homegarden and on farm and for exotic was recorded in homegarden when compared to other landuse types (Figure 3). This is due to the functions and purposes provided by different tree species at different landuse types for farming community of the study area.



(Values with different letter had a statistically significant difference at p<0.00)

Figure 3. Indigenous (left) and Exotic (right) tree species richness across landuse types

The highest species richness recorded in homegarden and on farm for indigenous tree species are due to most indigenous tree species such as *Cordia africana, Albizia gummifera, and Sesbania sesbain* are used as coffee shade in both homegarden and on farm landuse types (Appendix I).

Regarding density, numbers of stems per hectare, the overall density of woodlot were the highest (3,527.5 stems) when compared to other landuse types followed by farm boundary (1,323.4 stems) and the least were recorded in grazing land (72.5 stems). In terms of their origin the highest density for indigenous was recorded in farm boundary (460.1 stems) followed by homegarden (155.6 stems) whereas the least was recorded in woodlot where there is no indigenous trees.

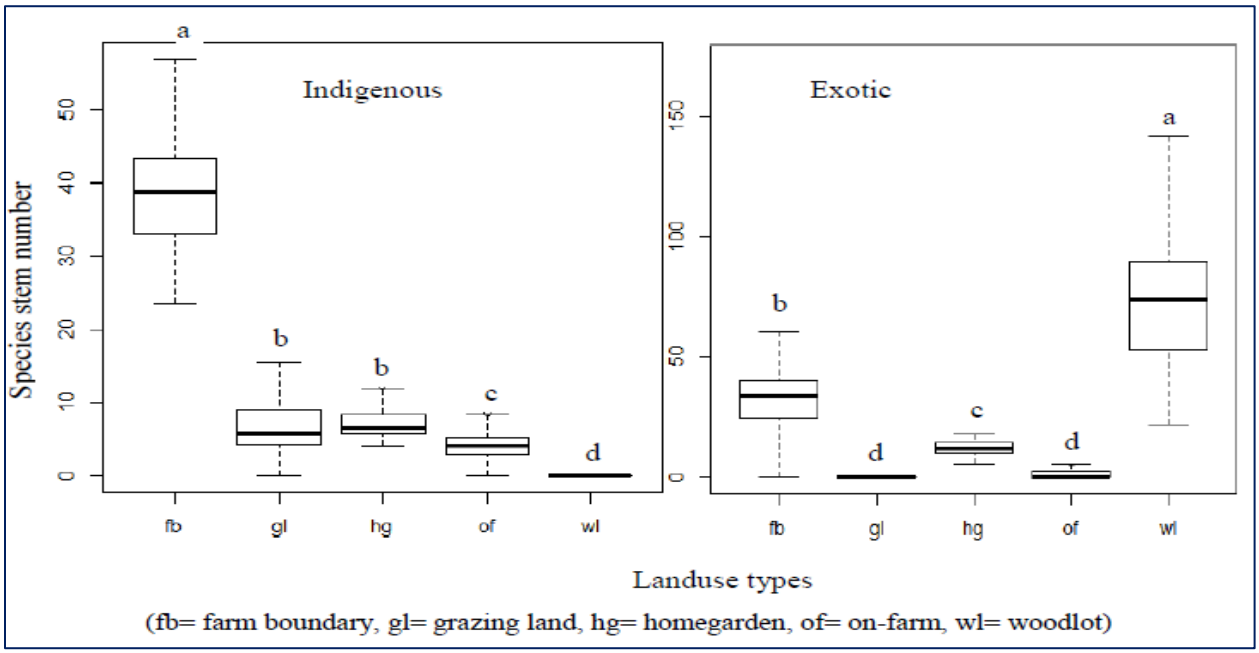
Table 7. Total density of tree species across different landuse types

	Density per hectare				
Origin	Homegarden	On farm	Woodlot	Grazing land	Farm boundary
Total	379.1	88	3,527.5	72.5	1,323.4
Indigenous	155.6	67.3	-	72.5	460.1

The difference in density of tree species across different landuse types was due to the spacing of trees during plantation. It is high in woodlot due to densely plantation of trees such as *Eucalyptus*

species, *Grevillea robusta*, and *Cupressus lusitanica*. In farm boundary there is dense plantation, next to woodlot, for protection and the community use as marking farm boundary from neighbor farm lands such as *Grevillea robusta*, *Erythrina abyssinica* and *Eucalyptus species*. However, due to availability of trees in scattered retaining form the density become low in grazing land.

Similar to species richness, the variation exists in mean number of stems for both indigenous and exotic per hectare among landuse types and such differences were statistically significant ($p<0.001$). The highest value for indigenous was recorded in farm boundary and for exotic it was recorded in woodlot when compared to other landuse types (Figure 4).



(Values with different letter had a statistically significant difference at p<0.00)

Figure 4. Indigenous (left) and Exotic (right) tree density across landuse types

4.3. Species diversity across landuse types

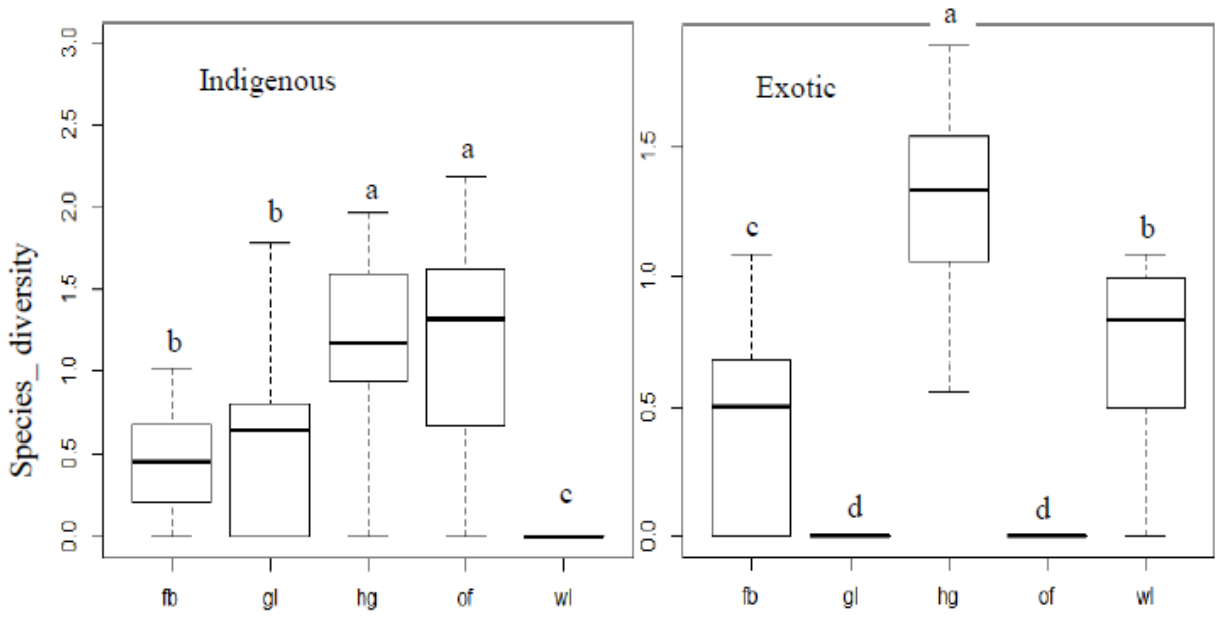
The overall higher Shannon diversity index was (H'=2.529) for homegarden followed by farm boundary (H'=2.492) and the least (H'=2.418) were for on farm when compared to other landuse types (Table 8). This result is not in agreement with the finding of Endale *et al*., (2017) from East Shewa that tree diversity was higher in farm boundary (line planting). This difference might be due to the agro-ecology of the study areas. The Shannon diversity index for indigenous tree species is higher for on farm (H'=2.459) and lower for woodlot (0.00).

From the total result of Shannon diversity index, on farm landuse has the lowest value (H'=2.418), but it has the highest species number from all landuse types. This indicates that tree diversity for on farm is low for most tree species and high number of trees for certain identified species.

Table 8. Shannon diversity Index (H') across different landuse types

Origin	Homegarden	On farm	Woodlot	Grazing land	Farm boundary
Total	2.529	2.418	2.450	2.441	2.4920
Indigenous	2.396	2.459	0.000	2.441	2.393

The diversity of both indigenous and exotic tree species showed highly significant difference among landuse types ($p<0.001$). For example, the indigenous tree species diversity is higher in homegarden and on farm when compared with that of grazing land and farm boundary landuse types. However, the exotic species diversity is higher in homegardens when compared with other landuse types (Figure 5). This is due to the benefits expected from the tree species. Most indigenous trees in homegarden and on farm are used for shade and exotic trees in homegarden are planted fruit trees that need protection.



(Values with different letter had a statistically significant difference at p<0.00)

Figure 5. Indigenous (left) and Exotic (right) tree species diversity across landuse types

4.4. Tree species selection for planting/retaining and their uses across landuse types

In the study area different tree species established across different landuse types through retaining of remnants or naturally regenerated plants and/or undertaking plantation activities. Out of 33 indigenous tree species recorded during the study 3 were planted and/or retained (*Cordia africana, Erythrina abyssinica* and *Annona senegalensis*) and 30 were retained mostly on different landuse types (Appendix I). This is in agreement with the finding of Yakob *et al.*, (2014) who studied in Southwest Ethiopia and reported that *Millettia ferruginia, Vernonia amygdalina, Ficus sur, Croton macrostachyus and Sapium ellipticum* were the major indigenous tree species more frequently retained than others. Almost all (11) exotic tree species were established by planting (Table 9).

Table 9. Tree establishment methods at different landuse types

Establishing mode	Origin	Homegarden	On farm	Woodlot	Grazing land	Farm boundary
Total*	Indigenous	15	28	0	10	8
	Exotic	10	6	3	0	4
Planting	Indigenous	3	2	0	0	1
	Exotic	10	6	3	0	4
Retaining	Indigenous	14	28	0	10	8
	Exotic	0	0	0	0	0

**Total number of tree species recorded in landuse types*

Farmers of the study area plant and/or retain different tree species in different landuse types for benefits they expect from trees species, for easing management practices and for better farm protection from theft, wild animals and livestock (Table 9). They have specific purposes for trees within their farming system. Mostly they are interested in planting/retaining tree species used for multipurpose trees that produce poles, construction material, and fodder. The current results supports the findings of Abreha and Gebrekidan (2014) that states the uses and benefits the farming community obtain from trees were the drivers for tree retention and plantation.

The farming community of the study area select the tree either indigenous or exotic that fulfill their criteria they expect from it and plant and/or retain on their farm lands. This can be summarized as follows:

4.4.1. Homegarden

Only 3 of indigenous tree species were either planted or retained in homegarden whereas 10 exotic tree species were totally planted (Appendix I). This landuse type comprise indigenous species such as *Cordia africana, Ficus sur* and exotic tree species such as *Grevillea robusta, Cupressus lusitanica, Jacaranda mimosifolia* and *Sphathodea nilotica* mostly used for timber. On other hand, fruit trees used for food and cash income that needs fertile soil and protection from either theft or wild animals/livestock such as *Persia americana, Mangifera indica, Psidium guajava, Citrus sinensis* and *Annona senegalensis* are planted in this landuse type (Appendix I).

Trees used for life fences and shelter belt such as *Grevillea robusta, Cupressus lusitanica* and *Eucalyptus species* as well as trees used for hanging traditional bee hive such as *Ficus vasta* and trees for fodder such as *Sesbania sesban* and *Leucaena leucocephala* are also some trees planted/retained in homegarden (Appendix I). The present finding is in line with the result of Abreha and Gebrekidan (2014); Amare (2018); Fikir *et al.,* (2018), which states that trees in homegardens benefit from the direct care of household members and provide continued benefits by their long-term presence in close proximity to the family and it is preferred landuse type by farmers because of the fact that homeowners feel a stronger sense of ownership.

4.4.2. On farm

Most of indigenous tree species (28) were retained on farm and 6 exotic are established by planting (Table 9). When it is compared to other landuse types it comprises tree species mostly used for coffee shade in coffee farm such as *Acacia species, Albizia gummifera, Millettia ferruginia, Croton macrostachyus* and *Sesbania sesbain,* since the study area is the area with high potential of coffee production (Appendix I).

Tree species, mostly indigenous tree species, used for fuel wood, timber, food, construction, SWC are retained in this landuse type (Appendix I). On the other hand, tree species economically useful and important for soil fertility, animals feed, no impact on crops like *Acacia species, Croton macrostachyus,* were retained in on farm (crop field). Because of their ability to fix nitrogen and produce large quantities of organic material such as *Acacia species, Ficus thonningii* used for soil and water conservation are retained in on farm (crop field). *Olea africana* and *Cordia africana* used for traditional medicine also retained in on farm. These were

also reported by the findings of Amare (2018) around Gurage Zone and Wari *et al*., (2019) conducted around Jimma town.

4.4.3. Woodlot

This landuse type is represented by 3 exotic tree species in plantation form and they were dominated by single tree species such as *Eucalyptus species, Cupressus lusitanica* and *Grevillea robusta* (Appendix I). The tree species planted in this landuse type are used for timber, fuel wood; especially *Eucalyptus species* are expanding in the study area by attracting the interest of the farmers due to its fast growth, generate income for them periodically and considered as cash crop. The present finding is in agreement with finding by Abiyu *et al.,* (2016) which was undertaken at upper Lake Tana watershed that states *E. camaldulensis, E. globulus* and *A. decurrens* are planted in compact blocks in woodlots because they are cash crops for the people around the study area.

4.4.4. Grazing land

Grazing land consists of 10 indigenous tree species that are large in size, grown by tolerating animals' browsing damages and very scattered by retaining (Appendix I). Such trees include *Ficus vasta, Ficus sur, Ficus thonningii, Acacia species, Croton macrostachyus, Polyscias fulva, Millettia ferruginia, Albizia gummifera*. This is in line with the findings of Abreha and Gebrekidan (2014) and Wari *et al*., (2019) that states grazing lands are known in scattered distributed remnants of forest and naturally grown very large size trees. The tree species available in this landuse type are used for shade for livestock, construction, and timber and also for fuel wood.

4.4.5. Farm boundary

Farm boundary contains 8 indigenous tree species by planting/retaining and 4 exotic tree species by planting mode (Appendix I). The tree species selected for this landuse type were trees that are able to coppice easily and thorny for protection against livestock, their leaves are not palatable by livestock, able to withstand trampling by livestock and some are widely grown as living fence. This was reported by Abreha and Gebrekidan (2014) as mostly the tree species in farm boundary are thorny. These includes *Erythrina abyssinica, Croton macrostachyus, Acacia species, Ficus thonningii, Vernonia amygdalina*.

4.5. Tree species management across landuse types

Farming community of the study area applied different traditional management practices for different tree species under different landuse types. These practices are depending on the benefits obtained from the system, the effect of these managements on tree products and sustainable land management and to reduce its negative effects on neighbor crops (Appendix I). According to the respondents, pollarding and lopping were applied mostly for indigenous tree species planted/retained in homegarden, on farm, woodlot, grazing land and farm boundary whereas coppicing, pruning, fencing, weeding and fertilizing (adding organic waste material from the household and animal manure) were applied mostly for exotic tree species planted in homegarden (Table 10).

Table 10. Number and management of tree species at different landuse types

Management practices	Homegarden	On farm	Woodlot	Grazing land	Farm boundary
Coppicing	0	0	1	0	0
Pollarding	5	4	1	2	4
Lopping	9	9	0	5	2
Pruning	6	2	2	1	3
Fencing	8	5	3	0	2
Weeding	9	6	3	0	4
Fertilizing	5	2	0	0	0

The indigenous tree species regenerate naturally from the soil seed bank and with minor/no management practices applied for them are frequently damaged and have poor quality due to frequent lopping, browsing or pollarding. This was also reported by Amare *et al*., (2019). On the other hand, the communities of the study area were experienced by conserving such tree species through selective management practices in maintaining across different landuse types.

Coppicing followed by burning is undertaken for *Eucalyptus species* in woodlot to facilitate the regeneration after cutting or to stimulate growth at woodlot (Appendix I). Pollarding and lopping are applied for trees planted/retained in homegarden and on farm landuse types to reduce the shade of trees in order to save from light competition, use branches for other purposes fuel wood, construction, fodder (Appendix I). A study by Endale *et al.*, (2017) indicated as trees in crop field can be managed by pollarding not only for reducing competition of light but also help to improve the productivity and resilience of the system simultaneously.

Pruning is another management activity mostly applied to trees planted/retained in homegarden, on farm and farm boundary. This is done in order to modify the overall stand of the tree, collecting wood to be used for fencing, constructing houses and firewood and it is mostly for trees used for timber such as *Cordia africana*, *Grevillea robusta* and *Cupressus lusitanica* (Appendix I). Fencing and weeding are applied for tree species planted in homegarden, on farm and woodlot to protect from animal attack and to reduce competition respectively. Fertilizing is the other traditional management practices undertaken by farming community of the study area especially those tree species planted in the homegarden such as fruit trees *Mangifera indica, Persia americana* and *Psidium guajava* (Appendix I).

4.6. Factors affecting management of indigenous tree species

4.6.1. Socio-economic characteristics of household heads

The result of the study shows, from the socio-economic characteristics of sampled household heads, the management of tree species are affected by differences in gender of households heads (x^2=16.9, df=1, p<0.001). Accordingly, female household heads mostly focus on tree species planted/retained in homegarden; while male headed households focus on farm in which they plant/retain tree species for the sake of coffee shade (in coffee farm) and manage trees in crop field by applying different management practices. On the other hand, the male headed farmers give more attention on woodlot plantation than female headed households for their immediate and high interest of economy. The present result is in line with the finding from upper catchment of Lake Tana Watershed, Northeast Ethiopia that states female headed households preferred planting trees in homegardens and farm boundary than other landuse types (Abiyu *et al.,* 2016).

Landholding size of households possession is another factor that affect the management of tree species (x^2=23.455, df =4, p<0.001). The farmers with large areas of farm land have an opportunity to plant/retain more trees than those with less farm land size. This implies as small farms have less species diversity than large farms. The result agreed with Endale *et al.,* (2017) that states as landholding size (especially for homegarden) had significant positive relationships with number of trees. Amare (2018) also indicated in his study as landholding size determines the composition of tree species.

On the other hand, landuse type affects the management of tree species (x^2=35.333, df =4, p<0.001). Homegarden comprises mostly fruit trees, shade trees that are planted and managed by the whole members of families that have a role in increasing the number of tree species. On farm there are different management practices undertaken (especially digging in coffee farm) for coffee that have advantages for regeneration of different indigenous tree species. In farm boundary the trees planted/retained have protection by the owner from either animal or human interference that inhibit the regeneration and growth of trees. The result is in agreement with the findings of Samuel *et al*., (2019), who conducted a study in West Shewa and East Wollega Zones of Western Oromia, and indicated that landuse category is a very important factor influencing tree species richness and diversity. Other studies by Wari *et al.,* (2019) also indicated as the landuse type determines the composition and diversity of tree species.

4.6.2. Over exploitation of wood products

According to the respondents, there are different threatening factors that could lead to over exploitation of the indigenous tree species in the study area. These factors include high economic interest (132 (97.1%)), lack of awareness on indigenous tree species (123 (90.4%)), agricultural expansion (88 (64.7%)) and selective cutting for their better benefit (for example, timber) or selective removal as they are not suitable for coffee (e.g. *Sapium ellipticum)* without replacing (74 (54.4%)) (Figure 6). Similarly the finding of Amare (2018) in his study conducted in Gurage Zone, SNNPR, indicated that from different factors related to human activities affecting tree species management in different landuse types, agricultural expansion and lack of awareness are the major ones, with agricultural expansion being the most important threatening factor.

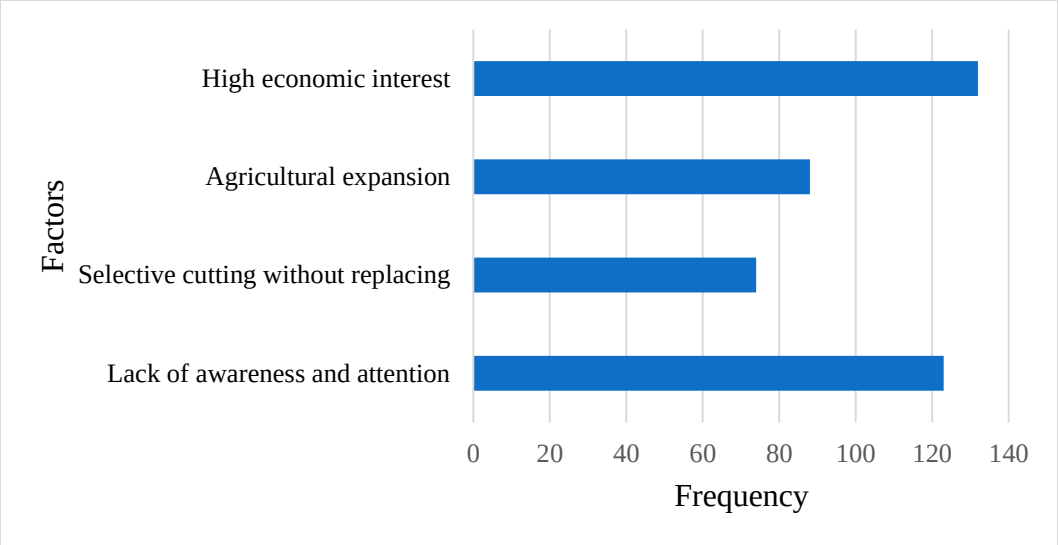


Figure 6. Threatening factors of indigenous tree species

High and immediate economic interest of the farming communities expected from exotic tree species than indigenous attracts the attention of farmers from planting and conserving indigenous tree species. Since the study was conducted around Jimma city where there was high demand of fuel wood, charcoal, construction, timber, food; the farmers of the study area focuses on the trees that fulfill the demand of the city and generate high income for them and received relatively more special attention than other tree species. This was reported by Endale *et al.,* (2017) and Wari *et al.,* (2019) as woodlots of *Eucalyptus* increase onward due to the necessity of wood product (construction, fuel wood), income and fast growing nature of the tree.

Other study by Solomon and Moon (2018) indicated that as *Eucalyptus* species describe as life savior, safety net or tree bank as it is converted easily and quickly to cash whenever needed. This implies that the value of indigenous trees and their multipurpose benefit is getting off and being replaced by exotic species. Due to this farmers prefer more and interested to expand exotic tree plantation, especially *Eucalyptus* species. Others such as *Grevillea robusta* and *Cupressus lusitanica* attracts the interest of farmers because of their pole quality, fast growth, easily establishment, easy silvicultural management, maximum yield and market demand and they are spreading widely while in woodlot and fruit trees such as *Mangifera indica, Persia americana, Psidium guajava* and *Citrus sinensis* on their farm land and/or homegarden are expanding.

On the other hand, agricultural expansion including plantation of exotic tree species, chat plantation; that were still increasing to degrade remnant forests was identified as the major factor for threatening indigenous tree species (Figure 7).

(Source: Photo taken during study- 22/01/2020)

Figure 7. Clearing remnant forests for agricultural expansion

According to the respondents, indigenous tree species were available mostly on farm (coffee farm and crop field), homegarden and grazing land in scattered form. This shows that most of these trees available at their maturity stage and their availability at sapling and seedling is rare or not. So, selective cutting of these species without either replacing or replacing by exotic tree species, especially *Cordi africana* for its quality timber; *Croton macrostachyus, Albizia gummifera, Acacia species* for charcoal production and agricultural expansion; was the other factor of threatening indigenous tree species.

The study by Solomon and Moon (2018) indicated that indigenous tree species in Ethiopia are declining rapidly due to their conversion to arable lands coupled with unwise and excessive utilization caused by increasing population growth and this have serious negative consequences on diversity and density of indigenous trees species in Ethiopia.

According to the respondents, there are indigenous tree species endangered from the local area due to the above listed factors (Figure 6). From these *Podocarpus falcatus* (67.65%), *Hagenia abyssinica* (61.03%) and *Pouteria adolfi-friedericii* (57.35%) are the first three ranked

(Appendix II). Other studies by Erenso and Maryo (2014), also noted as even though *Podocarpus falcatus*, that is used for timber, and *Hagenia abyssinica*, that is important as a source of medicine and timber, are enormously important tree species both economically and ecologically in Ethiopia, they are reducing in number, in their regenerative and productive capacity due to continuous and uncontrolled illegal logging.

According to the finding of Gurmessa (2010), *Albizia gummifera, Pouteria adolfi-friederici, Apodytes dimidiata, Celtis africana, Croton macrostachyus, Ekebergia capensis, Hagenia abyssinica, Olea welwitschii, Prunus africana* and *Syzygium guineense* are the major commercial indigenous tree species in Ethiopia. However, their number and abundance is reducing, even though the degree of threats varies from place to place and species to species. In addition, it was indicated as *Hagenia abyssinica, Ekebergia capensis* and *Millettia ferruginia* were some indigenous tree species that need attention to save from threats.

4.6.3. Shortage of planting materials of indigenous tree species

According to the respondents 86 (63.2%), the planting of trees are affected by the quality and quantity of planting materials (seeds, seedlings and cuttings) for each tree species. Almost all planting materials are used for indigenous tree species whereas seeds and seedlings are used for exotic tree species in the study area. In the study area there are different nursery sites (government, NGO, private) that produce seedlings for farming community. However, they provide mostly exotic tree species (Appendix I). This result agreed with the finding of Yakob *et al.,* (2014), where most farmers of Gimbo District of South West Ethiopia acquired seedlings of exotic woody species from private and government nursery and use naturally regenerated seedlings and cutting as a source of planting material for indigenous tree species which can be acquired from both garden and natural forest.

This implies as there are lack of planting material, especially seedlings of indigenous tree species, which affects management of indigenous tree species. This result is with the agreement of study by Amare *et al.,* (2019) that indicates even though the presence of a local nursery was positively related to tree species diversity; their predominant focus on production of exotic fast-growing timber species illustrates a lack of recognition of governmental development interventions.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The study generally revealed that 44 (33 indigenous and 11 exotic) identified tree species are planted and/or retained by farming community of the study area on their homegarden, on farm (coffee farm and crop field), woodlot, grazing land and farm boundary landuse types for their multipurpose benefits, easing management practices and protection of farms. With exception of woodlot and grazing land other landuse types consists of both indigenous and exotic tree species. The overall highest number of tree species were recorded in on farm (34) and the least were woodlot (3) when compared to other landuse types. Indigenous tree species were higher in on farm and exotic tree species were high in homegarden.

The overall density of woodlot were the highest (3,527.5 stems) when compared to other landuse types due to dense plantation. Shannon diversity index for homegarden (H'=2.529) were the highest value when compared to other landuse types. However, on farm landuse has highest species number from all landuse types but the lowest value in Shannon diversity (H'=2.418) that indicates tree diversity is low for most tree species and high for certain identified number of tree species.

The tree species management practices undertaken by farming community of the study area were different between landuse types and from species to species. Pollarding and lopping were applied mostly for indigenous tree species for reducing their shade effect and using branches for other purposes; whereas coppicing (for facilitating regeneration), pruning (for modifying overall stand of tree), fencing (for protection), weeding (for reducing competition) and fertilizing (for adding manure/organic matter to soil) were mostly applied for exotic tree species.

From socio-economic characteristics of household heads, gender of household heads, land size and landuse type are some factors that affect the management of indigenous tree species. High and immediate economic interest, and agricultural expansion including monoculture and degrading remnant forests are factors that expose indigenous tree species for over exploitation. Lack of planting materials of indigenous tree species that are not produced by local available nursery sites; selective cutting of indigenous tree species either for their better benefit (mostly timber) or selective removal as they are not suitable for coffee shade (e.g. *Sapium ellipticum*) are

also listed as threatening factors of indigenous tree species. Beside this, 20 indigenous tree species were identified as at risk including *Podocarpus falcatus, Hagenia abyssinica, Pouteria adolfi-friedericii* that were ranked from one to three.

5.2. Recommendations

Indigenous tree species provide multipurpose functions for the farming community in addition to their ecological values. Even though their number is higher than exotic tree species, the highly interested of farming community to expand planting exotic tree species for their economic value may replace the indigenous tree species in the long term. Therefore, in order to address the various threatening factors and thereby enhance the status of plantation and management of indigenous tree species, the following recommendations are forwarded:

- Interventions of extension services are the essential tools to create awareness on management and planting indigenous tree species;
- Agroforestry practices should be encouraged to maintain and conserve existing indigenous tree species and should be further diversified by planting;
- Quality seedlings of indigenous tree species should be produced and supplied by different nursery sites;
- Improving legal and institutional framework as well as enforcement of existing laws regarding indigenous tree species, strengthening the protection of remnant forests should be encouraged;
- The conservation priority should be given to indigenous tree species threatened or at risk and that are subject to destructive harvesting from the area;
- Private actors and NGOs focusing on indigenous tree species should be initiated and encouraged;
- There must be collaboration between NGOs and government sectors to sustain indigenous tree species;
- Further investigation should be conducted on characteristics of each tree species that might be a factor for reducing their abundance.

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7. APPENDIXES

Appendix I: Identified and recorded tree species during the study

No	Species name	Vernacular name*	Origin*	Family	Preferred landuse type					Benefits*	Establishment mode*	Planting material	Source of planting materials*	Management practices*
					Homegarden	On farm	Woodlot	Grazing land	Farm boundary					
1	*Grevillea robusta*	Gravila (Am)	E	Proteaceae	x	x	x		x	1,2,5,6	P	seedling, seed	Gov, NGO, Pr	Pru, Fn, We
2	*Cupressus lusitanica*	Gaattiraa (Or)	E	Cupressaceae	x		x		x	1,2,5,6,8	P	seedling, seed	Gov, NGO, Pr	Pru, Fn, We
3	*Olea africana*	Ejersa (Or)	I	Olacaceae	x	x			x	8,9	R			We
4	*Croton macrastchyus*	Bakkanniisa (Or)	I	Euphorbiaceae	x	x		x	x	2,6,7	R			Lo
5	*Erythrina abyssinica*	Waleensuu (Or)	I	Fabaceae	x	x			x	7,10	P	vegetative		Po
6	*Maesa lanceolata*	Abbayyii (Or)	I	Myrsinaceae		x			x	2	R			
7	*Jacaranda mimosifolia*	Muka qawwee (Or)	E	Bignoniaceae	x				x	1	P	seedling	Gov, NGO	Pru
8	*Persia americana*	Avocado (Am)	E	Lauraceae	x	x				3	P	seedling	Gov, NGO, Pr	Lo, We, Fr, Fn
9	*Cordia africana*	Waddeessa (Or)	I	Boraginaceae	x	x		x		1,2,5,6,9	P/R	seedling, seed	Gov, NGO	Lo
10	*Albizia gummifera*	Ambabbeessa (Or)	I	Fabaceae	x	x		x		2,6	R	seedling	Wld	Lo
11	*Millettia ferruginea*	Askiraa (Or)	I	Fabaceae	x	x			x	2,6,7	R			Lo
12	*Eucalyptus species*	Baargamoo (Or)	E	Myrtaceae			x		x	1,2,5,10	P	seedling, seed	Pr	Co, Po, Fn. We
13	*Mangifera indica*	Mango (Or)	E	Anacardiaceae	x	x				3	P	seedling	Gov, NGO	Lo, We, Fr, Fn
14	*Psidium guajava*	Zeituna (Am)	E	Myrtaceae	x					3	P	seedling	Pr, Wld	Pru, We, Fr, Fn
15	*Annona senegalensis*	Giishta (Am)	I	Annonaceae	x					3	P/R	seedling	Pr	Lo, We,Fr
16	*Acacia species*	Laaftoo (Or)	I	Fabaceae	x	x		x		2,6,7,10	R			Lo, Pru
17	*Polyscias fulva*	Kariyoo (Am)	I	Araliaceae		x		x		1,6	R			
18	*Ficus sur*	Harbuu (Or)	I	Moraceae	x	x		x		1,2,5,6,7	R			Lo
19	*Citrus sinensis*	Birtukaana (Or)	E	Rutaceae	x	x				3	P	seedling	Pr	We,Fr
20	*Sesbania sesban*	Sasbaaniyaa (Or)	I	Fabaceae	x	x				4,6,7	R			Po,Fn, We
21	*Ficus thonningii*	Dambii (Or)	I	Moraceae	x	x		x	x	7,10	R			Po
22	*Ficus vasta*	Qilxuu (Or)	I	Moraceae	x	x		x		2,6,11	R			
23	*Ekebergia capensis*	Somboo (Or)	I	Meliaceae	x	x				6	R			
24	*Casuarina cunninghamiana*	Shawshawwee (Or)	E	Casuarinaceae	x					8	P	seedling	Gov	Pru

25	*Spathodea nilotica*	Spaatoodaa	E	Bignoniaceae	x	x				1	P	seedling	Gov, NGO	
26	*Leucaena leucocephala*	Lukiinaa(Or)	E	Fabaceae	x	x				4	P	seedling	Gov	Po, Fn, We
27	*Entada abyssinica*	Ambaltaa (Or)	I	Fabaceae		x				6	R			
28	*Sapium ellipticum*	Bosoqa (Or)	I	Euphorbiaceae		x				1,2,6	R			
29	*Bersama abyssinica*	Lolchiisaa (Or)	I	Melianthaceae		x				6	R			
30	*Pittosporum viridiflorum*	Soolee (Or)	I	Pittosporaceae		x				6	R			
31	*Oncoba spinosa*	Akuukkuu (Or)	I	Flacourtiaceae		x				6	R			
32	*Premna schimperi*	Urgeessaa (Or)	I	Verbenaceae		x				6	R			
33	*Ehretia cymosa*	Ulaagaa (Or)	I	Boraginaceae		x				6	R			
34	*Ficus sycomorus*	Odaa (Or)	I	Moraceae		x				6	R			
35	*Olea welwitschii*	Bayaa (Or)	I	Oleaceae	x	x				7	R			
36	*Podocarpus falcatus*	Birbirsa (Or)	I	Podocarpaceae				x		1,6	R			
37	*Vernonia amygdalina*	Eebicha (Or)	I	Asteraceae				x	x	2,4,10,11	R			Po
38	*Dovyalis abyssinica*	Koshim (Am)	I	Flacourtiaceae					x	11	R			
39	*Prunus africana*	Hoomii (Or)	I	Rosaceae		x				6	R			
40	*Apodytes dimidiata*	Wandabiyyoo (Or)	I	Icacinaceae		x				6	R			
41	*Syzygium guineense*	Baddeessaa (Or)	I	Myrtaceae		x				6	R			
42	*Hagenia abyssinica*	Heexoo (Or)	I	Rosaceae		x				6	R			
43	*Pouteria adolfi-friedericii*	Qararoo (Or)	I	Sapotaceae		x				1,6	R			
44	*Maytenus arbutifolia*	Kombolcha (Or)	I	Celastraceae		x				2	R			Lo

- Or-Afaan Oromoo, Am-Amharic, I-Indigenous, E-Exotic, P-planted, R-retained
- 1-Timber,2-Fuelwood, 3-Food, 4-Fodder, 5-Construction, 6-Shade, 7-Soil and water conservation, 8-Aesthetic, 9-traditional medicine, 10-Life fence, 11-Beehive
- Gov- Government nursery, NGO-Non-government organization nursery, Pr-Private nursery, Wld-wildings
- Co-coppicing, Po-pollarding, Lo-Lopping, Pru-Pruning, Fn-Fencing, Mu-Mulching, We-Weeding, Fr-Fertilizing, Tn-Thinning

Appendix II. Endangered indigenous tree species

No.	Local name	Scientific name	Freq.	Percent	Rank
1	Birbirsa	*Podocarpus falcatus*	92	67.65	1
2	Heexoo	*Hagenia abyssinica*	83	61.03	2
3	Qararoo	*Pouteria adolfi-friedericii*	78	57.35	3
4	Waddeessa	*Cordia africana*	74	54.41	4
5	Ejersa	*Olea africana*	71	52.21	5
6	Oomoo	*Prunus africana*	67	49.26	6
7	Somboo	*Ekebergia capensis*	66	48.53	7
8	Qilxuu	*Ficus vasta*	63	46.32	8
9	Harbuu	*Ficus sur*	52	38.24	9
10	Bosoqa	*Sapium ellipticum*	49	36.03	10
11	Laaftoo	*Acacia species*	48	35.29	11
12	Ambabbeessa	*Albizia gummifera*	34	25.00	12
13	Baddeessaa	*Syzygium guineense*	29	21.32	13
14	Kombolcha	*Maytenus arbutifolia*	25	18.38	14
15	Bakkanniisa	*Croton macrastchyus*	17	12.50	15
16	Eebicha	*Vernonia amygdalina*	9	6.62	16
17	Kariyoo	*Polyscias fulva*	8	5.88	17
18	Askiraa	*Milletia ferruginea*	7	5.15	18
19	Soolee	*Pittosporum viridiflorum*	5	3.68	19
20	Wandabiyyoo	*Apodytes dimidiata*	4	2.94	20

Appendix III: Semi-structured interview questions with farming community

A) Personal data (Socio economic and demographic information of the respondent)

- Enumerator: _____
- Woreda: _____
- Kebele (PA): _____
- HH: ____
- Sex: _____
- Age:_____
- Marital status: _____
- Family size (number): _____
- Educational status (grade): _____
- Farm land size (hectare): _____

B) Main questions

I. Purpose of planting trees by smallholder farmers

1. Are you familiar with tree planting activities? 1) Yes 2) No
2. Can you list some of them and the benefits you get from them (put '**x**' under your selection)?

No	Tree species (local name)	Benefits									
		Tm	Fw	Fd	Fdr	Cn	Sd	SWC	Aes	Md	Lf

where, *Tm-timber, Fw-fuel wood, Fd-Food, Fdr-Fodder, Cn-Construction, Sd-Shade, SWC-soil and water conservation, Aes-Aesthetic, Md-Medicine, Lf-Live fence*

3. What type of planting material do you use for each tree species (seed, seedling, vegetative?

No	Tree species (local name)	Planting material	Source of planting material

II. Planting site preference by smallholder farmers

4. Do you have preference of the site characteristics for plantation for each tree species? 1) Yes 2) No
5. If yes, would you identify for each tree species (put 'x' under your selection)?

No	Tree species (local name)	Preferred site for plantation				
		Homegarden	On farm	Woodlot	Grazing land	Farm boundary

6. What types of planting activities do you prefer for indigenous trees? 1) Mono plantation of single tree species 2) Mixed plantation of different tree species 3) I don't know

III. Tree management activities by smallholder farmers

7. What are the plantation management activities did you undertake for each tree species (put 'x' under your selection)?

No	Tree species (local name)	Management activities							
		Cp	Pl	Lp	Pr	Fn	Ml	Wd	Fr

where, Cp-coppicing, Pl-pollarding, Lp-lopping Pr- pruning, Fn-Fencing, Ml-Mulching, Wd-weeding, Fr-Fertilizing

IV. Status of indigenous tree species of the area

8. What do you think on the status of indigenous tree species in your area (fill the next table)

No	Tree species (indigenous)	Status (put "x" under your selection			Reason
		increasing	decreasing	No change	

9. Are there trees threatened from your area today? 1) yes 2) no If yes, please mention the names of these trees.
   a. _____ d. _____
   b. _____ e. _____
   c. _____ f. _____
10. What do you think on the factors that threat them?
    a. _____ d. _____
    b. _____ e. _____
    c. _____ f. _____

Appendix IV: Tree assessment data collection format

Enumerator: _____ Kebele: _____

HH code: _____ Altitude: _____

District: _____ Assessment date: _____

No	Landuse type	Area (ha.)	Tree species (local name)	Origin (I/E)	Total trees	Natural/planted