ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE

DEPARTMENT OF ZOOLOGICAL SCIENCE

TREES IN AGROFORESTRY SYSTEM IN MENZ GERA MIDIR WOREDA, NORTH SHEWA, AMHARA REGION, ETHIOPIA

BY: YEMISRACH MENGISTU GEBREMARIAM

SEPTEMBER 2021

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GRADUATE PROGRAMME

This is to certify that the thesis prepared by Yemisrach Mengistu Gebremariam entitled TREES IN AGROFORESTRY SYSTEM IN MENZ GERA MIDIR WOREDA, NORTH SHEWA, AMHARA REGION, ETHIOPIA and submitted in fulfillment of the requirements for the Degree of Master of Science in Biology complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

Trees in Agroforestry system in Menz Gera Midir Woreda, North Shewa, Amhara Region, Ethiopia

Yemisrach Mengistu Gebremariam

Addis Ababa University, September 2021

An Ethnobotanical study was conducted from September 2019-September 2021 to document trees in agroforestry system in Menz Gera Midir Woreda, North Shewa, Amhara Region, Ethiopia. One hundred informants were selected from ten Kebeles using snowball sampling technique for the data collection. Twenty five of them were key informants which were selected purposively. Group discussions, guided field walk, semi-structured interviews and photographing were applied for gathering information. Sixty one species (37 trees and 24 shrubs) which belong to 51 genera and 31 families were recorded from farm lands and home gardens. Fabaceae was the dominant family which consists of 22.6% of the species collected in the woreda. *Acacia abyssinica* was the most preferred tree for agroforestry practice in the study area for its multi functionality. Home garden, scattered trees in farm land, silvopastoral, hedgerow and wind break were the agroforestry practices that were observed in the study area. Among these, home garden was the most widely practiced agroforestry system. The conservation methods of farm land trees in the area include deliberate planting, providing compost, pruning and protecting from animal damage. The farmers' attitude, perception and indigenous knowledge on agroforestry practice helped more on the selection of farm land trees and way of implementations of the system in the study area. If the farmers get updated knowledge on the usage, management and conservation methods of agroforestry practices a lot of benefits will be acquired from the system.

Key words: agroforestry, farm land, home garden, shrub, tree

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List of Acronyms

CSA	Central Statistical Agency of Ethiopia
FAO	Food and Agricultural Organization
ICRAF	International Centre for Research in Agroforestry
IDRC	International Development Research Centre
IPCC	International Panel on Climate Change
NASCO	National Agroforestry Steering Committee of Tanzania
OECD	Organization for Economic Co- operation and Development
SOC	Soil Organic Carbon

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the Study

Cultivating trees or shrubs together with food crops on the same piece of land is an agricultural system that farmers have been practicing for a long time. This type of agricultural practice is what is now known as agroforestry (Nair, 1993). Therefore, agroforestry is a new name for an old set of land use practices. Neither the concept nor the practice of agroforestry is new (Zinabu Wolde, 2015). Trees are an integral parts of agroforestry system specially when they are deliberately retained on farm lands to support agriculture. The ultimate objective of agroforestry system was not tree production but food production (Nair, 1993). As a scientific discipline the origin of agroforestry is fairly recent. Its modern re-establishment goes to the 1970's (Omar and Daniel, 2017).

As Badege Bishaw and Abdu Abudulkadir (2003) noted various definitions for the term agroforestry have been given through the years since it is taken as a scientific approach to land use problems in the early 1980s. The most recent definition of agroforestry is the one that is given by the International Centre for Research in Agroforestry (ICRAF). The ICRAF (1997) defined agroforestry as a dynamic, economically based, natural resources management system that through the integration of trees on farms and in agricultural landscape diversifies and sustains production for increased social, economic and environmental benefits for land users at all level.

Agroforestry systems and practices exist in many forms such as, home garden, boundary planting, shelter belt, wind breaks, trees on pasture and conservation hedges (Gitonga and Mukoya, 2016). Even though there are different types of agroforestry practices as Badege Bishaw and Abdu Abdulkadir (2003) stated, there is a common characteristic feature to all forms of agroforestry that is, a tree component is deliberately grown or retained in agricultural setting. About 1.2 billion people of the world's population depend on agroforestry practices and services for their livelihoods (Garrity, 2006). Agroforestry enhances food and nutritional security, human health and environmental sustainability especially among subsistence farmers (NASCO, 2006).

It is a long time history in the world to grow agricultural crops together with trees (Nair, 1979).Until the middle age, the Europeans had a habit of removing degraded forest and then they cultivate food crops on the degraded part. They also plant trees before, together with or after sowing agricultural crops. Nowadays they do not use this farming system (King, 1987).

Farmers in the Central America have been practicing agroforestry by planting agricultural crops together with fruit trees and shrubs such as coffee and cacao for long. Such an intimate mixture of various plants, each with a different structure, imitated the layered configuration of mixed tropical forests (Wilken, 1977). On the other hand agroforestry has a long tradition in other continents such as the Indian subcontinent. The socio religious rule of the subcontinent assists in caring and respecting trees. Trees are integrated extensively in the crops and livestock production systems of the region according to the agro-climatic and other local conditions (ICRAF, 1987).

The situation is a little different in Africa. For example in Southern Nigeria (Nair, 1993) reported that agricultural crops such as maize and bean were planted together with scattered trees. He also observed a system of integrating herbaceous plants, shrubs and crops claiming that the system is a means of conserving human energy by making full use of the limited space won from the dense forest. This system reduces energy consumption; creating a potential source of renewable energy and generating an energy product and it also reduces energy input.

Agroforestry is not a new practice for Ethiopian farmers and farming system. Kindu Mekonnen (2001) explained different types of traditional agroforestry practices in Ethiopia such as home garden, silvopastoral system, scattered trees on farm land. As Tanga and Amare Mezgebu (2016), stated the dominant agroforestry practices in rural Ethiopia are farm boundary tree planting, trees on grazing lands, scattered trees on farm land, coffee shade based system and home garden. In the Northern Ethiopian context, agroforestry is being encouraged through the government system (Hassen *et al.,* 2016) and it is taken as an agricultural practice that is favorable to the climate.

1.2 Statement of the Problem

Forests and forest products have a very big role to a household food security and to the national economy. However, because of severe deforestation the benefits that human beings get from forests decline from day to day. Deforestation resulted in environmental problems such as forest biomass reduction, decline in the productivity of the land, soil erosion, and loss of biodiversity.

Forest resources are major parts of the natural resource base in Ethiopia though suffered most in the country. The forest areas of the country have been reduced from 40% a century ago to an estimated less than 3% (Badege Bishaw, 1993). From this amount only one twelfth has a dense forest structure. The primary reasons for this decrease are out going population growth, over grazing and deforestation (Zewege Teklehaimanot and Healey, 2001). The forest coverage of Ethiopia becomes to 15.2% recently (FAO 2020).

As Zeleke Kassa (2016) explained the population is continuously growing and causing serious environmental problems in Ethiopia. As the population continues to grow, the decrease in agricultural productivity, due to land degradation, and the gap between supply and demand for agricultural land, continues to expand. Such a situation is leading to severe land-use conflicts between the crop productions, and other types of land use such as forests, which will cause further clearance of forestland and, consequently, environmental degradation. Moreover the country's topographic nature has made it more liable to degradation (Girma Kelboro, 2000). In relation to this, agroforestry is the best option to reduce pressure on the forest and enhance soil fertility.

Therefore proper emphasis should be given on the uses and practices of agroforestry. As agroforestry is very important to developing country such as Ethiopia, research on it is very limited in the country. This is also true for Menz Gera Midir Woreda where there is no study on the agroforestry practices of the area so far. Thus this study will help to show the economic and ecological role of agroforestry and also the practices of the system implemented in Menz Gera Midir Woreda, North Shewa, Amhara Region, Ethiopia. The study will also contributes to further agroforestry related studies.

1.3 Objectives of the Study

1.3.1 General Objective

The main purpose of this study is to investigate the agroforestry trees in Menz Gera Midir Woreda.

1.3.2 Specific Objectives

The specific objectives of this study are:

- To assess the practices of agroforestry in Menz Gera Midir Woreda.
- To document the role of agroforestry in Menz Gera Midir Woreda.
- To identify the types of agroforestry practices mostly used in the study area.
- To produce a checklist of the agroforestry trees/shrubs with their impact on agriculture.
- To find out the indigenous knowledge about agroforestry in the study area.

1.4 Research Questions

This study is mainly designed to address the following research questions:

1. How is agroforestry system practiced in Menz Gera Midir Woreda?
2. How the different types of agroforestry system are implemented in the study area?
3. Which trees are most-preferred for agroforestry practices in the study area and why those trees are preferred?

4. How does the benefits that derive from agroforestry systems are managed in Menz Gera Midir Woreda?
5. Why do people practice agroforestry in the study area?

1.5 Significance of the Study

In Ethiopia, agriculture is the main sources of livelihoods for the majority of the rural people. However the farming practice in the country is characterized by degraded soil, small farm size and low agricultural output. Because of these challenges agriculture in the country has not been fruitful. Severe deforestation because of rudimentary farming technique and land use competition is another challenge facing the country. In relation to this, agroforestry plays a great role to solve the problems mentioned above.

The results of this study are expected to have the following contributions:

- Show the types of agroforestry practices that are mostly used in the study area.
- Indicate the use trees in agroforestry system in Menz Gera Midir Woreda
- List agroforestry trees in the study area.
- Show the most preferred agroforestry trees in the study area and describes the reason for the selection of those trees.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 What is Agroforestry?

The mid of the 1970s was the time to start giving definitions to agroforestry. In the late 1970s and early 1980s there was a lack of enough information about agroforestry.

Because of this, so many definitions of agroforestry were on the table. These earlier struggles to define a broad new area of study have resulted in a conceptual understanding from which to examine complex systems and practices. The following definition summarizes the basis of the study of agroforestry. Agroforestry is thus defined as a sustainable management system for land that increases total production, combines agricultural crops, and forest plants and/or animals simultaneously or sequentially and applies management practices that are compatible with the cultural pattern of the local population (Bene *et al.,* 1977). However, among the many efforts to define the art and science of agroforestry, the following is perhaps the most appropriate: Agroforestry is a land-use system that involves deliberate intention, introduction or mixture of trees or other woody perennials in crop/animal production fields to benefit from the result ecological and economic interactions (Nair, 1984).

According to Nair (1993), for better understanding of an agroforestry system one should note the following three points:

- there must be two or more species of plant in an agroforestry system and at least one of the species should be woody plant,
- the product of agroforestry system are mostly two or more,
- since there are a variety of plant species in agroforestry practice, the system is more complex both ecologically and economically than a mono- culturing (cultivation of a single crop).

There are two important features that identify agroforestry from other land-use systems:

- There must be a tree component deliberately grown or retained in the land-use system.
- The woody and non woody components of the agroforestry system relates either positively, negatively or both positively and negatively.

Agroforestry is a multifunctional way of agriculture (Asaah *et al.,* 2011). This means as a system, it provides just more than food. Carbon storage, creation of beneficial micro climates, and economic diversification are some of the additional functions of the system (OECD, 2001). Agroforestry systems are distinct from other forms of agriculture in their ability to store higher amounts of carbon in total biomass and soils (Mbow *et al.,* 2014). Despite these facts, more than half of the global species diversity is still subject to increasing human pressure, leading to the replacement of natural vegetation by monocultures (FAO, 2012).To maintain balance between environmental protection and human needs agroforestry is thus a win-win strategy to combine the two.

Agroforestry is now receiving increasing attention as a sustainable land management option over the world because of its ecological, economic, and social values (Mowo *et*

al., 2013; Bajigo *et al.,* 2015; Daniel Hagos and Abeba Nigussie, 2015). It has also been used as a major strategy to persuade forest occupants to become partners in rehabilitating degraded forestlands. As an alternative to the destructive clearing of land by slash-and-burn farming system of most upland farmers, agroforestry becomes the best choice to reduce soil erosion, improve soil quality, vegetation cover, land productivity and uplift the farmers' level of living through sustained farm productivity (Leonida, 2003).

Even though there are many types of agroforestry systems, according to Nair (1993), all these systems consist of three common attributes. These are:

1. Productivity: agroforestry increase productivity through increased output of tree products, improved yields of associated crop and increased labor efficiency.
2. Sustainability: by conserving the production potential of the resource base mainly through the beneficial effects of woody perennials on soils, agroforestry can achieve and maintain fertility goals.
3. Adoptability: the word adopts here means accept. The fact that agroforestry is a new word for an old set of land use practices means that agroforestry has already been accepted by the farming community.

2.2 Historical Perspectives on Agroforestry

Planting trees together with agricultural crops started as humans begin to domesticate plants and animals (Williams *et al.,* 1997). Since then, a variety of agroforestry systems have been developed in Asia, Africa, Europe, and parts of North and South America. These early agroforestry practices, like modern agroforestry systems, had a strong focus on sustainable crop production and soil conservation. For example, integrating apple

orchards with sheep pasture or integrating timber or nut trees with cereal crops was a common agroforestry practice in Europe (Gordon *et al.,* 1997).

In the tropics, farmers imitated vertical forest structures by planting a variety of crops with different growth habits, resulting in high species diversity on a small land area (Kass and Somarriba, 1999). This system not only provided a diversity of crops to the farmer but it also protected the soil from erosion by reducing the impact from raindrops, and litter from trees provided organic material to sustain soil nutrient levels (Oelbermann *et al.,* 2003).

In response to increasing environmental degradation, the International Development Research Centre (IDRC) in Canada concluded that priority should be given to systems combining trees and crops to optimize sustainable land-use in areas with high population pressures (King, 1987). This results in the establishment of International Council for Research in Agroforestry in the year of 1977 in Nairobi, Kenya. Since the establishment of ICRAF, agroforestry has been promoted as a sustainable land use management system in both tropical and temperate latitudes. Modern experimental work in agroforestry began in the late 1970s including the first experiment on hedgerow intercropping (alley cropping) in Ibadan, Nigeria. Studies on nutrient cycling, using perennial crop combinations in Central America, and studies on the effectiveness of contour hedgerows on erosion control were also addressed (Young, 1997). In 1991, the International Council for Research in Agroforestry renamed as the International Centre for Research in Agroforestry (ICRAF) began to play a leading role in collecting information, conducting research, disseminating research result and pioneering new approaches and systems in agroforestry (Nair, 1993).

2.3 Types of Agroforestry System

Young (1989) reported that there are different types of agroforestry systems such as, agrosilvicultural system, silvopastoral system, agrosilvopastoral system, improved fallows, alley cropping, multipurpose tree on cropland, wind break, shelter belts, evergreen agriculture, and aqua - forestry. These systems, existing in different places, are so complex and diverse that they need to be grouped and classified into different categories in order to evaluate them and develop some action plans for their improvement. These agroforestry systems can be classified into various types and the most common set of criteria used as the basis to classify agroforestry systems and practices according to (Nair 1989; 1993) are:

- Structural basis— is the spatial and temporal arrangement of the components.
- Functional basis— is the benefits of trees or shrubs in agroforestry system for soil conservation and soil fertility improvement.
- Socioeconomic basis – is the level of management and goals of the system.
- Ecological basis – is the favorability of the practice both for the environment and the ecology.

All agroforestry systems are characterized by three basic components namely, the woody perennials (trees/shrubs), the herbaceous plants (crops, pasture species), and the animals. Based on these three basic components, agroforestry systems can also be classified for all practical purposes according to their component composition (Nair, 1989; 1993).

- Agrosilvicultural systems
- Silvopastoral systems
- Agrosilvopastoral systems.

2.3.1 Agrosilvicultural Systems

This is agroforestry system where agricultural crops are combined with shrubs/trees on the same unit of land for higher and sustained production of annual crops, fodder and fuel wood (Badege Bishaw and Abdu Abdelkadir, 2003). This system is best suited for lowland humid tropics (Nair, 1993). The arrangement of the components in agrosilvicultural system is spatial. Spatial arrangement of plants in agroforestry mixtures vary from dense mixed stands (as in home gardens) to sparsely mixed stands (as in most silvopastoral system (Nair, 1993).

2.3.2 Silvopastoral Systems

In silvopastoral system crops are planted together with trees. Animals could also be there. This combination creates better production of grasses and fodder. Since there are different species (food crops, trees, and animals) in this system it is beneficial to all species and the environment as well. The Acacia-dominant system in the arid parts of Ethiopia, Kenya, and Somalia are good examples of this system. The main objective of this practice is to supply feed for livestock during the dry season with high quality tree leaves and pods. Fuel wood and construction poles can also be produced with this system (Nair, 1989; 1993).

2.3.3 Agrosilvopastoral Systems

When crops, trees or shrubs, and pasture are deliberately integrated on a farm land to get different benefits such as fuel wood and foods, we call this agroforestry practice the agrosilvopastoral systems. Since this system is a combination of agrosilvicultural and silvopastoral systems the farmer can get the maximum benefit from it. The agrosilvopastoral system is helpful agroforestry practice to the farm land which is mostly affected by erosion (Nair, 1989; 1993).

2.4 Agroforestry in Ethiopia

2.4.1 Agroforestry Practices in Ethiopia

Farm products in Ethiopia account for over half the country's gross domestic product, and 90 percent of its exports (Badege Bishaw and Abdu Abdelkadir, 2003). While agriculture is the basis of the economy, productivity is significantly limited because of severe soil degradation. Soil degradation is more severe in Ethiopia than in any other place in the world (Hengsdijk, *et al.*, 2005). As the land is degraded, agricultural productivity is lowered, resulting in decreasing incomes and food security and vice versa.

According to Badege Bishaw and Abdu Abdelkadir (2003), reports on the forest resources of Ethiopia are dominated by the alarming deforestation that goes on unabated and at an accelerating rate. Deforestation takes place in both forests and farm woodlands and it is recognized as the most severe environmental problem in Ethiopia. In relation to this, agroforestry can help to reduce pressure on remnant natural forests from deforestation and enhances soil fertility.

According to Azene Bekele (1997), Ethiopian farmers have been used different agroforestry practices long ago. Even the highly complex agroforestry system that is agrisilvi-horticulture (an agroforestry system which combines horticultural crops such as vegetables, fruits, flowers and ornamentals with trees, pasture and agricultural crops) has been practiced by farmers in the southern region of the country. In central Ethiopia, farmers use different types of trees in their agriculture. For example, they use *Hagenia abyssinica, Dombeya torrida* and *Buddleja polystachya* to get fodder. For soil improvement they use *Senecio gigas, Hagenia abyssinica,* and *Dombeya torrida* (Alemu Mekonnen *et al.,* 2009). This shows that Ethiopian farmers have deep knowledge on different possibly beneficial properties of trees and choose trees in their farming system accordingly. Small holder farmers who are owners and custodians of indigenous knowledge in Ethiopia have good understanding about the multiple uses of trees on farm. They protect many woody plant species in and around their farm land and homesteads (Hachoofwe, 2008; Habtemariam Kassa *et al.,* 2011). The indigenous knowledge of trees held by local farmers in farmed landscape is important alongside modern science to manage, develop, conserve and use of farm land trees. This knowledge is mostly held by the community as a whole rather than by individuals (Hussien Adal and Zemede Asfaw, 2015).

As Badege Bishaw and Abdu Abdelkadir (2003), stated the way of land using system in rural Ethiopia is wasteful. This results in shortage of farm land. Therefore, farmers in rural Ethiopia cannot use some part of their land for agriculture and the other for forestry. The best solution to use their land for agriculture and forestry simultaneously is applying agroforestry.

The followings are some common examples of agroforestry practices in Ethiopia:

2.4.1.1 Scattered Trees in Crop Lands

This practice involves the growing of individual trees and shrubs in wide spaces in croplands. Dispersed trees grown in farmlands characterize a large part of the Ethiopian agricultural landscape. Trees would be grown in a scattered form over a crop field, usually between 1–20 trees per hectare to minimize impact on the companion crop. Some good examples of this practice include *Cordia africana* intercropping with maize in Bako and western Ethiopia; *Acacia albida* based agroforestry in the Hararghe Highlands and Debrezeit area (Hoekstra *et al.,* 1990). The system has much potential for supplying fodder, farm equipment, fuel wood and agricultural improvements (Tesfaye Abebe, 2000).

2.4.1.2 Home Garden

The word home garden has been used to describe diverse practices from growing vegetation behind house to complex multistoried system. It is used here to refer to intimate association of trees and shrubs with crops within the compound of individual house, and the whole vegetation is being managed by family labor (Fernandes and Nair, 1986). Home gardens are commonly found in many parts of southern and southwestern regions of Ethiopia. Crops such as coffee, enset, pepper, and numerous kinds of vegetables are dominant components of the Ethiopian home gardens (Amare Getahun, 1988). Trees like *Cordia africana, Millettia ferruginea, Albizia gummifera*, *Ficus* species, and *Acacia* species are among the species that frequently occur in the home garden. The structural complexity in the Ethiopian home gardens is varied and ranges from complex

and diverse forms containing numerous species and strata to the less complex forms, with one or two crop/tree mixtures, as in the Gurage Enset home compound farms. Home gardens supply much of the basic needs of the local population and help reduce the environmental deterioration. Besides home garden is a place for the generation and maintenance of valuable biological diversity and its associated cultural heritage. This heritage is revealed in the depth of local people's indigenous knowledge, practices, and skills (Zemede Asfaw, 2002).

2.4.1.3 Hedgerow Intercropping

This form of agroforestry is practiced in many parts of Ethiopia. The sorghum/maize and chat (*Catha edulis*) hedgerow intercropping in the Hararghe Highlands of eastern Ethiopia is one of such example. The shrub chat is a stimulant cash crop that generates cash for the farmer. Although the soil regenerative properties of the system are not obvious, it has undoubtedly helped in the soil conservation of the hilly landscapes of Hararghe (Badege Bishaw and Abdu Abdelkadir , 1989).

Another form of hedgerow intercropping that has recently been introduced and has been widely tested in the scientific community is alley cropping (Hoekstra *et al.*, 1990). Alley cropping is an agroforestry technology in which food crops are planted between rows of trees or shrubs. This system is suited to humid and sub-humid tropics (Nair 1989; 1993). Alley cropping is one of the best agroforestry systems for Ethiopia. It helps to improve soil and water conservation in hilly and mountain ranges for which Ethiopia is known (Badege Bishaw and Abdu Abdelkadir 1989).

2.4.1.4 Wind breaks / Shelterbelts

Wind breaks are narrow planting of tall woody species that form a linear barrier perpendicular to the prevailing winds. They protect crop land and pasture land from the harmful effects of wind (Zeleke Kassa, 2016). In wind breaks, at least three rows of trees are planted and are placed on the wind ward side of the land (Nair, 1993). When properly designed and maintained, a wind break reduces the velocity of wind, improve the microclimate in a given protected area by decreasing water evaporation from the soil and plants, and protect crops from loss of flowers (Nair, 1993; Torquebiau, 1994).

2.4.1.5 Boundary Planting

Boundary planting involves planting of trees or shrubs in single or multiple lines to define boundaries or spaces dividing separate land use units and it is mainly used along boundaries of farms, home compounds, pastures or scattered cropland (Torquebiau, 1994; Young, 1997). It is preferred to use tree species that provide useful products which could be sold to generate additional income while at the same time delineating the boundaries (Nair, 1993). Fruit trees like mangoes, avocadoes, citrus, oil palm, coconut, or timber trees are good species for boundary planting (Nair, 1993).

2.5 Uses of Agroforestry System in Ethiopia

Population needs are continuously growing for food, wood for fuel and construction and arable land (Abebaw Zeleke, 2006). In many parts of the world, food and wood supply are getting scarce and hence people relied mainly on the extension of the area of land under cultivation by clearing the remaining natural forest and wood-lands to satisfy their

need. (Zebene Asfaw, 2003). These are major contributing factors to land degradation, reduction in crop and livestock productivity, in turn undermining the efforts of food self-sufficiency (Abebaw Zeleke, 2006).

The adoption of improved agroforestry technology has become valuable to meet growing demands of increasing population. Agroforestry also helps to minimize deforestation and soil degradation and to conserve biodiversity (Batish *et al.,* 2008). Negussie Achalu (2004) stated that carefully planned and executed agroforestry practices could enormously enhance household food-security through improved and sustainable land productivity and meet the increasing demands for tree products.

2.5.1 Use of Agroforestry in relation to Carbon stocks and Carbon trading

Despite the fact that trees outside forests have a great potential for carbon storage, they are often not recognized by researchers and development organizations and the government, while discussing about carbon and climate change at large (Zewdu Eshetu *et al*., 2010). The garden coffee system (which is one of the four coffee production systems in Ethiopia) has a very high potential for carbon storage. The Gedeo traditional coffee-enset agro forests, for example store 70 tons of carbon ha-1 (Yitebitu Moges, unpublished data). Dossa *et al.,* (2008) reported a more or less similar value for carbon stock of 81 tons ha-1 in the shaded coffee system in Togo.

Carbon trading allows industries in developed countries to offset their carbon emissions by investing in reforestation and in clean energy projects in developing countries (Allen,

1998; Goodman, 1999). Landowners that could increase carbon storage through agroforestry practices are able to sell carbon as credits. Before 2000s, it was not known to which extent agroforestry practices could counter carbon emission from deforestation and their effectiveness in carbon trading. However in 2000s the International Panel on Climate Change (IPCC) estimates that the worldwide area under agroforestry is 400 million hectares, which results in a carbon gain of 0.72 Mg ha-1 year-1 (Watson *et al.,* 2000). It is estimated that the potential carbon gain could increase to 45 x 106 Mg ha-1year-1 by year 2040 (Watson *et al.,* 2000).

2.5.2 Use of Agroforestry for Soil Fertility Improvement

To control the problems of soil fertility, agroforestry approach might play a positive impact. There are different types of agroforestry practices that improve soil fertility management/ improvement: fallows, hedgerow, alley cropping, and tree on cropland (Nebiyou Masebo and Muluneh Menamo, 2016). Rao *et al.,* (1998) reported that leguminous trees species have shown some potential for soil fertility improvement and soil conservation since soil fertility improvement can be achieved through biomass transfer, long/short term fallows, and nitrogen fixation. In the same way, Ajayi *et al.,* (2008) reported that trees/shrubs improve the physical properties of soils. It is also reported by Acharya and Kafle (2009) that leaf litters in agroforestry systems enrich the soil fertility by providing organic matters, leaves control the speed of the raindrops and allow them to go down to the land surface slowly which helps water to infiltrate into lower part of the soil surface.

There are many perennial crops in different agro ecological zones of Ethiopia, such as; enset (*Ensete ventricosum*). Enset is Ethiopia's most important root crop in southern parts of Ethiopia. According to Rosell and Olvmo (2013), the soil organic carbons are much higher in the perennial enset fields (3.98%) than annual crop rotation (2.46%). Therefore, agroforestry for the perennial cropland needs to have a top priority for soil fertility management systems in Ethiopia.

2.5.3 Use of Agroforestry for Soil Conservation

Agroforestry has a potential for soil conservation through the soil cover provided by tree canopy and litter, in addition to the role of trees in relation to the runoff-barrier function (Nair, 1993). Shrubs and trees in agroforestry system have a direct or supplementary role in controlling soil erosion. In direct use, the trees are themselves the means of checking runoff and soil loss. In supplementary use, control is achieved primarily by other means (grass strips, and terraces); the trees serve to make the soil more fertile and comfortable for agricultural purpose. (Nair, 1993 and Young, 1989) supported that leguminous trees have shown potential of reducing soil erosion through five principal ways: interception of rainfall impact by tree canopy, surface runoff impediment by tree stems, soil surface cover by litter mulch, promotion of water infiltration, and formation of erosion resistant soil structure.

2.5.4 Ecological Role of Agroforestry

In short terms the ecological functions of agroforestry is to ensure maintenance of the ecosystem functions and global life support functions, including source/sink functions for

greenhouse gases, filtering of water and pollutants, and maintenance of global geochemical (nutrient) cycles etc. Agroforestry plays a positive role at balancing of ecology at micro/macro level (Nebiyou Masebo and Muluneh Menamo, 2016).

2.5.5 Economic Benefits of Agroforestry

Nowadays, at developing as well as advanced continents agriculture might be under pressure. Recent epidemics of animal diseases combined with government policies make it hard for farmers to make a living. Agroforestry could be a suitable option for socio-economic issue for different communities at different levels. It gives farmers the opportunity to spread their income (Jama and Zeila, 2005).Agroforestry could also reduce the costs for labor and chemical input by suppressing weeds and pests. For example, the tree might be a host of predators of crop pests and the intercropping of tree alleys decreases the weed problem heavily compared to a pure forest stand. Trees in agroforestry systems may benefit from the crop fertilization, weeding and irrigation increasing wood and/or fruit production. Animals often show to appreciate trees for their wind-protection and shade. Trees have a climate stabilizing effect and reduce wind-chill and heat-stress. As such trees not only contribute to the well-being of the livestock, but may also have an economic advantage (Jama and Zeila, 2005). Agroforestry also gives the following benefits for countries as well as for the farmers:

- Improve the resilience of agro ecosystems through diversification (Altieri *et al.*, 2015).
- Increased productivity (Atangana *et al.*, 2014).

- Helps to perpetuate local knowledge and social and cultural values (Buttound, 2013).
- Since leguminous trees have ability to fix atmospheric nitrogen, planting them in agriculture is beneficial to increase nitrogen availability (Munroe & Isaac, 2014).
- Trees in farm land are applicable as means of climate change mitigation due to an increased carbon sequestration (Atangana *et al.*, 2014; Mbow *et al.*, 2014).
- Diversifies rural income, ensures food diversity and seasonal nutritional security (Buttound, 2013).

2.6 Factors Influencing the Adoption of Agroforestry System

Similar to any other new technologies, agroforestry adoption is a complicated process that may be influenced by a number of factors such as, farmers' preference and awareness, farmers' education and extension services, and governmental policies (Zeleke Kassa, 2016). Agroforestry system can often be more complex than existing crop and other farming practices (Arnold, 1987). Thus there is a need to isolate factors that might affect the adoption of agroforestry technologies. The followings are some of the main factors that influence the adoption of agroforestry system.

2.6.1 Farmers awareness

According to Smith (2010), the primary barrier to wider adoption of agroforestry is inadequate awareness of farmers and land owners on agroforestry practices. Raising awareness of the potential of agroforestry is essential for promoting agroforestry as a mainstream land use system. For agroforestry to be adopted on a wider scale, economic

viability and practical management skills need to be demonstrated to farmers and land owners (Ndengahe, 2013).

2.6.2 Governmental policies

Agroforestry systems and technologies in many countries are hindered by the lack of appropriate policies to support their promotion (Ajayi *et al.,* 2006). Public policies such as land and agricultural policies have a great impact on land use system. According to NASCO (2006), agroforestry has a strong interconnectedness with land agriculture and forestry. Therefore support for agroforestry is reflected in the agricultural and forestry national policies as well as land policy. There must be specific policies, institutional and incentive structures that are needed to speed up the agroforestry adoption process (Kabwe, 2010).

2.6.3 Farmers education

Education is expected to have a positive effect on the decision to adopt agroforestry. To have effective adoption a farmer must understand the benefits, problems and management of agroforestry system and this requires formal education (Matata *et al.,* 2010). Buyinza *et al.,* (2008) reported that agroforestry is a knowledgeable and management intensive practice which requires ability to manage the tree - crop combination so as to achieve the optimal result.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location of the study area

The study was conducted in Menz Gera Midir Woreda, North Shewa Zone, Amhara Regional State of Ethiopia (Figure 1). Menz Gera Midir Woreda is located two hundred eighty two km Northeast of Addis Ababa and it is bordered on the south by Menz Lalo Midir, on the Southwest by Menz Keya Gebreal, on the West by the Qechene River which separates it from the Debub Wollo Zone, on the North by Gishe Rabel, on the Northeast by Antsokiyana Gemza, and on the East by Efratana Gidim. The administrative center of the Woreda is Mehal Meda which lies about two hundred sixty five Km Northeast of Addis Ababa and one hundred thirty five Km North of Deberebirhan, the capital of North Shewa zone. The study area lies between 10^{0}00'N to 10^{0}34'N and 39^{0}17'E to 39^{0}43'E with total area coverage of 165, 671 hectares. The Woreda consists of twenty rural kebeles and one administrative town (Menz Gera Midir Woreda City Administrative Office, 2019).

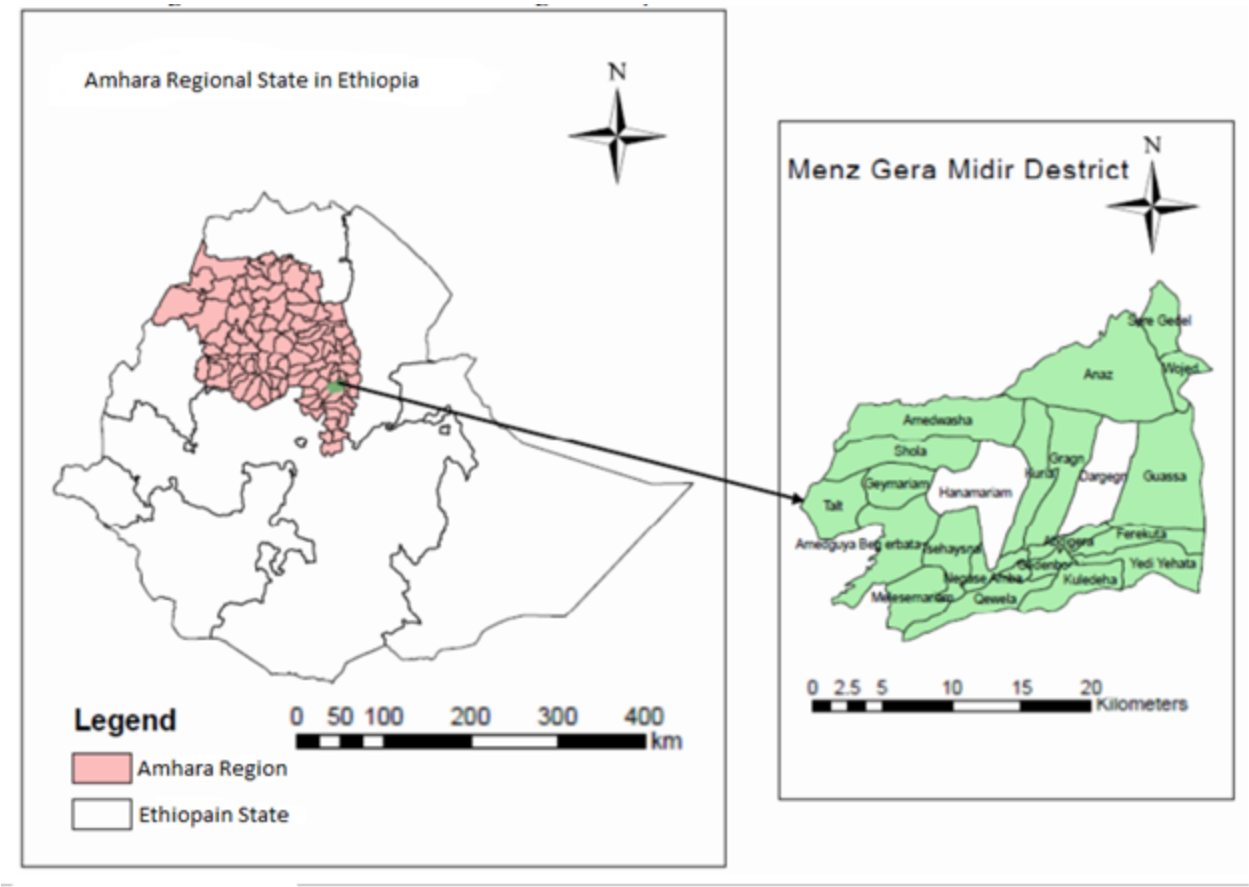

Figure 1: Map of Ethiopia showing Amhara Regional State and the study district

3.1.2 Climate

Menz Gera Midir possesses different topography with altitude that ranges from one thousand six hundred eighty to three thousand five hundred fifty four meter above sea level. The major agroecological zones are Dega (cold to cold-humid), Weina Dega (cool to sub-humid), Wurch (cold highland) and Kolla (warm to semi-arid). The rainy season usually runs from June to August and the annual rainfall under normal condition ranges between 800 mm and 1600 mm. The average temperature ranges between 8^0C and 20^0C (Menz Gera Midir Woreda Agricultural Office, 2019).

3.1.3 Flora and Fauna

The vegetation of the area is dry evergreen Afro-montane type with dominant trees such as *Juniperus procera, Acacia abyssinica, Podocarpus falcatus,* and *Hagenia abyssinica.* Maize, sorghum, wheat, bean, pea, barely, lentil, teff are the major crops grown in the area. The dominant livestock includes sheep, goat, mule, cattle, donkey and horses (Table 1) (Menz Gera Midir Woreda Agricultural Office, 2019).

Table 1: Major crops cultivated in the study area

Crop category	Scientific name	Family	Local name
Oil crops	*Sesamum orientale* L.	Pedaliaceae	Selit
	Helianthus annuus L.	Anteraceae	Suf
	Linum usitatissimum L.	Linaceae	Telba
Pulses	*Pisum sativum* L.	Fabaceae	Ater
	Vicia faba L.	Fabaceae	Baqella
	Lathyrus sativus L.	Fabaceae	Grass pea
	Lens culinaris Medik	Fabaceae	Miser
Cereals	*Sorghum bicolor* (L.) Moench	Poaceae	Mashella
	Zea mays L.	Poaceae	Beqollo
	Eragrostis tef (Zucc.) Trotter	Poaceae	Teff
	Triticum aestivum L.	Poaceae	Sinde
	Hordeum vulgare L.	Poaceae	Gebes
Vegetables	*Allium cepa* L.	Alliaceae	Key shinkurt
	Allium sativum L.	Alliaceae	Nech shinkurt
	Brassica carinata A.Br.	Cabombaceae	Gomen

3.1.4 Population

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), the Woreda has a total population of 120,469, of whom 58,827 are men and 61,642 women and 99.56% of the populations are followers of Ethiopian Orthodox Christianity and the major ethnic group is Amhara (Menz Gera Midir Woreda City Administrative Office, 2019).

3.2 Reconnaissance Survey and Selection of Study site

A reconnaissance survey of the study site was conducted on September, 2019 to obtain general information of the study area. Basic information was obtained from Menz Gera Midir Worda Agricultural Office. From the 21 Kebeles in the Worda ten Kebeles (small administrative units in Ethiopian administration system) (Gedenbo, Kewla, Gey Mariam, Sholla, Wozed, Negasi amba, Seregedel, Anatsed, Mehalmeda, Talt) were selected purposefully based on the information obtained from the Woreda Agriculural office on the availability of agroforestry practices. Agroecology of the Woreda was also another criterion for selecting the study kebeles.

3.3 Selection of informants

From ten kebeles one hundred informants were selected. Out of these; twenty five of them were key informants. The key informants were selected purposively based on the information locally obtained on their best implementation of agroforestry practice and owing large farm size. The rest informants were selected based on their local knowledge and using Snow ball sampling method. The age of the informants ranges from 23 to 71.

Seventy three of the respondents were men and twenty seven of them were women (Table 2).

Table 2: Profile of the Respondent

Age Range	Male	Female	Total	Percent
20-30	11	3	14	14%
31-40	20	5	25	25%
41-50	23	11	34	34%
Above 51	19	8	27	27%
Total	73	27	100	100%
Marital Status				
Single	4	-	4	4%
Married	48	18	66	66%
Divorced	9	5	14	14%
Widowed	12	4	16	16%
Total	73	27	100	100%
Educational Status				
Illiterate	8	7	15	15%
Read and Write	37	11	48	48%
Grade 1-8	16	5	21	21%
Grade 9-10	12	4	16	16%
Total	73	27	100	100%

3.4 Data collection methods

The data were collected from January to February 2020 by following the methods used by Martin (1995) and Cotton (1996). Semi-structured interviews, group discussions and guided field walk were the methods used to obtain information on the types of

agroforestry practices, benefits of the practice, types of trees used on the farm land and ways of conserving, managing and transferring knowledge of agroforestry practices in the study area.

3.4.1 Semi-structured interview

Semi-structure interviews with key and general informants were done following Martin (1995) and Cotton (1996) to gain information on the types of agroforestry practice in the study area, difference between each type of agroforestry practices, use of agroforestry for farmers and the environment, trees usually used in the area for agroforestry practice, benefits of each trees on the farm land (Figure 2 and 3, Appendix I).

Figure 2: Semi-structured interview with informant (Photo by Yemisrach Mengistu, 2020)

Figure 3: Semi-structured interview with key informant (Photo by Yemisrach Mengistu, 2020)

3.4.2 Group discussion

Two group discussions (one in Dega and the other in Kolla), shown in figure 4 and 5 respectively, were conducted on the ways of implementing, maintaining and transferring indigenous knowledge of agroforestry practices in the study area. The group discussion in Dega has six members (four men and two women) and the group discussion in Kolla consists of five members (four men and one woman).

Figure 4: Group discussion with farmers in Gey Mariam (Dega) /Photo by Yemisrach Mengitu, 2020/

Figure 5: Group discussion with farmers in Talt (Kolla) /Photo by Yemisrach Mengistu, 2020/

3.4.3 Field observation

Guided field walk was done together with local guides as shown in figure 6 and 7. By performing this, the different types of agroforestry practices in the area, common name of trees and their uses on farm land, indigenous knowledge of farmers on agroforestry practices were recorded. Informal interview with farmers was also done and images were taken.

Figure 6: Guided field walk with local guide (Photo by Yemisrach Mengistu, 2020)

Figure 7: Guided field walk with local guide (Photo by Yemisrach Mengistu, 2020)

3.5 Data analysis

3.5.1 Descriptive statistics

The data were entered into Microsoft excel 2007 and SPSS version 20 software and were analyzed with descriptive statistical methods and explained with frequency distribution and percentage. All useful information about agroforestry practices and uses, types of agroforestry, types of trees in agroforestry practices was recorded. Besides, pi-chart and graphs were also used to summarize the data.

3.5.2 Preference and direct matrix ranking

3.5.2.1 Preference ranking

Preference ranking activity was carried out following Martin (1995). This was done for those trees which were most commonly reported for their agroforestry usage in the study area. Ten key informants (seven men and three women) were selected based on their local knowledge and asked to rank eight farm land trees which were commonly reported for agroforestry practice. The informants were asked to give rank 8 for the most preferred tree for agroforestry practice and number 1 for the least preferred tree. Finally the total value was identified and the rank of each species was stated by integer value.

3.5.2.2 Direct matrix ranking

Direct matrix ranking was carried out following the method of Martin (1995) and Cotton (1996) to compare the multipurpose use of farm land trees. Based on the information gathered from the informants six farm land trees with five use values were selected and identified. Six key informants were selected and asked to score the highest value (5) for the farm land trees with a lot of benefits and the least value (1) for the trees with minimum function. Finally the total score summed up and ranked.

CHAPTER FOUR

4. RESULTS

4.1 Tree and Shrub Species Recorded from the Agroforestry Systems of the Study Area

The results showed that households in the study area planted sixty one tree and shrub species which belongs to 51 genera and 31 families in their agroforestry practices (Appendix 2). Fabaceae was the dominant family and represented by 22.6%. Family Rhamnaceae and Myrtaceae followed by 16.1% and 12.9% respectively. While family Rutaceae, Euphorbiceae and Oleaceae consists 9.7% each. The remaining 11 and 14 families only have two and one species respectively. From the total 61 species 60.7% of them were trees and 39.3% shrubs (Table 3).

Table 3: Growth form of farm land/home garden woody species in study area

	Habit	**Frequencies**	**Percent**
1	Tree	37	60.7%
2	Shrub	24	39.3%
Total		**61**	**100**

4.2 Farmers Attitudes on Agroforestry Practice in the Study area

Seventy eight percent of the respondents have planted or purposely retained trees on their farm land (Figure 8). The trees they planted have medicinal, economic and environmental values. The farmers in the study area have a good knowledge of agroforestry practices. They get this knowledge from their elder families, surrounding and the Woreda agricultural office. They understood on- farm trees give a lot of benefits such as increasing soil fertility, forage and fuel wood.

Information from the group discussion explained that 92% of the farmers understood agroforestry is a preferable land use system than mono-culturing through its potential of diversifying income, controlling soil erosion, providing raw materials for home furniture and making farm equipment. The group participants listed the conservation methods of farm land trees. This includes pruning and propagating the trees, transferring indigenous knowledge to the next generation.

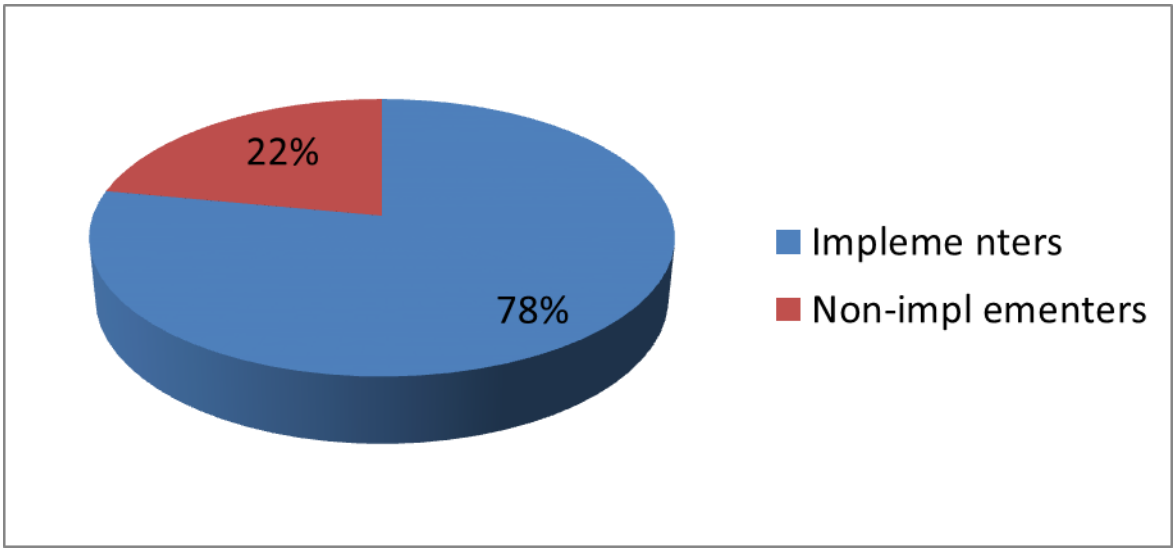

Figure 8: Agroforestry implementers and non-implementers of the study area

4.3 Planting time and Arrangement of Farm Land Trees in the Study area

The farmers of the study area planted their farm land trees at different time. About half of them planted the trees along with cultivating the agricultural crops, while 28.2% of the respondents explained that the trees in their farm land were not purposely planted by them rather they retained naturally growing trees. Trees that were planted before cultivating the crops hold 20.5% in the study area (Figure 9).

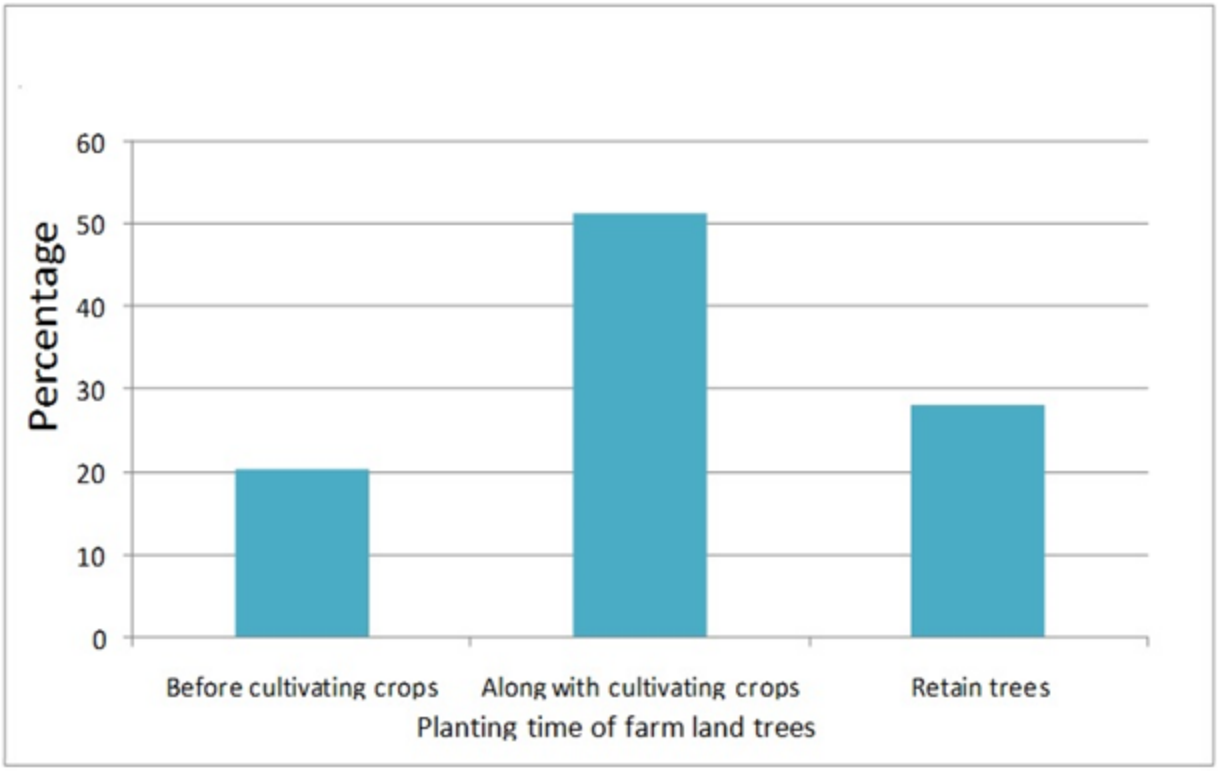

Figure 9: Planting time of farm land trees in the study area

The farmers who implemented agroforestry practice in the study area used different arrangements of tree in their farm land. They choose these arrangements according to the growth habit of the trees and the size of their farmland. Of the total respondents, 38.5% explained that they have used spontaneously scattered tree arrangements in their farm land, while 30.8%, 17.9% and 12.8% implemented hedgerow, trees at selected spots and boundary forming tree arrangement respectively (Figure 10).

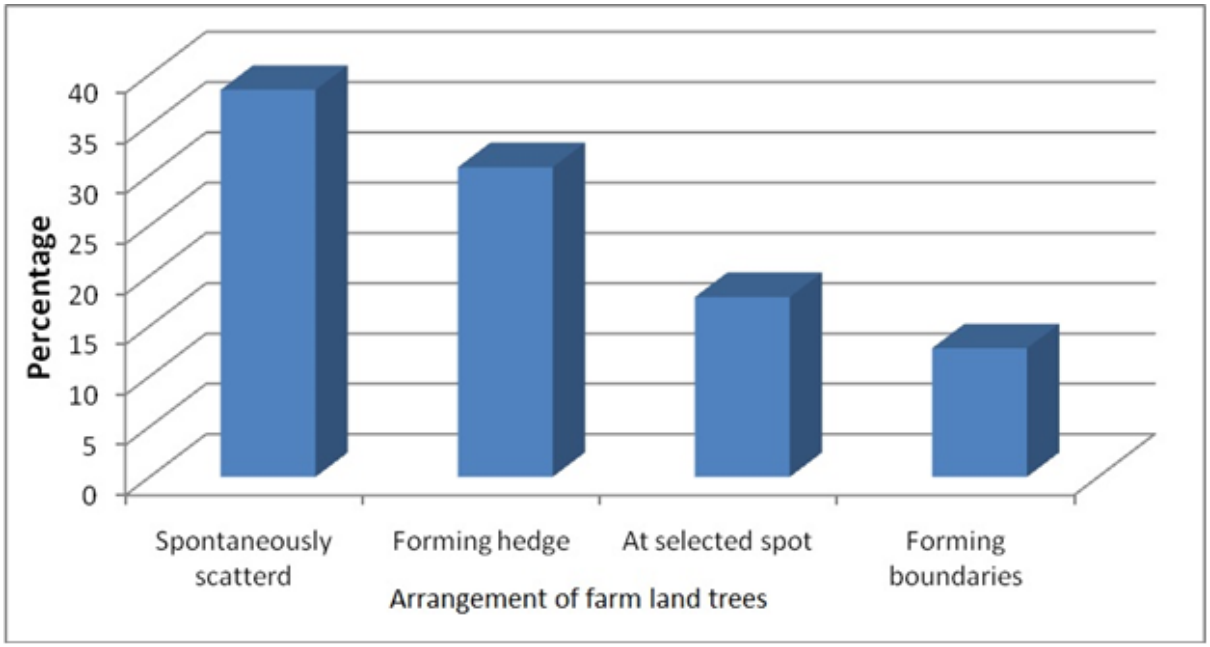

Figure 10: Arrangement of farm land trees in the study area

4.4 Common Agroforestry Practices in the Study area

4.4.1 Home garden

Home garden was the dominant agroforestry practice of the study area (Figure 11). The home garden of the study area consists of a variety of crops, vegetables, shrubs and trees (including fruit trees). *Pisum sativm, Vicia faba, Helianthus annuus, Sesamum orientale, Zea mays* were some of the crops found in the home gardens of the study area. The vegetable components of the home garden include *Allium cepa, Allium sativum, Brassica carinata*. Trees such as *Hagenia abyssinica, Croton macrostachyus, Malus sylvestris* were also the main components of the home garden. In total, thirteen tree/shrub species were recorded from the home gardens (Appendix 3). The crops and vegetables in the

home garden are the basic food supply for the households. The trees serve for traditional medicine, fire wood and fodder.

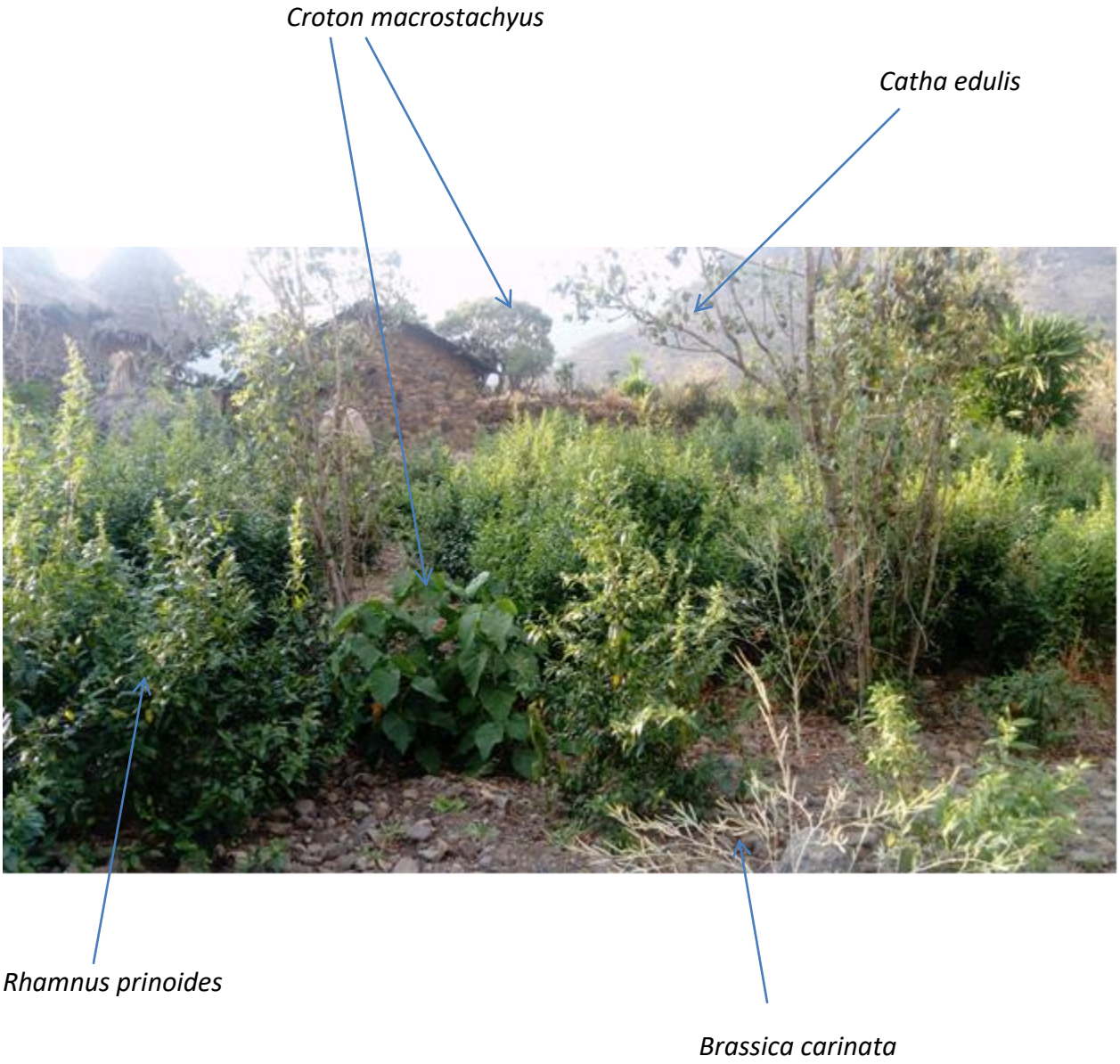

Figure 11: *Croton macrostachyus*, *Catha edulis*, *Rhamnus prinoides* and *Brassica carinata* in the home garden of the study area (Photo by Yemisrach Mengistu, 2020)

4.4.2 Scattered trees in the Farm land

Next to home garden this types of agroforestry practice was most common in the study area. In this system, most of the on-farm trees were naturally planted. The farmers deliberately retained the trees (Figure 12). A total of fourteen tree/shrub species (Appendix 4) that included *Acacia abyssinica*, *Acacia negrii*, *Croton macrostachyus*, *Hagenia abyssinica, and Juniperus procera*, which were the most commonly observed trees, were recorded in this form of agroforestry practice in the study area. The farmers use the trees for different purpose such as fuel wood, shading, making home furniture and traditional medicine. The trees provide shelter for animals and also increase the soil fertility.

Figure 12: *Albizia schimperiana* and *Croton macrostachyus* scattered in the farm land of *Sorghum bicolor* in the study area (Photo by Yemisrach Mengistu, 2020)

4.4.3 Silvopastoral agroforestry system

This type of agroforestry system (Figure 13) was observed in the urban kebele of the study area (Mehal meda, kebele 03). The main objective of this agroforestry practice in the study area was for pasturing.

Figure 13: *Eucalyptus globulus* and *Juniperus procera* together with *Panicum maximum* in silvopastoral agroforestry system (Photo by Yemisrach Mengistu, 2020)

4.4.4 Hedgerow- Trees planting as Living fence

This was another form of agroforestry practice in the study area. In this form agroforestry system trees were planted around farm land/ plots (Figure 14). *Buddlega polystachya, Erica arborea, Sesbania sesban, Cupressus lusitanica, Hypericum revolutum* were some

of plant species used in hedgerow. These plants besides protecting the farm land from high velocity of wind they also used as fuel wood and fodder.

Figure 14: *Sesbania sesban* planted as live fence in the farm land of the study area (Photo by Yemisrach Mengistu, 2020)

4.4.5 Wind break

Wind break was a narrow planting of woody species that form linear perpendicular to the prevailing wind. The trees surrounding the farm land protected the crops from harmful effect of wind (Figure 15). *Sesbania sesban, Juniperus procera* and *Hypericum revolutum* were some of trees used for wind break in the study area.

Figure 15: ***Juniperus procera*** **planted as wind break in farm land (Photo by Yemisrach Mengistu, 2020)**

4.5 Uses of Agroforestry Practice in the Study area

Since agroforestry is the integration of trees/ shrubs with agricultural crops, the trees/shrubs gives a lot of benefit for the farmers and the environment. All the different types of agroforestry practices have their own specific advantages. But in general speaking when we want to list the role of agroforestry, the core point we can explain is the function of the trees/shrubs.

From the total sixty one trees/shrubs that were collected from the study area sixteen of them were recorded for their role as a traditional medicine. While thirteen of the trees/shrubs were involved in income generating. Trees/shrubs that were used in fuel

wood, home consumption and fodder were 13, 9, and 4 respectively. Sixteen trees/shrubs play a great role in soil fertility, shading and furniture.

4.5.1 Income generating

The farmers in the study area purposely plant cash generating shrubs and trees such as *Catha edulis, Rhamnus prinoides, Coffea arabica, Cordia africana,* and *Eucalyptus globulus* in their farm land and home garden. By selling these plants they increase their annual income. The flowers of some tress such as *Strychnos innocua* and *Maytenus arbutifolia* attract honey bees. By planting these trees the farmers collect honey and use it for market purpose. A total of thirteen trees/shrubs used for income generation were recorded from the study area (Appendix 5).

4.5.2 Medicinal value

Like most rural Ethiopians, people in the study area mostly depend on traditional medicinal plant to treat different human and livestock aliments. Trees and shrubs in the home garden or farm land have their own role to serve as a medicinal plant besides their contribution to different purposes. *Croton macrostachyus, Hagenia abyssinica, Eucalyptus globulus*, and *Withania somnifera,* were trees used to treat skin disease, taeniasis, common cold and evil eye respectively. A total of sixteen trees/shrubs recorded from the agroforestry system of the study area reported for medicinal use (Appendix 6).

4.5.3 Making farm equipment

Even though agriculture is the backbone of Ethiopian economy, farming in the country is very traditional. Most farmers plough by cattle and use farming materials that are prepared by them. To make this material they mainly use wood. The trees in the farm land and home garden are the main source of wood for making of the farm equipment. *Olea europaea* Subspp. *cuspidata, Albizia schimperiana, Allophyllus abyssinicus* were some of the trees that mainly use to make farm equipments known as 'Mensh', 'Erif', and 'Digir' respectively.

4.5.4 To feed livestock (as a fodder)

Animals in rural Ethiopia give a lot of functions. Cattle for ploughing, donkey and mule for transportation, sheep and goat for household consumption and generating income. Leaves and branches of trees in the farm land were used as fodder for these animals. Trees that serve as fodder include *Allophyllus abyssinicus, Buddlega polystachya, Strychnos innocua, Sesbania sesban.* In the silvopastoral agroforestry practice there was a pasture that serves to feed animal.

4.5.5 Household energy

Ninety six percent of the respondents use fire wood for their household energy supply. Trees in the farmland and home garden were the main source of fire wood in the study area. *Acacia abyssinica, Erica arborea, Juniperus procera, Strychnos innocua* were some of the trees used as fire wood. Trees such as *Acacia negrii, Albizia schimperiana,* and *Erica arborea* were used to make charcoal.

4.5.6 Furniture

Most home furniture of the respondents such as bed, chair and shelf are made of wood. They use trees from their farm land to make this home furniture. Trees mostly used in making the furniture include *Cordia africana, Eucalyptus globulus, Juniperus procera* and *Cupressus lusitanica*. A total of seven farm land trees were recorded for making furniture in the study area.

4.5.7 Home consumption

Some trees/shrubs in the home garden of the study area besides increasing income they are also reported for their edibility. *Carica papaya, Citrus medica, Coffea arabica, Malus sylvestris, Rhamnus prinoides, Vitex doniana, Ziziphus mucronata* were some of the plants used by the farmers for home consumption.

4.6 Preference ranking

Eight dominant farmland trees in the study area were identified by key informants and then preference ranking was carried out on them to identify the most preferred tree for agroforestry practice. The informants were asked to give rank 8 for the most preferable tree for agroforestry practice and number 1 for the less preferable one. *Acacia abyssinica* scored first and *Allophyllus abyssinicus* scored last (Table 4).

Table 4: Preference ranking of preferable trees for agroforestry practice in the study area

	Key informants											
Farmland tree	1	2	3	4	5	6	7	8	9	10	**Total**	**Rank**
Erica arborea	1	4	4	3	5	2	2	1	3	1	**26**	**7th**
Croton macrostachyus	4	5	3	2	3	6	5	4	4	2	**38**	**3rd**
Allophyllus abyssinicus	3	2	4	2	1	1	3	4	2	2	**24**	**8th**
Acacia abyssinica	6	7	4	4	5	7	6	5	4	5	**53**	**1st**
Albizia schimperiana	5	3	3	4	4	2	2	3	3	1	**30**	**6th**
Juniperus procera	4	5	6	5	2	2	3	4	2	2	**35**	**4th**
Hagenia abyssinica	5	2	5	3	1	3	2	4	4	2	**31**	**5th**
Cordia africana	3	3	6	5	7	4	3	3	4	4	**42**	**2nd**

4.7 Direct matrix ranking

Six farm land trees with five use values were selected by key informants and direct matrix ranking was carried out on them to compare the multipurpose use of farm land trees. The informants were asked to score the highest value (5) for the farm land trees with a lot of benefits and the least value (1) for the trees with minimum function. The result showed that *Acacia abyssinica* scored first and *Cordia africana* scored second (Table 5).

Table 5: Direct matrix ranking of six multipurpose farm land trees in the study area

(5 = best 4 = very good 3 = good 2 = less used 1 = least used 0 = not used)

Use	Farm land trees							
	Juniperus procera	***Hagenia abyssinica***	***Acacia abysinica***	***Cordia africana***	***Croton macrostachyus***	***Olea europaea* Subspp. *cuspidata***		
Key informants	**R_1**	**R_2**	**R_3**	**R_4**	**R_5**	**R_6**	**Total**	**Rank**
Fire wood	5	4	5	5	3	3	**25**	**1st**
Charcoal	3	2	5	3	3	2	**18**	**4th**
Furniture	3	3	4	5	3	3	**21**	**3rd**
Medicinal	3	4	3	3	5	4	**22**	**2nd**
Fodder	2	1	4	3	4	1	**15**	**5th**
Total	**16**	**14**	**21**	**19**	**18**	**13**		
Rank	**4th**	**5th**	**1st**	**2nd**	**3rd**	**6th**		

4.8 Indigenous knowledge of agroforestry in the study area

The respondents explained that they got the knowledge of planting or retaining farmland trees from their parents and the society. The elders transfer their indigenous knowledge of selecting, planting and managing on farm tress/shrubs to the follower generation through telling and showing. Of the total respondents, 13% explained that the Woreda

Agricultural Office also help them to implement apple based agroforestry system by donating apple seedlings.

4.9 Conservation Methods of Farmland Trees in the Study area

The field trip and the result of the interview showed that the conservation mechanism of trees either in the farm land or home garden was poor. The propagation of trees was not satisfactory. Some of the conservation methods taken by the farmers were pruning (41%), providing compost (37%), protecting the trees from animals during its seedling stage (22%).

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Tree and shrub species recorded from the agroforestry systems of the study area

A total of sixty one farmland/home garden trees/shrubs which belongs to 51 genera and 31 families were observed and recorded in the study area. This result is supported by Abiyot Molla and Gonfa Kewessa (2015) who recorded fifty five woody species in farm land at Dellomenna District, Bale Zone. Yemenzwork Endale (2014) also documented seventy six farm land trees/shrubs in East Shewa Zone of Oromiya Regional State and Gezahegn Kassa *et al.,* (2015) identified one hundred on farm trees and shrubs at Yem Special District, Southern Ethiopia. This indicated that farmers in different area of the country have a habit of planting or retaining different species of tree/shrub in their farm land or home garden.

5.1.2 Attitudes of Farmers on Agroforestry Practice in the Study area

From the total respondents 78% of them implement agroforestry practices while the rest did not implement the practice. The farmers who implemented agroforestry practices in study area planted multipurpose trees/shrubs in their farm land; they also deliberately retained naturally planted trees. This describes farmers in the study area have positive attitudes and also good knowledge of agroforestry practices. Besides they understood the

benefits of on farm trees/shrubs. This result agrees with the finding of Negussie Achalu *et al.,* (2003) who did his research in Central Ethiopia, Western Gurage Highland and reported that 83% of the respondents planted one or more farmland trees/shrubs to improve their land soil fertility, shade, fuel wood and fodder. Hussien Adal Mohammed and Zemede Asfaw (2015), Mulugeta Sisay and Kindu Mekonnen (2013) and Berhanu Bekele (2018) found agroforestry implementers in their study area account for 83.5%, 74.16%, and 83.7% of the population respectively. This shows that most farmers in different area of Ethiopia have a good knowledge and habit of agroforestry practices. While Mehari Alebachew (2012) found only 48% of agroforestry implementers in his study site at Guder District West Shewa Zone of Oromiya Administrative Region. This may be due to the farmers in his particular study site obtain their tree/shrub needs from other sources such as the immediate forest.

5.1.3 Common Agroforestry Practice in the Study area

In Menz Gera Midir Woreda, North Shewa, Amhara Region of Ethiopia different types of agroforestry practices such as home garden, scattered on farm tree, hedgerow, wind break and silvopastoral practices were implemented. Among these, home garden was the most common one. Scattered on farm tree and hedgerow were the second and third commonly practiced. This result was similar to the practice of farmers at Mana Woreda, Oromiya Regional State of Ethiopia. In this Woreda, Berhanu Bekele (2018) noted that home garden was the most common agroforestry practice. Omarsherif Mohammed and Daniel Callo- Concha (2017) reported a more or less similar result in their study site at Yayu, South Western Ethiopia. In this area Multistory coffee system, home garden and scattered

tree on farm were the most commonly practiced agroforestry systems. Mehari Alebahew (2012) reported that scattered tree in farm land was the most common agroforestry practice in his study site. While live fence, home garden and farm boundary were placed in descending order.

This implies that different types of agroforestry practices are implemented throughout the country. Accordingly the more benefit they get, the farmers in different areas select the more appropriate type of agroforestry practice to their specific place.

5.1.4 Arrangement of Farm land Trees in the Study area

Since there were different types of agroforestry systems in the study area, the arrangement of the trees in the farm land was also varied. Spontaneously scattered tree arrangement throughout the farm land covers 38.5%. Hedgerow and trees at selected spots inside the farm land consists of 30.8% and 17.9% respectively.

The study by Hussien Adal Mohammed and Zemede Asfaw (2015) in the Northeastern Ethiopia explained similar farm land tree arrangements. Their findings showed that the farmers in their study sites planted on farm trees in scattered form throughout their farm plots, in forming boundaries, at selected spot and standing between farm boundaries at 23.6%, 7.8%, 18.4%, and 17.1% respectively. This implies that the agroforestry implementers in different parts of the country planted farm land trees in diverse arrangement patterns according to their farm land size and the specific function of tree arrangement on farm plot.

5.1.5 Use of Agroforestry Practices in the Study area

The agroforestry practicing community of the Menz Gera Midir Woreda listed many uses of agroforestry practices. This includes income generating, medicinal value, fodder, fire wood, home consumption, and soil fertility. This result is supported by the finding of Ernstberger (2016) who recorded construction, fuel wood, income generation, bee forage as a benefit of agroforestry in his study site at Abreha We Atsbah and Mayberazio, North Tigray.

Other authors such as Mesele Negash (2007), Zeleke Kassa (2016) and Mehari Alebachew (2012) also indicated very similar benefits of agroforestry practice in different areas in Ethiopia. This shows that the benefit that derives from the agroforestry practice is almost very similar in different corners of the country. But based on the different types of agroforestry practices the farmers implement, the benefits they earned exhibits little variation.

5.1.6 Preference ranking

The result of preference ranking indicated that *Acacia abyssinica* was the most preferred tree for agroforestry practice in the study area. *Cordia africana* and *Croton macrostachyus* placed in the 2nd and 3rd ranks respectively. *Allophyllus abyssinicus* was found in the last rank. The farmers prefer *Acacia abyssinica* for its contribution in charcoal, shade, fuel wood and soil fertility. The same result was obtained by Mulugeta Sisay and Kindu Mekonnen (2013) in which *Acacia abyssinica* was the most preferred tree in their study area because of its capacity to improve soil fertility, and other services

such as shade and bee forage. While Ernstberger (2016) stated that *Eucalyptus globulus* was the most preferred tree in farm land of his study site for its role in income generating, wind break, fire wood and fast growing habit.

In contrary Negussie Achalu *et al*., (2003) explained the majority of the households at his study area rated *Eucalyptus globulus* as the most undesirable species in the farm land because of its competition with food crops and drying up of the soil. The research of Gezahegn Kassa *et al.,* (2015) identified that *Ficus sur* was the most preferred species in their study site because of the ability of the tree in soil fertility, fire wood, furniture, and house construction.

All these findings showed that the trees/shrubs that were preferred for agroforestry practice in different areas of the country were directly related to the functions of the trees/shrubs. The findings also illustrated the major needs of farmers on farm trees vary from place to place thus it sounds that they plant trees that fulfill their major needs.

5.1.7 Direct matrix ranking

The results of the direct matrix ranking showed that *Acacia abyssinica* was the best farmland tree because of its multi functionality. *Cordia africana* placed in the second rank. The respondents explained that *Acacia abyssinica* has a great contribution in soil fertility and shade. Besides they used the tree for different purposes such as charcoal, fire wood and furniture. This result was more or less similar with the finding of Yemenzwork Endale (2014) who reported that *Acacia* species was the most commonly cited farmland tree for its multipurpose uses. Omarsherif Mohammed Jemal and Daniel Callo-Concha (2017) have also showed that *Cordia africana* and *Euclyptus grandis* were the best farm

land trees in their study area because of their multi-functionality. This implies that on farm trees gives different functions and the farmer who practiced agroforestry in different areas of the country planted tress with varied functions to get environmental and economic benefits.

5.1.8 Indigenous knowledge and conservation methods of on farm trees in the study area

The majority of the respondents explained that they get the knowledge of agroforestry practice from their parents. The elder families transfer their knowledge to their offspring by showing and telling. Some respondents also mentioned the Woreda agricultural office supported them to plant apple in their farm land and home garden. This result was in agreement with the findings of Abiyot Legesse *et al.,* (2013) who studied in Wonago Woreda, Gedeo Zone, Southern Ethiopia, and reported that most informants transfer their indigenous agroforestry knowledge to their children by oral communication and demonstration. Aklilu Medalcho and Mengesha Tefera (2016) also stated that local people knew the suitable tree/shrub species for their specific agroforestry practice in which they established.

The common conservation mechanisms of farm land trees/shrubs in Menz Gera Midir Woreda includes pruning, providing compost and protecting the trees from animal during its seedling stage. Similar findings were reported by Aklilu Medalcho and Mengesha Tefera (2016) who reported that compost application, prescribed burning, protection from animal damage are the main conservation methods of farm land trees. Tadesse Dejene (2011) has also reported a more or less similar conservation techniques in that people use

animal manures such as 'fig' and byproduct of local food processes such as 'atela'. Mesele Negash (2007) found pollarding and lopping of side branches were the major conservation practice in his study site. All these indicated that farmers share relatively similar ways of conservation for their farm land trees and shrubs.

5.1.9 Determinants of Agroforestry implementation in the Study area

From the total respondents 22% did not planted trees in their farm land. Sixty three percent of the farmers who did not practice agroforestry have positive attitude and good understanding on the system. They reported that that agroforestry is a better agricultural system than a simple mono-culturing. The size of their farm land, the shadow of the trees, the uncomfortability of tree's root during ploughing were the main reasons the farmers mentioned for not practicing agroforestry system. Similar findings were obtained by Hussien Adal Mohammed and Zemede Asfaw (2015) who reported that respondents in their site explained that small plot size; shading effects on crops, lack of external support were the main factors for not planting trees in their farm land. This indicates that even most farmers who did not practice agroforestry understood the system as a better agricultural practice. But they lack awareness on the ways of implementation and management of agroforestry systems.

5.2 Conclusion

The purpose of this study was to investigate trees in agroforestry system in Menz Gera Midir Woreda of North Shewa, Amhara Region, Ethiopia. In the study, one hundred respondents participated from ten kebeles. Semi-structured interview, group discussion and field survey were used to gather information on the types and uses of trees in agroforestry. In the area, variety practices of agroforestry such as home garden, trees scattered on farms, hedgerow, wind break and silvopastoral were observed. Home garden and scattered trees in farm land were the most commonly used agroforestry practices. These varied practices were implemented by most (78%) of the respondents.

The good perception and knowledge of agroforestry in the study area plays a great role in the implementation of the varied practices and this helps the farmers to get the different benefits from the system. The farmers in the study area apply suitable agroforestry practices based on their farm land size and the crops they cultivate. The transfer of indigenous knowledge on agroforestry practice helps more to select, use and manage on farm and home garden trees /shrubs in the area.

The farmers deliberately plant multipurpose trees on their farm land and home garden. From those trees they get fuel wood, fodder and traditional medicines. Trees and shrubs on farm land also contribute to soil fertility, income generation and home consumption. *Acacia abyssinica, Olea europaea* subspp. *cuspidata* and *Hagenia abyssinica* were the major farm land trees in the area. Overall, sixty one farm land / home garden tree species which belong to 51 genera and 31 families were observed and recorded. The management methods of farm land trees in the area include deliberate planting, providing compost,

pruning and protecting from animal damage. The farmers did not get a satisfactory support from the Woreda Agricultural Office. The only contribution of the office is providing seedlings. If the farmers get assisted by the stakeholders and acquire the necessary knowledge on the system, together with their indigenous knowledge, they would have earned the highest benefit from the system.

5.3 Recommendations

Based on the findings of the study the following recommendations are forwarded.

- Since the agricultural lands in the study area are much degraded, agroforestry practice should be implemented successfully by the farmers to maintain soil fertility and to protect the soil from erosion and get the benefit from the trees.
- Nowdays the forest resource of Ethiopia becomes decreasing. So the agricultural centers in the study areas should take agroforestry as a means of forest protection and should assist the farmers to practice a well-managed agroforestry system.
- Even if the farmers in the study area have indigenous knowledge on the use and practice of agroforestry, a continuous awareness raising on the selection, management and conservation of farm land tree have to be given by the Woreda agricultural office.
- The agricultural offices of the Woreda have to support the farmers by giving seedlings of trees that have multi-functions.
- Farmers in the study area should take agroforestry as a solution to overcome scarcity of agricultural land by planting crops and trees/shrubs on the same piece of land than using some part of their small farm land for crop cultivation and the rest for planting trees.
- The conservation methods of farm land trees in the area are not satisfactory. The farmers only use their indigenous knowledge to conserve and manage tress in their farm land. They should be assisted by the local agricultural sectors.

- The Woreda agricultural office should give due attention to threatened species of farm land trees in the study area such as *Cordia africana, Juniperus procera* and *Hagenia abyssinica.*

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Appendices

Appendix 1 Semi-structured interview

Dear respondent

The purpose of this questionnaire is to investigate the uses and practices of agroforestry in Menz Gera Midir Woreda, North Shewa, Amhara Regional State of Ethiopia. To achieve this goal, your genuine response is important and essential. I kindly request to read the entire questions and give your response. I assure you that your response will be used for the research purpose.

N.B

- Response to the close - ended questions by putting (✓).
- Write short and clear explanation for the open - ended questions.

Part I. Background of the respondents

1. Name …….District …… Kebele ……
2. Age 20-30 ☐ 31-40 ☐ 41-50 ☐
   Above 51 ☐
3. Sex: Male ☐ Female ☐
4. Marital status
   Single ☐ Married ☐ Divorced ☐ Widowed ☐

5. Education level
    i. Can read and write ☐
    ii. Can't read and write ☐
    iii. 1 – 8th grade ☐
    iv. 9 – 10th grade ☐
    v. Above 10th grade ☐
6. Years of experience in farming
    i. 1 -5 years ☐
    ii. 6 -10 years ☐
    iii. 11 – 15 years ☐
    iv. Above 16 years ☐
7. Years of living in the study area
    i. 1 -5 years ☐
    ii. 6 -10 years ☐
    iii. 11 -15 years ☐
    iv. Above 16 years ☐

Part II. Information on knowledge, practice and uses of agroforestry

8. Do you plant trees in your farm land?

    Yes ☐ No ☐

9. If your answer is yes,
    i. Please list their vernacular names.

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ii. When do you plant the trees?

A. Before cultivating the crops. ☐

B. Along with cultivating the crops. ☐

If any other, please specify.

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iii. What is the arrangement of trees in your farm land?

A. Spontaneously scattered throughout ☐

B. Forming hedge around the farm land ☐

C. At selected spot inside the farm land ☐

D. Forming boundaries in the farm land ☐

If any other, please specify.

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10. If your answer is no for question nº 8, why is it so?

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11. What criteria do you use to select the types of trees grown in your farm land?

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12. Does the criterion differ with the crop types you cultivate?

Yes ☐ No ☐

13. If your answer is yes for question nº 12, would you please explain why he selection criterion varies?

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14. What are the dominant crops that you cultivate?

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15. What benefits do you get by planting trees in your farm land?

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16. From where did you get the knowledge of planting trees together with agricultural crops?

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17. Is there any difference between mono-culturing and integration of trees with agricultural crops?

Yes ☐ No ☐

18. If your answer is yes,

i. What are the differences?

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19. What problems do you face to plant trees in your farm land?

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20. How do you overcome these problems?

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21. Is there any governmental or non – governmental organization that supports you to implement agroforestry practice?

Yes ☐ No ☐

22. If your answer is yes for question n^{o} 20,

i. Please list their names.

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ii. What kind of support do you get?

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23. Do you have an ownership right to use trees growing in your farm land?

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24. Are there trees in your farm land that are used for market purpose?

Yes ☐ No ☐

25. If your answer is yes for question nº 24,

i. Please list their names.

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ii. For what purpose does the society use those trees?

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26. What are the conservation practices you implement to manage agroforestry practice?

Thank you!!

Appendix 2: Farm land/home garden trees /shrubs in the study area

Roll Nº	Scientific name	Local name	Family name	Habit	Habitat	Collection Nº	Uses
1	*Acacia abyssinica* Hochst. ex Benth	Girar	Fabaceae	Tree	Farm land	YM 21	For shading, fire wood
2	*Acacia negrii* Pic.Serm.	Girar	Fabaceae	Tree	Farm land	YM 24	Fire wood Charcoal
3	*Albizia anthelmintica* (A.Rich.) Brogn.	Shina	Fabaceae	Shrub	Farm land		Making furniture
4	*Albizia schimperiana* Oliv.	Sesa	Fabaceae	Tree	Farm land		Farm equipment, Charcoal
5	*Allophyllus abyssinicus* (Hochst.) Radlk	Embus	Sapindaceae	Tree	Farm land	YM 02	Live fence, fodder farm equipment
6	*Balanites aegyptiaca*(L.)Del.	Kudkuda	Balanitaceae	Tree	Farm land		Soil fertility, fodder
7	*Berberis holstii* Engl.	Zinkila	Berberidaceae	Shrub	Farm land		Live fence
8	*Brucea antidysenterica* J.F. Mill.	Aballo	Simaroubaceae	Shrub	Farm land		Traditional medicine, fire wood
9	*Buddleja polystachya* Fresen.	Amfar	Loganiaceae	Shrub	Farm land		Fodder
10	*Canthium lactescens* Hiern	Seged	Rubiaceae	Shrub	Farm land		Fire wood

Roll Nº	Scientific name	Local name	Faimly name	Habit	Habitat	Collection Nº	Uses
11	*Capparis tomentosa* Lam.	Gmero	Capparidaceae	Shrub	Farm land		Traditional medicine
12	*Carica papaya* L.	Papaya	Caricaceae	Tree	Home garden		Edible fruit
13	*Catha edulis*(Vahl) Forssk ex Endl.	khat	Celastraceae	Shrub	Home garden	YM 20	Market purpose
14	*Citrus aurantifolia* (Christm.) Swingle	Lomi	Rutaceae	Tree	Home garden		Market purpose, home consumption
15	*Citrus medica* L.	Tirngo	Rutaceae	Tree	Home garden	YM 06	Edible fruit
16	*Citrus sinensis* (L.) Osb.	Birtukan	Rutaceae	Tree	Home garden		Edible fruit
17	*Coffea arabica* L.	Bunna	Rubiaceae	Shrub	Home garden		Commercial value
18	*Cordia africana* Lam.	Wanza	Boraginaceae	Tree	Farm land/home garden	YM 11	Timber tree, edible fruit
19	*Croton macrostachyus* Del.	Bisana	Euphorbiaceae	Tree	Farm land/home garden	YM 19	Soil conservation, shade
20	*Cupressus lusitanica* Mill.	Yeferenji tid	cupressaceae	Tree	Farm land/home garden	YM 15	Timber tree, shelter belt

Roll Nº	Scientific name	Local name	Faimly name	Habit	Habitat	Collection Nº	Uses
21	*Dodonaea angustifolia* L. f.	Kitkita	Sapindaceae	Shrub	Farm land	YM 17	Fodder, Fire wood
22	*Dombeya torrida* (J.F.Gmel.) P.Bamps	Welkefa	Steruliaceae	Shrub	Farm land		Fire wood, furniture
23	*Erica arborea* L.	Asta	Ericacceae	Tree	Farm land	YM 07	Charcoal
24	*Erythrina brucei* Schweinf.	Korch	Fabaceae	Tree	Home garden	YM 09	Beehives, traditional medicine
25	*Eucalyptus camaldulensis* Dehnh	Key bahirzaf	Myrtaceae	Tree	Home garden		Construction
26	*Eucalyptus globulus* Labill	Nech bahirzaf	Myrtaceae	Tree	Home garden		Construction, traditional medicine, Charcoal
27	*Euclea racemosa* Murr.	Dedeho	Ebenaceae	Shrub	Farm land/home garden	YM 18	Live fence, fire wood
28	*Euphorbia tirucalli* L.	Kincheb	Euphorbiaceae	Shrub	Home garden		Live fence
29	*Ficus sur* Forssk	Shola	Moraceae	Tree	Farm land	YM 10	Edible fruit, shade
30	*Ficus vasta* Forssk	Warka	Moraceae	Tree	Farm land		Shade, soil fertility

Roll Nº	Scientific name	Local name	Faimly name	Habit	Habitat	Collection Nº	Uses
31	*Gossypium arboretum* L.	Tit	Malvaceae	Shrub	Home garden	YM 12	Market purpose
32	*Hagenia abyssinica* (Brace) J.F.Gamel.	kosso	Rosaceae	Tree	Farm land/home garden	YM 22	Soil conservation
33	*Hypericum revolutum* Vahl	Ameja	Hypericaceae	Shrub	Farm land	YM 08	Live fence
34	*Jasminum abyssinicum* Hochst. ex DC.	Tembelel	Oleaceae	Shrub	Farm land		Traditional medicine
35	*Juniperus procera* Hochst. ex Endl.	Yeabesha tid	Curpressaceae	Tree	Farm land/home garden	YM 23	Timber and furniture, shading
36	*Maesa lanceolata* Forssk.	Kelewa	Myrsinaceae	Shrub	Farm land		Traditional medicine
37	*Malus sylvestris* Mill.	Pom	Rosaceae	Tree	Home garden	YM 03	Edible fruit
38	*Maytenus arbutifolia* (A.Rich.) Wilczek	Atat	Celastraceae	Tree	Farm land		Honey production
39	*Millettia ferruginea* (Hochst.) Bak	Birbira	Fabaceae	Shrub	Farm land		Traditional medicine, shade plant
40	*Myrica salicifolia* A. Rich	Shinet	Myrtaceae	Tree	Farm land	YM 04	Furniture

Roll Nº	Scientific name	Local name	Faimly name	Habit	Habitat	Collection Nº	Uses
41	*Myrsine africana* L.	Kechmo	Myrsinaceae	Shrub	Farm land		Traditional medicine
42	*Olea europaea* L. subsp. *cuspidata* (Wall. ex G.Don) Cif.	Weira	Oleaceae	Tree	Farm land/home garden		Herbal medicine
43	*Persea americana* Mill.	Avocado	Lauraceae	Tree	Home garden	YM 13	Edible fruit
44	*Podocarpus falcatus* (Thunb.) R. B. ex. Mirb.	Zigba	Podocarpaceae	Tree	Farm land		Soil fertility, furniture
45	*Premna schimperi* Engl.	Chocho	Lamiaceae	Shrub	Farm land		Fire wood, charcoal
46	*Rhamnus prinoides* L Herit.	Gesho	Rhamnaceae	Shrub	Home garden	YM 25	For making alcoholic drinks
47	*Rhamnus staddo* A. Rich	Tedo	Rhamnaceae	Tree	Farm land		Fire wood
48	*Rhus natalensis* Krauss	Miset aybelash	Anacardiaceae	Tree	Farm land		Edible fruit, making tools,
49	*Rhus retinorrhoea* Oliv.	Tilem	Anacardiaceae	Tree	Farm land	YM 01	Fire wood, Making tools
50	*Ricinus communis* L.	Gullo	Euphorbiaceae	Shrub	Home garen		Traditional medicine

Roll Nº	Scientific name	Local name	Faimly name	Habit	Habitat	Collection Nº	Uses
51	*Senra incana* Cav.	Nechlo	Malvacee	Shrub	Home garden		Fire wood
52	*Sesbania sesban* (L.) Merr.	Shewshewe	Fabaceae	Tree	Home garden		Shading, live fence,
53	*Strychnos innocua* Del.	Merenz	Loganiaceae	Tree	Farm land	YM 14	Making tools, attract bees
54	*Syzygium guineense* (Willd.) DC.	Doqma	Myrtaceae	Tree	Farm land		Bee forage, furniture
55	*Vernonia schimperi* DC.	Gerawa	Asteraceae	Shrub	Home garden		Honey production
56	*Vitex doniana* Sweet	Plem	Lamiaceae	Tree	Home garden	YM 05	Edible fruit
57	*Withania somnifera* (L.) Dunal	Gezawa	Solanaceae	Shrub	Farm land		Traditional medicine
58	*Ximenia americana* L.	Inkoy	Olacaceae	Tree	Farm land		Live fence, fodder
59	*Ziziphus abyssinica* Hochst. ex A. Rich	Abetere	Rhamnaceae	Tree	Farm land		Edible fruit
60	*Ziziphus mauritiana* Lam.	Qurqura	Rhamnaceae	Tree	Fam land		Edible fruit, fodder
61	*Ziziphus mucronata* Willd.	Geba	Rhamnaceae	Tree	Farm land	YM 16	Edible fruit

Appendix 3: List of home garden trees /shrubs in Menz Gera Midir woreda in their local name, family name, habit and function/s

Roll Nº	Scientific name	Local name	Family name	Habit	Function/s
1	*Carica papaya*	Papaya	Caricaceae	Tree	Edible fruit
2	*Catha edulis*	khat	Celastraceae	Shrub	Market purpose
3	*Citrus aurantiifolia*	Lomi	Rutaceae	Tree	Market purpose, home consumption
4	*Citrus medica*	Tirngo	Rutaceae	Tree	Edible fruit
5	*Coffea arabica*	Bunna	Rubiaceae	Shrub	Commercial value
6	*Croton macrostachyus*	Bisana	Euphorbiaceae	Tree	Shade, soil conservation
7	*Eucalyptus globulus*	Nech bahirzaf	Myrtaceae	Tree	Construction, traditional medicine
8	*Gossypium arboreum*	Tit	Malvaceae	Shrub	Market purpose
9	*Hagenia abyssinica*	kosso	Rosaceae	Tree	Fire wood, soil conservation
10	*Malus sylvestris*	Pom	Rosaceae	Tree	Edible fruit
11	*Olea europaea* subsp.*cuspidata*	Weira	Oleaceae	Tree	Herbal medicine
12	*Persea americana*	Avocado	Lauraceae	Tree	Edible fruit
13	*Rhamnus prinoides*	Gesho	Rhamnaceae	Shrub	For making alcoholic drinks

Appendix 4: List of scattered trees in farm land of the study area with their local name, family name, habit and function

Roll Nº	Scientific name	Local name	Family name	Habit	Function
1	*Acacia abyssinica*	Girar	Fabaceae	Tree	For shading
2	*Acacia negrii*	Girar	Fabaceae	Tree	Fuel wood, Charcoal
3	*Albizia schimperiana*	Sesa	Fabaceae	Tree	Fuel wood, shade, furniture
4	*Buddlega polystachya*	Amfar	Loganiaceae	Tree	Fodder, live fencing
5	*Cordia africana*	Wanza	Boraginaceae	Tree	Timber tree, edible fruit
6	*Croton macrostachyus*	Bisana	Euphorbiaceae	Tree	Shade, soil conservation
7	*Dodonaea angustifolia*	Kitkita	Sapindaceae	Shrub	Fire wood, fodder
8	*Erica arborea*	Asta	Ericacceae	Shrub	Charcoal
9	*Euclea racemosa*	Dedeho	Ebenaceae	Shrub	Live fence
10	*Ficus sur*	Shola	Moraceae	Tree	Shade, edible fruit
11	*Ficus vasta*	Warka	Moraceae	Tree	Soil fertility, shade
12	*Hagenia abyssinica*	kosso	Rosaceae	Tree	Traditional medicine
13	*Juniperus procera*	Yeabesha tid	Curpressaceae	Tree	Timber and furniture, shading
14	*Olea europaea* subsp. *cuspidata*	Weira	Oleaceae	Tree	Herbal medicine

Appendix 5: Farm land/home garden trees/shrubs used for market purpose in the study area

Roll Nº	**Scientific name**	**Local name**	**Family name**	**Habit**	**Uses**
1	*Acacia abyssinica*	Girar	Fabaceae	Tree	Fire wood
2	*Acacia negrii*	Girar	Fabaceae	Tree	Carcoal and fire wood
3	*Catha edulis*	khat	Celastraceae	Shrub	Market purpose
4	*Citrus aurantifolia*	Lomi	Rutaceae	Tree	Market purpose, home consumption
5	*Citrus medica*	Tirngo	Rutaceae	Tree	Edible fruit
6	*Citrus sinensis*	Birtukan	Rutaceae	Tree	Edible fruit
7	*Coffea arabica*	Bunna	Rubiaceae	Shrub	Commercial value
8	*Cordia africana*	Wanza	Boraginaceae	Tree	Timber tree, edible fruit
9	*Erica arborea*	Asta	Ericacceae	Shrub	Charcoal
10	*Eucalyptus globulus*	Nech bahirzaf	Myrtaceae	Tree	Construction, traditional medicine, Charcoal
11	*Gossypium arboreum*	Tit	Malvaceae	Shrub	Market purpose
12	*Rhamnus prinoides*	Gesho	Rhamnaceae	Shrub	For making alcoholic drinks
13	*Ziziphus mucronata*	Geba	Rhamnaceae	Shrub	Edible fruit

Appendix 6: Farm land/home garden tree/shrubs used for medicinal purpose

Roll Nº	Scientific name	Local name	Family name	Habit	Medicinal value
1	*Balanites aegyptiaca*	Kudkuda	Balanitaceae	Tree	For elephantiasis
2	*Berberis holstii*	Zinkila	Berberidaceae	Shrub	For cancer
3	*Brucea antidysenterica*	Aballo	Simaroubaceae	Tree	For diarrhea and rabies
4	*Capparis tomentosa*	Gmero	Capparidaceae	Shrub	For headache and evil sprit
5	*Croton macrostachyus*	Bisana	Euphorbiaceae	Tree	For skin disease (‘Chirt’and ‘Quaqucha’)
6	*Euphorbia tirucalli*	Kincheb	Euphorbiaceae	Shrub	For rabies
7	*Eucalyptus globulus*	Nech bahirzaf	Myrtaceae	Tree	For common cold
8	*Hagenia abyssinica*	kosso	Rosaceae	Tree	For taeniasis, eye disease
9	*Jasminum abyssinicum*	Tembelel	Oleaceae	Shrub	For wound
10	*Millettia ferruginea*	Birbira	Fabaceae	Tree	For skin infection(‘Chifey’)
11	*Olea europaea* subsp. *cuspidata*	Weira	Oleaceae	Tree	For treating hemorrhoid
12	*Rhus retinorrhoea*	Tilem	Anacardiaceae	Shrub	For rabies
13	*Ricinus communis*	Gullo	Euphorbiaceae	Shrub	For ‘Nekersa’ and hemorrhoid
14	*Syzygium guineense*	Doqma	Myrtaceae	Shrub	For taeniasis
15	*Withania somnifera*	Gezawa	Solanaceae	Shrub	For evil eye
16	*Ximenia americana*	Inkoy	Olacaceae	Shrub	For treating malaria