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ASSESSMENT OF TREE SPECIES, DIVERSITY DISTRIBUTION PATTERN AND SOCIOECONOMIC USES ON FARMLAND IN OROMIA REGIONAL STATE: THE CASE OF EAST SHEWA ZONE

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This is to certify that the thesis prepared by Yemenzwork Endale entitled: *Assessment of tree species diversity, distribution pattern and socioeconomic uses on farmland in Oromia Regional State: the case of East Shewa Zone* in partial Fulfillment of the requirements for the degree of master of science in (environmental science) compiles with the regulations of the University and meets the accepted standards with the respect to originality and quality.

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ABSTRACT

Assessment of tree species diversity, distribution pattern and socioeconomic uses on farmland in Oromia Regional State: the case of East Shewa Zone

Yemenzwork Endale Tesema, MSc Thesis

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The study presents analysis of farmland tree species composition diversity, distribution pattern and socioeconomic uses in East Shewa Zone of Oromia National Regional State. With the intention of well characterizing tree diversity in terms of crop/tree management systems five Kebeles were selected from five purposively selected Woredas of East Shewa Zone and 20 HHs in each Kebele were selected randomly. From the selected 20 households 4 of them were selected randomly to survey all plots owned by them and for the remaining 16 households, plots investigated were those with the main homestead. All trees and shrubs for all the farms owned by the selected households were surveyed. A total of 172 farm plots were surveyed in the study area and 76 woody plant species, representing 63 genera and 23 families were recorded. The Family Fabaceae with twenty species had the highest number of species. Homestead planting, boundary planting, mixed with crop, grazing land, small scale woodlot and hedge row planting were land use practices that were observed in the study sites. Maximum richness and abundance were recorded in homesteads followed by boundary plantings and on-farms having Shannon diversity index value of 3.05, 3.02 and 2.43 respectively. There were significance relationship between land holding and number of individual trees however; land holding with species richness, Shannon diversity and evenness index didn't show significant relationship. Better management strategies and approaches would improve the existing agroforestry system.

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Abbreviations

AF	Agroforestry
CBD	Convention on Biological Diversity
CSA	Central Statistics Agency
CGIAR	Consultative group on International Agricultural Research
DBH	Diameter at Breast Height
ERA	Ethiopian Road Authority
FAO	Food and Agriculture Organization
GPS	Geographical Positioning System
GRFA	Genetic resources for food and agriculture
HHs	Households
ICRAF	World Agroforestry Centre
IPGRI	International Plant Genetic Resources Institute
NEMA	National Environmental Management Authority

CHAPTER I

1. Introduction

1.1. Background

Agroforestry system in Ethiopia has received increasing consideration as a way of improving food security and environmental sustainability. The main purpose of practicing agroforestry land use systems is domestication of soil-improving trees for enhancing soil productivity through a combination of selected trees and food crops on the same farm field (ICRAF, 2000). Here, the role of woody perennials in agroforestry systems can be both productive (producing food, fodder, fuel, wood, etc.) and protective (soil conservation, wind breaks and shelterbelts, etc.). However, the current agroforestry system needs development of management approaches especially in tree species selection and management to enable positive interaction of the system. Therefore, assessing the existing farmland tree species diversity is necessary to fill the gap.

Though, the forest areas of Ethiopia have a high biodiversity and considerable economic and ecological importance to the nation, ecological and historical studies have demonstrated the dramatic human influences on the forest vegetation. The main driving forces behind deforestation are the expansion of agricultural land, uncontrolled exploitation of forest resources, overgrazing and establishment of new settlements into forested land coupled with increasing population pressure. As a result, forest biodiversity is threatened rapidly in the forest landscapes of Ethiopia (Sanbeta Feyera and Denich Manfred, 2006). Therefore, there is a need to encourage and monitor tree diversities on farmland.

Moreover, the concept of agroforestry is based on the development of the interface between agriculture and forestry and agriculture in Ethiopia is the foundation of the country's economy, accounting for half of gross domestic product (GDP), 83.9% of exports, and 80% of total employment. Because of such reason biodiversity conservation must include landscape used for farming and pastoralism (NEMA, 2001).

Most often in natural and agricultural systems, species counts are provided as the measure of diversity. Continuing this logic, diversification equates to adding more species. Species diversity, however, is both a function of the number of species, and the evenness in distribution of abundances of species (Magurran, 1988).

One of the purposes of agro-forestry tree domestication through one focus on landscape diversity and the other on genetic diversity within priority species is the enhancement of stability and productivity of agro-ecosystems by diversifying on-farm tree species composition. Information on landscape-level diversity as provided by the methods presented here will assist in targeting tree domestication activities, and will provide benchmark information so that the impact of these interventions on diversity can be measured.

1.2. Statement of the problem

Famers in Ethiopia usually manage and plant tree species around their homesteads as a shade and fencing material and out fields in integration with crops. But the integration of trees with crops is not in view of enhancing productivity and production that lacks selecting trees species having positive relationship and proper management of trees within existing agroforestry systems. The key principle of any agroforestry system is that minimizing competition between the plants and maximizing complementarity (Sanchez, 1995). This needs planned and technical support to farmers. Additionally, current trends of growing pressure on limited natural forest resources, coupled with a rising demand for forest products, propose that reliance on on-farm forest resources (which critically requires appropriate management and continual follow up) is likely to increase in the future.

Therefore, to address such issues or in order to prescribe appropriate management and conservation measures, there is a definite need for baseline information on prevailing land-use systems that facilitate the design, implementation and evaluation of agroforestry interventions and to assist the local people in the conservation, management and protection of farmland trees. Thus, the main purpose of this study is providing some of such required information through assessing tree species composition, diversity and distribution patterns in farmland which in turn contributes for further agroforestry related studies.

1.3. Objective

1.3.1. General objective

The overall objective of this research is to investigate farmland tree species diversity, distribution pattern and socioeconomic uses in East Shewa Zone of Oromia National Regional State.

1.3.2. Specific objectives

More specifically, the study aspires to:

1. Investigate the composition, diversity and population structure of trees on the farmland.
2. Assess socioeconomic uses of farmland trees for farmers in the study area.
3. Investigate the relationship between land holding and tree diversity in the main homestead area of farmers.

1.4. Research questions

Based on the above stated objectives the following questions are posed as a basis for the research.

1. What is the species composition of farmlands in the study area?
2. What is the composition, diversity and structure of farmland trees?
3. What patterns do exist in farmland tree management system?
4. What social and economic functions do farmland trees have for farmers?
5. Does land holding have significant relationship with diversity of trees species?

1.5. Significance of the study

The findings of this study on tree species composition, diversity and distribution pattern on farmlands will provide basic information about existing agroforestry systems which will be useful in redirecting, improving and strengthening it and to introduce new agroforestry systems and for doing further studies. This in turn contributes to the national policies and strategies that support sustainable management of farmland tree species.

CHAPTER II

2. Literature Review

2.1. The concept and definition of agroforestry

Agro-forestry is a new name for a set of old practices (Nair, 1993). Farms have nurtured trees on their farm, pasture lands and around their homes. Therefore, neither the concept nor the practice of agroforestry is new (Sen et al. 2004). As a scientific discipline the origin of agroforestry are fairly recent (Wojtkowski, 1998). Agroforestry may be a traditional and/or introduced and can be defined as; a symbiosis of tree growing, crop production and livestock raising where each component is beneficial to each other. (Bandyopadhyay, 2001). It is also defined as; a dynamic, ecological based, natural resource management system through integration of trees on farms and agricultural landscapes that diversifies and sustains production for the purpose of increasing social, economic, and environmental benefits for land users at all levels (World Agroforestry Center 2003).These definitions imply that in agroforestry system: 1) there are two or more species of plants (and/or animals) at least one of which is woody perennial; 2) there should be biological and economical interaction with in the components; 3) the cycle of an agroforestry system is always more than one year (Mesele Negash, 2002).

2.1.1. Agroforestry systems and practices

The word " systems" and "practices" are often used synonymously in agroforestry literature (Nair, 1993). However, some distinction can be made between these two concepts. An agroforestry system consists of one or more agroforestry practices that are practiced extensively in a given locality or area; the system is usually described according to its biological composition and arrangement, level of technical management or socio- economic features. An agro forestry practice, on the other hand, denotes a specific land management operation on a farm or other management unit, and consists of arrangements of agro forestry components in space and/ or time (Gholz, 1987) . All agroforestry systems consist of at least two of the three major groups of agro-forestry components; trees (including shrubs), agricultural crops, and pasture/livestock, trees being present in all agro forestry system. Occasionally there may be other components also, such as fish, honey bees, etc. Depending on the nature and type of components involved, agro forestry system can be classified as agrisilvicultural (tree + crops), silvopastural (tree + pasture and /or livestock) and agrosilvopastural (all three types of components) (Gholz, 1987).

2.1.2. Traditional agroforestry practices in Ethiopia.

Agroforestry has been an age-old practice in the Ethiopian farming system. Kindu Mekonnen (2001) noted the types of traditional agroforestry practices in Yeku watershed northeastern Ethiopia as trees and shrubs in silvipastoral lands, trees on farmlands and trees in homesteads. Growing *Acacia albida* as a permanent tree crop, on farmlands with cereals, vegetables and coffee underneath or in between, is an indigenous agroforestry system in the Harrarghe highlands of Eastern Ethiopia (Poschen, 1986).

Home gardens in central, eastern, western and southern Ethiopia are characterized as backyards, front-yards, side-yards and enclosing yards (Zemede Asfaw and Ayele Nigatu, 1995). Farmers in Wondo-Genet, which is located within the Ethiopian Rift Valley, have been planting trees near and around homestead, along external and internal boundaries to a lesser scale as woodlot. Fruit trees, coffee, and *Cordia* *africana* in most cases are planted in the home garden together with *Ensete ventricosum* (Abebe Seifu, 2000).

There are also numerous types of traditional agro-forestry practices in different parts of our country, in southern Ethiopia (Zebene Asfaw 2003; Tesfaye Abebe, 2005), northern Ethiopia (Kindeya Gebrehiwot, 2004) and north western Ethiopia (Yeshanew, 1997).

2.2. Agro-biodiversity and sustainability

2.2.1. Agro-biodiversity

The Convention on Biological Diversity (CBD) defines agricultural biodiversity as "all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agro-ecosystem: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro- ecosystem, its structure and processes" and involving the whole agro ecosystem that is actively managed by farmers (IPGRI, 2010; Cromwell et al., 1999). Agricultural biodiversity can be split into two broad categories. The first consists of the genetic resources for food and agriculture (GRFA) that provide food and other essential harvested products from domesticated crops and domestic animals and fungi and microbes that support food processing. The second comprises all those non-harvested components that contribute to and sustain agricultural productivity by provisioning, supporting and regulating ecosystem services that underpin agriculture (IPGRI, 2010).

2.2.2. Sustainable agriculture

Sustainable agriculture is delivered when farming (and other productive systems) produces food and other agricultural products to satisfy human needs indefinitely without unsustainable impacts on the broader environment. This requires agriculture to avoid severe or irreversible damage to the ecosystem services (such as soil fertility, water quantity and quality, genetic variability, pollinators, etc.) upon which it depends and to have acceptable impacts on the broader environment (environmental stewardship) (IPGRI, 2010).

Agricultural sustainability is defined as 'the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources' (CGIAR, 1988). Here, under a condition of limited resource maintaining of species diversity in agro ecosystems is one of the factors contributing towards sustainability (Tesfaye Abebe, 2005). Other studies have also shown that the existence of relationship between species diversity and ecosystem stability and / or productivity (Kindt et al., 2005).

Even though, sustainable agriculture depends on the way in which water, land, chemicals, energy and other nonrenewable inputs, the use or deployment of agricultural biodiversity is an essential part of making agriculture more sustainable. Crucially, the eco system services upon which agriculture relies can be over-used, whereas concerns of over-exploitation do not apply directly to many components of agricultural biodiversity. The biological diversity found in crops and animals is perpetuated as agricultural seeds and reproduced animals. There should be no need to reconcile the conservation and use of this agricultural biodiversity as antagonistic goals, because genetic resources are essentially public goods. Indeed, the actual or potential benefits arising from its use are often the main incentive for the conservation of agricultural biodiversity. The principal threat to genetic resources then is not over-use but under-use in agricultural systems and breeding programmes. Steps must be taken to ensure that the world can conserve and build the agricultural biodiversity needed to adapt global food and farming under an evolving landscape of climate change and increased competition for space and water (IPGRI, 2010).

For climate change adaptation and mitigation, agricultural biodiversity is being recognized as critically important for the development of the new varieties and farming systems that will be needed to adapt to predicted future environmental conditions. Agricultural biodiversity will also help to underpin farming systems that can capture more carbon and emit fewer greenhouse gases. It is striking that despite the enormous contribution that agricultural biodiversity makes to global food security and sustainable agriculture, its role is still not widely recognized or understood. Greater efforts are needed to estimate the full value of genetic diversity, to assess the impact of its use and to bring this information to the attention of policy-makers and the general public so as to help generate the political will and financial support needed to strengthen programmes for the conservation and sustainable use of agricultural biodiversity (IPGRI, 2010).

2.3. Farmland trees in agroforestry system

2.3.1. Distribution pattern of farmland trees

To manage tree cover in agricultural landscapes for both conservation and production goals, it is important to understand the existing patterns of tree cover. Besides, understanding of the roles of trees on farms and diversification of the farm in terms of species richness, as well as evenness through increase in number of trees of rare species, or through replacement of more common species are the best options for preventing degradation of agro-forest ecosystems on farms (Kindt *etal*., 2005).

Trees can be found in farming landscapes in various forms of spatial and temporal arrangements for different purposes. One of the features of farm tree management is that the biological characteristics of trees are often taken into account to determine where it should be grown (Tesfaye Abebe, 2005). For instance, trees that contribute positively to agricultural crops are grown dispersed in crop fields while trees that compete with crops are planted separately in block arrangements. Trees are planted on farms in different niches (Nair, 1993). Depending on the type of ecological settings, trees will be arranged in different patterns. For example, (Arnold and Dewees,1995) have identified different patterns of planted trees on farmlands as: Trees planted on non-arable or fallow land, trees grown in homestead areas, tree growing along boundaries, intercropping on arable land and mono cropping on arable lands.

2.3.2. Farmland tree species diversity and their role in biodiversity conservation

On many fronts throughout the word - in every biome at local, regional, national and global levels - biodiversity is declining and previously, efforts to preserve biodiversity have focused in natural eco systems, despite the fact that these areas make up only about 5% of the terrestrial environment. In contrast, approximately 50% of worldwide land is currently under agricultural production and 20% is in commercial forestry (Vandermeer et al., 1998). In the tropics, conservationists have focused their attention on the protection of natural forests and woodlands, and until recently (Schelas and Greenberg, 1996) have not given much attention to the widely dispersed farmland woody species. However, these patches are often critical components of a farmers' environment being a source of products and environmental services of importance to the farmers' livelihood and welfare. Recently, it has been recognized that the part played by the woody species in these landscapes play an important role in maintaining biological diversity (Schelas and Greenberg, 1996; Nikiema, 2005).

The integration of woody species into crop fields, has been proposed as one way of diversifying agro-ecosystems in a way that is beneficial to the environment and can maintain and perhaps enhance biodiversity (Sanchez *et al*., 1997). They could provide replenishment of soil fertility and could also provide marketable forest products. The relevant services of woody species are those that increase the crop yields (nitrogen fixation, increased soil organic matter content, nutrient cycling, soil conservation, etc.), create environmental resilience (niche diversification, food-web complexity, reduced greenhouse emissions through carbon sequestration, etc.).

Remnant woody species in crop fields may play an important role in conserving biodiversity within agricultural systems because they provide habitats and resources that are otherwise absent from agricultural landscapes (Harvey and Haber, 1999). They also serve as critical nesting, feeding, and roosting sites for a variety of bird and bat species. They also provide transient habitats for many migratory birds. The presence of woody species in crop fields also favors the survival of native forest plants. In addition, farm trees often serve as a source of propagates for forest regeneration both because they produce seed locally, and because the birds that visit their canopies regurgitate or defecate seeds of forest plants while perched in the trees. As a result, the seed rain beneath farmland trees is significantly higher than in open areas (Harvey and Haber, 1999). The woody species also contribute to the enrichment of faunal biodiversity in the agricultural landscapes.

Farm tree diversification provides biological assets for maximizing farm resources, thus lowering the cost of production. Farm trees, in the form of agroforestry, are uniquely suited to provide eco-agricultural solutions that successfully combine the objectives of increased food security and conservation gains, especially by promoting the greater use of native tree species (Atta-Krah *et al*., 2004). Diversifying the composition of farm tree species also enhances the stability and productivity of agro-ecosystems (Kindt and Coe, 2005) and combines the objectives of attaining gains in food security and in conservation of biodiversity (Atta-Krah *et al*., 2004; Garrity, 2004).

2.4. Socioeconomic uses of farmland trees

In many rural areas farm trees play an important role in household food security. Forests and trees provide critical support to agricultural production, they provide food and fuel, and they provide cash income particularly for the poor, and they provide insurance against drought and crop failure. Thus, both directly and indirectly, many forestry activities have an impact on rural people's food situation. According to the study of Tesfaye Abebe (2005) farm trees of diverse tree species serve different socioeconomic and ecological functions. Farmers have historically protected, planted and managed trees on their land in order to maintain supplies of sought-after products no longer readily available from the natural forest which is cleared, degraded or is no longer accessible. Many species of trees in the tropics are used for fodder, either for browse or stall feeding. Wickens et al. (1985) estimate that 75% of the tree species (7,000-10,000) of tropical Africa are used as browse. Fodder trees contribute in several ways to the overall food security of households: they make a significant contribution to domestic livestock production which in turn influences milk and meat supply; in addition, fodder contributes to maintaining draught animals and producing manure for organic fertilizer, there by supporting agricultural production (Wickens et al.1985).

2.5. Factors influencing farmland tree species diversity

The number of tree species and number of individual trees on farms varies due to physical and socio-economic factors. The resources of the household, mainly land have an impact on tree species diversity. For instance, farmers with small land holding cannot have a large stock of trees since the available land is primarily used to produce crops for consumption. Large holders, on the other hand, could produce a large volume of wood (Scherr, 1995). The study conducted by Tesfaye Abebe (2005) also shows that size of the farm (home-garden) affect tree species richness of farms.

CHAPTER III

3. Materials and Methods

3.1. Description of the study area

3.1.1. Location and description

The study was conducted in East Shewa Zone of Oromia Regional State, Ethiopia. It has 13 Woredas (districts). According to the zonal statistics and information center the zone is found between 38^{0}57'and 39^{0}32' E and 7^{0}12' and 9^{0}14'N (Figure 1). Most of the Woredas in East Shewa Zone fall in the lowlands of the central Rift Valley. The average altitude is 1600 m, but rises up to 2300 m at the north western and western mountain fringes of the Rift on one hand, and it falls to 900-1000 m towards northeast. Specifically, this study was conducted in Boset, Lume, Bora, Dugda and Adamitulu Jido Kombolcha Woredas.

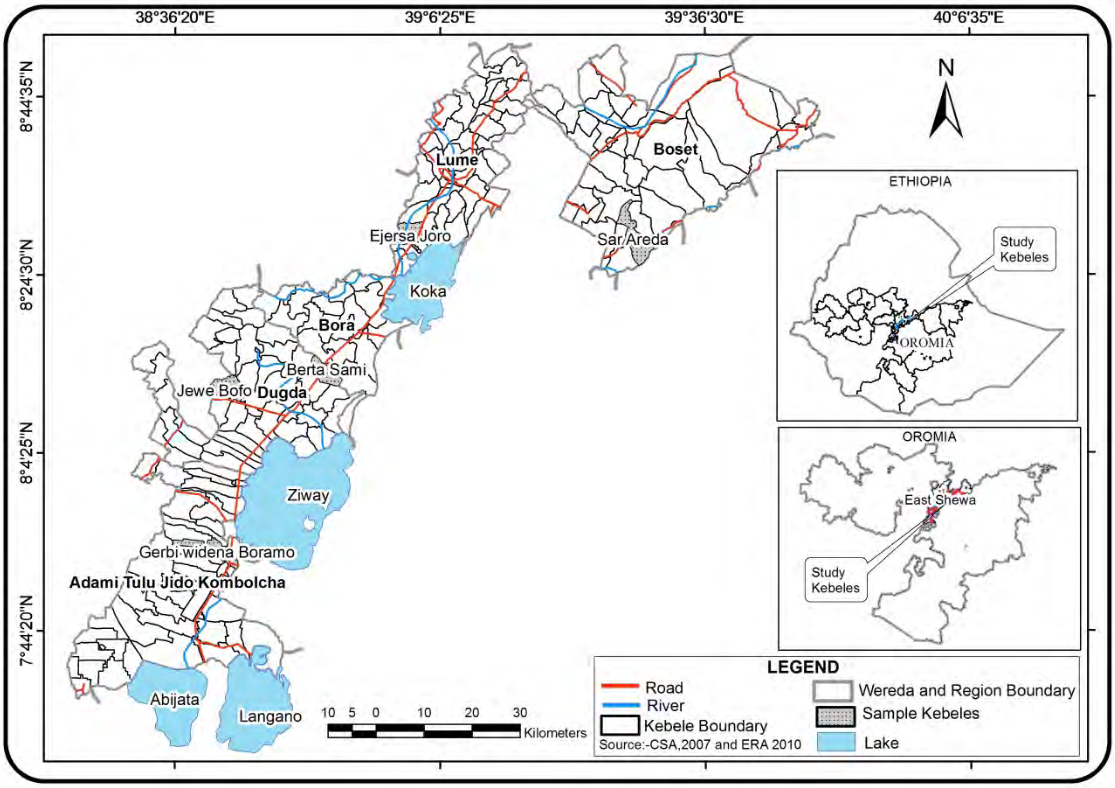
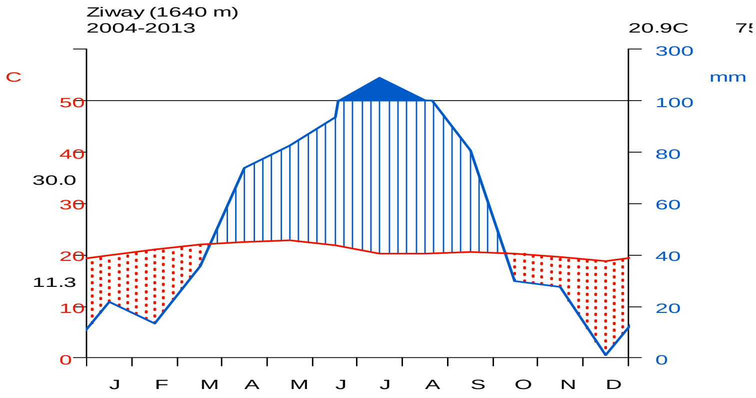


Figure 1: Map of East Shewa Zone showing research Woredas and Kebeles

3.1.2. Climate and agro-ecology

According to the zonal statistics and information center based on the general land form classifications of Oromia Region, East Shewa Zone can be categorized under rift system since about 93% of the total area of the zone is located in the rift valley system. Agro ecology of the zone is divided in to three, 0.2% area of the zone is found in the high land, 61.1% midland and the rest 38.7% is found in the low land with a mean annual temperature of 12.5^{0}c, 17.5^{0}c and 22.5^{0}c respectively. The rift valley floor of East Shewa Zone receives mean annual rainfall of 650mm. While, the northwestern and eastern highland sections of the zone receive up to 1200mm mean annual rainfall. By taking ten years rainfall and temperature data of two districts namely Adamitulu Jido Kombolcha and Boset, climate diagram was constructed (figure 2).



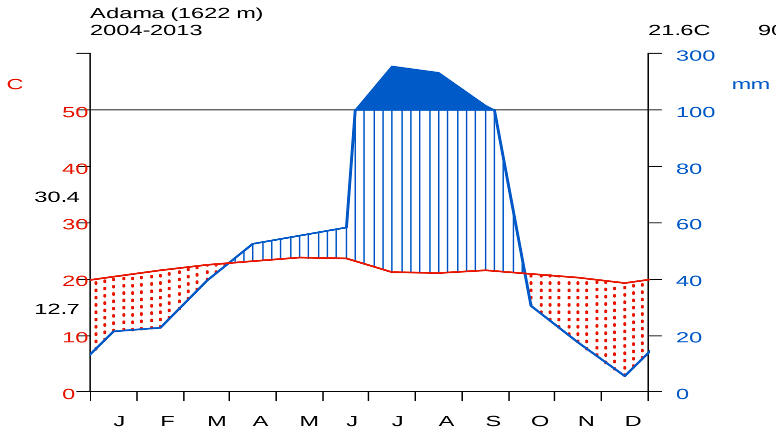


Figure 2: Climadiagram of Ziway town (Adamitllu Gido Kombolcha district) and Adama town (Boset district) based on climate data from 2004- 2013

Data source: National Metrological Service Agency (NMSA)

3.1.3. Land use and agriculture

As th e z onal s tatistics a nd in formation c enter p resented t otal a rea of t he Z one i s estimated to be about 979,907 k m^2 which is divided for various purposes as stated in the (Table 1) below.

Table 1: Land use types in the study area

S/N	Land use types	Area coverage	
		Km²	%
1	Cultivation land	440,958	45
2	Bush and forest land	156,785	16
3	Grazing land	88,191	9
4	Water bodies	48,995	5
5	Settlement areas	244,976	25
Total area		**979,907**	**100**

Source: East Shewa Zone statistics and information center

Across the East Shewa Zone, grain crop and livestock farming are dominant, whereas in areas adjacent to rift valley lakes and rivers, irrigated vegetable farming and horticulture are practiced. Pastoralism becomes more common towards northeastern arid areas. Within the grain-livestock areas, the further diversity is observed in terms of the combination and management of crop/tree systems; Teff-wheat plus *Faidherbia albida* to maize-beans-sorghum plus *Acacia tortilis* across the north-south transect, and Teff-wheat plus *Faidherbia albida* to Teff-maize-sorghum plus *Acacia tortilis* across the west-east transects, while the livestock system is commonly communal/free grazing of cattle.

3.1.4. Soil

According to the zone statistics and information center and based on FAO's soil classification, about 9 major types of soils are found in the Zone and such groups are based on their origin as well as variations in the process of their formation. The major types of soils can be categorized into Andosols, Vertisols, Cambisols, Regosols, Luvisols, Phaeozems and Fluvisols forming the major soil group of high agricultural potential (ESZFEDO, 2011).

For instance Andosols (Mollic and Vitric Andosols) are light, loose, and porous, have high drainability and absorb much water. They extend over larger portions of Adamitulu Jido Kombolcha, Boset, Dugda, Adama, Lume and Bora districts of the zone, accounting for about 23.43% of the land area of the zone. Other groups such as Vertisols also found in the northern Lume and are heavy, mostly dark colored clay soils containing more than 30% clay content. Such soils are fairly good, but limited agricultural potential. Phaeozems groups which are in most cases sodic having limited agricultural value are found in Dugda and Bora, and smaller portions of Ade'a, Adama and Liben Chukala districts of the zone (ESZFEDO, 2011).

3.1.5. Vegetation

As shown in the document of the zone statistics and information center, East Shewa has generally about four major types of vegetation regions: woodland, the coniferous forest, broad leaved forest and grasslands. Furthermore, natural vegetation grown in East Shewa Zone is grouped under the *Acacia* woodland and savannah vegetation grown at an altitude of 1500 to 2200m.a.s.l. and it covers large parts of lakes region and Awash valley. Beside *Acacia* woodland, grassland areas also occupy lowland parts of East Shewa Zone with various species and tall grasses (ESZFEDO, 2011).

3.1.6. Human and livestock population

According to the CSA (2011) data the total human population of East Shewa Zone is about 1, 587,062 of which 814,392 (51.3%) male and 772,672 (48.7%) female. Livestock population of the zone is Cattle 1,090,091, Sheep 319,598, Goats 568,761 and 10,644, 284,583, 6,818 Horse, Donkey and Camel respectively (CSA, 2013).

3.2. Research design

Five Woredas of East Shewa Zone namely, Boset, Lume, Bora, Dugda and Adamitulu Jido Kombolcha were selected purposively. Then the selection procedures of the study Kebeles was adopted in order to well characterize the diversity in terms of crop/tree management systems and five Kebeles; one from each Woreda were selected. In each Kebele a total of 20 HHs were selected randomly. From the selected 20 HHs 4 of them were selected randomly to conduct a complete inventory of all trees and shrubs on all plots owned by the selected HHs and for the remaining 16 HHs the investigated lot was the plot with the main homestead (home compound) (Table 2).

Homestead was defined as the nearest farm plot to the house including its front, back and side yards and managed by family members and characterized with manure application rather than artificial fertilizer. Its size range in this study includes ≤ 0.25ha (69%) with a minimum value of 0.0144ha, ≥0.25-0.5ha (20%), >0.5-0.75 (7%) and with some exceptional plot sizes having 1 and 1.5ha which encompasses only four farmers' plot. The overall average of the homestead size was 0.287ha.

The above homestead definition can be evidenced by other case studies from some observations and generalizations of home gardens in Ethiopia. According to Watson and Eyzaguirre (2002) "a very common vernacular equivalent for the term home garden is yeguaro-ersha (Amharic language) and another is 'Oddo' (Oromic language) in eastern Ethiopia. The former term literally means the backyard farm while at the same time indicating the closeness of the cultivation plot to the house. The latter term alludes to the preclusive and private nature of the holding. Common locations for gardens in relation to the house in Ethiopia are backyards (48%), front yards (26%), side yards (13%) and those that almost encircle the house (13%)"(Watson and Eyzaguirre 2002). Common garden sizes in the study sites ranged from about 100 m^2 to more than 2000 m^2, but in extreme cases, sizes as low as 20 m^2 and as high as 6000 m^2 (Watson and Eyzaguirre 2002) .

Table 2: Summary of Woredas, Kebeles, and HHs that were selected for the study

Site code	Woreda Name	Name of study sites	Total HHs in the study sites	Target HHs	HHs selected for complete inventory of trees on all plots	HHs selected for inventory of trees on main homesteads
1	Adamitulu Jido Kombolcha	G/W/ Boramo	672	20	4	16
2	Dugda	Jewe Bofo	314	20	4	16
3	Boset	Sara Areda	1002	20	4	16
4	Bora	Berta Sami	463	20	4	16
5	Lume	Ejersa Jero	314	20	4	16
Total			2765	100	20	80

3.2.1. Tree species identification

All tree species were identified and recorded in each sample plot. Identification include both local and scientific name of each tree species and was carried out in the field and in the herbarium. Voucher specimens were prepared for all plant species that were recorded in the field. Then plant specimens were properly pressed, dried, transported and deposited at the National Herbarium, Addis Ababa University, Ethiopia for subsequent identification. Nomenclature of species was following the publications of the Flora of Ethiopia and Eritrea. However, tree species identification in the field was done with the help of field guide book (e.g. Azene Bekele, 2007).

3.2.2. Tree inventory

All trees and shrubs for all the farms owned by the selected households were surveyed. In order to determine abundance (number of individual) of each tree species occurring on farms a complete count was done. Since this research focuses on tree diversity, measurement was taken only on mature trees having a height greater than or equal to two meters ($\geq$ 2m). However, saplings (with a height of 1 to 2 meters) and seedlings (with a height of less than 1 meter) were also counted to know the number of newly generated and/or planted individuals in the farm. Moreover, crown of each tree on crop plots was measured to show the canopy cover of trees in crop fields.

Land use types in which the woody plants are grown like small-scale woodlot, boundary planting, and homestead and on farm were identified. For all trees and shrubs existing in each land use type, the species of the encountered trees and shrubs were identified, number of stems was counted and the diameter at breast height (DBH) and height of each tree were measured. In addition to such data, farm holding of surveyed farmers was recorded to see its relationship with abundance, species richness, Shannon and evenness diversity indices.

3.2.3. Socioeconomic uses of tree species

Socioeconomic uses of tree species were assessed through focus group discussions in each study site with representatives from different economic status (wealth classes), religion, gender, age group (youth, adult and elderly), and community-based organizations. Here, for the purpose of this study, wealth classes were categorized into three major groups poor, medium and rich based on criteria like land holding, livestock holding and number of houses and wives owned. The wealth classification was done by the help of local administrative bodies and the local elders.

3.3. Data analysis

All tree species recorded in all plots were used in the analysis of the vegetation structure. The tree density, diameter at breast height (DBH), and basal area were used for description of vegetation structure. For analysis purpose Microsoft Excel, SPSS and Biodiversity R software were used extensively and the results were presented in tables, and graphs.

3.3.1. Diversity analysis

Shannon and Wiener (1949) index were used for description of species diversity. This method is one of the most widely used approaches in measuring the diversity of species. Species richness and evenness of all identified species were calculated using the Shannon-Wiener index and calculated as follows:

Shannon Diversity Index $= H' = \sum_{i=1}^{s} pi \ln pi$

Where:

- H'= Diversity of species (Shannon - Wiener diversity index)
- S = the number of species

- Pi = the proportion of individuals abundance of the i^{th} species (the ratio of a species average to the total species average)
- In = log base e

Although as a heterogeneity measure Shannon's index takes into account the evenness of abundance of species, it is possible to calculate a separate additional measure of evenness. The ratio of observed Shannon index to maximum diversity (Hmax = ln S) can be taken as a measure of evenness (E) (Krebs 1985; Maguran, 1988; Kent and Coker, 1992).Therefore, equitability (evenness) was calculated as:

$$E = \frac{H'}{HMAx}$$

- ✓ Where:
- ✓ H' max= ln S
- ✓ H'= Shannon diversity index
- ✓ ln = the natural logarithm of the total number of species in each community
- ✓ S= number of species in each community (Shannon-Weiner, 1949).

3.3.2. Species composition assessment

In order to express the difference in species composition a single statistic was used to calculate instead of stating the difference in abundance between each and every species. An ecological distance was summarized these differences in a single distance statistic using biodiversity R software. The main advantage of using an ecological distance is that differences in species composition can be summarized with a single statistic. (Kindt and Coe 2005). There are many different methods of calculating a distance Bray-Curtis distance is the one that is used to calculate ecological distance. Since Bray- distances are calculated from differences in abundance of each species, the final distance can be influenced more by species with largest differences in abundances that make the distance to reflect differences for those dominant species only (Kindt and Coe 2005). Therefore, the species matrix (data set) in this study was transformed by a square-root, to reduce influence of dominant species on the analysis (Kindt and Coe 2005). The ecological distance between two sites for instance A and B can be calculated as:

$$D = 1 - 2\frac{\sum_{i=1}^{s} min(ai, bi)}{\sum_{i=1}^{s} (ai + bi)}$$

Where, D = ecological distance

S= number of species,

ai and bi = number of individuals of site a and site b

3.3.3. Population structure analysis

Population structure provides valuable information about the regeneration status of the population that could further be employed for devising evidence based conservation and management (Haile, *et al*., 2008). This was done by employing the total number of individuals that were grouped in to different arbitrary diameter and height classes. From the arbitrary diameter and height class population structure was constructed using graphs.

Density

Density is defined as the number of individuals of a certain species per unit area. It is closely related to abundance but more useful in estimating the importance of a species. It was calculated by summing up all stems across all area and converting into hectare basis.

$$Density = \frac{Total\ number\ of\ indvidual}{Sampled\ area\ in\ hectar(ha)}$$

Relative density

$$\text{Relative Density} = \frac{Total\ number\ of\ individual\ of\ a\ species}{Total\ numberof\ individuals\ of\ all\ species} * 100$$

Diameter at breast height (DBH)

DBH measurement was taken at about 1.3 m from the ground using a measuring tape. This technique is easy, quick, inexpensive and relatively accurate. There is direct relationship between DBH and basal area.

Basal area = $\varepsilon\Pi(d/2)^2$

Where, d is diameter at breast-height and $\Pi = 3.14$..

Relative dominance

$$Relativedominance = \frac{Dominance\ of\ a\ species}{Dominance\ of\ all\ species} * 100$$

Where:

Dominance = mean basal area per tree times the number of tree species.

Frequency

It is the frequency of quadrats occupied by a given species. It is calculated with formula:

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

The frequencies of the tree species in all plots were computed. A better idea of the importance of a species with the frequency can be obtained by comparing the frequency of occurrences of all of the tree species present. The result is called the relative frequency and is given by the formula:

$$\text{RelativeFrequency} = \frac{Frequency\ of\ all\ species}{Frequency\ of\ a\ species} * 100$$

Importance value index (IVI)

Importance value index combines data for three parameters (relative frequency, relative density and relative abundance). That is why ecologists employ it to compare the ecological significance of species (Lamprecht, 1989). The importance value index (IVI) for each woody plant species was calculated following Kent and Coker (1992) using the formula indicated below.

Importance value = Relative density + Relative frequency + Relative dominanc

3.3.4. Crown area

Average crown spread is the average of the lengths of longest spread from edge to edge across the crown and the longest spread perpendicular to the first cross-section through the central mass of the crown. Under such condition, it is possible to measure the opposite side of the land in which the crown locates and covers (Blozan, 2004 and 2008). Hence, using cross- method, the average crown spread of a tree can be calculates as:

Average crown spread= (longest spread + longest cross-spread)/2

Approximately (relatively) tree crown covers circular shape and has its own diameter in which the tree crown covers. Hence the average crown spread result can help us to calculate the total plot of land or the area which is covered by tree crown. Here, the result of average crown spread of a tree assumed to represent the diameter of the plot of land that coved by a tree. Based on this notion, the tree crown area can be calculated using the result of the average crown spread which is represented as diameter (d) of a particular area covered by a given tree. Thus, tree crown area can be calculated as:

Average crown area= $\pi d^2/4$ Where; d is the diameter of the crown

3.3.5. Analysis of correlation and socio economic uses of species

Correlations of land holding with abundance other diversity indices (species richness, diversity and evenness) were examined. Non-parametric statistical analysis was applied to find the impact of land holding on species abundance, Shannon diversity, species richness and evenness**.** Likewise statistical mean was used to summarize farmers' preference rank of each species in relation to their socio-economic uses.

CHAPTER IV

4. Results and Discussion

4.1. Tree species composition and abundance

A total of seventy six plant species representing 63 genera and 32 families were identified and recorded within 172 sampling plots (Appendix 1). These identified species encompasses 51.3% trees, 36.8% trees/shrubs, 10.5% shrubs and 1.3 % climber (Figure 3). Likewise, of all the species, 26.3 %, 7.9%, and 7.9% of species belonged to the families Fabaceae, Capparidacea and Euphorbiaceae and were among the dominant families while, family Anacardiaceae, Rhamnaceae and Boraginaceae contributes 5.2%, 5.2% and 3.9% respectively. Besides the remaining seven and nineteen families contained only two and one species respectively. Among the total number of species, only 29.8% were exotic while the remaining 70.1% were indigenous (Appendix 1).

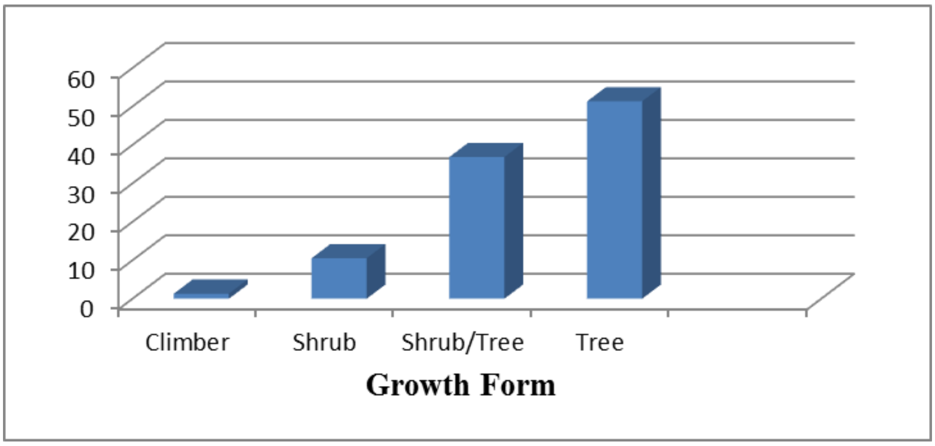


Figure 3: Growth forms

From the total 76 species *Acacia tortilis* with an abundance value of (1050), *Eucalyptus camaldulensis* with an abundance value of (817) and *Acacia senegal* with an abundance value of (513) were the most abundant species in the study area. According to finding of (Asferachw Abate *et al*., 1998 and Zerihun Woldu *et al*.,

1999) which was conducted in the Ethiopian rift valley system that is part of the current study area; *Acacia tortilis* and *Acacia senegal* were dominant species. In Figure 4 below all species were ranked from the most abundant to the least abundant.

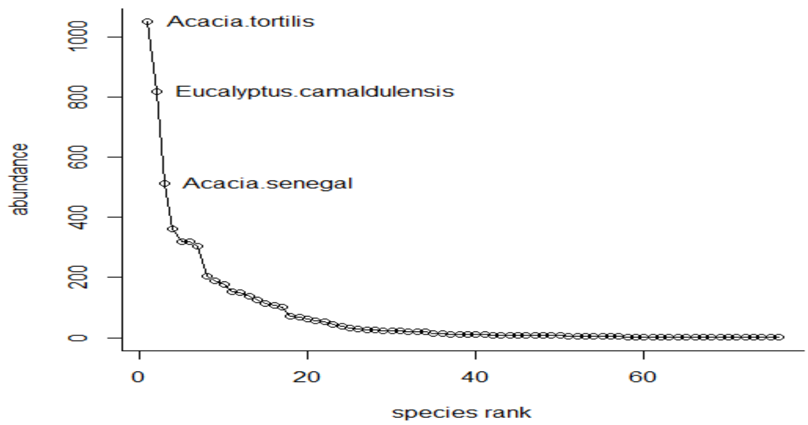


Figure 4: Rank abundance curve of all species in the study area

4.1.1. Tree species diversity and distribution patterns in farmlands

As indicated above a total of 76 tree species were recorded in farmlands of the study area which is relatively high woody species diversity as compared to Lalisa and Herbert (2010) findings in northern high lands of Ethiopia. This may be due to small size of farmlands in the northern part of the country. Moreover, the study conducted in the Ethiopian rift valley areas by Enrico Feoli and Zerihun Woldu (2000) had shown less sensitivity of tree-shrub stratocoena for anthropogenic influences which is the main cause of vegetation destruction. Thus, less sensitivity of tree-shrub stratocoena for anthropogenic factor can be the reason for high species diversity in the present study area. However, according to Tesfaye Abebe (2005) finding which was carried out in Sidama Zone there were higher woody diversity than the present finding. This is due to the fact that unlike the present study area Sidama Zone is well known area in growing various tree species as a shade in integration with coffee planting.

The average number of tree species existing per farm was 4.7 having a maximum and minimum value of 36 and 0 respectively. The maximum number of species was recorded in homestead plot and the minimum value (0) was in 10 on-farm plots and 1 homestead plot which mean such plots were without any species. Here, it is important to notice the significance difference in species richness was not due to the difference in farm size since most homestead plots had small size than farthest farm plots in the study area. Thus, around homestead plots there were higher species abundance, richness, diversity and evenness than farthest farm plots (Table 3).

Table 3: Tree species diversity around homesteads and farthest farm plots

S/N	Plot types	Number of plots surveyed	Abundance (number of individuals)	Species Richness	Shannon diversity index	Evenness index
1	Homestead farm plots	102	4329	71	3.2	0.347
2	Farthest farm plots	70	1669	28	2.21	0.327
Total		172	5998	--	--	--

A total of 5,598 individuals were recorded with an average, maximum and minimum value of 34.87 (approximately 35), 814 and 0 individuals per farm plot respectively. Species richness, abundance and diversity of farm land tree species were different among different land use practices (Table 4). Lalisa Alemayehu and Herbert (2010) also reported presence of significance difference in species richness and abundance among land use practices.

Table 4: Farm land tree species diversity among different land use practices

Land use types	Species Richness	%	Abundance (Total number of individuals)	Percentage of abundance	Shannon diversity index	Evenness index
Homestead	62	81.5	1985	33.1	3.05	0.34
Boundary planting	44	57.9	1038	17.3	3.02	0.47
Mixed with crops (on-farm)	37	48.7	1033	17.2	2.43	0.31
Grazing land	10	13.1	64	1.1	1.9	0.67
Small scale woodlot	29	38.1	1497	24.9	1.8	0.21
Hedge row	5	6.6	381	6.3	1.27	0.72
Total	76	--	5998	100	3.09	0.29

From (Table 4) maximum richness and abundance were recorded in homesteads followed by boundary plantings and on-farms (mixed with crops). Similarly highest value of Shannon diversity index was observed in homesteads (3.05) followed by boundary planting (3.02) and on-farms (2.43) with a total value of 3.09. Again small scale wood lots and grazing lands had intermediate value of diversity and with the last diversity rank hedge row planting had lowest diversity. But, the evenness value indicates that hedge row planting followed by grazing land had highest equitability.

The reason for highest diversity around homesteads and boundary planting may be due to proximity and presence of favorable condition for management. This can be convinced that, most of species in homestead areas were planted (54.8%) rather than naturally regenerated species (which was 45%). The case was reverse for on-farm species richness as most of farm tree species (64.8%) were naturally regenerated and the remaining 35% (Appendix 2) species were planted tree species indicating slight interest of farmers to plant trees in cultivated lands. Thus, on-farm plots had less diversity than homestead plots. Still the same reason is raised for boundary planting since farmers mostly plant and manage tree species around their homes as a support of fences and as fencing material. Lalisa Alemayehu and Herbert (2009) finding also shows presence of high farmers' preference to this practice next to small scale woodlot. Whereas, diversity in grazing lands was relatively low due to the fact of shortage of land to leave lands as grazing land and presence of disturbance with cattle. Small scale woodlot had low diversity index (this is because, this practice is not common and needs a piece of free land) but had highest abundance next to homesteads this is mainly for the reason that farmers plant and manage single species (mostly *Eucalyptus camaldulensis*) (Table 5) that is reported by Abebe Tesfaye (2005). The last practice which was observed in the study area was hedge row planting that was only in one farm plot having 5 rows with a length of 53m each and 0.5-2m spacing (the longest spacing was observed among fruit trees) between trees and in this plot a total of 5 species and 381trees were recorded. According to findings of Lalisa Alemayehu and Herbert (2009) which was done on farmers' preference and response regarding various agroforestry practices, hedge row planting was ranked the least out of all the options agroforestry systems that indicates its newness and unfamiliarity of farmers to it.

In other case the most abundant species in homesteads was *Acacia tortilis* followed by *Jatropha curcas*, *Croton macrostachyus* and *Azadirachta indica*. While, *Schinus molle* followed by *Jatropha curcas, Ricinus communis* and *Acacia tortilis* were most abundant species in boundary planting. In on farm plots *Acacia tortilis* followed by *Balanites aegyptiaca*, *Acacia senegal*, and *Croton macrostachyus* were most abundant species. Whereas, *Balanites aegyptiaca*, *Eucalyptus camaldulensis* and *Cajanus cajan* were most abundant species in grazing land, small scale woodlot and hedge row plantings respectively (Table 5). The remaining species exist having different abundance among various land practices (Appendix 2).

Table 5: Five abundant species in different land use practices

Land uses	Species	Abundance(Total number of individuals)	Percentage of abundance
Homestead	*Acacia tortilis*	408	20.5
	Jatropha curcas	210	10.6
	Croton macrostachyus	202	10.1
	Azadirachta indica	192	9.6
	Acacia Senegal	115	5.8
Boundary planting	*Schinus molle*	122	11.7
	Jatropha curcas	108	10.4
	Ricinus communis	93	8.9
	Acacia tortilis	88	8.5
	Lantana camara	88	8.5
Mixed with crop	*Acacia tortilis*	333	32.2
	Balanites aegyptiaca	123	11.9
	Acacia senegal	120	11.6
	Croton macrostachyus	72	7.9
	Acacia albida	71	6.8
Grazing land	*Balanites aegyptiaca*	19	29.7
	Acacia tortilis	16	25
	Acacia etabica	8	12.5
	Rhus natalensis	7	10.9
	Croton macrostachyus	5	7.8
small scale woodlot	*Eucalyptus camaldulensis*	711	47.5
	Acacia senegal	257	17.1
	Acacia tortilis	205	13.7
	Balanites aegyptiaca	89	5.9
	Azadirachta indica	51	3.4
Hedge row planting	*Cajanus cajan*	142	37.3
	Jacaranda mimosifolia	121	31.7
	Sesbania sesban	94	24.6
	Prunus persica	21	5.5
	Psidium guajava	3	0.8

Proper integration of trees and crops ensure both agricultural and environmental sustainability. However, if there is no better management in the integration it is impossible to achieve such sustainability. In the study area the most dominant crops in the surveyed plots were maize and Teff with a proportional value of 45.87% and 32.2% respectively (Figure 5).

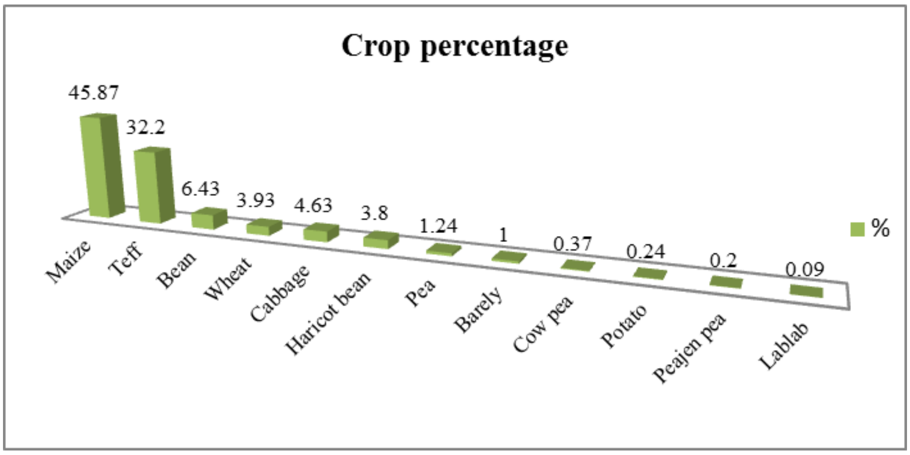


Figure 5: Percentage of cultivated crops in the study area

Trees on-farm plots were associated with such different crops having an average crown spread of 0.1m. The total 1033 recorded tree individuals in on-farms covered a total area of 2.2 ha. *Acacia tortilis* (6m) and *Cordia africana* (5.5m) had highest average crown spread (Table 6). Here, *Acacia tortilis* promote high cover that can be exploited for better growth and productivity of agricultural crops growing under its canopy and therefore used for agroforestry in the ecological condition of the rift valley areas (Zerihun Woldu et al., 1999). Average crown area of each tree species which were on-farms was calculated and presented in table 6 which help to suggest appropriate silvi-cultural practices to reduce competition of biophysical resources. For instance some farmers in this study area tried to manage trees mixed with crops by pollarding tree branches in order to save crops from competition of basic growth factors.

Table 6: Average crown spread, average crown area and total crown area of trees on-farms.

Species	Number of individual	ACS (m)	TCA (m^2)	ACA (m^2)
Acacia tortilis	332	6.0	12592.1	37.9
Cordia africana	4	5.5	106.9	26.7
Commiphora confusa	1	5.2	21.6	21.6
Ficus sycomorus	9	5.1	206.8	22.9
Acacia senegal	119	4.9	2971.7	24.9
Grewia mollis	1	4.9	18.8	18.8
Schinus molle	3	4.7	52.1	17.4
Gerwia velutina	2	4.2	30.1	15.1
Lannea schimpeli	2	4.1	27.0	13.5
Acacia seyal	16	4.0	288.4	18.0
Acacia albida	71	3.9	1227.4	17.
Acacia abyssinica	20	3.6	281.1	14.0
Balanites aegyptiaca	122	3.5	1454.8	11.9
Acacia nilotica	11	3.2	107.5	9.8
Croton macrostachyus	73	3.2	735.4	10.1
Olea europaea	1	3.2	8.0	8.0
Ziziphus mucronata	66	3.2	670.9	10.2
Dichrostachys cinerea	52	3.1	476.5	9.2
Maerua angulansis	2	2.9	13.7	6.8
Ehretia cymosa	10	2.7	91.8	9.2
Carissa spinarum	2	2.7	11.8	5.9
Eucalyptus camaldulensis	6	2.7	41.2	6.8
Acacia etabica	26	2.6	205.4	7.9
Scolopia theifolia	1	2.4	4.7	4.7
Erythrina abyssinica	3	2.4	13.8	4.6
Azadirachta indica	13	2.3	62.8	4.8
Carica papaya	1	2.1	3.6	3.6
Acokanthera schimperi	4	2.0	13.4	3.3
Ziziphus hamur	25	1.9	99.8	4.0
Calpurnia aurea	2	1.9	11.6	5.8
Ricinus communis	2	1.9	5.9	3.0
Maytenus arbutifolia	2	1.8	10.7	5.4
Leucaena leucocephala	1	1.7	2.3	2.3
Moringa oleifera	2	1.3	5.1	2.5
Sesbania sesban	12	0.8	13.7	1.1
Cajanus cajan	11	0.8	20.6	1.8
Morus alba	3	0.7	3.8	1.3
Total	1033	--	21913.8	21.2

Where, ACS= Average crown spread, TCA= Total crown area and ACA= Average crown area

4.1.2. Species composition of land use practices

For sites /management practices that share most of species in common, the ecological distance is small. While, sites having few species in common showed large ecological distance and if a given site does not share any species with the other sites the value become one (Kindt and Coe 2005). According to distance matrix calculation boundary planting with homestead showed least distance which is 0.3 that means such land uses were most similar than other combined land use practices. This may be because of such land use practices are mostly managed around homes with similar species preference. The largest ecological distance was observed between hedge row planting and grazing land species indicating complete dissimilarity and other land use combinations showed in (Table 7).

Table 7: Differences of species composition between land use practices

	BO	GL	HS	MA	WL
GL	0.7	0	--	--	--
HS	0.3	0.8	0	--	--
MA	0.5	0.7	0.4	0	--
WL	0.5	0.7	0.5	0.4	0
HG	0.9	1.0	0.9	0.9	0.9

Where, BO= boundary planting, HS= homestead, MA= mixed with crop, WL= small scale wood lot and HG=hedge row planting

4.2. Population structure of farmland trees

4.2.1. Density

Density calculations are significant for analysis of vegetation and comparison of individuals which are found in the same species of a given communities (Kent and Coker, 1992). A total of 5988 individuals in 76.1 ha were recorded thus, the average density of individual trees was 78.8/ha. Seven arbitrary diameter classes were constructed (figure 6). *Acacia tortilis, Acacia albida* and *Acacia abyssinica* were abundant species in highest DBH classes (in 50.1-60 and >60cm DBH classes). The middle DBH classes were dominated by *Acacia tortilis* followed *Acacia Senegal*, *Balanites aegyptiaca*, *Acacia albida*, *Azadirachta indica* and *Schinus molle*.

As shown in Figure 6 total number of trees in each DBH class decreased with an increasing tree diameter classes. This was a normal DBH distribution pattern when viewed from the whole set of plant community, confirming reversed J shape (Figure 6).The majority of the populations, 48.8 individuals per ha (62%), were found in the first lower DBH class showing the dominance of small trees in the agricultural landscape and continuity of planting and managing trees, while the rest 27.3 individuals per ha (38%) were distributed in remaining six DBH classes. This is similar with the finding of Lalisa Alemayehu and Herbert (2010).

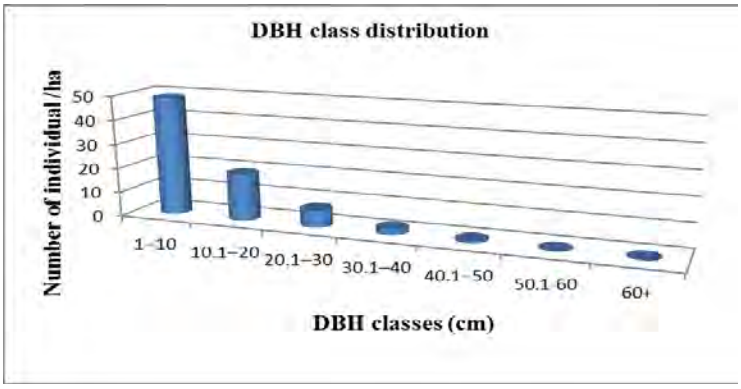


Figure 6: DBH distribution patterns (structure) of farmland trees in the study area

4.2.2. Height distribution

Seven height classes were conventionally established (Figure 7). In a similarly fashion with that of DBH class distribution the total number of individuals in each successive height class was decreasing from the first lower height class to the highest class. The majority of individuals contributing to the first height class came from *Acacia tortilis, Eucalyptus camaldulensis* and *Jatropha curcas. Acacia tortilis* and *Eucalyptus camaldulensis* contributes the highest value in all established classes because of their high abundance value.

As shown in (Figure 7) height distribution patterns of farm land trees in the study area were characterized by higher population at young and middle stage than mature stage indicating recurrent management of tree species. Thus, the general structure of height class d istribution co nfirms i nverted J sh aped pattern w hich sh ows t he st ability o f population structure (Figure 7).

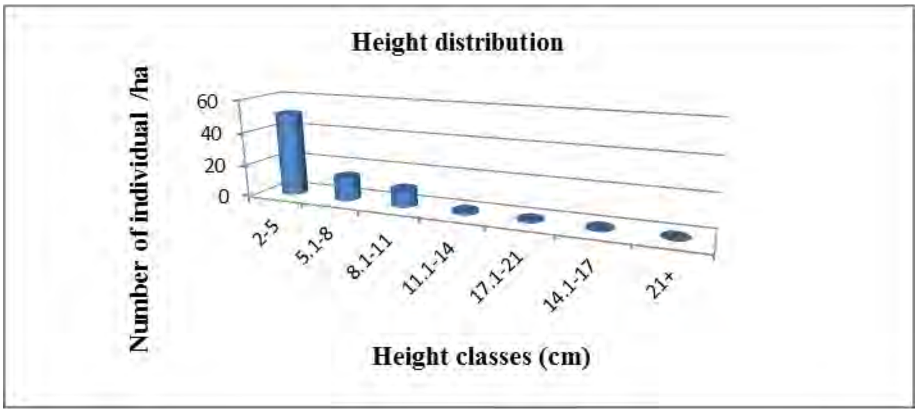


Figure 7: Height distribution patterns (structure)

4.2.3. Basal area

The total basal area (BA) of tree/shrub species was 2.2m^2/ha (Appendix 3). Here, value of basal area was very small and it was expected since the study was carried out in farmlands rather than forest areas. *Eucalyptus camaldulensis* followed by *Acacia tortilis* and *Jatropha curcas* had highest basal area which is 0.5m^2/ha (24.9%), 0.54m^2/ha (22.6%) and 0.15m^2/ha (6.7%) respectively (Table 8). Smallest basal area (< 0.001m^2/ha) was observed in about 32 species.

Table 8: List of species having highest basal area (in decreasing order) with respect to BA in m^2, BA m^2/ ha, %BA.

Species	BA	BA/ha	%
Eucalyptus camaldulensis	41.4	0.54	24.9
Acacia tortilis	37.6	0.49	22.6
Jatropha curcas	11.2	0.15	6.7
Acacia senegal	10.2	0.13	6.1
Balanites aegyptiaca	6.4	0.08	3.8
Acacia albida	6.0	0.08	3.6
Sesbania sesban	6.0	0.08	3.6
Croton macrostachyus	5.3	0.07	3.2
Schinus molle	4.7	0.06	2.8
Azadirachta indica	4.3	0.06	2.6

4.2.4. Frequency

Frequency is the number of sampled farm plots in which a given species occurred in the study area. *Acacia tortilis* followed by *Balanites aegyptiaca* and *Acacia Senegal (*by occurring in 114, ,59 and 51 plots out of 172 and having a relative frequency of 14%, 7.3% and 6.3% respectively*)* were the most frequent species in the study area (Table 11). However, from the total 76 species, 22 species were found only each in one farm plot with the relative frequency value of 0.1% (Appendix 4).

Frequency is the indication of homogeneity and heterogeneity of given vegetation in which the higher number of species in higher frequency classes and low number of species in lower frequency classes show similar species composition while large number of species in lower frequency classes and small number of species in higher frequency classes indicates higher heterogeneity (Lambrecht Hans, 1989). For convenience, the woody species of the study site had been classified into seven frequency classes (Table 9).

Table 9: Species frequency classes of the study area

Number of Frequency classes	1-10	11-20	21-30	31-40	41-50	51-60	>60
Number of species	53	12	2	4	2	2	1

Based on classified frequency classes in the above table, there was high value in lower frequency classes and low values in higher frequency. Therefore, it indicates that the study site had heterogeneous species composition. However, finding of Enrico Feoli and Zerihun Woldu (2000) suggests that presence relatively homogeneous vegetation of the Rift Valley floor and is tending to a climax dominated by Acacia tortilis. This is due to the fact this suggestion was based on species characteristics belonging to the protected sites rather than cultivated sites.

4.2.5. Important value index (IVI)

Important value index indicates the extent of the dominance, occurrence and abundance of a given species in relation to other associated species in an area (Kent and Coker, 1992). According to Lamprecht Hans, (1989) important value index is used to compare the ecological importance of species. Species with the greatest importance value are the primary dominant of specified vegetation (Simon Shibru and Girma Balcha, 2004). The result of Importance Value Index (IVI) showed that *Acacia tortilis* (18.1%), *Eucalyptus camaldulensis* (14.2%) *Acacia senegal* (7%) had highest importance value index (Table 10).

Table 10: Importance value index (IVI) of 15 dominant tree/shrub species

Species	Relative dominance	Relative density	Relative frequency	IVI
Acacia tortilis	22.6	17.5	14.2	54.3
Eucalyptus camaldulensis	24.9	13.6	4.1	42.6
Acacia senegal	6.1	8.6	6.2	20.9
Balanites aegyptiaca	3.9	5.3	7.1	16.3
Croton macrostachyus	3.2	6.1	5.4	14.6
Jatropha curcas	6.7	5.3	1.9	13.9
Azadirachta indica	2.6	5.1	4.6	12.3
Acacia albida	3.6	1.7	5.4	10.7
Schinus molle	2.8	3.1	3.4	9.3
Dichrostachys cinerea	1.8	3	4.1	8.9
Ziziphus mucronata	1.5	2.1	4.7	8.4
Sesbania sesban	3.6	3.4	0.7	7.7
Ricinus communis	2.5	2.5	1.5	6.5
Acacia etabica	1.8	1.8	2.4	6
Lantana camara	0.8	1.9	2.6	5.3

Acacia tortilis and *Eucalyptus camaldulensis* were the leading dominant and ecologically most significant species and might be the most successful species in the regeneration.

4.3. Regeneration status of farmland trees

In fact regeneration capacity of farmland trees unlike intact forest would be affected by different activities and preference of farmers. However, existed seedlings and saplings by resisting various challenges can indicate the regeneration capacity of a given species. Therefore, it is possible to see regeneration capacity of the single trees species and to quantify newly planted tree species by farmers. Thus, composition and density of seedlings and saplings of tree species were included in this study. A total of 1094 seedlings and 1560 saplings having a total density of 14.37/ha and 20.44/ha were recorded respectively. From the total 76 recorded tree species 25 species had seedlings and 34 species had saplings and one additional species (*Fueggea virosa*) was recorded having one sapling. From naturally regenerated plants *Acacia tortilis and Croton macrostachyus* followed by *Acacia Senegal, Balanites aegyptiaca,* and *Dichrostachys cinerea* and have relatively high regeneration capacity (Figure 8) even with the presence of disturbance by farmers during land preparation and other activities. Whereas, *Jatropha curcas* and *Eucalyptus camaldulensis* are planted species having high number of newly planted seedlings and saplings (Appendix 5).

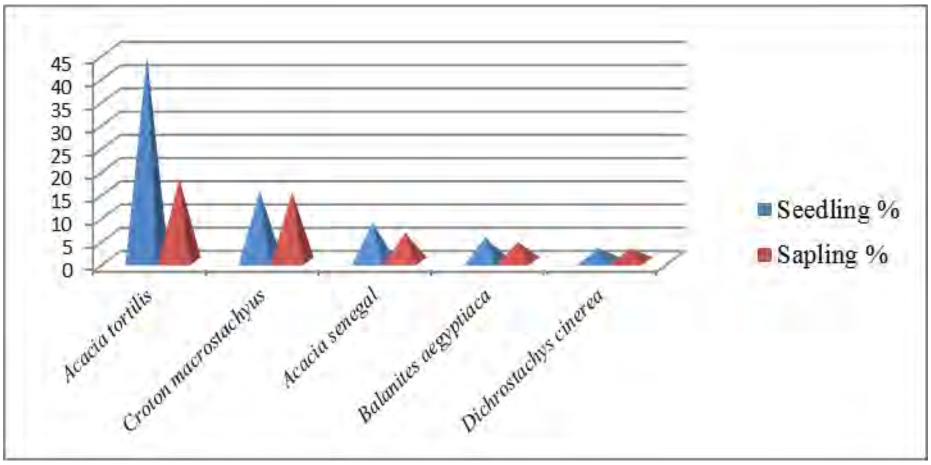


Figure 9: Regeneration statuses of highly regenerated tree species in the study area

4.4. Establishment and planting material of farmland trees in the study area

From the total 76 recorded species 46 of them having 3382 (56.4%) individuals were generated naturally whereas, 39 species with 2616 (43.6%) individuals were planted by farmers. Here, nine species were established in both cases. Seeds, seedlings and cuttings were used as plant material. About 48 species with 3744 (62.4%) individuals and 37 species with 1913 (31.9%) individuals were established with seed and seedlings respectively and 12 species were established with both seeds and seedlings. The remaining 3 species with 341 (5.7%) individuals were established through cutting. Most of planted trees (93.9%) in the study area were planted by husbands; however women and children also participate in planting process (Appendix 8).

4.4. Socioeconomic uses of selected trees species

Based on important value index (except *Jatropha curcas*) 10 species were selected for assessing socio economic uses of abundant and frequent species in the study area (Table 13). Here, Jatropha curcas was excluded from the selection as its rank influenced more by relative dominance with low relative frequency and relative density. On the other hand this species was less frequent and not known by most farmers in the study area. Tree species in the study area were ranked by taking mean of ranks at site level. From the selected 10 species based on their socio economic uses *Acacia tortilis,* followed by *Eucalyptus camaldulensis* and *Acacia albida* ranked top in the list. From this result, communities' preference for *Acacia tortilis* is highest and *Schinus molle* is the least.

Table 11: Tree Species ranking based on their socio economic uses in the study area

Tree Species	Mean Rank	Overall Rank	Std. Deviation	Minimum	Maximum
Acacia tortilis	2.40	1st	2.191	1	5
Eucalyptus camaldulensis	2.60	2nd	2.074	1	5
Acacia albida	4.20	3rd	1.483	2	5
Ziziphus mucronata	4.80	4th	.837	4	5
Dichrostachys cinerea	6.60	5th	4.099	3	8
Acacia senegal	6.80	6th	3.701	2	8
Balanites aegyptiaca	7.80	7th	3.271	3	9
Azadirachta indica	8.20	8th	1.095	6	9
Croton macrostachyus	8.60	9th	1.817	7	9
Schinus molle	10.40	10th	1.949	9	10
Total	6.24	50	3.396	1	10

Farmland trees contribute indispensable social, economic and environmental significance for farmers in the study area. All of selected tree species has more than five functions. The function of each species was ranked from highest to the least and summarized and presented in Appendix 7. For instance, *Acacia tortilis* was ranked to be first as a shade and least ranked as erosion control. During focus group discussions farmers didn't gave priority regarding uses of trees for soil conservation as most of the areas are characterized by uniform topography rather than sloppy one. But they understand that most species contribute for soil conservation and they put in the lower rank (Appendix 7).

4.5. The influence of land holding on tree species diversity

To see the correlation between land holding on tree species abundance and other diversity indices only data on homestead plots was used and summarized using descriptive statistics (Appendix 8). As it is computed using non parametric correlation coefficients by Kendall's tau b and Spearman's rho, it is only abundance found to be significantly related to land holding. The correlation coefficient between abundance and land holding was 0.149 (Kendall's tau b) and 0.209 (Spearman's rho) both of which were significant to (p=0.03) 3% level of error and to (p=0.037) 3.7% level error respectively. Others Richness, Shannon and Evenness indices were not significant to 5 even 10 % level of error (Table 13).

Table 13: Correlation coefficients of land holding versus abundance, species richness, Shannon diversity and Evenness index

Response variables	Method	Independent variable (land holding)	
		Correlation coefficient	P- value
Abundance	Kendall's tau b	.149*	0.3
	Spearman's rho	.209*	.037
Richness	Kendall's tau b	.074ns	.295
	Spearman's rho	.106 ns	.293
Shannon	Kendall's tau b	.096 ns	.158
	Spearman's rho	.150 ns	.138
Evenness	Kendall's tau b	-.026 ns	.705
	Spearman's rho	-.034 ns	.733

The significance relationship between land holding and number of individual trees shows that farmers with small farm size give more priority of for growing crops than planting and managing trees. On the other hand, the more land farmers own, the higher is the chance to grow trees. Significance relation of tree individuals with land holding was also reported by Tesfaye Abebe (2005). However, lack of significant relationship between land holding and species richness contradict with his finding as he reported the presence of significant relationship between them. Insignificant relation of land holding with species richness, Shannon diversity and evenness indicates that land holding alone is not the dominant contributing factor of the species diversity in the present study area.

CHAPTER V

5. Conclusion and Recommendations

5.1. Conclusion

Even though, East Shewa zone is among the most severely deforested parts of Oromia National Regional State and farm land trees could be exist trough passing various challenges, results of the present study showed that studied farmlands had considerable species richness and diversity. A total of seventy six species representing 63 genera and 32 families were recorded in the 172 farm plots of study sites under different land use practices.

Homestead planting, boundary planting, mixed with crop, grazing land, small scale woodlot and hedge row planting were land use practices that were observed in the study sites. There were highest species diversity and richness in the homesteads and boundary plantings respectively which indicates farmer's willingness to plant and manage trees in such areas due to the fact of proximity for management. Trees with crops (on-farm planting) had also considerable species richness and abundance.

In the study area farm land trees play a significant role for farmers through various social, economic and environmental benefits. There were significance relationship between land holding and number of individual trees however; land holding with species richness, Shannon diversity and evenness index didn't show significant relationship implying land holding couldn't be taken as a main determinant factor in the study area for species diversity except abundance of a given tree species.

5.2. Recommendations

- To meet growing demand for tree products; improving and encouraging of homestead and boundary plantings become a vital activity as such activities already common and practiced by most of farmers.
- In order to make the existing agroforestry system successful trough enhancing agricultural productivity sustainably and as trees with crops (on-farm planting) play a great role for both environment and economic development there is a need to use extension system in order to convince local farmers and to create awareness about planting and managing of multipurpose and nitrogen fixing tree plants.
- Moreover, introducing and expanding of new practices like hedge row planting would be necessary as this agroforestry practice can facilitates nutrient cycling (the roots of trees bring up nutrients from deeper soil horizons to the surface for crops), keeps the soil from drying by shading it against sunlight and reduce soil erosion.

Generally, designing appropriate management strategies and approaches should be required for domestication and integration of improved tree crops by diversifying and intensifying a wide range of priority species for meeting the needs of farmers and environmental services. Primarily these activities go to Woreda's agriculture and rural development offices trough assisting farmers and feeding information for and following activities of non-government organizations like ICRAF who aimed at solving problems related to above stated issues.

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Appendices

Appendix 1: List of plant species collected from farmlands in the study areas. Key: T=Tree, SH=Shrub, T/S= Tree/shrub, S/C= Shrub/climber, Or= Oromifa, Amh=Amharic, Eng= English

S/N	Scientific Name	Vencular name	Origin	Family	Habit
1	*Acacia abyssinica Hochst. ex Benth*	Lafto (Or)	Indigenous	Fabaceae	T
2	*Acacia albida (Faidherbia albida)*	Gerbi (Or)	Indigenous	Fabaceae	T
3	*Acacia brevispica Harms*	Qwentr (Gora) (Or)	Indigenous	Fabaceae	S/T
4	*Acacia etabica Schweinf.*	Dodota (Or)	Indigenous	Fabaceae	T
5	*Acacia nilotica (L) Wild. ex Del*	Koredimo/Kasale (Or)	Indigenous	Fabaceae	S/T
6	*Acacia saligna (Racosperma saligna) (Labill.) Wendl*	Akacha saligna (Or)	Australia	Fabaceae	S/T
7	*Acacia senegal (L.) Willd*	Kerteta (Sabansa) (Or)	Indigenous	Fabaceae	S/T
8	*Acacia seyal Del*	Wachu (Or)	Indigenous	Fabaceae	T
9	*Acacia tortilis (Forssk) Hayne*	Tedecha (Or)	Indigenous	Fabaceae	T
10	*Acokanthera schimperi (A.DC.) Schweinf*	Qararo(Or)	Indigenous	Apocynaceae	T
11	*Albizia corialia Welw ex Olill*	Muka-arba(Or)	Indigenous	Fabaceae	T
12	*Albizia gumnifera (J.F. Gmel.) C.A. Sm*	Muka-arba (Or)	Indigenous	Fabaceae	T
13	*Azadirachta indica A. Juss*	Neem (Or)	North-east India, Burma	Meliaceae	T
14	*Balanites aegyptiaca (L.) Del*	Bedena (Or)	Indigenous	Balanitaceae	T
15	*Boscia salicifolia Oliv.*	Qalqualcha(Or)	Indigenous	Cappalidaceae	S/T
16	*Boscia senegalensis Lam. ex. Poiret.*	Lenquata (Amh)	Indigenous	Cappalidaceae	S/T
17	*Cadaba farinosa Forssk.*	Arengaba ((Or))	Indigenous	Capparidacea	S
18	*Cajanus cajan (L.) Millsp*	Yergib ater (Amh)	S.E. Asia	Fabaceae	S
19	*Calotropis procera (Ait.) Ait.f*	Qimbo(Falfala adal) (Or)	Indigenous	Asclepiadaceae	S
20	*Calpurnia aurea (Ait) Benth*	Ceka, Cekata (Or)	Indigenous	Fabaceae	S/T
21	*Capparis tomentosa Lam.*	Gumero/Gora (Or)	Indigenous	Capparidacea	S/C
22	*Carica papaya L.*	Papaya (Amh)	Indigenous	Caricaceae	T
23	*Carissa spinarum (C. edulis) L.*	Agamsa (Or)	Indigenous	Apocynaceae	S/T
24	*Casimiroa edulis La Llave*	Kazamora (Or)	Mexico, South America	Rutaceae	T

Appendix 1 Continued

25	*Casuarina equisetifolia*	Shewshewe (Amh)	S.E. Asia, northern and north-eastern	Casuarinaceae	T
26	*Celtis africana Burm. F*	Meto koma (Or)	Indigenous	Ulmaceae	T
27	*Commiphora confusa Vollesen*	Hamessa (Hamecha) (Or)	Indigenous	Burseraceae	T
28	*Cordia africana Lam.*	Wadessa (Or)	Indigenous	Boraginaceae	T
29	*Cordia monoica Rucb.*	Menero(mintiro) (Or)	Indigenous	Boraginaceae	T
30	*Croton macrostachyus Del.*	Bakanissa (Or)	Indigenous	Euphorbiaceae	T
31	*Delonix regia (Boj. ex Hook)*	Dire Dawa zaf (Amh)	Madagascar	Fabaceae	T
32	*Dichrostachys cinerea (L.) Wight & Arn*	Hatte (Geto) (Or)	Indigenous	Fabaceae	T
33	*Dodonaea viscosa auct. Mult., Jacq.*	Etacha (Or)	Indigenous	Sapindaceae	S/T
34	*Dovyalis abyssinica (A. Rich.) Warb.*	Koshim (Amh)	Indigenous	Flacourtiaceae	S/T
35	*Ehretia cymosa Thonn.*	Ulaga (Or)	Indigenous	Boraginaceae	S/T
36	*Erythrina abyssinica Lam. Ex Dc.*	Welenisu (Or)	Indigenous	Fabaceae	T
37	*Eucalyptus camaldulensis Dehnh*	keyi baher zafe (Amh)	Eastern	Myrtaceae	T
38	*Euphorbia tirucalli L.*	Anno (Or)	Indigenous	Euphorbiaceae	T
39	*Ficus sycomorus L.*	Oda (Or)	Indigenous	Moraceae	T
40	*Gerwia velutina (Forssk.) Vahl.*	Haroresa (Or)	Indigenous	Tiliaceae	S/T
41	*Gossypium arboreum L.*	Tit (Amh)	Indigenous	Manaceae	S
42	*Grevillea robusta R. Br.*	Grevila (Amh)	Eastern	Proteaceae	T
43	*Grewia mollis Juss*	Drisa (Or)	Indigenous	Tiliaceae	S/T
44	*Jacaranda mimosifolia D. Dan.*	Yetebmenja zaf (Amh)	Brazil	Bignoniaceae	T
45	*Jatropha curcas L.*	Physic nut, purging nut (Eng)	Tropical America	Euphorbiaceae	S/T
46	*Lannea schimpeli (A.Rich.) Engl.*	Anderko (Or)	Indigenous	Anacardiaceae	T
47	*Lantana camera L.*	Yewof qolo (Amh)	South America	Verbenaceae	S
48	*Leucaena leucocephala (Lam.) De Wit*	Lukina (Or)	Central America	Fabaceae	S/T
49	*Maerua angulansis. Angula, Bangula, Jose da silva s.n (pholo)*	Dergu (Or)	Indigenous	Capparidacea	
50	*Mangifera indica L.*	Mango) (Or)	Northern India Myanmar	Anacardiacea e	S/T

Appendix 1 continued

51	*Maytenus arbutifolia (A.Rich.) Wilczek*	Kombolcha (Or)	Indigenous	Celastraceae	T
52	*Melia azedarach.L*	Persian lilac (Eng)	Western Asia, Himalayas	Meliaceae	T
53	*Moringa oleifera Lam.*	Shiferaw (Amh)	India	Moringaceae	T
54	*Morus alba*	Yeferenji injori (Amh)	China	Moraceae	T
55	*Olea europaea subsp. cuspidata (Olea africana) L.*	Ejerssa (Or)	Indigenous	Oleaceae	T
56	*Osyris queadripartita Decn.*	Gale korma (Or)	Indigenous	Santalaceae	S/T
57	*Parkinsonia aculeata L.*	Ye-eyerusalem eshoh (Amh)	Tropical America	Fabaceae	S/T
58	*phyllanthus ovalifolius Forssk.*	Egri (Or)	Indigenous	Euphorbiaceae	S/T
59	*Prunus persica (L.) Batsch*	Kock (Amh)	South-West, Asia, China	Rosaceae	T
60	*Psidium guajava L.*	Zeituna (Amh)	Tropical America	Myrtaceae	T
61	*Rhamnus prinoides L 'Herit.*	Gesho (Or)	Indigenous	Rhamnaceae	S
62	*Rhus natalensis Krauss*	Debobessa (Or)	Indigenous	Anacardiaceae	S/T
63	*Ricinus communis L.*	Qobo (Or)	Indigenous to Africa	Euphorbiaceae	S/T
64	*Ritchiea albersii Gilg.*	Chubeterie (Or)	Indigenous	Cappalidaceae	S/T
65	*Rosa abyssinica Lindley*	Gora (Or)	Indigenous	Rosaceae	S/T
66	*Schinus molle L.*	T'our-Berberie (Amh)	Peru, Andes	Anacardiaceae	T
67	*Scolopia theifolia Gilg*	Bunity (Or)	Indigenous	Flacourtiaceae	T
68	*Senna didymobutrya (Fresen.) Irwin & Barneby*	Asene meka (Or)	Indigenous	Fabaceae	S
69	*Senna siamea (Cassia siamea) (T2) (Lam.) Irwin & Barneby*	Yeferenji digita (Amh)	S. E. Asia	Fabaceae	T
70	*Sesbania sesban (L.) Merr.*	Suspania (Or)	Indigenous	Fabaceae	S/T
71	*Spathodea campanulata P. Beauv.*	Yechaka nebelbal (Amh)	Indigenous	Bignoniaceae	T
72	*Synadenium comyactum N. E. Br.*	Yegoma zaf (Amh)	Eastern	Euphorbiaceae	S/T
73	*Vernonia amygdalina Del.*	Ebicha (Or)	Indigenous	Asteraceae	S/T
74	*Ziziphus hamur Engl.*	Bulecha (Or)	Indigenous	Rhamnaceae	S
75	*Ziziphus mauitiana Lam.*	Qurqura (Nimora) (Or)	Indigenous	Rhamnaceae	S/T
76	*Ziziphus mucronata Wild*	Qurqura (Or)	Indigenous	Rhamnaceae	S/T

Appendix 2: L ist o f s pecies a long w ith their e stablishment a nd a bundance a mong different land uses (R= retained, P= planted, HS= homestead, BO= Boundary planting, MA= Mixed with crop, GL= grazing land, WL= wood lot and HG= hedge row)

Species	Establishment	HS	BO	MA	GL	WL	HG	**Total**
Acacia abyssinica	R	6	6	19	0	0	0	31
Acacia albida	R/P	20	3	71	0	7	0	101
Acacia brevispica	R	1	24	0	0	0	0	25
Acacia etabica	R	44	4	26	8	27	0	109
Acacia nilotica	R	7	0	11	0	2	0	20
Acacia saligna	P	33	20	0	0	10	0	63
Acacia senegal	R	115	19	120	3	257	0	514
Acacia seyal	R	7	3	16	0	0	0	26
Acacia tortilis	R	408	88	333	16	205	0	1050
Acokanthera schimperi	R	0	0	4	0	0	0	4
Albizia corialia	P	0	2		0	0	0	2
Albizia gumnifera	P	2	0	0	0	0	0	2
Azadirachta indica	P	192	48	13	0	51	0	304
Balanites aegyptiaca	R	50	37	123	19	89	0	318
Boscia salicifolia	R	4	3	0	0	0	0	7
Boscia senegalensis	R	4	8	0	1	0	0	13
cadaba farinosa	R	8	0	0	0	0	0	8
Cajanus cajan	P	1	0	11	0	0	142	154
Calotropis procera	R	0	2	0	0	0	0	2
Calpurnia aurea	R	62	4	2	0	4	0	72
Capparis tomentosa	R	2	0	0	0	0	0	2
Carica papaya	P	21	0	1	0	1	0	23
Carissa spinarum	R	26	12	2	0	4	0	44
Casimiroa edulis	P	2	0	0	0	0	0	2
Casuarina equisetifolia	P	3	0	0	0	1	0	4
Celtis Africana	R	2	1	0	0	0	0	3
Commiphora confusa	R	0	11	1	0	0	0	12
Cordia Africana	P/R	14	2	3	0	3	0	22
Cordia monoica Rucb.	R	1	0	0	0	0	0	1
Croton macrostachyus	R	202	67	72	5	17	0	363
Delonix regia	P	2	0	0	0	0	0	2
Dichrostachys cinerea	P	58	27	52	2	38	0	177
Dodonaea viscosa	P	3	0	0	0	5	0	8
Dovyalis abyssinica	P	4	3	0	0	0	0	7
Ehretia cymosa	P/R	24	2	10	0	3	0	39
Erythrina abyssinica	R	0	0	3	0	0	0	3
Eucalyptus camaldulensis	P	41	59	6	0	711	0	817
Euphorbia tirucalli	R/P	28	2	0	0	0	0	30

Appendix 2 Continued

Ficus sycomorus	R	0	0	9	0	0	0	9
Gerwia velutina	R	2	3	2	0	0	0	7
Gossypium arboreum	P	5	0	0	0	0	0	5
Grevillea robusta	P	3	0	0	0	9	0	12
Grewia mollis	R	0	0	1	0	0	0	1
Jacaranda mimosifolia	P	15	1	0	0	0	121	137
Jatropha curcas	P	210	108	0	0	0	0	318
Lannea schimpeli	R	0	0	2	0	0	0	2
Lantana Camara	R	25	88	0	0	0	0	113
Leucaena leucocephala	P	34	31	1	0	2	0	68
Maerua angulansis	R	0	0	2	0	0	0	2
Mangifera indica	P	0	0	0	0	2	0	2
Maytenus arbutifolia	R	1	0	2	0	0	0	3
Melia azedarach	P	3	7	0	0	0	0	10
Moringa oleifera	P	7	1	2	0	10	0	20
Morus alba	P	2	1	3	0	0	0	6
Olea europaea subsp. cuspidata (Olea africana)	P/R	3	1	1	0	0	0	5
Osyris queadripartita	R	0	0	0	0	8	0	8
Parkinsonia aculeata	P	2	6	0	0	0	0	8
phyllanthus ovalifolius	R	7	0	0	0	0	0	7
Prunus persica	P	0	0	0	0	0	21	21
Psidium guajava	P	2	0	0	0	0	3	5
Rhamnus prinoides	P	4	0	0	0	0	0	4
Rhus natalensis	R	35	10	0	7	0	0	52
Ricinus communis	P/R	54	93	2	0	0	0	149
Ritchiea albersii	R	4	4	0	1	1	0	10
Rosa abyssinica	R	1	2	0	0	0	0	3
Schinus molle	P/R	56	122	3	0	7	0	188
Scolopia theifolia	P	0	0	1	0	0	0	1
Senna didymobutrya	R	22	0	0	0	0	0	22
Senna siamea (Cassia siamea)	P	4	6	0	0	0	0	10
Sesbania sesban	P/R	29	61	12	0	8	94	204
Spathodea nilotica	P	2	0	0	0	0	0	2
Synadenium comyactum	P	3	0	0	0	0	0	3
Vernonia amygdalina	P	6	0	0	0	8	0	14
Ziziphus humur	P	20	10	25	0	0	0	55
Ziziphus mauitiana	R	0	0	0	0	1	0	1
Ziziphus mucronata	R	27	26	66	2	6	0	127
Grand total		1985	1038	1033	64	1497	381	5998

Appendix 3: Species basal area (in descending order)

Species	Basal area	Basal area/ha	%
Eucalyptus camaldulensis	41.37929	0.543749	24.851
Acacia tortilis	37.57886	0.493809	22.569
Jatropha curcas	11.2	0.147174	6.726
Acacia senegal	10.21292	0.134204	6.134
Balanites aegyptiaca	6.413948	0.084283	3.852
Acacia albida	6.065682	0.079707	3.643
Sesbania sesban	5.993621	0.07876	3.600
Croton macrostachyus	5.31864	0.06989	3.194
Schinus molle	4.708341	0.06187	2.828
Azadirachta indica	4.361543	0.057313	2.619
Cajanus cajan	4.336872	0.056989	2.605
Ricinus communis	4.234874	0.055649	2.543
Dichrostachys cinerea	3.093021	0.040644	1.858
Acacia etabica	2.979065	0.039147	1.789
Ziziphus mucronata	2.49185	0.032744	1.497
Jacaranda mimosifolia	1.68656	0.022162	1.013
Carica papaya	1.627646	0.021388	0.978
Prunus persica	1.48359	0.019495	0.891
Lantana camara	1.382147	0.018162	0.830
Acacia abyssinica	1.261556	0.016578	0.758
Moringa oleifera	0.761268	0.010004	0.457
Ziziphus humur	0.739295	0.009715	0.444
Acacia saligna	0.697318	0.009163	0.419
Cordia africana	0.696324	0.00915	0.418
Euphorbia tirucalli	0.519356	0.006825	0.312
Ehretia cymosa	0.487845	0.006411	0.293
Acacia seyal	0.47148	0.006196	0.283
Leucaena leucocephala	0.453563	0.00596	0.272
Rhus natalensis	0.425684	0.005594	0.256
Calpurnia aurea	0.308602	0.004055	0.185
Lannea schimpeli	0.302699	0.003978	0.182
Ficus sycomorus	0.273838	0.003598	0.164
Acacia nilotica	0.257587	0.003385	0.155
Grevillea robusta	0.223285	0.002934	0.134
Senna didymobutrya	0.169421	0.002226	0.102
Ritchiea albersii	0.162205	0.002131	0.097
Acacia brevispica	0.142182	0.001868	0.085
Carissa spinarum	0.140656	0.001848	0.084
Celtis africana	0.133437	0.001753	0.080
Commiphora confusa	0.122095	0.001604	0.073
Delonix regia	0.109931	0.001445	0.066

Appendix 3 Continued

Grewia mollis	0.104009	0.001367	0.062
Vernonia amygdalina	0.087696	0.001152	0.053
Maytenus arbutifolia	0.076987	0.001012	0.046
Olea europaea subsp. cuspidata (Olea africana)	0.072046	0.000947	0.043
Melia azedarach	0.071799	0.000943	0.043
Senna siamea (Cassia siamea)	0.063337	0.000832	0.038
Spathodea nilotica	0.061056	0.000802	0.037
Erythrina abyssinica	0.054794	0.00072	0.033
Parkinsonia aculeata	0.051914	0.000682	0.031
Gerwia velutina	0.050716	0.000666	0.030
Casimiroa edulis	0.045773	0.000601	0.027
cadaba farinosa	0.039861	0.000524	0.024
Boscia senegalensis	0.038426	0.000505	0.023
Boscia salicifolia	0.036364	0.000478	0.022
Maerua angulansis	0.029539	0.000388	0.018
Morus alba	0.024797	0.000326	0.015
Mangifera indica	0.023438	0.000308	0.014
Albizia corialia	0.02318	0.000305	0.014
Osyris queadripartita	0.015041	0.000198	0.009
Psidium guajava	0.014544	0.000191	0.009
Capparis tomentosa	0.013874	0.000182	0.008
phyllanthus ovalifolius	0.012257	0.000161	0.007
Casuarina equisetifolia	0.011993	0.000158	0.007
Calotropis procera	0.011484	0.000151	0.007
Dovyalis abyssinica	0.010944	0.000144	0.007
Dodonaea viscosa	0.010619	0.00014	0.006
Acokanthera schimperi	0.008243	0.000108	0.005
Gossypium arboreum	0.00612	8.04E-05	0.004
Rosa abyssinica	0.005558	7.3E-05	0.003
Rhamnus prinoides	0.005382	7.07E-05	0.003
Cordia monoica Rucb.	0.004776	6.28E-05	0.003
Scolopia theifolia	0.003957	5.2E-05	0.002
Synadenium comyactum	0.003895	5.12E-05	0.002
Albizia gumnifera	0.002211	2.91E-05	0.001
Ziziphus mauitiana	0.001809	2.38E-05	0.001
Total	166.50	2.18	100

Appendix 4: Relative density, relative dominance, relative frequency and important value index of species (in descending order for important value index).

Species	Relative dominance	Relative density	Relative frequency	IVI
Acacia tortilis	22.569	17.5	14.2	54.3
Eucalyptus camaldulensis	24.851	13.6	4.1	42.6
Acacia senegal	6.134	8.6	6.2	20.9
Balanites aegyptiaca	3.852	5.3	7.1	16.3
Croton macrostachyus	3.194	6.1	5.4	14.6
Jatropha curcas	6.726	5.3	1.9	13.9
Azadirachta indica	2.619	5.1	4.6	12.3
Acacia albida	3.643	1.7	5.4	10.7
Schinus molle	2.828	3.1	3.4	9.3
Dichrostachys cinerea	1.858	3	4.1	8.9
Ziziphus mucronata	1.497	2.1	4.7	8.4
Sesbania sesban	3.6	3.4	0.7	7.7
Ricinus communis	2.543	2.5	1.5	6.5
Acacia etabica	1.789	1.8	2.4	6
Lantana Camara	0.83	1.9	2.6	5.3
Cajanus cajan	2.605	2.6	0.1	5.3
Jacaranda mimosifolia	1.013	2.3	1.5	4.8
Ziziphus hamur	0.444	0.9	2.2	3.6
Acacia abyssinica	0.758	0.5	2.2	3.5
Leucaena leucocephala	0.272	1.1	1.7	3.2
Acacia saligna	0.419	1.1	1.2	2.7
Calpurnia aurea	0.185	1.2	1.2	2.6
Cordia africana	0.418	0.4	1.7	2.5
Acacia seyal	0.283	0.4	1.5	2.2
Ehretia cymosa	0.293	0.7	1.2	2.2
Carica papaya	0.978	0.4	0.7	2.1
Rhus natalensis	0.256	0.9	0.9	2
Acacia nilotica	0.155	0.3	1.4	1.9
Carissa spinarum	0.084	0.7	0.7	1.6
Euphorbia tirucalli	0.312	0.5	0.6	1.4
Moringa oleifera	0.457	0.3	0.6	1.4
Prunus persica	0.891	0.4	0.1	1.4
Ritchiea albersii	0.097	0.2	0.7	1
Acacia brevispica	0.085	0.4	0.5	1
Senna didymobutrya	0.102	0.4	0.5	1

Appendix 4 continued

Gerwia velutina	0.03	0.1	0.7	0.9
Grevillea robusta	0.134	0.2	0.5	0.8
Senna siamea (Cassia siamea)	0.038	0.2	0.5	0.7
Vernonia amygdalina	0.053	0.2	0.4	0.7
Boscia salicifolia	0.022	0.1	0.5	0.6
Commiphora confusa	0.073	0.2	0.4	0.6
Olea europaea subsp. cuspidata (Olea africana)	0.043	0.1	0.5	0.6
Boscia senegalensis	0.023	0.2	0.4	0.6
Melia azedarach	0.043	0.2	0.4	0.6
Lannea schimpeli	0.182	0	0.2	0.5
Casuarina equisetifolia	0.007	0.1	0.4	0.4
Parkinsonia aculeata	0.031	0.1	0.2	0.4
Ficus sycomorus	0.164	0.2	0.1	0.4
Dodonaea viscosa	0.006	0.1	0.2	0.4
Dovyalis abyssinica	0.007	0.1	0.2	0.4
Celtis Africana	0.08	0.1	0.2	0.4
Maytenus arbutifolia	0.046	0.1	0.2	0.3
Gossypium arboreum	0.004	0.1	0.2	0.3
Delonix regia	0.066	0	0.2	0.3
Erythrina abyssinica	0.033	0.1	0.2	0.3
Casimiroa edulis	0.027	0	0.2	0.3
Rosa abyssinica	0.003	0.1	0.2	0.3
cadaba farinosa	0.024	0.1	0.1	0.3
Osyris queadripartita	0.009	0.1	0.1	0.3
phyllanthus ovalifolius	0.007	0.1	0.1	0.2
Morus alba	0.015	0.1	0.1	0.2
Psidium guajava	0.009	0.1	0.1	0.2
Acokanthera schimperi	0.005	0.1	0.1	0.2
Rhamnus prinoides	0.003	0.1	0.1	0.2
Grewia mollis	0.062	0	0.1	0.2
Spathodea nilotica	0.037	0	0.1	0.2
Synadenium comyactum	0.002	0.1	0.1	0.2
Maerua angulansis	0.018	0	0.1	0.2
Mangifera indica	0.014	0	0.1	0.2
Albizia corialia	0.014	0	0.1	0.2
Capparis tomentosa	0.008	0	0.1	0.2

Appendix 4 continued

Calotropis procera	0.007	0	0.1	0.2
Albizia gumnifera	0.001	0	0.1	0.2
Cordia monoica	0.003	0	0.1	0.1
Scolopia theifolia	0.002	0	0.1	0.1
Ziziphus mauitiana	0.001	0	0.1	0.1

Appendix 5: Number of seedling and sapling in the study area

Species	Number of seedling	%	Number of sapling	%
Acacia albida	7	0.639854	6	0.384615
Acacia saligna	5	0.457038	3	0.192308
Acacia senegal	90	8.226691	97	6.217949
Acacia seyal	0	0	2	0.128205
Acacia tortilis	483	44.14991	235	15.0641
Azadirachta indica	22	2.010969	51	3.269231
Balanites aegyptiaca	57	5.210238	66	4.230769
Cajanus cajan	0	0	150	9.615385
Calpurnia aurea	5	0.457038	33	2.115385
Capparis tomentosa	4	0.365631	0	0
Carica papaya	1	0.091408	0	0
Carissa spinarum	0	0	6	0.384615
Celtis africana	0	0	1	0.064103
Cordia africana	15	1.371115	3	0.192308
Cordia monoica	0	0	1	0.064103
Croton macrostachyus	166	15.17367	278	17.82051
Delonix regia	2	0.182815	4	0.25641
Dichrostachys cinerea	31	2.833638	44	2.820513
Dovyalis abyssinica	14	1.279707	22	1.410256
Ehretia cymosa	7	0.639854	2	0.128205
Eucalyptus camaldulensis	104	9.506399	91	5.833333
Fueggea virosa	0	0	1	0.064103
Grevillea robusta	4	0.365631	0	0
Jacaranda mimosifolia	0	0	18	1.153846
Jatropha curcas	11	1.005484	249	15.96154
Mangifera indica	4	0.365631	3	0.192308
Rhamnus prinoides	3	0.274223	25	1.602564
Rhus natalensis	0	0	1	0.064103
Ricinus communis	0	0	4	0.25641
Ritchiea albersii	0	0	5	0.320513
Schinus molle	24	2.193784	51	3.269231
Senna didymobutrya	2	0.182815	6	0.384615
Senna siamea (Cassia siamea)	1	0.091408	9	0.576923
Sesbania sesban	30	2.74223	49	3.141026
Ziziphus humur	2	0.182815	12	0.769231
Ziziphus mucronata	0	0	32	2.051282
Grand Total	1094	100	1560	100

Appendix 6: Establishment and planting material of species including its abundance

Species	Establishment		Planting material			
	Planted	Retained	cutting	Seed	Seedling	**Grand Total**
Acacia abyssinica	31			31		31
Acacia albida	98	3		98	3	101
Acacia brevispica	25			25		25
Acacia etabica	109			109		109
Acacia nilotica	20			20		20
Acacia saligna		63			63	63
Acacia senegal	514			514		514
Acacia seyal	26			26		26
Acacia tortilis	1050			1050	0	1050
Acokanthera schimperi	4			4		4
Albizia corialia		2			2	2
Albizia gumnifera		2			2	2
Azadirachta indica		304			304	304
Balanites aegyptiaca	318			318		318
Boscia salicifolia	7			7		7
Boscia senegalensis	13			13		13
cadaba farinosa	8			8		8
Cajanus cajan		154		153	1	154
Calotropis procera	2			2		2
Calpurnia aurea	72			72		72
Capparis tomentosa	2			2		2
Carica papaya		23			23	23
Carissa spinarum	44			44		44
Casimiroa edulis		2			2	2
Casuarina equisetifolia		4			4	4
Celtis Africana	3			3		3
Commiphora confusa	12			12		12
Cordia Africana	10	12		10	12	22
Cordia monoica Rucb.	1			1		1
Croton macrostachyus	363			363		363
Delonix regia		2			2	2
Dichrostachys cinerea	177			177		177
Dodonaea viscosa		8			8	8
Dovyalis abyssinica		7			7	7
Ehretia cymosa	20	19		20	19	39
Erythrina abyssinica	3			3		3
Eucalyptus camaldulensis		817		76	741	817
Euphorbia tirucalli	2	28	30			30
Ficus sycomorus	9			9		9

Appendix 1 continued

Gerwia velutina	7			7		7
Gossypium arboreum		5			5	5
Grevillea robusta		12			12	12
Grewia mollis	1			1		1
Jacaranda mimosifolia		137			137	137
Jatropha curcas		318	310		8	318
Lannea schimpeli	2			2		2
Lantana Camara	113			113		113
Leucaena leucocephala		68		4	64	68
Maerua angulansis	2			2		2
Mangifera indica		2			2	2
Maytenus arbutifolia	3			3		3
Melia azedarach		10			10	10
Moringa oleifera		20			20	20
Morus alba		6			6	6
Olea europaea subsp. cuspidata (Olea africana)	2	3		2	3	5
Osyris queadripartita	8			8		8
Parkinsonia aculeata		8			8	8
phyllanthus ovalifolius	7			7		7
Prunus persica		21			21	21
Psidium guajava		5			5	5
Rhamnus prinoides		4			4	4
Rhus natalensis	52			52		52
Ricinus communis	16	133		146	3	149
Ritchiea albersii	10			10		10
Rosa abyssinica	3			3		3
Schinus molle	2	186		4	184	188
Scolopia theifolia		1	1			1
Senna didymobutrya	22			22		22
Senna siamea (Cassia siamea)		10			10	10
Sesbania sesban	7	197		7	197	204
Spathodea nilotica		2			2	2
Synadenium comyactum		3			3	3
Vernonia amygdalina		14			14	14
Ziziphus humur	53	2		53	2	55
Ziziphus mauitiana	1			1		1
Ziziphus mucronata	127			127		127
Grand Total	3382	2616	341	3744	1913	5998

Appendix 7: Socio economic uses of ten selected tree species in the study area (numbers indicating uses rank)

Tree Species	Uses of tree species																	
	Shade	Fodder	Fence	Construction	Farm tools	Fire	Charcoal	Income	Fruit	Timber	Bee forage	Erosion control	Soil fertility	Wind break	Medicine	Anti pest	Incense	For material washing
Acacia tortilis	1	4	2	5	6	3	7	9			8	11						
Eucalyptus camaldulensis			9	1	3	5		4		2	7			8	6			
Acacia albida	9	6	2	3		5	7	4		1	10	12	8	13	10			
Ziziphus mucronata	4	5	2	6	1	6			3		9	8						
Dichrostachys cinerea	6	4	1	2	3	5	7				9	8						
Acacia senegal	8	6	1	4	2	3	5	10			7	9	11					
Balanites aegyptiaca	2	4	10	6	2	7	5	8	1						9			
Azadirachta indica	2	7		4	3	6						8			1	5		
Croton macrostachyus	6			4	1	5	8	8		2	8	11			3	7		12
Schinus molle	1	10		2		3		4				6		9	5	7	7	

Appendix 8: Descriptive statistic summery of data which used for analyzing the correlation of land holding with abundance and other diversity indices

Descriptive Statistics									
	Count	Min.	Max.	Mean	SD	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Symmetricity	Statistic	Flatness
Farm holding	100	.030	10.58	2.73	2.15	1.47	Positively skewed	3.04	Peaked
Abundance	100	0	814	43.29	92.18	6.37	Positively skewed	50.19	Peaked
Richness	100	0	37	7.07	5.09	2.75	Positively skewed	11.95	Peaked
Shannon	100	.000	2.088	1.49	.309	-1.23	Negatively skewed	4.55	Peaked
Evenness	100	.000	.974	.640	.193	-.46	Negatively skewed	.002	Normal

Appendix 9: Tree diversity interview

Section A: Interview and plot identification

1. Village name	
2. Plot number	/ / / (village/household/plot)
3. Interview date	/ / / (day/month/year)
4. Name household head	
5. Plot has main homestead	Yes No
6. GPS positions (WGS 84)	Longitude: E Latitude: N /S
7. Name(s) of interviewer(s)	
8. Name(s) of respondent(s)	
9. Respondent(s) is/are (circle)	Husband Wife Child(ren)
10. N umber of pl ots owned by t he household	
11. I nformation on m ain crops t hat ar e now in the field	Main crop 1: Percentage of cropland: Main crop 2: Percentage of cropland: Main crop 3: Percentage of cropland: Main crop 4: Percentage of cropland:
12. When fertilized last	/ / / (day/month/year)
13. Comments	

Section B: Tree inventory data

Plot number: / / (village/household/plot)

Inventories done for: trees (height ≥ 2 m) or hedges (pruned trees)

<table>
<tr><th>CH</th><th>1. Tree names / 2. Niche</th><th>3. Dimensions</th><th>4. Establishment</th><th>5. Planting materials</th></tr>
<tr><td rowspan="2"></td><td>Local:
Scientific:
Identification is c ertain: Y / N</td><td>Height(m):
NA
DBH(cm):
NA
Hedge length(m):
NA</td><td rowspan="2">Planted / Retained
NA
When / Age of tree:
NA
Whom:
NA</td><td rowspan="2">Origin:
NA
Distance (km):
NA
Form: seed seedling cutting
NA</td></tr>
<tr><td colspan="2">Niche (circle) : HS B O C O W L O R MA MP other:</td></tr>
<tr><td rowspan="2"></td><td>Local:
Scientific:
Identification is c ertain: Y / N</td><td>Height(m):
NA
DBH(cm):
NA
Hedge length(m):
NA</td><td rowspan="2">Planted / Retained
NA
When / Age of tree:
NA
Whom:
NA</td><td rowspan="2">Origin:
NA
Distance (km):
NA
Form: seed seedling Cutting</td></tr>
<tr><td colspan="2">Niche (circle) : HS B O C O W L OR MA MP other:</td></tr>
<tr><td rowspan="2"></td><td>Local:
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NA
When / Age of tree:
NA
Whom:
NA</td><td rowspan="2">Origin:
NA
Distance (km):
NA
Form: seed seedling Cutting</td></tr>
<tr><td colspan="2">Niche (circle) : HS B O CO W L OR MA MP other:</td></tr>
</table>

Section C: Socioeconomic uses tree species through group discussion

S/N	Species	Uses of species (ranked in descending order)														
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	11th	12th	13th	14th	15th	16th
		Code : Purpose 1 =Fruit 2= Timber 3 =Charcoal 4 =Firewood 5 =Medicine 6 =Income 7 =Fodder 8 =Bee forage 9 =Shade 10 =Windbreak 11= Erosion control 12 =Soil fertility 13 =Riverbank stab 14 =Live-fence, 15=Farm tools making wood 16=Other, Specify………….														

Declaration

I, the undersigned, declare that this thesis is my original work and all that sources of materials used for the thesis have been correctly acknowledged. I also confirm that this work has not been submitted anywhere else for the same purpose.

Name: Yemenzwork Endale Tesema

Signature ______________________________

Date ______________________________

This thesis work has been submitted for examination with my approval as advisors:

Dr. Mekuria Argaw

Signature_______________________________________

Date____

Dr. Abayneh Derero

signature_______________________________________

Date____

Dr. Roeland Kindet

Signiture_______________________________________

Date____

Place and date of submission

Addis Ababa University

April, 2014