Jimma University

College of Natural Sciences

School of graduate study

Department of Biology

Scattered woody species diversity in different land use types in Mana district, Jimma Zone, Southwest Ethiopia

A thesis Submitted to the Department of Biology, College Of Natural Sciences, Jimma University, in Partial Fulfillment of the Requirements for the Degree of Master of Science in Botanical sciences

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October, 2019

Jimma, Ethiopia

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Acknowledgement

First of all I would like to thank my advisors professor Kitessa Hundera and Mr. Desalegn Raga for guiding me during this research work. I would also like to thank Department of Biology, Research and Post graduate Office and Herbarium of Jimma University for their support. I also thank Mana District Agriculture and Natural Resource offices ,study sites development agents (DAs) for material provision and valuable contribution in data collection; the local residents of the study area who contributed to conserve those isolated woody species and those kind enough to share their knowledge and experiences without reservations in data collection. Finally, I would like to thank my family members and friends who supported me morally and financially from the beginning to the end of this study.

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List of Acronyms

BA -Basal area

CSA -Central Statistics Agency

DBH-Diameter at breast height

GPS-Global Positioning System

RAMA-Routine Agricultural Management Activity

SSA -Sub-Saharan Africa

TOF-Trees outside Forests

WCMC- World Conservation Monitoring Center

Abstract

Scattered wood species are found in different land use systems in diverse density. Those isolated woody species are declining in different land uses. The study was conducted to assess isolated woody species diversity in different land use types of Mana district, Jimma zone, Southwest Ethiopia. The study was conducted from October 2018 to September 2019. Three study sites were selected based on the presence of crop land, pasture land and coffee farm. Transect line laid at a distance of 500m systematically and along this transect plots laid at an interval of 200m in study sites. Fifty four (54) sample plots having an area of 100m×100 m, laid along transect lines. Descriptive statistics was used to show the population density, tree height, DBH and basal area (BA) for each isolated woody species. The evenness and diversity of woody plants was analyzed using the Evenness Index (E) and Shannon-Wiener Diversity Index (H'). Sorenson's similarity index was used to calculate the similarity of different land use types in richness of isolated woody species. A total of 56 scattered woody species belonging to 49 genera and 33 families were identified and documented from three land uses. Out of identified woody species, 46 (82.143%) species were trees, 10 (17.85%) species were shrubs. The Fabaceae was the most dominant family followed by Euphorbiaceae and Moraceae. In terms of species diversity grazing land is more diversified (with H' 3.3, E=0.889). The highest similarity index showed in current study 0.864 between coffee farm and pasture land. In study areas some scattered woody species were decreasing due to human activities. Therefore; Practices which aimed at maintaining these scattered woody species should be encouraged and applied to support the conservation of those species in different land uses.

Keywords: Coffee farm, Crop land, Isolated woody species, Land Use Types and Pasture land.

1. Introduction

1.1. Background of the study

Ethiopia is a country with greatly varying landscapes ranging from high and rugged mountains, flat-topped plateaus, deep gorges and incised rivers to valleys and rolling plains. The geographical location of Ethiopia covers wide agro-climatic zones and very significant biodiversity. This wide geographical condition of Ethiopia has created diverse and convenience environments for the survival and development of a variety of flora and fauna. According to WCMC (1994), Ethiopia is one of the top 25 biodiversity rich countries of the World.

The term scattered woody species refers to woody species that are scattered in different land uses occurring in pasture land, coffee farm, crop fields, along roadsides and around homes and that occur in varying densities (Harvey and Haber, 1999). Isolated trees also referred to as scattered trees, pasture trees, paddock trees, remnant trees and trees outside forests (TOF) (Gibbons *et al*., 2008; Manning *et al.,* 2006). The concept of "Trees outside Forests" emerged in 1995 to designate trees growing outside the forest and not belonging to Forest or Woody Land (Kleinn, 2002) and increasingly recognized as a prominent feature of agricultural landscape. A unique defining feature of scattered trees is their dispersed, open pattern in a landscape (Foresta *et al*., 2013). In some areas, isolated trees from a single species or group of species may dominate the landscape or isolated trees with no single species or group of species being dominant.

Scattered woody species have variable origin naturally regenerated, left when the forest was originally cleared, actively planted by farmers or were once part of a vast woodland ecosystem that has now been largely replaced by agriculture. Isolated trees typically are retained in pastures and agricultural areas because of their importance (Bird *et al* 1992).

For example, pastures in the mountains of Costa Rica often contain a local alder species (*Alnus acuminata*), genus of flowering plant; belong to family Betulaceae because farmers plant this species to provide timber. In modified landscapes, scattered trees can often result from the modification of denser or more intact forests (Harvey and Haber, 1999).

Scattered trees have been nominated as keystone structures (keystone features) because of their high ecological importance relative to their low abundance (area of cover) (Plieninger *et al.,* 2004; Manning *et al*., 2006). Isolated trees are also conspicuous features of many fragmented tropical landscapes, occurring in pastures in Central America, South America, Australia and African parklands (Manning *et al*., 2006). Despite the increasing recognition of the ecological importance of scattered woody species, they were ignored in natural resource assessments, absent from statistics, policy and legislation and only mentioned in the public discourse specially over the last two decades, they are still largely ignored from both a theoretical and applied perspective, being rarely considered in research programs and in management plans to restore and conserve landscapes (Barth *et al*., 2015;Réti and Craioveanu, 2017).

In Ethiopia, these scattered trees occurred in different land use systems such as in the public land, coffee farm, crop fields and along roadsides (Tesfay Teklay, 2005). Some of these woody species were left when the natural forest was converted to other land use system; others regenerated after the land was cleared or were actively planted by farmers. For example, parkland agroforestry in the farmland of Northern Ethiopia often contain a local momona species (*Faidherbia albida*) because farmers plant or maintain this species to provide soil quality and productivity (Tesfay Teklay, 2005). Farmers are growing and conserve trees on their agricultural land for different variety of products and services, and manage a mix of invasive and indigenous trees in different ways (Nyaga *et al*., 2015). Isolated trees typically retained in agricultural areas because of their value as sources of timber, firewood, charcoal, fruits, as shade and feed for livestock, medicines and natural gums (Kuyah *et al.,*2016). Also used as sources of organic matter for improving soil fertility or because their cutting is prohibited by law. They may also be retained or planted to beautify the farm landscape and increase its economic value (Bird, 1992).

Ango *et al.* (2014) also indicated that many trees are retained in the agricultural landscape.Different types of land uses might be associated with certain tree compositions. For instance, certain species might be preferred in pasture land as shade for the animals (Esquel et al., 2008), while others are important as nitrogen fixers in arable fields. In some landscape live fences are common and again certain species may be chosen for such structures

The variation in biodiversity in many agricultural landscapes is due to different factors .. The most important driver is of course the management by the farmers. They decide where to plant or retain trees, at which densities and which species (Ango *et al.*, 2014).

Coffee (Coffea arabica L.) is a major crop in SW Ethiopia. It is a native species in the understory of forests, but is also actively managed in many different parts of the landscapes. The most common traditional coffee cultivation system in Ethiopia is semi-forest coffee (SFC) characterized by an active management of coffee, but still under a more or less natural canopy of original forest trees (Lemessa Kumsa *et al*.,2016 ;Kitessa Hundera *et al*., 2013)

Agriculture is the main backbone of the economy and also is the major occupation of Ethiopian population (MoMe, 2003). The increment of population growth has changed the land cover systems and caused environmental degradation in many developing countries including Ethiopia (Feoli *et al.*, 2002). Cropland agroforestry is the integration of trees on farms that diversifies agricultural landscapes and sustains production for improved social, economic and environmental benefits. In general, isolated woody species diversity in agricultural land (grazing land, crop land and coffee farm) is those isolated from the forest and distributed in agricultural lands.

1.2. Statement of the problem

Scattered woody species are very important elements and conspicuous features of many fragmented landscapes globally. In Ethiopia, these scattered trees occurred in different land use types (Tesfay Teklay, 2005). Also scattered woody species have many ecological functions in landscapes (Rossi, 2016). Though, scattered woody species are declining in different land uses due to population growth and to make way for agricultural machinery, lack of sufficient recruitment due to intensive grazing by stock cultivation, competition with other plant species and introducing of exotic species. In addition in Africa, as in many other parts of the world, trees on farms are often ignored in research and policy making. Forestry focus mostly on trees in forests not on scattered trees that are found outside of forest. Also in agriculture and livelihood studies, the focus is typically on annual crops and their effects on household income. There are a few reports in diversity of woody species in different land uses of Southwestern Ethiopia. There is no any report on the isolated woody species diversity in pasture land, crop land and coffee farm of Mana district. Therefore, the study was carried out to collect, identify and record isolated woody species diversity in crop land, coffee farm and grazing land and to create awareness on conservation of isolated wood species in the community.

Research question

- Which isolated woody species are found in different land use of the study site of Mana district?
- Which land use (crop, pasture and coffee farm) has more diversity of isolated woody species?
- What is the common conservation practices carried out in the study area to conserve isolated woody species?

1.3. Objectives of the study

1.3.1. General objective

The general objective of the study was to assess the diversity of isolated woody species in a farmscape in different land use types of Mana district, Jimma zone.

1.3.2. The specific objectives of the study were:

- To asses and document the isolated woody species in crop land, pasture land and coffee farm of study sites
- To compare the isolated woody species diversity in different land use types of the study area
- To investigate the diversity of isolated woody species
- To identify conservation methods used by local peoples of study sites

1.4. Significance of the study

The result of this study will be used to show the diversity of isolated woody species among different land use types in Mana district. Also the study will be in raising awareness in the effective conservation and management system of the isolated woody species. Furthermore, the results of the study will provide a good feedback for various governmental, nongovernmental organizations and private investors who need to contribute for conservation, management and sustainable utilization of isolated woody species.

2. Literature Review

2.1. Over view of isolated woody species diversity

Agricultural lands are important components of land use in many parts of the world. Scattered trees and shrubs occurring throughout the farmland matrix are important features of agricultural landscapes (crop land, pasture land and coffee farm) around the globe; including southern Europe, North America, Central America, Africa and Australia. Zomer *et al.* (2014) estimated that close to 50% of global agricultural land has more than 10% tree cover. Approximately one-third has more than 20% tree cover and about 7% of global agricultural land has more than 50% tree cover. One third of the agricultural land in Sub-Saharan Africa is estimated to have had at least 10% tree cover during 2008-2010 (Zomer *et al.*, 2014).

Isolated trees may represent a higher floristic and structural diversity depending on the tree origin, density, scattered within the different land uses and management by farmers. Although the floristic diversity represented by isolated trees is highly variable, in some regions these trees may represent a significant portion of the original tree species present in the forest. For example, isolated trees in pastures of Monteverde, Costa Rica, represented 60 percent of the species present in the study area (Harvey and Haber, 1999), whereas isolated trees in pastures in Veracruz, Mexico, represented 33 percent of the total rainforest tree flora, while at greatly reduced densities. In the traditional agricultural systems where farmers cut trees to provide mulch for crop production, tree diversity within the system can be relatively high because many trees survive despite being cut in subsequent years (Barrance *et al*., 2003).

Scattered trees are declining in Australia, Central America, North America, Europe and Asia (Bird, 1992). The decline of scattered trees are increasingly recognized as a threat to biodiversity and associated ecosystem services, both in the academic literature and increasingly in conservation policy (Fischer and Mayer, 2002). Scattered trees are declining also in Africa. In Africa, as in many other parts of the world, trees on farms are often ignored in research and policy making. Forestry focus mostly on trees in forests not on scattered trees that are found outside of forest. Also in agriculture and livelihood studies, the focus is typically on annual crops and their effects on household income. When perennials (such as coffee trees) are considered, it is mostly from a value chain perspective. Little remains known about their prevalence and economic contribution, particularly at the national scale (Foresta *et al*., 2013).

In some areas, isolated trees from a single species or group of species may dominate landscape. For example, in Moropotente, Nicaragua; pastures are dominated by *Acacia penatulata,* which occurs at mean densities of 240 trees per hectare (Nieto *et al.*, 2001). Maize plots in Ilobasco, El Salvador, are dominated by *Cordia alliodora* trees that occur at mean densities of 86 trees per hectare (Garcia Rodriguez *et al*., 2001). In contrast, the species composition of isolated trees differs widely among pastures in Veracruz, Mexico with no single species or group of species being dominant. In Africa ,different countries dominate by various species of isolated trees for example, in Uganda, isolated Guavas (*Psidium guajava*) in study area is dominant species, supported high levels of frugivorous bird richness, which increased the density of seed rain and proportion of late-succession recruits under their canopies. *Grevillea robusta* was its dominance as a scattered tree species in Rwanda. The parklands of Burkina Faso, West Africa, are dominated by *Vitellaria paradoxa* and *Parkia biglobosa* which produces edible fruits and a few other species such as *Faidherbia albida.*

2.2. Scattered woody species in different land use of Ethiopia (Crop land, pasture land and coffee farm)

Scattered trees within crop fields, pasture lands and coffee farms are common features of Ethiopian landscapes, which dominate both economic and social activity for millions of farmers in the country (Yemenzwork Endale, 2017). With the exception of commercial crops grown in large expanses (example, sugarcane, pineapple, and banana), most tropical agricultural landscapes contain at least some trees, although the density, diversity and spatial arrangement vary significantly between sites (Paap, 1993). While the contribution of isolated trees to environmental sustainability is well established (Tscharntke *et al.*, 2011) their impact on agricultural productivity is often based on specific location ,tree species dependent and greatly varies with tree-crop configuration in the fields (Siriri *et al.*, 2010). Isolated trees includes some dominant scattered tree species like, *Cordia africana, Acacia tortilis, Croton macrostachyus* and *Faidherbia albida.* Scattered *Cordia africana* trees in particular are common features across the agricultural landscapes of Ethiopia. People's preference its timber for household furniture made of *Cordia africana*, highly affected its population density in the wild and now days are limited to the private farms and home gardens in southwest Ethiopia (Desalegn Raga and Dereje Denu, 2017). Because of this, farmers have intentionally retained this valuable species on their farms.

A shade grown coffee farm practice is one of the land uses that contain various types of plant species diversity. As the name specifies it contains different types of shade tree species and coffee shrubs as the major component. Due to the high income source, coffee based agro forestry practices are strongly developed and cultivated by many farmers. Because of the reduction of land and the need to increase income from coffee monoculture system, the introduction of multi-purpose timbers species in to this system is a good system to get different benefits at the same time. Many small coffee farms around the world integrate trees as part of the production system, as wind breaks and to protect the coffee plants from excessive sun and high temperature (Travis and Adel, 2010).

In Ethiopia the coffee shade based agro forestry practices also conserve various native woody species (Mesele Negash, 2015). In their assessment of socio-economic benefits of coffee shade trees in Ethiopia Diriba Muleta *et al*. (2011) stated that farmers retain shade trees in their coffee farms based on leaf and tree height and their impact on coffee yield. They also reported farmers' knowledge on the disadvantages of growing coffee without shade. In the traditional coffee management systems in Southwest Ethiopia, farmers select certain species of trees as coffee shade tree and remove others which they believe having an adverse effect on the coffee shrub growth and productivity Kitessa Hundera (2016). Farmers generally select healthy trees and retain in their coffee farms that have valuable timber, firewood, provide fruits for humans, serve as cattle forage and honey production (Soto-Pinto *et al.*, 2007; Diriba Muleta *et al*., 2011; Barrance *et al*., 2003).

2.3. Some major benefits of scattered woody species

2.3.1. Improve soil fertility

Perennials, either planter owing tree species or naturally grown scattered mature trees in crop fields, have been encouraged as an affordable and sustainable means to improve and sustain soil fertility for small holder farmers in SSA (Glover *et al.*, 2012). They can be used to minimize the problem of soil fertility decline, which is reported to have an indirect negative impact on household food security in Ethiopia. Agricultural soils under large trees contain more soil moisture, carbon and nitrogen than soils under small trees or away from tree cover and sources of organic matter for improving soil fertility. It regulates nitrogen dynamics, mitigation of erosion and carbon sequestration (Cottee-Jones *et al*., 2015). On farm trees contribute to soil fertility due to their organic inputs during the nutrient cycling (Desalegn Raga and Dereje Denu, 2017).

2.3.2. Act as regeneration of nuclei

In recently disturbed ecosystems, scattered trees can act as regeneration nuclei. The concept of nucleation is used to describe the spreading of recovery from many different foci following a disturbance and is a particularly important function of scattered trees. This can be in the form of seed directly from the trees or indirectly from seeds deposited in droppings by organisms attracted to the trees, such as birds and bats. If the fields or pastures are later uncontrolled, the reservoirs of woody seedlings that grow beneath remnant trees serve as nuclei for forest regeneration, accelerating the rate at which the land returns to forest (Guevara and Labored, 1993). Natural regeneration is a substantially cheaper and ecologically preferable form of restoration than tree planting (Manning, 2006)

2.3.3. Increase landscape heterogeneity

Scattered trees increase landscape heterogeneity on farm land biodiversity and thereby can increase the conservation of insect species diversity in simplified landscapes. An isolated tree is a ‘living zoo’, supporting many of the elements of the invertebrate fauna that formerly occupied the landscape. Over 1600 species, from 67,000 individual insects, were found associated with single Eucalypt paddock trees in NSW and the wheat belt of W. Compared to sites with no trees, even a small increase in the number of trees in agricultural land markedly increases the numbers of species of bats and birds present. In fact, the presences of a single tree can double the number of bird species (Fischer *et al.,* 2010). This is as a result of high ecological importance of scattered trees relative to their low abundance (area of cover) (Plieninger *et al.,* 2004; Manning *et al*., 2006). Trees are considered to be key structures in enhancing biodiversity in many types of agricultural landscapes (Perfecto and Vandermeer, 2002).

2.3.4. Source of income

Isolated trees typically are retained in pastures and farm land areas because of their value as sources of timber, firewood, building materials and fruits. They may also be retained or planted to beautify the farm landscape and increase its economic value (Bird, 1992). *Cordia africana* is an economically important asset providing many uses and services to farmers in Oromia. Because of this, farmers have deliberately retained this valuable species on their farms. Western Oromia is notable for providing high quality furniture and household materials made from *Cordia africana* trees to other parts of the country. The income generated from the sale of these products and the timber itself, is one of the mechanisms of making a livelihood for many rural poor (Abebe Yadessa *et al*., 2009).

2.3.5. Food, shade and some other importance

Scattered trees have many ecological functions in landscapes, for example, forage for cattle (Rossi, 2016). It is habitat or shelter and shade for stock. Many small coffee farms around the world incorporate trees as part of the production system, as wind breaks and to protect the coffee plants from excessive sun and high temperature. In Ethiopia the coffee shade based agroforestry practices indirectly conserve various native woody species (Travis and Adel, 2010). Isolated trees in agricultural fields serve as critical nesting, feeding and roosting sites for a variety of bird and bat species, many of which are forest species. They also provide transient habitats for many Neotropical migratory birds and enhancing landscape connectivity by acting as stepping stones (Derroire *et al*., 2016). Isolated and widely spaced trees have a high root volume and potentially intercept and pump considerable volumes of subsurface water, thus helping to reduce salinity risk (Saunders and Hobbs, 1995). For example big scattered trees provide substrate for epiphytic plants (Hylander and Nemomissa, 2008) or fruits on which birds and bats feed (Harvey *et al.*, 2006).

Tree on the agricultural landscape is also important in enhancing farmers' adaptive capacity and reducing the susceptibility of farming systems to climate change impacts. In addition, trees provide a wide range of environmental benefits such as control of erosion and storing a significant amount of carbon on both above and below ground in the form of soil organic carbon. Also in some regions, isolated trees have enhanced cultural status through their associations with major religions, local faiths or traditional belief systems. For example, Ficus trees are used as sites of worship in many faiths and taboos on cutting down large Ficus trees have been reported from several sites across Asia. The cultural standing of Ficus trees may be instrumental in conserving their populations in rural landscapes by lowering mortality from direct felling by, potentially increasing their importance as food sources for frugivores and restoration sites for plants (Wilson and Wilson, 2013).

2.4. Threats of scattered woody species

2.4.1. Human activity

The most direct threat to all scattered trees is human activities. For example, the legal and illegal removal of scattered trees is widespread in Australian grazing landscapes (Gibbons and Boak, 2002). Similarly, widespread land clearing continues in some Central American landscapes. Clearing of paddock trees in an agricultural area is currently already permitted as a Routine Agricultural Management Activity (RAMA). The RAMA permits the clearing of isolated paddock trees. 200 trees can be cleared per 1000ha per notification. But paddock trees will be one of the big losers from the new Biodiversity and Local Land Services Amendment Bills should they become law.

In cropping landscapes, trees are cleared to make way for agricultural machinery. In livestock grazing landscapes, trees are declining because of a combination of natural or accelerated tree mortality coupled with widespread recruitment failure. Intensive agriculture is associated with the decline of scattered trees. Farmers may protect individual trees by clearing around the stem when they are saplings. To minimize competition between the trees and agricultural crops or pastures, farmers not only regulate tree densities and arrangements but also cut the lower branches of trees to reduce shade (Barrance *et al*., 2003). Thus, tree management by farmers influence diversity of scattered woody species and the potential of the land to conserve biodiversity. Scattered trees are declining in remnant oak (*Quercus*) woodlands in Europe, North America and Asia, remnant Eucalyptus and Allocasuarina woodlands in Australia. In Australia, scattered trees are more likely to be lost in crop lands than in grazing landscapes (Ozolins *et al*., 2001); rainforest remnants in Central America and grazed landscapes, such as Aspidosperma stands in arid South America. These declines are due to clearing , lack of sufficient recruitment due to intensive grazing by stock cultivation ;browsing by dense populations of invertebrate and vertebrate herbivores; competition with other plant species.

Tropical agricultural landscapes has received little attention regarding how trees and associated biodiversity are distributed, perhaps due to a focus on tropical forests and the negative effects of fragmentation on its biodiversity (Tabarelli *et al*., 2004). Also in Ethiopia, much focus has been on forest decline (Hylander *et al*., 2013) and how the forest composition is affected by various forms of disturbances. Moreover, substantial research has been devoted to the study of the effect on biodiversity of the traditionally so called semi-forest coffee production system (Taye Jaraa *et al*.,2017; kitessa Hundera *et al*., 2013). This is a system of coffee production in which natural forest coffee is managed to give higher yields or when improved varieties of coffee is planted under a thinned canopy of indigenous trees .

In any case are open agricultural landscapes and landscapes with homegardens widespred and so far, quite few studies are available on the distribution of trees and associated biodiversity in such areas in Ethiopia. One type of landscape that have been identified for its high density of trees is the coffee/ensete agricultural system of the Sidama people in southern Ethiopia (Abebe *et al*., 2010).

Intensive monocultures of Eucalyptus plantations have attracted much criticism because the species have been considered to deplete soil nutrients, decrease available water resources, suppress ground vegetation by secretion of allopathic chemicals and favor weeds before native plants. For example, the regeneration of native tree species was poor in Eucalyptus plantations when compared with that in other exotic plantations such as with Cupressus, Pinus, and Grevillea in southern Kenya (Thijs *et al*., 2014). However, several studies have shown that not all Eucalyptus plantations have suppressed vegetation, but instead natural recolonization by native trees can sometimes take place in the understory of Eucalyptus plantations. For instance, one study reported 123 native species in plantations of Eucalyptus grand is in Brazil, which was the same number as in adjacent natural forests. Another example is that the number of native trees as well as their cover could be higher in plantations of Eucalyptus than that in other plantation species(Telila *et al*., 2015).

2.4.2. The tree root pathogen (poor tree health)

Scattered trees may be threatened by poor tree health. In the Mediterranean, the tree root pathogen *Phytophthora cinnamomi* is causing a severe decline of oak species (Quercus spp.) (Plieninger *et al.*, 2003). In Australia, rural dieback of eucalypts, where trees are severely defoliated, is leading to large-scale and premature tree death. It is caused by complex interactions between numerous biotic and a biotic factors, including land management practices.

2.4.3. Lack of natural regeneration

A slower, but equally problematic, threat to scattered trees is the lack of natural regeneration. Recruitment failure is often related to high grazing pressure and may be a problem in natural, cultural and recently modified landscapes with scattered trees. Reduced recruitment of scattered trees has been reported in African, savannas, Central American farming, landscapes, dehesas , British wood-pastures and temperate Australian grazing areas. In the latter, the lack of recruitment threatens the persistence of scattered trees across vast areas of the wheat-sheep zones in eastern and Western Australia (Manning, 2006). In these landscapes, scattered trees without any younger generations of trees are the living dead because many scattered trees are dying of old age, a study in eastern Australia estimated a narrow window of opportunity spanning only a few decades in which large-scale tree regeneration will be possible (Dorrough and Moxham, 2005). In many human-modified landscapes around the world, isolated woody species face a regeneration crisis, where high mortality together with low recruitment are predicted to cause major population decreases (Fischer *et al.*, 2010).

2.4.4. Salinity

Salinity can be an additional threat to scattered trees in both natural and human-dominated dry ecosystems. Scattered trees contribute to maintaining the ground water table at naturally low levels. The removal of scattered trees, in turn, can lead to a rising ground water table, which can bring naturally occurring salts to the surface. The widespread removal of trees in temperate Australia has led to large-scale salinity problems, which now threaten both biodiversity and agricultural productivity. Similar mechanisms also have led to increased salinity in some natural ecosystems such as the Negev desert in Israel (Saunders and Hobbs, 1995).

2.5. Way of mitigation of scattered woody species decline

Preserving a cover of scattered mature trees should be an objective for the sustainable management of agricultural landscapes. In addressing the isolated tree recruitment crisis, several studies have recommended increasing recruitment rates. While improving recruitment is certainly a major issue, it must be accompanied by reducing mortality in mature trees. In the absence of management strategies that address both issues, isolated trees in human landscapes may in fact be the fast-disappearing' living dead' (Harvey *et al.*, 2011).

Indirectly promoting scattered trees for soil conservation, biodiversity maintenance, climate change mitigation and multiple other ecosystem service is a valid goal in itself; there is a tendency for considering them as a solution for every problem that smallholder farmers face. For example, the Ethiopian government has planned to include a 100 million scattered Faidherbia *(Faidherbia albida)* trees into smallholder farms covering up to 15 million ha of land (Mekonnen Kindu *et al.*, 2013). The aim was to make the economy green and climate resilient, improve food security of smallholders, adapt to and mitigate climate change. Although such political will is encouraging, studies that explore natural functionalities by which presence of trees could enhance benefits have usually been less emphasized.

The centuries-old practice of managing scattered trees on crop fields has been suggested as one of the pathways for sustainable intensification of smallholder agriculture in the Ethiopia (Pretty *et al.*, 2011). It is for this reason the original submission to the Biodiversity Review panel urged the government to consider incentive payments for farmers dependent on their maintaining or establishing a minimum density of paddock trees per hectare.

3. Materials and Methods

3.1. Description of the study area

The study was conducted in Mana district, Jimma Zone, Oromia Regional state, Southwestern Ethiopia geographically located between 37° 39' -37°.52' N latitude and 36° 36' -36°53' E longitude. The administrative center of the district is Yebu, located at about 22km from Zonal capital Jimma. It has an area of 49,480 hectare (See figure 1). The district has a total population of 188,045 of which 95,409 were male and 92,636 female. The majority of inhabitants are Muslim (90.23%), while 8.44% of the populations are followers of Ethiopian Orthodox Christianity and 1.15% is Protestant (CSA, 2013). The district gets maximum and minimum temperature of 28ºc and 9ºc respectively while the mean annual rainfall is 1561mm. The altitude of the district lies in the range of 1470 and 2610m above sea level. Mana is one of the districts in Jimma zone where agricultural practices commonly carried out and isolated woody species are found in different land uses. A coffee farm agroforestry system is the major agroforestry in the district.

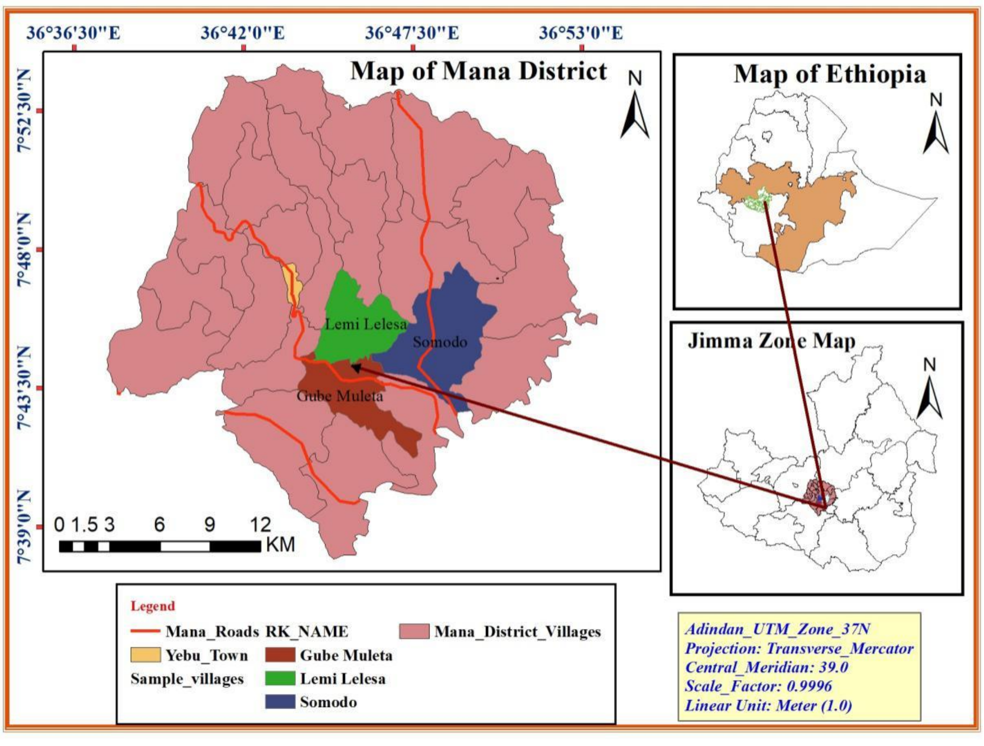

Figure 1 **:** Location map of the study area**.**

3.2. Methods

3.2.1. Reconnaissance Survey

Before staring the actual fieldwork and sample collection, reconnaissance survey was carried out through observation of the study areas in order to obtain information, identify the study site and verifies the land use types and sampling method from 9/10/18-12/10/2018.

3.2.2. Sampling Design

Nine transect lines were laid at a distance of 500m from each other in different land use types. Six plots (total 18 for each land use types) with a size of 100m ×100m (1ha) were laid at interval of 200m along each transect line.

3.2.3. Sampling technique and sample size determination

A purposive sampling method was used to select the study sites. Based on the existing land use types (crop land, grazing land and coffee farm), transect lines were aligned at an interval of 500m in each selected villages. The first transect line and the first plot was purposely selected. The data was collected from 54 total sample plots of each 1 hectare (100 m × 100 m).

3.2.4. Data collection

Data on isolated woody species was gathered from 54 plots (100mx100m) laid across three land use types from October 2018 to September 2019. All isolated woody species during this assessment were recorded in their local names from all plots by the help of local peoples. DBH of all isolated woody species (at 1.3m) ≥ 5cm (Hernandez, 2004) was measured and recorded using measuring tape and heights of all individuals were also recorded using Clinometer. For the stem abnormalities, RAINFOR protocol was followed (Phillips *et al*., 2009). Latitude, longitude and altitude of the study site were recorded by using Garmin 60 GPS (Global Positioning System). The collected specimens were taken to Jimma University Herbarium and identified by consulting advisors and referring to the published volumes of Flora of Ethiopia and Eritrea.

3.2.5. Data analysis

Descriptive statistical methods were employed to determine frequencies, relative frequencies, densities and relative densities. Shannon diversity index and Sorensen's index were used to estimate species diversity and similarity, respectively.

3.2.5.1. Density (D)

Density is the count of individuals per unit area. The density of isolated woody species was one of the most important structural parameters considered during data analysis. Density per hectare of trees and shrubs were calculated by summing up all stem across all sample plots and converted into hectare and explained by using graph.

.

$$\text{Relative Density} = \frac{\text{Number of individuals of a species}}{\text{Total number of all individuals}} \times 100$$

3.2.5.2. Basal area

The basal area for the isolated woody species was determined from the DBH measurement. Basal area of the woody species in the three land use types was calculated on Microsoft office excels 2007 using the following equation:

$$BA = \pi \left(\frac{D}{2} \right)^2$$ Where, $\pi = 3.14$

BA = basal area (m^2)

D = diameter at breast height

3.2.5.3. Frequency (F)

The number of plots in which a given species found in the study area is referred to as frequency. The frequency values was obtained reflects pattern of distribution as well as diversity. Relative frequency was calculated using the following formula:

$$\text{RF} = \frac{\text{Frequency of an isolated woody species}}{\text{Frequency of all isolated woody species}} \times 100$$

3.2.5.4. Species diversity index

Isolated woody species diversity was calculated by using Shannon diversity index (H') (Kent and Coker, 1992). The Shannon diversity index was calculated on Microsoft office excels 2007 using the following equation:

$$H' = -\sum_{i=1}^{s} Pi \, ln \, Pi$$

Where,

Pi is the relative abundance of the i^{th}species, ln is the natural logarithm.

3.2.5.5. Shannon's Equitability (E)

Evenness was calculated using the ratio of observed diversity to the maximum diversity using the following equation.

E = H'/H'max, H'max = lnS

Where, H' = Shannon-Wiener diversity Index

S = total number of species in the sample

ln = natural logarithm

3.2.5.6. Important value Index

The Important Value Index (IVI) is a composite index based on the relative measures of species frequency, density and basal area (Kent and Coker, 1992). It indicates the significance of species in the system. Importance value index for each isolated woody species was calculated by summing up relative density (abundance), relative frequency and relative dominance (basal area).

Relative dominance (RBA) $= \frac{\text{Basal area of species}}{\text{total basal area of the sample}} \text{x}100$

3.2.5.7. Sorensen's Similarity Index of isolated Woody Species

Similarity among the three land use types in woody species composition was calculated by using Sorenson's similarity index.

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

Where, a = number of common species

b = number of species unique to the first site

c = number of species unique to the second site

4. Results and Discussions

4.1 Results

A total of 56 isolated woody species belonging to 49 genera and 33 families were recorded from the three land use types. *Fabaceae* was the most species rich family recorded in the study area with 7 species. From crop land, grazing land and coffee farm 35, 41 and 49 scattered woody species were recorded respectively. There were high over lapping scattered woody species in land uses. Most of the collected scattered woody species were trees (See figure 2).

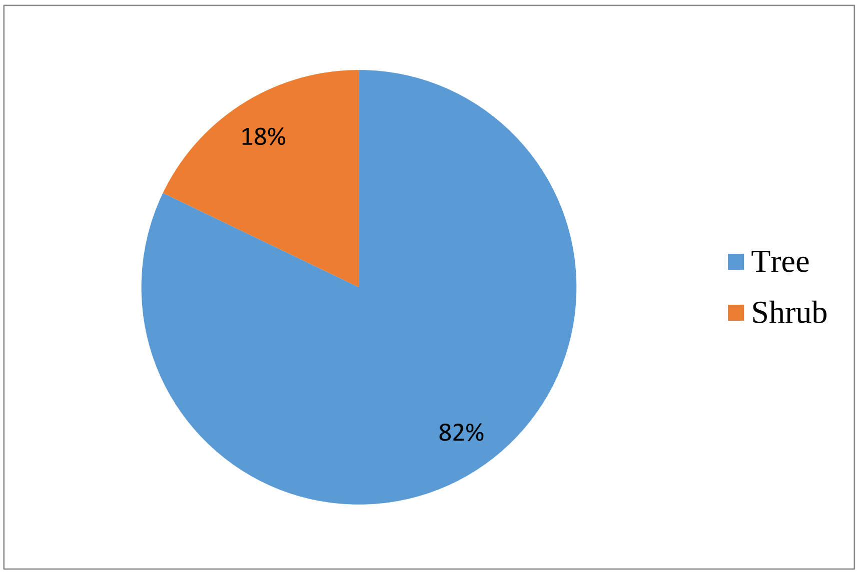

Figure 2: Habit of scattered woody species recorded from different land use types.

4.1. 2.Density of isolated woody species

703 individuals per hectare of 56 isolated woody species with $\geq$ 5 DBH were recorded from three land use types (cropland, grazing land and coffee farm). From the total individuals 160 (22.76%) were recorded from crop land, 172 (24.47%) grazing land and 371 (52.77%) were recorded from coffee farm. The result indicated that, the highest scattered woody species density was found in coffee farm followed by pasture land and crop land.

4.1.3. Diameter and Height class of scattered woody species

The scattered woody species collated from study areas were classified in to six classes (5-20cm, 20-35cm, 35-50cm, 50-65cm, 65-80cm and >80cm) in each land use type (See figure 3). Most of the scattered woody species grouped under lowest class DBH .This was due to farmers deliberately cut woody species with highest coverage like *Ficus vasta* because occupy large areas and crops under its shade give less quantity .

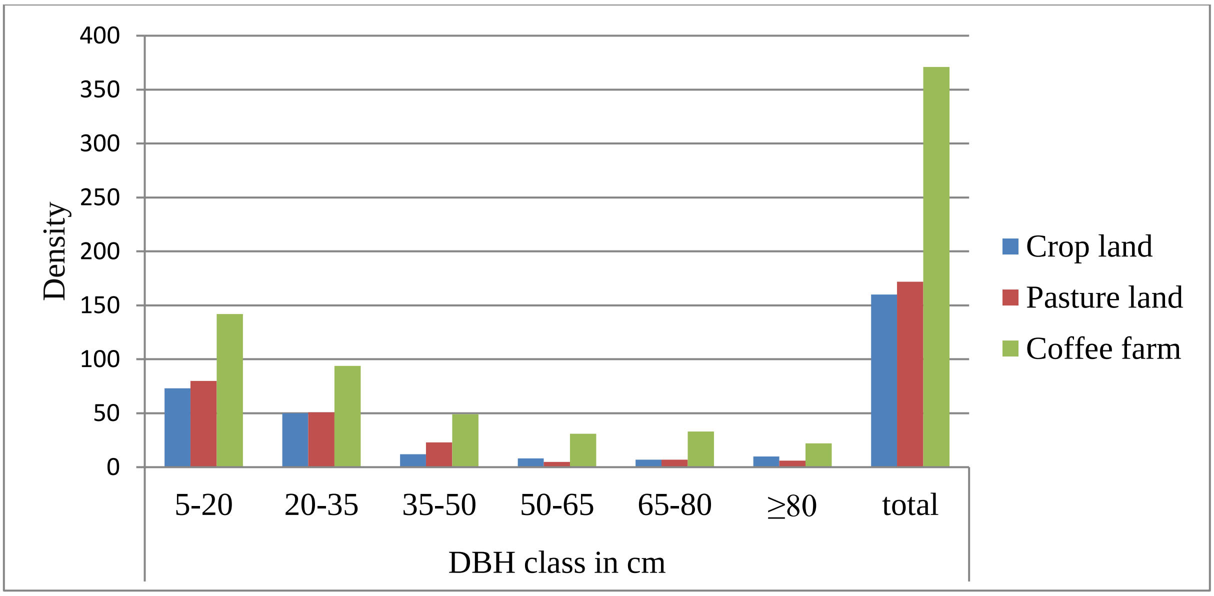

Figure 3: Diameter class of the three land use types.

Height is grouped in to three classes (<10 m, 10-15m and >15m) in each study site (See figure 4). In crop land and grazing land the highest percentage of scattered woody species under lowest class distribution. This is due to in crop land and grazing land farmers deliberately manage height of scattered woody species since its shade decreases the productivity. In coffee farm the majority of scattered woody species (46.63%) classified under medium class because coffee needs shade (10-15m).

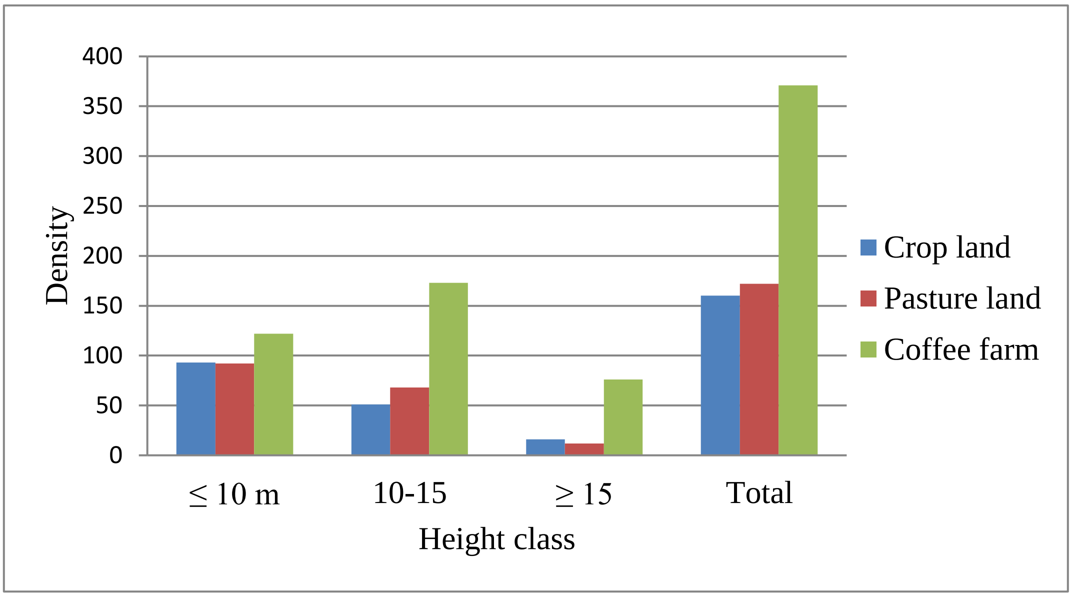

Figure 4: Height class of scattered woody species in three land use of study of area

4.1.4. Shannon-Wiener diversity index and evenness

Pasture land has the highest diversity of scattered woody species (Shannon diversity index H’) and Equitability (E) followed by Crop land and Coffee farm with the lowest diversity (Table 1).

Table 1: Isolated woody species diversity and evenness across the three land uses of study site.

Land use type	Species richness	Diversity index(H')	H'max (lnS)	Equitability
Crop land	35	3.13	3.56	0.879
Pasture land	41	3.3	3.71	0.889
Coffee farm	49	2.87	3.89	0.737

4.1.5. Sorenson's Similarity

Pasture land and coffee farm consists of the highest similarity 0.864 (86.4%) and 0.613 (61.1%) the lowest similarity was between Crop land and Pasture land (Table 2).

Table 2: Similarity of the three land use types in isolated woody species composition of study site of Mana district.

Land use type	Crop land	Pasture land	Coffee farm
Crop land	-	0.613	0.650
Pasture land	-	-	0.864
Coffee farm	-	-	-

4.1.6. Basal Area

From the individual stem count collected from crop land, *Eucalyptus camaldulensis* (BA/ha = 0.431) has relatively the highest BA/ha followed by *Podocarpus falcatus (*BA/ha = 0.283) (Table 4). *Albizia gummifera* (BA/ha = 0.250) and *Ficus ovata* **(**BA/ha = 0.130) species with the highest BA/ha in pasture land. In coffee *farmAlbizia gummifera* **(**BA/ha = *1.748)* and *Croton macrostachyus (*BA/ha = *0.278)* were species with highest BA/ha.

Table 3a: Basal area for ten most important woody species in crop land of study area of Mana district

NO	Scientific name	Local name	BA	BA/ha
1	*Podocarpus falcatus*	Birbirssa	5.0955	0.283
2	*Cordia africana*	Waddessa	3.415	0.189
3	*Ficus vasta*	Qilxuu	3.036	0.168
4	*Albizia gummifera*	Hambabessa	2.771	0.153
5	*Ficus ovate*	Qilinxoo	2.343	0.130
6	*Erythrina brucei*	Walensu	1.945	0.108
7	*Croton macrostachyus*	Bakkannisa	1.261	0.070
8	*Eucalyptus camaldulensis*	Bargamoo diimaa	0.776	0.431
9	*Prunus africana*	Omo	0.656	0.036
10	*Ricinus communis*	Qobboo	0.628	0.034

Table 3b**:** Basal area of ten most important woody species in pasture land

No	Scientific names	Local name	BA	BA/ha
1	*Albizia gummifera*	Hambabessa	4.515	0.250
2	*Ficus ovate*	Qilinxo	2.343	0.130
3	*Croton macrostachyus*	Bakkannisa	2.329	0.129
4	*Acacia abyssinica*	Lafto	1.071	0.059
5	*Cordia africana*	Waddessa	0.566	0.031
6	*Ficus vasta.*	Qilxuu	0.554	0.030
7	*Macaranga capensis*	Kofali	0.500	0.027
8	*Eucalyptus camaldulensis*	Bargamoo dimaa	0.435	0.024
9	*Syzygium guineense.*	Baddessaa	0.421	0.023
10	*Podocarpus falcatus*	Birbirssa	0.407	0.022

Table 3 c: Basal area of ten most important woody species in coffee farm

No	Scientific names	Local name	BA	BA/ha
1	*Albizia gummifera*	Hambabessa	31.472	1.748
2	*Croton macrostachyus*	Bakkannisa	5.0	0.278
3	*Cordia africana*	Waddessa	2.189	0.121
4	*Ekebergia capensis*	Somboo	0.954	0.053
5	*Spathodea campanulata*	Anunnuu	0.861	0.047
6	*Syzygium guineense.*	Baddessaa	0.848	0.047
7	*Macaranga capensis*	Kofali	0.822	0.045
8	*Acacia abyssinica*	Lafto	0.804	0.044
9	*Erythrina brucei*	Walensu	0.691	0.038
10	*Eucalyptus camaldulensis*	Bargamoo dimaa	0.605	0.033

Table 4: Dominant scattered woody species of study area

Dominant isolated woody species	**No**	**Habit**
Albizia gummifera	160	T
Croton macrostachyus	73	T
Cordia africana	59	T
Acacia abyssinica	31	T
Eucalyptus camaldulensis	22	T

Rare isolated woody species collected include *Pouteria adolfi-friedericii*, *Apodytes dimidiata, Olea welwitschii, Casuarina equisetifolia, Euphorbia trucalli, Ficus thonningii, Ficus sur* and *Jacaranda mimosifolia* all contain 3 individuals.

4.1.8. Frequency of isolated woody species

Scattered woody species with highest frequency from the three land use types were *Albizia gummifera, Croton macrostachyus* and *Cordia africana.* The most frequently observed species in crop land (Table 7), grazing land (Table 8) and coffee farm (Table 9) listed below:

Table 5a: Frequency (F), Relative frequency (RF) and Relative density (RD) of 10 species with highest density collected from crop land of the study area.

No	Species name	D	RD	F	RF
1	*Cordia africana*	23	14.38	12	9.30
2	*Albizia gummifera*	18	11.25	13	10.08
3	*Eucalyptus camaldulensis*	11	6.88	10	7.6
4	*Croton macrostachyus*	11	6.88	8	6.20
5	*Erythrina brucei*	10	6.88	10	4.65
6	*Acacia abyssinica*	8	5	6	4.65
7	*Grevillea robusta*	7	4.38	7	5.43
8	*Persea americana*	7	4.36	6	4.65
9	*Mangifera indica*	5	3.125	4	3.10
10	*Ricinus communis*	5	3.125	3	2.33

Table 5b: Frequency (F), Relative frequency (RF) and Relative density (RD) of 10 specie with highest density collected from grazing land of the study area

No	Species name	D	RD	F	RF
1	*Croton macrostachyus*	18	10.465	13	9.56
2	*Albizia gummifera*	18	10.465	13	9.56
3	*Maytenus arbutifolia*	14	8.139	8	5.88
4	*Acacia abyssinica*	11	6.395	8	5.88
5	*Cordia africana*	9	5.232	7	5.15
6	*Eucalyptus camaldulensis*	7	4.069	6	4.41
7	*Maesa lanceolata*	6	3.488	5	3.68
8	*Macaranga capensis*	6	3.488	6	4.41
9	*Premna schimperi*	6	3.488	4	2.94
10	*Syzygium guineense*	6	3.488	5	3.68

Table 5c: Frequency (F), Relative frequency (RF) and Relative density (RD) of ten species with highest density collected from coffee farm of the study area.

No	**Species name**	**D**	**RD**	**F**	**RF**
1	*Albizia gummifera*	124	33.423	18	8.96
2	*Croton macrostachyus*	44	11.859	18	8.96
3	*Cordia africana*	27	7.277	12	5.97
4	*Syzygium guineense*	13	3.504	9	4.48
5	*Acacia abyssinica*	12	3.234	10	4.98
6	*Grevillea robusta*	12	3.234	8	3.98
7	*Macaranga capensis*	7	1.886	6	2.99
8	*Ekebergia capensis*	7	1.886	5	2.49
9	*Prunus africana*	6	1.617	5	2.49
10	*Erythrina brucei*	6	1.617	5	2.49

4.1.9. Important value Index

The IVI of woody species recorded in each land use were estimated to evaluate the significance of each species. The IVI indicates the importance of individual woody species in the land use systems which were related with farmers species preference and objectives.

Table 6: Six Species with highest important value index in three land use types

Land use type	**No**	**Species name**	

			IVI
Crop land	1	*Cordia africana*	37.76
	2	*Albizia gummifera*	32.76
	3	*Podocarpus falcatus*	22.41
	4	*Erythrina brucei*	21.25
	5	*Croton macrostachyus*	18.28
	6	*Eucalyptus camaldulensis*	17.83
Pasture land	1	*Albizia gummifera*	48.37
	2	*Croton macrostachyus*	34.65
	3	*Acacia abyssinica*	19.00
	4	*Ficus ovata*	18.66
	5	*Maytenusarbutifolia*	14.74
	6	*Cordia africana*	13.94
Coffee farm	1	*Albizia gummifera*	103.94
	2	*Croton macrostachyus*	30.61
	3	*Cordia africana*	17.53
	4	*Acacia abyssinica*	9.78
	5	*Syzygium guineense*	9.64
	6	*Grevillearobusta*	7.73

4.2 .Discussion

The number of species richness in current study is relatively similar with the study reported by Buchura Negesse *et al*.(2019) in which a total of 60 woody species belonging to 34 families and 54 genera were identified. Also this study agreed with the work of Abiot Molla and Gonfa Kewessa (2015) who collected, identified, and recorded 55 woody species belonging to 31 families in the traditional agroforestry practices of Dello Menna District, Southeastern Ethiopia.

The result of current study indicated that the largest proportion of identified woody species were trees followed by shrubs in study sites. This study result is in line with the finding of several studies, (Buchura Negesse *et al*., 2019; Abiot Molla and Gonfa Kewessa, 2015; Motuma Toler *et al*., 2008) who reported that the identified woody species were dominated by trees.

The crop land of current study has lowest number of species richness. It was sparsely distributed in the field and relatively less in number compared with grazing land and coffee farm in terms of species richness. This is due to farmers deliberately cut and thinning of scattered woody species in crop land because they believe that the shade decrease productivity. The current result is greater than the study reported by Buchura Negesse *et al*. (2019) around Jimma in crop fields (25), Motuma Tolera *et al.* (2008) in South-Central Ethiopia (32) and Etefa Guyassa and Raj (2013) in Tigray Region (15), Tola Gemechu *et al.* (2014) in Southern Ethiopia (49). This difference may be due to environmental factors and farmers preference of land use to conserve woody species.

In the study area, 41 scattered woody species were identified and distributed in the grazing land. This study result is higher than study reported by Buchura Negesse *et al*. (2019) around Jimma (33 species) and Belay Tefera *et al*. (2014) in Northern Ethiopia (11 species). The most frequent woody species recorded from pasture land of the current study areas include *Croton macrostachyus, Albizia gummifera* , *Maytenus arbutifolia* , *Cordia africana* and *Acacia abyssinica*.

The Fabaceae was the most species rich family (7 species) followed by Euphorbiaceae (6) and Moraceae (5 Species), Rutaceae (3), Myrtaceae (3) and Asteraceae (2), Boraginaceae

(2), Bignoniaceae (2) and the remaining 26 families each with one species. This study result is in line with the report of Belay Tefera *et al*. (2014) in northwestern Ethiopia and Buchura Negesse *et al.* (2019) in Jimma zone.

From the three land use types coffee farm contain highest density and species richness of scattered woody species. Out of 56 scattered woody species 49 (87.5%) isolated woody species recorded in coffee farm. This study result is higher than study reported by Buchura Negesse *et al*. (2019) around Jimma (34 species) in the coffee farm, Bikila Mengistu and Zebene Asfaw (2016) in Dellomenna distric, only 10 (25.64%) species shade grown coffee and Ebisa Likassa and Abdela Gure (2017) in the coffee farms of western Oromia (36species). The current result is lower than study reported by Lemessa Kumsa (2016) 88 species of woody plants recorded, of which 39 were classified as shrubs, 10 woody climbers and 39 as trees.

In current study *Albizia gummifer, Croton macrostachyus, Cordia africana*, *Acacia abyssinica* and *Syzygium guineense* are the top five species with highest density in coffee farm. This relatively similar with the study reported by Buchura Negesse *et al*. (2019) around Jimma *Albizia gummifera, Acacia abyssinica* and *Millettia ferruginea* species were the most preferred species as shade for coffee, Tola Gemechu *et al*. (2014) also reported small leaf tree species (*Albizia* gummifera, Acacia *abyssinica* and *Millettia ferruginea*) were most preferred for coffee shade,also Kitessa Hundera (2016) reported *Albizia gummifera, A. schimperiana, Millettia ferruginea* and *Acacia abyssinica*the most preferred shade tree species, Ebisa Likassa and Abdela Gure (2017) reported the most preferred tree species were *Cordia africana* , *Acacia abyssinica* , *Albizia*gummifera , and *Vernonia amygdalina* in the coffee farms of western Oromia.

The most frequent woody species recorded from crop land of current study is almost different with the most frequent woody species recorded from crop land of study areas reported by Buchura Negesse *et al.* (2019) C*offee arabica, Catha edulis, Croton macrostachyus, Acacia Abyssinica, Grevillea robusta*, *Vernonia auriculifera* and *Mangifera indica* were the top seven important species among the 25 woody species that were recorded in crop land. This deference is because of the current study only includes scattered woody species in different land uses.

In the current study the most frequent isolated woody species in coffee is different from study reported by Bikila Mengistu and Zebene Asfaw (2016), the most frequently observed woody species was *Coffea arabica* (92%) followed by *Afrocarpus falcatus* in Dellomenna distric. It is relatively similar with the study reported by Buchura Negesse *et al.* (2019) the most frequently observed woody species in coffee farm agroforestry were *Coffea arabica* , *Croton macrostachyus* , *Albizia gummifera* , *Cordia africana* and *Acacia abyssinica* in the study areas. The difference is in current study *Coffea arabica* does not include (only include scattered woody species). The current study is in line with study reported by Tola Gemechu *et al*. (2014) trees most preferred as shade for coffee were *Albizia gummifera, Acacia abyssinica,* and *Millettia ferruginea*. The reasons they mentioned were that the leaves of these trees were thin, small, and elongated, and the trees were chosen because they allow an appropriate amount of light to reach the coffee trees. It was also mentioned that the foliage of their leaves did not damage coffee trees and berries, and that they were friendly to soils, or at least without negative impact on them. In most semi managed forest coffee systems, however, it is common to find other trees species as well.

The highest species diversity and evenness in current study were recorded from grazing land (H'= 3.3, E=0.889). This is relatively similar with the study reported by Buchura Negesse *et al*. (2019) the highest species diversity was recorded in grazing land (H'=3.1). Also the Shannon diversity index and evenness of grazing land were higher than study reported by Etefa Guyassa and Raj (2013) in Tigray region, Ethiopia (H'=2.04,E=0.71). The species diversity of current study in crop land was (H'=3.13,E=0.879). This result is in line with Buchura Negesse *et al.* (2019) who reported the species diversity of crop land was (H'=2.555) higher than coffee farm. Also the Shannon diversity index and evenness of crop land was higher than study reported by Etefa Guyassa and Raj (2013) in Tigray region, Ethiopia(H'=1.12,,E=0.41). In current study the lowest species diversity and evenness were recorded from coffee farm (H = 2.87,E=0.737) this is because scattered woody species not evenly distributed. This is much lower than the study in smallholder coffee farm (Buchura Negesse *et al.*, 2019) in southwestern Ethiopia (H'=0.643). The species diversity of the current study in coffee farm was much higher than study result reported by Bikila Mengistu and Zebene Asfaw (2016) in coffee farm of Dellomenna district (H'= 0.466,E=0.812) this is because one species (*Coffea arabica*) was dominated the coffee farm in Dellomenna distric and the current result was not include *Coffea arabica*. The current study is also higher than the study reported by Ebisa Likassa and Abdela Gure (2017) (H'=1.63+/-0.42,E=0.91+/-0.07).

The highest similarity index showed in current study between coffee farm and pasture land is 0.864 followed by crop land and coffee farm 0.650 and the lowest similarity index recorded between crop and pasture land (0.613). This implies that the degree of species similarity within the three land use system is high and almost the same woody plant species diversity was observed within each land use. This indicates that, the three land uses have high overlapping species with each other.

In the crop field, *Cordia africana*, *Albizia gummifera*, , *Podocarpus falcatus*, *Erythrina burecei and Croton macrostachyus* were the top five important species among the 35 woody species that were recorded in the study sites. *Albizia gummifera*, *Croton macrostachyu*s, *Acacia abyssinica*, *Ficus ovata* and *Maytenus arbutifolia* were specie with top five IVI in pasture land of current study. In current study coffee farm scattered woody species with top five highest IVI are *Albizia gummifera, Croton macrostachyus, Cordia africana , Acacia abyssinica and Syzygium guineense*.

The majority of the species had the highest number of individuals in the lowest DBH class 5-20cm and 20-35cm distribution in all land use types. Relatively similar with study reported by (Buchura Negesse *et al.*, 2019) the majority of the species had the highest number of individuals in the lowest DBH class distribution

Most isolated woody species diversity is found in coffee farm as compared to crop land and pasture land due to coffee needs shade to increase productivity and when compared with areas with no shade woody species.

In crop lands there were only rare and short height woody species are abundant because the farmers remove and thinning them due to their shade decline crop growth and productivity. In addition to increase land for crop production farmers clear most of isolated woody species in crop land. Also the land owners deliberately cut some isolated woody species from pasture land because it destroyed grasses under isolated woody species.

5. Conclusion and recommendation

About 56 woody species were collected from study area of Mana district 46 were trees while 10 were shrubs. Of all woody species recorded from the three land use systems, *Albizia gummifera* was the most frequent and abundant species. Coffee farm was the highest land use type in isolated wood species density followed by pasture land. Scattered Woody species are mainly grown naturally and very scattered in crop field as compared to other land use type. Amongst the three land use types, coffee farm woody had the largest basal area (51.12) followed by crop lands (24.25). The least value of basal area was calculated from pasture land (15.93). The highest H' was recorded in the pasture land followed by crop land study sites. In study areas many scattered woody species were decreasing. The major treats of isolated woody species were human activities. Based on the results obtained from the study, the following recommendations are offered.

- People of the study area are relatively conserving scattered woody species found in coffee farm and very well than crop land and pasture land which indicates, there were over exploitation and lack of conservation in crop land and pastureland. Bearing this in mind any concerned body including the local people of the study area should work for the conservation and plantation of the isolated woody species in crop land and pasture land
- Raise awareness regarding wise utilization of the scattered woody species in the area is crucial in order to prevent the loss of scattered woody species. The governmental and non-governmental organizations should promote different programs to create awareness to increase species that are much decreased.
- This study was about scattered woody species diversity of the three land use types (cropland, pasture land and coffee farm) and did not include other land use types. Therefore, any concerned body can fill the above mentioned gaps.

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7. Appendixes

Appendix1: List of all isolated woody species in three land uses (H=Habit, T=Tree, S=Shrub).

No	Scientific name	Local name	Family	H
1	*Acacia abyssinica* Hochst exBench	Lafto	Fabaceae	T
2	*Acacia etbaica ssp. etbaica* Schweinf.	Doddota	Fabaceae	T
3	*Albizia gummifera* (J. f Gmel.) C.A.Sm.	Hambabessa	Fabaceae	T
4	*Apodytes dimidiata* E.Mey.ex Am	Wendabiyo	Icacinaceae	T
5	*Allophylus abyssinicus*(Hochst.)Radlk	Sehoo	Sapindaceae	T
6	*Annona reticulata* L.	Gishxa	Annonaceae	T
7	*Brucea antidysenterica* J.F. Mill.	Qomonyoo	Simaroubaceae	T
8	*Bersama abyssinica* Fresen.	Lolchisa	Melianthaceae	T
9	*Calpurina aurea* (Ait.) Benth.	Chekata /chekata	Fabaceae	S
10	*Casuarina equisetifolia* L.	Shuwashuwee	Casuarinaceae	T
11	*Clausena anisata* (Wild.) Hook. F.ex. Benth	Ulmayii	Rutaceae	S
12	*Cordia africana* Lam.	Waddessa	Boraginaceae	T
13	*Croton macrostachyus* Del.	Makanisa	Euphorbiaceae	T
14	*Cupressus lusitanica* Mill.	Gattiraa	Cupressaceae	T
15	*Celtis africana* Burm.f.	Qahee/ Cayii	Ulmaceae	T
16	*Carica papaya* L.	Papaya	Caricaceae	T
17	*Citrus sinensis* (L.) Osbeck	Burtukana	Rutaceae	S
18	*Ehretia cymosa* Thonn.	Ulaagaa	Boraginaceae	T
19	*Ekebergia capensis* Sparm.	Somboo	Meliaceae	T
20	*Erythrina brucei* Schweinf	Walensuu	Fabaceae	T
21	*Euphorbia trucalli* L.	Cadaa	Euphorbiaceae	S
22	*Eucalyptus camaldulensis* Dehnh	Bargamodiimaa	Myrtaceae	T
23	*Euphorbia abyssinica* Gmel.	Adami	Euphorbiaceae	T
24	*Ficus exspert*	Baalansoofii	Moraceae	T

List of all isolated woody species in three land uses (H=Habit, T=Tree, S=Shrub).

No	Scientific name	Local name	Family	H
25	*Fagaropsis angolensis* (Engl.Dale	Sigiluu	Rutaceae	T
26	*Ficus thonningii* Blume	Dambii	Moraceae	T
27	*Ficus sur* Forssk.	Harbuu	Moraceae	T
28	*Ficus vasta* Frossk	Qilxuu	Moraceae	T
29	*Ficus ovata* Vahl	Qilinxo	Moraceae	T
30	*Flacourtia indica* (Brm.f.)Merr	Akukkuu	Flacourtiaceae	T
31	*Grevillea robusta A. Cunn.*	Giravillaa	Proteaceae	T
32	*Jacaranda mimosifolia* D. Don	Jakarandaa	Bignoniaceae	T
33	*Macaranga capensis* (Baill.) Sim.	Kofalii	Euphorbiaceae	T
34	*Maesa lanceolata* Forssk.	Abbayyii	Myrsinaceae	S
35	*Mangifera indica* L.	Maango	Anacardiaceae	T
36	*Millettia ferruginea* (Hochst.) Bak	Askira/Sotello	Fabaceae	T
37	*Maytenus arbutifolia* (A. Rich.) Wilczek	Kombolcha	Celastraceae	S
38	*Olea welwitschii* (Knobl.) Gilg. and Schellenb	Bayaa	Oleaceae	T
39	*Osyriss wightiana*	Wantafullaasa	Santalaceae	T
40	*Ritchiea albersii Gilg*	Xuphannoo	Capparidaceae	T
41	*Ricinus communis* L.	Qobboo	Euphorbiaceae	T
42	*Rhamnus prinoides* L.'Herit	Geshoo	Rhamnaceae	S
43	*Pouteria adolfi-friederici* (Eng.) Baehni	Qararoo	Sapotaceae	T
44	*Persea americana* Mill.	Avokado	Lauraceae	T
45	*Polyscias fulva* (Hiern) Harms	Kariyoo	Araliaceae	T
46	*Premna schimperi* Engl.	Qorasuma	Lamiaceae	S
47	*Prunus africana* (Hook.f.) Kalkam.	Omo/Hoomii	Rosaceae	T
48	*Psidium guajava* L.	Zayituna	Myrtaceae	T
49	*Podocarpus falcatus* (Thunb.) R. B. ex Mirb.	Birbirssa	Podocarpaceae	T
50	*Sesbania sesban* (L.)Merr	Tasbaniyaa	Fabaceae	T

List of all isolated woody species in three land uses (H=Habit, T=Tree, S=Shrub).

No	**Scientific name**	**Local name**	**Family**	**H**
51	*Spathoda campanulata* P.Beauv	Anunnuu	Bignoniaceae	T
52	*Schefflera abyssinica (*Hochst.ex. A.Rich.) Harms	Bottoo/ Gatamaa	Araliaceae	T
53	*Sapium ellipticum* (Krauss) Pax	Bosoqa	Euphorbiaceae	T
54	*Syzygium guineense (Willd.) DC. subsp.afromontanum* F. White.	Baddessa	Myrtaceae	T
55	*Vernonia amygdalina* Del	Dhebicha	Asteraceae	S
56	*Vernonia auriculifera* Hiern	Rejji	Asteraceae	S

Appendix 2: Number of species and families

NO	Family	NO of species	NO of genera
1	Anacardiaceae	1	1
2	Annonaceae	1	1
3	Araliaceae	1	1
4	Asteraceae	2	1
5	Bignoniaceae	2	2
6	Capparidaceae	1	1
7	Boraginaceae	2	2
8	Caricaceae	1	1
9	Casuarinaceae	1	1
10	Celastraceae	1	1
11	Cupressaceae	1	1
12	Euphorbiaceae	6	5
13	Fabaceae	7	7
14	Flacourtiaceae	1	1
15	Lamiaceae	1	1
16	Lauraceae	1	1
17	Meliaceae	1	1

Number of species and families

NO	Family	NO of species	NO of genera
18	Melianthaceae	1	1
19	Icacinaceae	1	1
20	Moraceae	5	1
21	Myrsinaceae	1	1
22	Myrtaceae	3	3
23	Oleaceae	1	1
24	Podocarpaceae	1	1
25	Sapotaceae	1	1
26	Proteaceae	1	1
27	Rhamnaceae	1	1
28	Rosaceae	1	1
29	Rutaceae	3	3
30	Santalaceae	1	1
31	Sapindaceae	1	1
32	Simaroubaceae	1	1
33	Ulmaceae	1	1

Appendix 3: List of isolated woody species commonly found in three land use

No	Scientific name	Local name	Family	Habit
1	*Acacia abyssinica* Hochst ex *Bench.*	Laftoo	Fabaceae	T
2	*Albizia gummifera* (J. f Gmel.)C.A.Sm.	Hambabessa	Fabaceae	T
3	*Cordia africana* Lam.	Waddessa	Boraginaceae	T
4	*Croton macrostachyus* Hochst.ex *Del.*	Makkannisa	Euphorbiaceae	T
5	*Ekebergia capensis* Sparm.	Sombo	Meliaceae	T
6	*Erythrina burecei* Schweinf.	Walensuu	Papilionoideae	T

List of isolated woody species commonly found in three land use

No	Scientific name	Local name	Family	Habit
7	*Eucalyptus camaldulensis* Dehnh	Bargamo diimaa	Myrtaceae	T
8	*Euphorbia abyssinica* Gmel.	Adamii	Euphorbiaceae	T
9	*Ficus sur* Forssk.	Harbuu	Moraceae	T
10	*Ficus thonningii* Blume	Dambii	Moraceae	T
11	*Grevillea robusta* A. Cunn.	Gravillia	Proteaceae	T
12	*Polyscias fulva* (Hiern)Harms	Kariyoo	Aralisceae	T
13	*Macaranga capensis* (Baill.) Sim.	Kofalii	Euphorbiaceae	T
14	*Maesa lanceolata* Forssk	Abbayyii	Myrsinaceae	S
15	*Millettia ferruginea* (Hochst.) Bak	Askiraa	Fabaceae	T
16	*Podocarpus falcatus*	Birbirssa	Podocarpaceae	T
17	*Prunus Africana*	Omo	Rosaceae	T
18	*Psidium guajava* L.	Zytunaa	Myrtaceae	S
19	*Rhamnus Prinoides* L. Her.	Geshoo	Rhamnaceae	S
20	*Vernonia auriculifera* Hiern	Rejji	Asteraceae	S