CONTRIBUTION OF AGROFORESTRY TO SOIL PROPERTIES AND LIVELIHOOD IMPROVEMENT: THE CASE OF LEMMO WOREDA, HADIYA ZONE, SNNPR

M.SC. THESIS

MISGANU ARIDE

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JIMMA ETHIOPIA

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M.Sc. Thesis

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APPROVAL SHEET

SCHOOL OF GRADUATE STUDIES

As thesis research advisors, we hereby certify that we have read and evaluated this thesis prepared, under our guidance, by Misganu Aride Someno, entitled **CONTRIBUTION OF AGROFORESTRY TO SOIL PROPERTIES AND LIVELIHOOD IMPROVEMENT: THE CASE OF LEMMO WOREDA, HADIYA ZONE, SNNPR**

.We recommend that it be submitted as fulfilling the thesis requirements.

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As member of the Board of Examiners of the MSc Thesis Open Defense Examination, we certify that we have read, evaluated the Thesis prepared by Misganu Aride and examined the candidate. We recommended that the thesis can be accepted as fulfilling the thesis requirement for the Degree of Master of Science in Natural Resource Management (Integrated Watershed Management).

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External Examiner Signature Date

DEDICATION

I dedicate this thesis to my wife Mulunash Beyikaso and my Elder son Biruk Misganu Motivation for nursing me with affection, and for their dedicated partnership in the success of my life.

DECLARATION

This thesis is my original work it has never been submitted in any form to other university and it has never been published nor submitted for any journal by another person and all sources of materials used for the thesis have been duly acknowledged.

Name___________________________________

Signature________________________________

Place ___________________________________

Date of submission________________________

BIOGRAPHICAL SKETCH

The Author, Misganu Aride, was born on 22th of July 1972 in Misha District of Hadiya Zone, SNNPR, Ethiopia. He attained his Junior Elementary School at Morsito School from 1980 to 1989 and his secondary school at Wachamo comprehensives secondary school from1989-1993. He awarded BA degree in Community Development and Leadership in 2010. Since then he was an employee of SNNPR Bureau of Education where he has served for 15 years as Quality of education process Owner at Gomebora district of Hadiya Zone. Finally, he joined the School of Graduate Studies at Jimma University, College of Agriculture and Veterinary Medicine (JUCAVM) in September, 2013 to pursue his MSc study in Natural Resource Management (Integrated Watershed Management).

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ABBREVIATION

AFP	Agroforestry Practices
ANOVA	Analysis of Variance
CEC	Cation Exchange Capacity
CSA	Central Statistics Authority
DA	Developmental Agent
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization of the United Nation
FGD	Focus Group Discussion
HH	Household
IFPRI	International Food Policy Research Institute
LSD	Least Significance Differences
LWARDO	Lemo Woreda Agriculture and Rural Development Office
MoARD	Ministry of Agriculture and Rural Development
NCS	National Conservation Secretariat
NGO	Non-Governmental Organizations
SAS	Statistical Analysis System
SNNPR	Southern Nations and Nationalities Peoples' Region
SPSS	Statistical Package for Social Sciences
UN	United Nations
USDA	United States Department of Agriculture

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ABSTRACT

Land is a place from which human beings are exploiting a number of resources. Almost all food production for the world population is derived from land, and the need to produce more is increasing from time to time due to an increase in population. For increasing production, either area under cultivation must expand or its productivity needs to increase .To this effect, the way how farmers use the land influence the covering capacity of smallholder farmers to external shocks. The main objective of the study was, therefore, to assess the contribution of agroforestry to soil properties and livelihood improvement. In order to chick the Socio-economic aspect of contribution of agro forestry practices to soil properties on there unit of land. The survey data collection were carried out by using questionnaires, key informant interview and observation methods .So as to carry out this assessment from total of 1131 HHs of the two study site only 123 HHs were randomly selected by using the sampled size determination techniques. For the soil physico-chemical properties undisturbed core and disturbed composite soil samples were collected randomly with three replication at the depth of 0-15 and 15- 30cm from three different land management's, agro forestry, cultivated and area enclosure that were located on similar soil types and slope classes. The survey analysis results showed that AF practices contributed the highest net income for rural livelihoods as compared to cultivated and AE. The reason to this AF providing cereal crops, fodders and fuel wood at the same time than others land use types. The major tree species preferred for annuals and perennial crops yields improvement are Croton macrostachyus, Cordia africana and *Acacia abyssinica, in Hayise and Lisana study site respectively. Whereas majorities of the respondent have negative response towards Eucalyptus globulus and Eucalyptus camaldulensis trees plantation due to its high soil nutrient extraction that leads to the competition with annual and perennial agricultural crops. The soil analysis result revealed that OC, OM, pH, AvP, Ca and CEC were significantly higher in the agro forestry as compared to AE and cultivated land. This may be due to high erosion prevented capacity of AF practices and addition of high plant biomass, litters, to the soil which enhances soil fertility. But soil bulk density, were significantly lowest in the agro forestry as compared to area enclosures and cultivated land. .In this study only limited socio economic data and* *selected soil macro nutrients were considered. So, further research is required on detail socio economic information, soil micro nutrients and biological soil fertility indicator.*

Key words*:* Agro Forestry, Land Use, Rural Livelihoods, Physic-Chemical Properties

1. INTRODUCTION

1.1. Background and Justification

Land is the most important natural resource all over the world. It is a place from which human beings are exploiting a number of resources (Taffa, 2002). Almost all food production for the world population is derived from land, and the need to produce more is increasing from time to time due to an increase in population. For increasing production, either area under cultivation must be expands or its productivity needs to be increases (Woldeamlak, 2003). To this effect, the way how farmers use the land influence the covering capacity of adding inorganic fertilizer is to external shocks (Canali and Slaviero, 2010).

The agroforestry practices for land management's make an adjustment to cultivate and area enclosure land practices to best take advantage and it makes them better off to improving livelihood. Hence, land use option that increases livelihood security and reduce vulnerability to climate and environmental changes are necessary. Traditionally, local farmers are known to have practiced the system that encourages the development of agro forests through fallow system as sustainable land use (Nyong *et al.,* 2007). With increasing population the fallow system is no longer possible. Agroforestry is emerging over period of time as the promising land use option to sustain agricultural productivity and livelihoods of farmers (Syampunani *et al.,* 2010). Hence agroforestry plays a major role in strengthening the system's ability to cope with adverse impacts of changing climate conditions (Verchot *et al.,* 2007). Income obtained from agro forestry also helps smallholder farmers to reduce poverty, maintain their socioeconomic needs and sustain their livelihoods (Rahman and Kabir, 2008). Agro forestry in different parts of the world differs in nature and complexity and objective (Nair, 2007). Moreover, fundamental to realization of the promise of agroforestry system is agroforestry species (Nair, 2008).

Agroforestry as, a land management system was receiving greater attention in many countries to protect the land from various types of degradation. Agroforestry practices offer considerable benefits for the long term agricultural sustainability (ICRAF, 2004), it is a tool for achieving sustainable agricultural farming and improving the quality of life of affected communities while simultaneously reversing the process of environmental as well as land degradation (UNCCD, 2003), it is a dynamic ecologically based natural resources management system (Young, 1989).

Land degradation is a major cause of poverty in rural area of developing countries (Tesfaye and Debebe, 2013). In many areas, farming population has experienced a decline in real income due to demographic, economic, social and environmental changes. Land degradation is result of several factors of both physical and socio-economic nature. The immediate consequence of land degradation was reduced crop yield followed by economic decline and social stress. The integrated process of land degradation and increased poverty has been referred to as the "down hill spiral of unsustainably" leading to the "poverty traps" (Green land *et al.*, 1994). During the past decade, Ethiopia has faced serious ecological imbalance mainly due to a large-scale deforestation, uncontrolled grazing practices, soil erosion caused by improper farming practices and destructive forests exploitation and wildfire. The consequence of which have been a declining agricultural production, water depletion, disturbed hydrological behavior in the river basins, and food insecurity (Daniel, 2001).

According to FAO (1994) the major evidence for soil fertility decline includes the reduction of organic matter, soil biological, availability of nutrients (both macro and micros), and soil of physical degradation .In Ethiopian highlands soil erosion is the main cause of deterioration for soil productivity (NCS, 1994). Annual soil loss in Ethiopia is estimated to be 1.5 up to 3 billion tons. Out of this 50 % is occurred in croplands where soil loss may be as high as 296, tons/ha/year (FAO, 1986 and Scoones *et al*., 1996). This was causing decline in food production by one to two percent per annum (NCS, 1994).

To tackle the problems of land degradations (such as soil fertility depletion and erosion) agroforestry practices, area enclosure and prevent the entrance of collectively land management unit that helps to sustain production by increasing social, economic and environmental benefits (Hamid *et al*., 2012). The purpose of adopting agroforestry based farming practice is to obtain maximum possible production from a fixed area of land possibly from each and every crop and tree plants. According to Dechasa, (1999), there are several types of agroforester type exist in different parts of Ethiopia and there are new technologies starts by several institutions at a national level across different land use systems. These systems mostly follow similar patterns and sequencing of crops but with variations in the number and species of vegetation planted. The crops grown largely depend on specific area and socio-cultural conditions. For instance the agroforestry practice of the Gedeo is among the best sustainable land management systems adopted by communities in the South Eastern, South Central and South Western highlands of the SNNPR and Oromia regions in Ethiopia.

Although the agroforestry practices in the study area, most common in the agricultural landscape are scattered trees in crop lands and Enclosures and natural regeneration of species in woodlands (Joffre, *et al*., 1999). From that home garden, live fence and shelterbelt of agro forestry practice was dominated in the Hayise and Lisana village helps to contribute for their livelihood improvement by combating ecological degradation and increasing agricultural productivity. The objective of the study was to assess the contribution of agroforestry practices for the improvement of selected soil physic-chemical properties and farmers livelihood conditions **.**This finding may play significant role for rural communities in Lemmo Woreda by sustaining the productive capacity of their land which lead to improve their life standard also used for research institute and academic pursers.

1.2.Objectives of Study

1.2.1. General objective of the study

The general objective of this study is to assess the contribution of agroforestry practices for the improvement of selected soil physico-chemical properties and farmer's livelihood conditions.

1.2.2. Specific Objectives of the Study;

- To assess the contribution of agroforestry practices to soil property.
- To assess the potential benefits of agroforestry practices for local community in the study area.
- To evaluate effects of agroforestry practices on selected soil physico-chemical properties.

1.3. Research Questions

1. What are the benefits that the local communities obtain from agroforestry Practices?

2. How do agroforestry can incorporate and interaction into crops and animals?

3. What types of agroforestry practiced in the study area?

4. How agroforestry practices contribute for soil physico-chemical properties improvement?

2. LITERATURE REVIEW

2.1 Land Management Practices

Land management practices allow for a variety of uses and can satisfy a diverse range of objectives. Land management practices are a basic element in human activity much of what we humans do requires land (Young, 1998). Although, land management practice is defined as “the actual practice of the use of the land by the local human population, which should be sustainable”(FAO, 1991). Land management has many components, including land-use planning, as agreed between stakeholders; legal, administrative and institutional oversight; clearly defining the land areas in question; inspection and control of compliance with the decisions; resolving land tenure issues; settling of water rights; issuing of concessions for plant and animal extraction (timber, fuel wood, charcoal and peat, non-wood products, hunting); promoting the role of women and other disadvantaged groups in agriculture and rural development; and safeguarding the traditional rights of indigenous peoples (FAO, 1996).According to Ethiopia land policy and administration assessment final report (2004) land management practices addresses all issues related to the sound and sustainable use of land. It is the process by which the resources of land are put to good use. It covers all activities concerned with the management of land as a resource both from an environmental and an economic perspective. These include, but are not limited to:

- ❖ Improving the efficiency of land resource use to support a growing population;
- ❖ Conducting land use planning;
- ❖ protecting the natural environment from degradation;
- ❖ Providing equitable and efficient access to the economic benefits of land and real estate markets;
- ❖ Supporting government services through taxation and fees related to land and improvements; and
- ❖ Providing incentives for development, including the provision of residential housing and basic infrastructure such as open drain and water facilities.

2.2. Concept of land management

The concept of land management refers to a series of activities done to generate one or more products or services. The same land management can occur on several different practices of land, and the same land may have several uses. An activity-based definition of land management allows for a detailed quantitative analysis of both economic and environmental impacts, as well as enabling different land uses to be clearly distinguished (FAO, 1998).

Land managing towards sustainability in agriculture and more specifically inland use has been on the top of priority list of natural management issues in developing countries. Sustainable soil management means cropping, pastoral and forestry use of the limited and only partially renewable resources soil, water and plant nutrients to maintain soil productivity also for future generations and prevent or reverse degradation process (Senait,2002).The objective of sustainable land management is to harmonize the complementary goals of providing environmental, economic and social opportunities for the benefit of present and future generations, while maintaining and enhancing the quality of the land (soil, water and air) resource.

There are various technical solutions recommended for managing land towards sustainability. Techniques aimed at erosion control include contour tillage, construction of physical soil conservation measures, etc. Soil nutrient replenishment has to be achieved through organic and inorganic fertilizer applications. Traditional erosion control practices, for example; mulch application and long-term fallow management no longer keep pace with the increasing frequency of land use. They include the stabilization of the soil by stone lines, terraces, herbal (grass) strips and various forms of agroforestry measures, for example; planting and management of trees, shrubs and windbreaks/ shelter belt .However, these technical solutions alone are not the remedy for the problem (Senait, 2002). To understand soil erosion we must be aware of the political and economic factors affecting land users' and preventing soil erosion requires political, economic and technical changes. Land management measures need to be adapted to specific soil and landscape characteristics such as soil texture or terrain slope and to socio-economic circumstances of the largest population.

2.3. Agroforestry Practices and their Multiple Roles

Agroforestry has been defined as "a dynamic ecologically based natural resource management system that through the integration of trees in agricultural landscapes diversifies and sustains production for increased social, economic and environmental benefits" (ICRAF, 2007). It is practiced for a variety of objectives and represents an interface between agriculture and forestry and encompasses mixed land use practices. These practices have been developed primarily in response to the special needs and conditions of tropical developing countries that have not been satisfactorily addressed by advances in conventional agriculture or forestry (Nair, 1993). Agroforestry systems are viewed as an alternative to the ever increasing demand for food (Soemarwoto, 1987) and a practical solution that brings together scientific as well as traditional techniques to diversify production.

2.4 .Types of Agroforestry Practices

An agroforestry practice denotes a specific land management operation on a farm or other management unit, and consists of arrangements of agroforestry components in space and time (Gholz, 1987). Examples of agroforestry practices are home gardens, Woodlot, Windbreaks/shelterbelts, Boundary planting, Live fences, Hedgerow intercropping, improved fallow, Intercropping under scattered or regularly planted trees ,Trees on rangelands ,Trees on soil conservation and recovery structures.

2.4.1. Home gardens

According to Nair (1993) home gardens have been defined as a small-scale, supplementary food production system by and for household members by mimicking the natural, multilayered ecosystem. Home gardens are characterized by being near residence, composed of a high diversity of plants, small, and an important source of household subsistence and cash needs. Tropical home gardens consists of an assemblage of plants which may include trees, shrubs, vines, and herbaceous plants, growing in or adjacent to a homestead or home compound and these gardens are planted and maintained by members of the household . Ethiopia is one of the tropical countries where home garden agro forestry practice practiced in extensively. The most common known example of perennial crop based home garden is practiced in the Ethiopian highlands of the Southern Nation's Nationalities and Peoples' Regional State (Tesfaye, 2005). These practices are found both in lowland and highland tropics, but are more common in humid lowlands characterized by high population density. Home garden have received considerable attention as potential models for economically and ecologically sustainable systems (Padoch and De Jong, 1991). The economic importance’s of home garden to the small farm households as they provide supplementary and continuous flow of products such as food for household consumption, medicine, poles, and offer a buffering capacity when the main crops fail (Torquebiau, 1992).

Similarly, home gardens display number of features of sustainable agro-ecosystems, including efficient nutrient cycling, high biodiversity, low use of external inputs and improved soil conservation potential. Moreover, home garden provides a diverse and stable supply of socio-economic products and benefits to the families that maintain those (Gautam *et al.,* 2004). It has been practiced in Ethiopia since time immemorial by villagers on farm lands. It is recognized worldwide as a sustainable system characterized by the production of multiple species closely arranged in several overlapping canopy layers and in association with livestock (Peyreet *et al.,* 2006). Even though the integrated land use types are believed to enhance agriculture due to the association between multiple crops and trees on one hand, and various ecological and economic benefits on the other.

2.4.2. Windbreaks/Shelterbelts

Windbreaks are narrow plantings of trees and shrubs, mainly tall woody species that form a linear barrier perpendicular to the prevailing winds; they protect cropland, pastureland, roads, farm buildings and houses from the harmful effects of wind and wind-blown sand and dust. Windbreaks usually consists of multi-story strips of trees and shrubs planted at least three rows deep and are placed on the windward side of the land to be protected and are most effective when oriented at right angles to the prevailing winds (Nair, 1993). When properly designed and maintained, a windbreak reduces the velocity of the wind, and thus its ability to carry and deposit soil and sand, improve the microclimate in a given protected area by decreasing water evaporation from the soil and plants, protect crops from loss of flowers, reduce crop loss due to sand-shear of seedlings, in addition windbreaks can provide a wide range of useful products from poles and fuel wood to fruits, fodder, fiber, and mulch (Torquebiau, 1994).

2.4.3. Woodlot

A woodlot is an agro forestry practice where multi-purpose woody perennials are planted and managed a restricted area of woodland use, privately maintained as a source of fuel, posts, and lumber over time stakes for climbing crops; food and animal components may be integrated into woodlots, especially during the initial establishment phase (Nair, 1993).

Depending upon the nature of the land and the purpose for which the woodlot is being established the selected plot of land is marked, lined, and pegged at the recommended or required spacing and on marginal or degraded lands, a spacing of 1m x 1m is recommended to ensure early canopy closure, soil protection and weed suppression (Young, 1997). He reported that where food crops are integrated into woodlots, pruning from the trees should be spread on the ground to serve as mulch and green manure. Harvesting regime and frequency depends on the type of species, the rate of growth and the purpose to which harvested tree is going to be put (Nair, 1993).

2.4.4. Boundary Planting and Live Fencing

Boundary planting is an agro-silvicultural technology and the components are spatial zoned (Torquebiau, 1994). It involves planting of trees (including fruit trees), shrubs and grasses 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). Moreover, Nair (1993) reported that planting trees on boundaries will affect more than one land user and crops on neighboring farms could be affected through shading at some time of the day. This could lead to conflicts between farmers and in practice, it is important that all land owners and users agree on its establishment. This is often practiced to keep out domestic or wild animals. The native tree species are planted around a compound, house, cropland, fodder lot and garden(Kindeya, 2004).

2.4.5 Hedgerow intercropping

This form of agro forestry is practiced in many parts of Ethiopia. The sorghum/maize and khat (*Catha edulis*) hedgerow intercropping in the Hararghe Highlands of eastern Ethiopia is one 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 Harangue (Badeg and Abdu ,1989). Another form of hedgerow intercropping that has recently been introduced and has been widely tested in the scientific community is alley cropping. Alley cropping is an agro forestry technology suited to humid and sub-humid tropics and entails the growing of food crops between hedgerows of planted shrubs and trees, preferably leguminous species. The hedges are pruned periodically during the crops' growth to provide biomass and enhance soil nutrient status .There is great potential for use of the system in Ethiopia, particularly to improve soil and water conservation in the hilly and mountain ranges for which Ethiopia is known (Badeg and Abdu ,1989).

2.5. The contribution of Area Enclosure for land management.

2.5.1. What is Area Enclosure?

The terms "Enclosures" and "closed area" were chosen to denominate those areas set aside, where agriculture and grazing became forbidden and the natural vegetation could start to regenerate (Shitarek *et al.* 2001). Enclosures which are a type of land management, implemented on degraded, generally open access land are a mechanism for environmental rehabilitation with a clear biophysical impact on large parts of the formerly degraded commons (Tucker, 1997). In principle, human and animal interference is restricted in the AEs to encourage natural regeneration. In practice, however, cattle are allowed to free graze in several of the AEs. Cutting grass and collection of fuel wood from dead trees and bee keeping is also allowed. In some areas, soil and water conservation activities are also being undertaken. Area closure is the most crucial method of rehabilitating lands through natural regeneration. It is method for land reclamation and re vegetation by protecting the area from human and animals' interference for limited period of time depending on the re vegetation capacity of the area together with native species plantations were widely practice in severely degraded lands (Mulugeta,2004). In some places in Ethiopia these communal plantations or forests are being distributed among young people who do not have land to farm (Kindeya, 2004). Increased involvement of people in forests through community-based management programs has in many cases proven to benefit the environment (soil erosion reduction, water supply and biological diversity) and reducing local poverty. According to (Maginnis and Jackson, 2003) tree planting contribute to conservation of biological diversity, both at the site and landscape level, extensive reforestation with plantation species can help ameliorate long-term environmental degradation in badly eroded landscapes, restoring not only ecological functionality but also site productivity. The establishment of forest plantations can meet a number of needs, including; carbon fixing, the provision of a wood supply source that is an alternative to the natural forest; the restoration of degraded land and generation of income and employment (FAO, 1999).

Having realized the seriousness of the problem, the government and the people in Ethiopia are trying to rehabilitate degraded land in an effort to reverse the problem, to do this several approaches have been tried. Among the various ways of overcoming environmental degradation, loss of biodiversity and deforestation problem of the country, area enclosure is the most crucial one because it is specially the determinant way of rehabilitating severely exploited vegetation and degraded dry land environment (Ediyo Mieso, 2005 cited in (Abiy,2008). It is generally believed that the land resources such as, soil, wild flora and fauna or water will be protected from degradation through area enclosure. The main objective of establishing such enclosures is to improve the overall ecological conditions of degraded areas so that they can provide better socio-economic benefits and environmental services to the local communities. In this regard, it has become a common phenomenon to observe change on soil quality and increase of plant as well as animal biodiversity with time after the establishment of enclosures.

2.5.2. Benefits of area enclosures for soil physical properties

Rapid vegetation restoration through area enclosures are an efficient measure for soil and water conservation because of their increased capacity for infiltration and sediment trapping. If vegetation coverage is chosen to be the best alternative form of land use, not only prevent the loss of soil prevented, but also that it is not deposited in river bottoms, lakes and dams (FAO, 2005). Restoration involves returning native species to an area, stabilizing soil and reducing soil erosion. The influence of trees in soil physical to improve fertility properties is also very important in augmenting the overall capacity of the land to be productive.

Enclosures also play an important role in conserving remaining soil resources and improving soil fertility. This improves soil fertility by adding soil nutrients from decomposed plant remains. Enclosures also reduce nutrient loss from a site by controlling runoff (vegetation acting as a physical barrier to soil erosion). This eventually improves the capability of the land to support other vegetation types, including exotic plantations and/or support livestock (Tefera *et al.*, 2005). Soils with good structure absorb water quickly, and minimize surface runoff. Soil structure determines how easily the particles detach to start the erosion process. Steeper sites provide energy for the scouring action of surface water run-off. Maintaining good ground cover lessens the effect of all erosive forces. While plants absorb the impact of raindrops, their litter and roots enhance infiltration and hold soil in place (Wild, 1993). Maintaining vegetation covers reduce soil loss and enhance soil equality. The presence of trees and shrubs deposited litters on the soil. The addition of litter built up under the tree increases cations (inorganic nutrients) through the active release of them from the accumulated litter (Skarpe, 1991).

Enclosures also improve the hydrology and soil inside the forested land in several ways: they prevent physical soil loss, maintain or increase soil water holding capacity, protect or increase top soil depth, prevent the loss of soil nutrient content and increase soil organic matter. This unction's of enclosures improve soil quality within the forested land itself (Deschee maeker *et al.,* 2006). An increase in soil quality within enclosures has a number of biophysical and socioeconomic implications. As a result of improved soil quality and soil water content the total amount of biomass production will increase with its subsequent ecological and economic benefits. In general, establishing enclosures is considered advantageous since it is a quick, cheap and lenient method for the rehabilitation of degraded lands (Bendz, 1986).

2.6. The contribution of agro forestry for the livelihoods of the communities

Farming or agriculture is the main source of livelihoods for the people of Ethiopia. Trees on farmland or in forest form an integral part of the farming system. Nutrients for cropland come from animal manure and leaf material. Timber for construction, firewood as a form of energy, fodder, grass and bedding materials for livestock all come from both the forest and the farmland. Trees are also important for the protection of environment and conservation of biodiversity (Gilmour and Fisher, 1991; Grimble *et al.*, 1997).

Agro forestry can play a vital role to meet the need of the growing population in terms of sustaining crop agriculture and livestock, production of commodities for exchange and as a form of energy and providing diverse tree products for sustaining rural livelihoods (Chew, 2001). A review of approaches on farm tree management practices by farmers conclude that trees in farming systems are not seen as a part of forest resource, rather farmers see trees in terms of how they contribute to their livelihood needs and strategies (Arnold and Dewees, 1998). In addition to increasing crop yield, agro forestry provides fodder for on-farm livestock. They also make firewood available, freeing women's time, and supply families with nutritious and medicinal leaves or fruits (Landsberg *et al.*, 2014). Furthermore, agroforestry increasing and diversifying agricultural yields through improved soil and water management practices and also agro forestry significantly impacts on the well-being of farmers. First, it increases and diversifies their source of food and income. Not only income sources are diversified at the family level but within the family, the women start to earn an income from selling wood fuel, leaves and fruits harvested from the trees, making them more financially independent. There are also strong indications that the implementation of these improved practices has recharged groundwater locally, increasing the number of months with water in wells (Reijntjes *et al.* 2009; Belemviré *et al.*, 2008).

According to Kanungwe (2010), the services provided by agroforestry practices to rural livelihoods and conservation of biodiversity have attracted wide attention among agroforestry and conservation scientists. Agroforestry technologies (AF) focus on the role of trees on farms and agricultural landscapes to meet economic, social and ecological needs (Garrity, 2006). The use of agroforestry technologies mitigate biodiversity loss and provide opportunities for improving diversification and range of livelihood options for rural households (Akinnifesi *et al.,* 2008).

2.7. Contribution of agroforestry on physical properties of the soil

Soil texture refers to the relative proportions of various soil separates, such as sand, silt, and clay. Presence of each type of soil particles makes its contribution to the nature and properties of soil as a whole. Most of the important soil quality indicator was significantly affected by different land management. Soil particle size distribution varied across different land use systems (Alemayehu *et al.,* 2010) who reported high percentage of clay content in forest lands than grazing land. Similarly (Solomon *et al*., 2002: Mulugeta *et al*., 2005) reported that soil under the natural forest showed lower silt fractions than the soils on the cultivated land, which may be attributed to the effect of deforestation and subsequent cultivation. There is high percentage of clay content and low silt fractions under agro forestry plantation than other land use (Solomon *et al.*, 2002; Mulugeta *et al.*, 2005; Nugussie and Kissi 2012). Changes in land use and management practices often modify most soil physical and biological properties to the extent reflected in agricultural productivity (Gebrekidan and Negese, 2006).

The conversion of native forest and native rangeland into cultivated land is known to deteriorate soil properties (Yitbarek *et al*., 2013). Although (Beyene *et al.,* 2013) reported increment of bulk density, which in turn reduce the fertility status of the given soils, as main impacts. For instance, an increase in soil bulk density due to deforestation and subsequent cultivation (Emiru and Gebrekidan, 2009). Total available water was the highest in natural forestland since it has more available water holding capacity in clay particles compared to other soil particles (Materechera and Mkhabela, 2001; Ayoubi, 2011). At field capacity, Agro forestry land retained the highest moisture content than cultivated land (Brady and Weil, 2002).

The lower bulk density under agroforestry due to organic matter accumulation and less trampling by livestock, structure, texture, and porosity of soils, together with their organic matter content, combined to together to determine bulk density of a soil (Ayana *et al.*, 2012). In the same us (IAEA, 2008) studies in eastern Zambia have shown that trees and tree biomass can improve soil physical properties, particularly on Alfisols. Alley cropping with hedgerow species can reduce soil bulk density, increase porosity and increase water infiltration .Compared with traditional grass fallow, the percentage of water stable aggregates under Sesbania fallow was less, but was much greater under Sesbania than under continuous maize. These differences were inversely related to time-to-runoff measurements (FAO, 2008).

2.8. The contribution of agro forestry on soil chemical properties

Decline in soil organic Carbon and total N due to continuous cropping compare to the natural forest and conversion of natural forest land into cultivate lands caused losses of cation exchange capacity (Mulugeta *et al.,* 2005). Due to a complete removal of crop residues for animal feeds and fire wood, organic carbon is lowest in cultivated land as compared to other land uses in the central highlands of Ethiopia. Soil under agro forestry, show that increase in soil organic matter. It is obvious that high accumulation of organic matter can be found in the surface soil where large amount of root biomass and other plant debris can be found (Alemayew *et al*., 2010). Soils under forests has larger soil nitrogen due to the long period of time under tree cover and soil nitrogen mineralization could be increased under forest by 11-14 ppm per year (Alemayew *et al*., 2010; Chanie *et al*., 2012 and Yitaferu *et al*., 2013). Generally higher N near forest might be due to the higher N in the plants of forest and low uptake by the tree. The plant life of forest accounted 45-48% of total N from above ground parts but the mean annual nitrogen accumulation of forests ranged from 8-13 Kg N ha^{-1} y^{-1}. The other reason for high N under agro forestry woodlots might be due to the low temperature and very limited radiation reached on the surface of the soil that leads to low volatilization of $NH_3^{-}N$ (Kidanu, 2004).

The amount of available phosphorous content in agro forestry is much larger than in area closure and cultivated land due to annual leftover of phosphorous from fertilizer application is not larger than obtained from leaf decomposition from trees. Maximum availability of phosphorus generally occurs in a pH range of 6.0 to 7.0. The lower available phosphorous content at agro forestry lands is due to the lower pH conditions that can permanently fix phosphorus, a high proportion of P is retained and immobilized by microbes (Woldeamlak , 2003 and Kebede; 2011).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study area is located in $7^0 22'$-$7^0 45'$ latitude and $37^0 40'$-38^0 00' longitudinal and at an altitude range between 1900 -2700 m.a.s.l (meter above sea level). The LemmoWoreda is 232 kms far from Addis Ababa, the capital of Ethiopia. The mean annual maximum and minimum temperature is 13^0c and 23^0c respectively. The mean annual rain fall of the study area ranges from 250 to 1200 mm (LWoA, 2009). Soil of the study site is characterized as Nitisols which derives from highly weathered rocks, mainly basalts. Nitisols is the most dominate soil in the study area that support highly intensive land use (Habtamu, 2006).

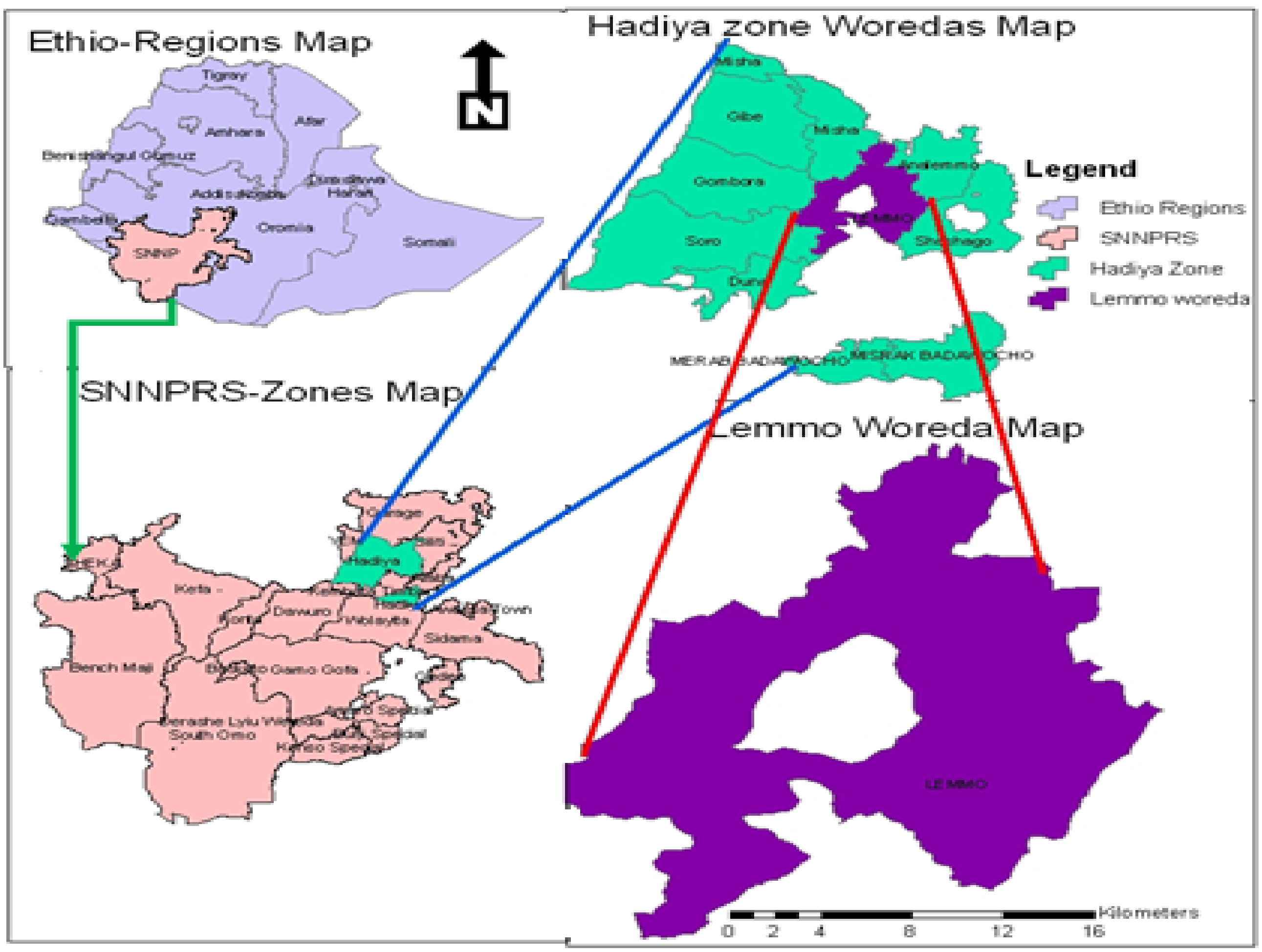

Figure1: Map of study area

3.2. Demographic Characteristics

According to CSA (2007) the total population of the Woreda is 118, 578 of which 58,663 are males and 59,915are females. The population density is 437.1 per square kilometer which is greater than the average zonal and regional population density (378.7 and 133.9 people per square kilometer respectively).

Land Use and Agriculture, Agriculture, mainly composed of crop production and animal husbandry, is the main livelihood of the population in the woreda. The agricultural practice employed in the area is traditional oxen-plough and hoe-culture practices. The main food crops grown in the woreda are wheat, teff, barley, maize, peas and beans. Root crops, enset, and potato are also grown in the study area. Among the perennial crops enset (false banana) plays an important role in the life of the people by its multi-uses as a source of food, fiber, animal fodder.

Livestock are integral part of the agricultural production system. It plays an important role in the economy of the study area in general. Despite its role in the economy, the output of the livestock sub-sector has remained low. Poor nutrition, prevalence of diseases and insufficient veterinary services as well as traditional animal husbandry is some of the detrimental factors that affect the productivity of the livestock sub-sector. One of the factors that contributed to low productivity of the livestock is lack of sufficient feed due to declining of natural grazing land. The natural grazing lands are diminishing very fast due to expansion of crop farm. The major livestock diseases that have significant impacts in livestock productions are internal parasites, external parasites black leg (Abba Gorba) and Anthrax.

Poor management in animal husbandry coupled with high prevalence of animal diseases that contribute to low livestock production and productivity. There is only one veterinary clinic in the woreda. The development of the sub-sector is further hampered by shortage of veterinary drug supplies, skilled man power, and infrastructure, shortage of budget and transport services. Land use denotes the pattern of land allocation to various agricultural activities. In Lemmo woreda land was hold both at private and communal basis and used mainly for farming, grazing, forest and settlement. Out of the total cultivated land 11607 ha (67.87%), used for Perennial crops 2785ha (16.29%), use for grazing land 533 ha (3.12), use for Agro forestry land 889 ha (5.3) and others land1287 ha (7.42) respectively (LWoA, 2013). The average arable land holding size is 0.98 hectares per household, varying from 0.25 ha to 2.0 hectares. More than 85% of households own less than one hectare of farmland (LWoA, 2001).The Woreda has total population of 126,786 cattle, 27,488 sheep, 24,395 goats, 7839 horses, 15934 donkeys, 5820 mules and 78563 chickens (LWoA, 2013).

3.3. Sample Size and Sampling Technique.

There are total numbers of 1131 HHs present in study area .From those 123 sampling size were selected by random sampling technique to extract information on the overall aspect of farmers' knowledge on the management of agroforestry practices in the study area and the research to include 11% from total numbers because the sampling population is few in number and manageable in size

1.3.1. Type of Data to be Collection

Primary and secondary data sources were collected contribution of agroforestry to soil properties and livelihood improvement. Field survey and soil analysis were carried out in order to collect primary data like, physical observation and the household survey is used to collect quantitative information from representative households. Key informant interview is particularly important in getting qualitative information relevant of AFPs for land management and improving livelihood. Through such instrument, information regarding the views of experts from Woreda Agriculture Office 1, DAs from two villages 2, from Kebeles administrator's representatives 1, and from community elders 2, total 6, KII were selected purposely to extract information on the overall aspect of farmers' knowledge on the management of agro forestry practices in the study area. Secondary sources of information used for this study include published materials such as office documents, reports, journal, research papers and articles.

3.4. Site Selection and Soil Sampling

Before collecting the soil samples, a survey was carried out to identify the dominant land uses in the study area .The area was stratified into three land use systems namely, Agroforestry, area enclosure and cultivated land; that were located nearly on similar soil types and slope classes were taken for study. Agroforestry land is a land that combines trees with crops and animals on the same land management unit. Area enclosure is land excluded from human and animal entrance and it is dominated by trees and grasses. Cultivated land is rain-fed agricultural land allocated for annual crop production such as Barely, Wheat, Teff, Beans, and peas without trees species. For each land use, three replication and two soil depths was used for soil sampling. For each land use and soil depth (0-15 and 15-30cm) three soil samples was collected using soil auger. To reduce the error ten composite soil samples were collected from different point randomly. A total of 18 soil samples were collected for laboratory analysis.

3.5. Socio-Economic Information

The total sample size for household interview was determined using probability proportional to sample size-sampling technique (Cochran's 1977).

$$no = \frac{Z^2 * (P)(q)}{d^2} \qquad n_1 = \frac{no}{(1 + no/N)}$$

$n_{o=}$ desired sample size Cochran's (1977) when population greater than 10,000

n_1 = finite population correction factors (Cochran's formula, 1977) less than10, 000

Z = standard normal deviation (1.96 for 95% confidence level)

P = 0.1 (proportion of population to be included in sample i.e. 10%)

q =is 1-P i.e. (0.9)

N = is total number of population

d =is degree of accuracy desired (0.05)

The total number of household in Hayise and Lisana village were 1131. Based on Cochran's techniques, 123 households were randomly selected for the interview. The Structured and semi-structured questionnaire were prepared to collect the quantitative information. These two villages were selected purposively based on enclosed area and dominant agroforestry land as compared to other villages.

Table 1: Total of HHs sampling size in Hayise and Lisana village

Village	Total HHs	No, sampling size
Hayise	763	83
Lisana	368	40
Total	1131	123

Source: Own Field survey, carryout in 2014.

3.6. Soil laboratory analysis

Soil particle size distribution was determined by Boycouos hydrometric method (Bouyoucos, 1962; VanReeuwijk, 1992) after destroying OM using hydrogen peroxide (H_2O_2) and then sodium hexameta phosphate $(NaPO_3)_6$was used to disperse the soil. The soil textural classes were determined using the international society of soil science system (Rowell, 1994), triangular guideline. Moisture content was determined by Gravimetric method. Initially, weight the field samples and dry it at 105^{o}C for 24 hours, then weighing them again. The percentage of water held in the soil was calculated as the weight difference of field and oven dried soils divided by weight of oven dried soil multiplied by 100 (Simkins, 2008);

$$Percent\, of\ moisture\,(wt\,\%) = \frac{(A-B)x100}{B-C}$$

Where A=fresh weight (g) + weight of empty core (g), B=weight of oven dry soil (g) + weight of empty core (g) and C=weight of the empty core (g), B-C= weight of oven dry soil (g).

Soil bulk density also determined by the undisturbed core sampling method after drying the soil samples in an oven at 105$^o{}_C$ to constant weight and calculated by the following formula indicated by (FAO, 2007)

$$\text{BD} = \frac{Wt of\ oven\ dry\ \ soil\ (g)}{Volume\ of\ the\ core (cm3)}$$

W is Weights of oven dry soils (g) and V are the volume of the cylindrical core (cm^3).

Soil pH was measured by using a pH meter in a 1:2.5 soil: water ratios (Reeuwijk, 1992) whereas electrical conductivity (EC) was measured in soil to water ratio of 1:2.5 (Reeuwijk, 1992). The soil organic carbon was determined by the Walkley-Black oxidation method with potassium dichromate (K_2Cr2O_7) in a sulfuric acid medium then converted to soil organic matter by multiplying it by the factor of 1.724 following the assumptions that OM is composed of 58% carbon (Walkley and Black, 1934).The Total Nitrogen was determined by micro-Kjeldahl digestion method (Bremmer and Mulvancy, 1982) by oxidizing the OM in concentrated sulfuric acid solution (0.1N H_2SO_4) and the digest was distilled and about 50 ml of the distillate was collected which was then titrated with 0.05N H_2SO_4 to pink end point. Available phosphorus was determined using Bray II extraction method as described by Reeuwijk, (1992).Cation exchange capacity (CEC) was determined by the saturated ammonium acetate (1 Normal NH_4OAc at pH 7.0) method (Chapman, 1965). Exchangeable calcium ($Ca^{2+)}$ and magnesium (Mg^{2+}) by ammonium acetate extraction and measured by the atomic absorption spectrometry (AAS) method. Exchangeable potassium (K^+) and sodium (Na^+) extracted by sodium acetate method and measured by flame photometer. Percent base saturation (PBS) was calculated by dividing the sum of the base forming cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+) by the CEC of the soil and multiplying by 100 (Fageria, 2009):-

$$\mathbf{PBS} = \frac{(\mathbf{Ca^{2+}} + \mathbf{Mg^{2+}} + \mathbf{K^{+}} + \mathbf{Na^{+}})}{\mathbf{CEC}} \mathbf{x100}$$

Where the values of CEC, $Ca^{2+,}$ $Mg^{2+,}$ K^+, and $Na^+$are expressed in cmol (+)/kg

3.7. Statistical Analysis

Prior to data analysis the data was checked for the assumption of ANOVA following standard procedure of the statistical analysis software SAS version 9.2 The mean separation in soil parameters among land uses was carried out using LSD at the p-value of 0.05. Simple correlation analysis was performed using SPSS version 20 in order to reveal the relationship and magnitude between the selected soil parameters. The socioeconomic factors of each household affecting agroforestry planting were analyzed by descriptive statistic.

4. RESULTS AND DISCUSION

4.1 Sample Characteristics

The survey results showed that (46.34 %) was mean age of sampled HH of the study area. About 50.4% of the people in study area occupied in land cultivation, (34.2%) used agro forestry practices and only (15.5%) used area enclosure for conservation of their land. This result indicated that majority of the HH in study area due emphasis for cultivation land rather than used agro forestry and area enclosure to manage their land. The reason for this, majority of sampled HH almost (32.5%) were none educated due to this reason may fail to understand the contribution of agro forestry practices for land management very well. The average land holding size per individual farmers was less than 1 ha and mean of family size per individual farmers was (1.73) (Table 2). The small size of land holding and increasing family size forced the farmers to cultivate share crop by moving from place to place in order to win their life than using AFPs for their land management. But, AFPs have a great contribution for land management by improving the fertility status of the soil.

Table 2: HHs characteristics and their wealth status

HH characteristics	N	Min	Max	Mean	Valid percent
Age classes(no)	123	30	67	46.34	100
Family size(no)	123	1	2	1.73	100
Landholding size(ha)	123	1	2	1.08	100
Cultivated land	62				50.4
Agro-forestry	42				34.2
Area closure	19				15.4
Educational level	123				100
Illiterate	40				32.5
Read and write	53				43.1
1^{st} cycle (1-8)	19				15.4
High school	8				6.5
College level	3				2..4
Wealth status	123				100
Medium	51				41.5
Poor	57				46.3
Rich	15				12.2

Source: Own Field survey, 2014.

4.2 Household Income Contribution of three land use categories

The study shows that, HH income contribution net is highest (6225, ETB) in agro forestry as compared to cultivated land (3715, ETB) and area enclosure (1030 ETB). AF contributes the highest net income because of it combines cereal crops, fodder and fuel woods as shown (Table 3).

In another income get from annual AF crops in (ETByears^{-1}) correlation with source of cash in cereals was significant at the ($p<0.01$; $r=1.00^{**}$) and source of fodder for animals significant at the ($p<0.05$; $r=0.06$) and positively correlation with Estimated total size of farm land and current land hold to support the HHs (0.03) and (0.02) respectively (Appendix Table7).

Table 3: Estimated income contribution of HHs at three land unit of comparison.

LU types	cereal	revenue	fodder	revenue	fuel wood	revenue	total
AF	Wheat	1145	Crop residual	180	Coppicing	1500	2825
	Teff	1760	Grass cut &carry	60	Pollarding	560	2380
	Maize	840	Leaf palatable	30	Pruning	150	1020
	Total	**3745**	**total**	**270**	**total**	**2210**	**6225**
CL	Wheat	1165	Crop residual	250	-	-	1415
	Teff	1460	-	-	-	-	1460
	Maize	840	-	-	-	-	840
	Total	**3465**	**-**	**250**	**-**	**-**	**3715**
AE	-	-	Grass cut and carry	580	-	-	580
	-	-	Leafs for Palatable	450	-	-	450
	-	**-**	**Total**	**103**	**-**	**-**	**1030**

Source: Field survey, 2014

4.3. Different tree management in agro forestry practices

According to the respondents in study area tree species are to provide multiple contributions. The purpose of pruning was to provide fuel wood, use for fencing, to reduce shade effect and to minimize competition. Application of compost and insecticides (especially for fruit trees and khat) was carried out to encourage the growth and disease prevention .This finding harmonized with; Abebaw (2006) in Lay-Gatint district of South Gonder Zone supports that growing trees as living fences is the most common socio cultural practices and deliberate benefits of as fencing, are providing other services . On another hand trees are as shelter belt, fencing of croplands from animals and as ornamentals of homesteads. In the study area respondents have reported pruning activities for *Croton macrostachyus* (34.1 %), *Eucalyptus globulus* (18.6 %), *Eucalyptus camaldulensis* (16.7%),*Acacia abyssinica* (26.2%)*Cordia africana* (41.9%), *Olea africana* (42.3%), *Erithyrinabrucei* (38.3%) and *Rhamnusprinoides* (50.3%) for the management of competition and to make a tree free from knot (Table 4).These finding also agrees with the research conducted in Awi Zone by Workineh (2002) where he reported that pruning of trees on croplands by farmers was common to reduce competition for nutrients and water with crops and to obtain fuel wood and construction wood. According to the respondents (Table 4), thinning activities for *Croton macrostachyus(19.24%)*, *Eucalyptus globulus (22.5%),Eucalyptus camaldulensis (24.6%),and Olea africana(18.78%)* for the management of removal entire branches back to the main stem, a side branch, or the ground that are too close for health or normal development.

Table 4: Different tree management in agro forestry practices

Tree and shrub species	**Management practices of respondents in (%)**			
	Coppicing	**pollarding**	**pruning**	**thinning**
Cordia Africana	13.5	51.02	41.9	-
Croton macrostachyus	20.9	39.62	34.1	19.24
Eucalyptus globules	60.3	-	18.6	22.5
Eucalyptus camaldulensis	70.8	-	16.7	24.6
Olea Africana	9.0	46.42	42.3	18.78
Acacia abyssinica	27.2	48.12	26.2	-
Erithyrina brucei	20.7	38.52	38.3	-
Rhamnus prinoides	-	-	50.3	-
Average	**27.8**	**27.96**	**33.6**	**10.64**

Source: Field survey, 2014.

4.4. Tree species selection criteria of incorporate into AF systems

The result of the household survey indicated that, farmers' preference of tree species was based on different criteria, namely, soil fertility improvement(59.35 %), palatability of leaves (13.82%), shade provision(15.45%) and as well as fast decomposition(11.38), of tree species through which plan appropriate management in home garden agroforestry practice and they also planted tree and shrub species in their home gardens for a different services like Supplementing their diets, satisfy household fuel, wood consumption, timber, forage, and to some extent for cash income generation (Table 5).

Table 5: Selection criteria of tree species to incorporate into AF systems

Criteria	Frequency	No of respondents in (%)
Soil fertility improvement	73	59.35
Palatability of leaves	17	13.82
Shade provision	19	15.44
Fast decomposition	14	11.38.
Total	123	100

Source: Field survey, 2014

4.4.1. Types of agro forestry practices and commonly practiced in the study area

The result shows that home garden (38.21%), woodlot (21.13%) and live fences (16.26%) are the main agro forestry practices identified in the study area. Among them, home garden were characterized by being near residence, composed of a high diversity of plants, small, and an important source of household subsistence and cash needs is the best preferred practice followed by live fences and woodlot(Table 6).

Table 6: Types of agro forestry practices dominated in the study area

	Frequency	No of respondents in (%)
Home garden	47	38.21
Alley cropping	5	4.1
Live fence	20	16.26
Woodlot	26	21.13
Hedgerow/intercropping	10	8.13
Windbreak/shelter belt	15	12.20
Total	**123**	**100**

Source: Field survey, 2014

Tree competition: In the study area farmers had an indigenous knowledge about tree competition with perennial or agricultural crops. The high competition was either root or crowns in the study sites. Accordingly, household respondents mentioned that *Eucalyptus globules* (38.2%) and *Eucalyptus camaldulensis* (26.8%) compete with crops for water and nutrient (Fig.3). Therefore, farmers manage tree species in the agro forestry practice to reduce competition. Moreover, farmers also manage tree species in the agro forestry practices mainly to provide shade, enhance growth and obtain fuel wood. Tree species pruning provide as mulching, fuel wood and farm implements for resource for poor rural household (Table 4). Hayise and Lisana village farmers manage trees species in their farm land by pollarding averagely (27.96) a yearly pruning of deciduous trees to the same point on the same main branches each year to keep them at a modest size and give them a rather formal appearance. This gives a manicured style to trees. Branch ends become large and knobby. In summer they create a compact, leafy dome and interesting look during dormant months.

4.5. Tree-crop integration in agroforestry practices

In Lemmo woreda farmers have profound knowledge depending on the relationship between the various agroforestry components when they are grown together. The component interaction between the crop and tree may be positive or negative. The majority of the respondents (50.3%) in the study area claim to have knowledge to decide which tree species fits with a given crop species or which can improve the productivity of the land for example, *Croton macrostachyus, Cordia africana and Acacia abyssinica (27.64), (22.76) and (21.14), respectively* (Fig 2) .This indicates that the farmers have the knowledge about the role of trees in the agricultural production system, or the role of trees or shrubs to increase yields. Based on their accumulated experience, farmers have been developing considerable practices to improve or maintain improving soil fertility. It is well known to them which tree species and their respective tree parts will contribute to and are very important in improving the soil fertility status. Also they well recognize that, the tree or shrubs decompose faster and change to soil (Fig 2). This finding was good understanding of how and when leaf material is decomposed and release nutrients into the Similar with (Grossman(2003)and Abebaw(2006) done in Mexico supports that farmers had a good understanding of how and when leaf material is decomposed and release nutrients into the soil.

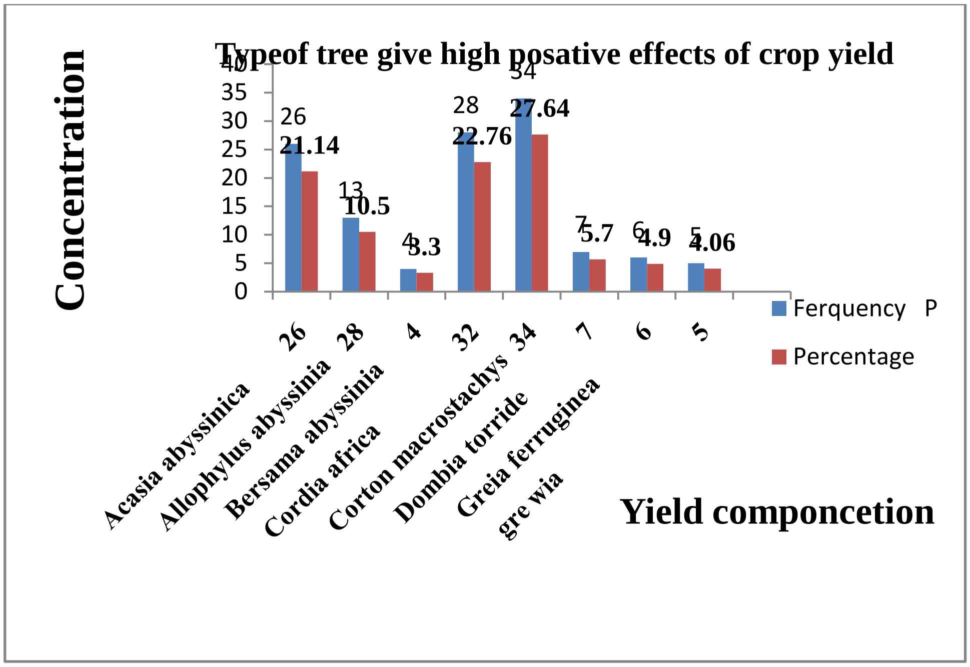

Figure 2: Trees have given high positive effect on crop yield

In another also the response obtained, negative effects of trees and tree parts on crops that were identified. Some species noted to have adverse effect to crops yield were *Eucalyptus globulus* and *Eucalyptus camaldulensis* in terms of water competition in the study area (Fig.3). These species are not allowed to grow in crop fields due to their perceived negative effect. The negative effects were explained in terms of water and nutrients (Ca, K, P and N) competition, light shade and late decomposition. The roots of *Eucalyptus globulus* and *Eucalyptus camaldulensis* were perceived to have a negative effect to crops, owing to severe competition for nutrients and water the respondent mentioned. According to personal observation leaves and branches of *Eucalyptus globulus* and *Eucalyptus camaldulensis* were not easily decomposed on the ground for many months or years. As a result, farmers in the study area were not interested to incorporate the species in agricultural crop fields. This finding agrees with the study in south Gonder Zone by Abebaw (2006) that reported *Eucalyptus* species and *Agave sisalina*'*dry out*' the land and compete with crops for nutrients and water. In another study in Tigray by Tesfaye (1996) noted most of the respondents were against integrating trees especially, Eucalyptus, with crops because competition with crops was perceived by farmers in terms of direct effects of the trees on water and nutrient depletion which is in agreement with this study. Similarly, the study in Sidama by Zebene (2003) reported that the tree species were known to have negative influence on agricultural crops including avocado, mango, and *Psidium guajava*; and timber species such as *Eucalyptus spp*.

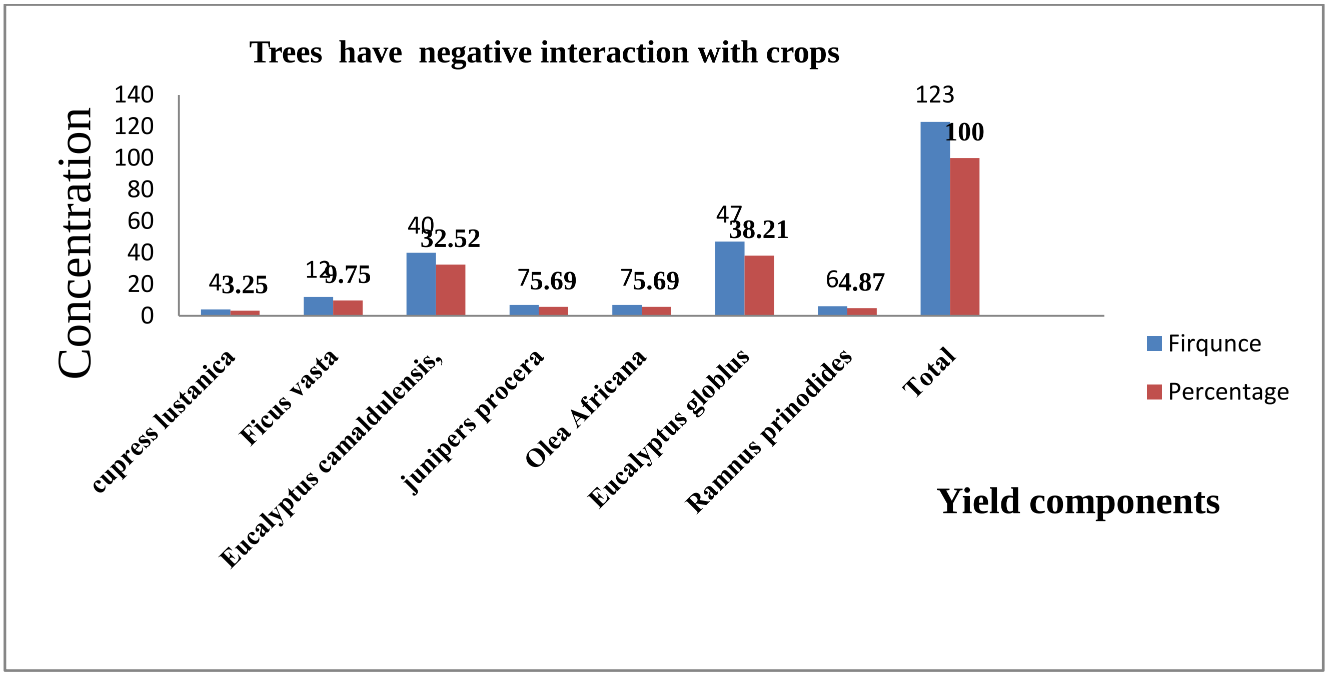

Figure3: Trees have negative interaction on crop productive concentration

4.6. Tree –animal interaction in agroforestry practices

In Hayise and Lisana villages about 46.9% of farmers are highly dependent on tree or shrub species about the availability of fodder supply. The farmers claimed that currently the number of animals especially cattle is decreasing per household because of the shortage of grazing land. About 5.7% of the household respondents indicated that the shortage of livestock feeding was the major problem for animal production mainly in dry season. Based on farmers' accumulated experience, they have clearly identified the positive and negative interactions of components in the various agro forestry practices (Fig 2 and Fig 3).

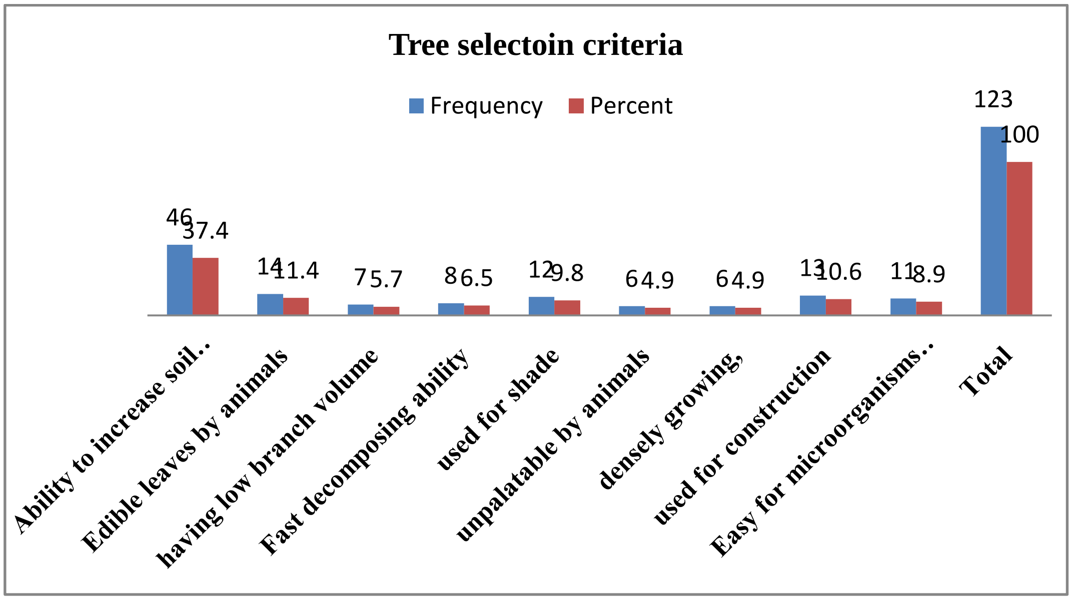

Figure 4: Selection criteria of tree species to incorporate into AF systems

4.7. Effects of Agroforestry practices on selected soil physical and chemical properties

4.7.1. Physical properties

Soil texture: The particle size distributions of the three study land management units showed significant difference in percentage of sand and clay ($P \leq 0.05$) (Table 7). The highest mean value of sand (27 %) and clay (48 %) particles were recorded at cultivated land and area enclosure while, the lowest value of sand (22.34 %) and clay (42.34 %) were observed at area enclosure and cultivated land, respectively. Based on USDA soil textural class soils in area closer and agro forester had clay texture while cultivated land had clay loam texture. This could probably be attributed to the selective removal of clay particles by erosion leaving the sand particles in the cultivated land. In line with this, Mulugeta (2004) and Belayneh (2009) reported that farming practices change soil texture by aggravating soil erosion.

The mean value of sand particles had shown significant variation ($P \leq 0.05$) along sampl ing. This result was harmonized with (Gebeyhu Tilahun, 2007) reported that sand and clay fractions were significantly ($P \leq 0.05$) affect ed by land use, in soil depth .The interaction effects of land use by the soil depth also showed a significant difference ($P \leq 0.05$) for mean value of sand and clay particles for 0-15cm soil depth at area enclose and cultivated land (Table 7).

Table 7: Main effects of land use and soil depth on selected physical properties of soils in the study area

Land uses	Sand (%)	Silt (%)	Clay (%)	SMC (%)	BD(g/cm^3)	Textural classes
			Land use			
AE	22.34±1.62^b	29.66±2.25	48.00±3.34^a	32.61±2.11^a	1.14±0.06^b	clay
AF	24.66±3.01^{ab}	31.67±2.25	43.67±3.72^{ab}	28.74±1.21^b	1.12±0.06^b	clay
CL	27.00±2.52^a	30.66±4.50	42.34±5.88^b	23.24±0.56^c	1.37±0.15^a	Clay loam
P value	0.003	0.57	0.11	0.000	0.002	
LSD(0.05)	2.41	3.97	5.61	1.84	0.13	
			Soil depth(cm)			
0-15	26.11±3.37^a	30.00±2.95	43.88±5.66	28.31±4.73	1.22±0.17	clay
15-30	23.22±1.85^b	31.33±3.27	45.44±4.12	28.08±3.83	1.20±0.13	clay
P value	0.007	0.39	0.47	0.74	0.82	
LSD(0.05)	1.96	3.24	4.58	1.50	0.10	
CV (%)	7.89	10.45	10.15	5.28	8.67	

Main effect means within a column followed by the same letter are not significantly different from each other at $P \leq 0.05$; NS = not significant.

Bulk density (BD): as presented in (Table 7) there was significantly different ($P \leq 0.05$) in BD between agro forestry practices and cultivated land. The highest value (1.37 g/cm^3) was recorded in cultivated land while the lowest value (1.12 g/cm^3) was also under the agro forestry practices the medium value (1.14 g/cm^3) was recorded under area enclosure. High bulk density values in cultivated land might be due to the result of livestock trampling and continuous shallow depth cultivation and low organic matter input. The lowest bulk density under agro forestry due the addition of organic matter from plant residues and litters According to Woldeamlak and Stroosnijder (2003) and Mulugeta (2004) bulk density of cultivated soils was higher than forest soil. The correlation analysis (Appendix Table 8) results also showed that soil bulk density was negatively correlated with soil organic matter ($P \leq 0.05$; r=-0.15). The combined effects of land use and soil sampling depth showed significant variation in soil bulk density on 0-15 and 15-30 cm soil depth we carefully compared agro forestry, area enclosure with cultivated land of the study site. The result was statically significant different at 0.05 levels of significance.

Moisture content (MC %): result showed that, significant difference ($P \leq 0.05$) was observed for MC under the three sampled land uses. The higher soil moisture content was recorded in area enclosure (32.61%) followed by that of agro forestry (28.74%) and cultivated land (23.23%) (Table7). The value was however, non-significance variation was observed along sampling depths (0-15 vs15-30cm) (Table 7).

The interaction of land use by the soil depth raveled that there were significant variation ($P \leq 0.05$) of mean value of soil moisture contents under area enclosure and cultivated land at 0-15cm soil depth and area enclosure and agro forestry in compared with cultivated land at the soil depth of 15-30cm (Table 8).The highest value (33.79 %) at area enclosure and the lowest value (23 %) was recorded at cultivated land of 0-15 cm depth. The reason for this was due to high clay content and organic matter of area enclosure can contribute to high soil moisture retention. For the lowest value of soil moisture the reverse of this can be taken. The correlation analysis (Appendix Table 8) indicated that there was positive and significant relationships between soil organic matter and soil moisture contents ($P \leq 0.05$; r=0.26).

Table 8: The mean (±SD) interaction effects of land use by soil depth on Sand, Silt, Clay, SMC and BD

	Sand (%)		Silt (%)		Clay (%)		SMC (%)		BD(g/cm 3)	
	sample depth(cm)									
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
AE	22.33±2.30[c]	22.33±1.15[c]	28.66±	30.66±	49.00±4.00[a]	47±3.00[ab]	33.79±0.82[a]	31.43±2.50[ab]	1.13±0.05[bc]	1.15±0.08[bc]
AF	27±1.00[ab]	22.33±2.30[c]	30.66±	32.66±	42.33±1.15[ab]	45±5.29[ab]	28.15±1.06[c]	29.34±1.22[bc]	1.09±0.07[c]	1.15±0.03[bc]
CL	29±2.00[a]	25.00±0.00[bc]	30.66±	30.66±	40.33±7.02[b]	44.33±5.03[ab]	23±0.64[c]	23.480.44[d]	1.42±0.14[a]	1.32±0.17[ab]
P value	0.0001		0.84		0.30		0.0001		0.02	
LSD(0.05)	2.98		NS		8.32		2.47		0.19	
CV (%)	6.66		11.34		10.23		4.8		8.8	

*Interaction means within a specific soil parameter followed by the same letter (s) are not significantly different from each other at $P \leq 0.05$.

4.7.2. Chemical properties

Soil reaction (pH): statistical analysis showed significant variation ($P \leq 0.05$) the highest pH (7.28) was observed on agro forestry and lowest (6.98) on cultivated land (Table 9). The reason for this can be the presence of relatively high amount of basic cation (Ca^{+2}, $Mg^{+2}$and K^{+}) and organic matter in agro forestry soils contribute for the improvement of soil pH. The lowest value of soil pH in the cultivated land was due continuous cultivation practices and application of inorganic fertilizer could have attributed for the reduction of soil pH (Table 9). The correlation analysis (Appendix Table 8) revealed positive and significance relationships between soil pH and basic cation ($P \leq 0.05$; $r=0.96^{**}$).

Table 9: Main effects of land use and soil depth on selected chemical properties of the soils in the study area

Treatments	pH	EC(cmol(+)/kg	OC (%)	OM (%)	TN (%)	AvP (ppm)
			Land use			
AE	7.01 ± 0.19^{b}	0.12 ± 0.05^{a}	1.98 ± 0.41^{b}	3.65 ± 1.01^{ab}	0.12 ± 0.06	11.69 ± 0.27^{b}
AF	7.28 ± 0.05^{a}	0.08 ± 0.01^{b}	2.84 ± 1.04^{a}	4.90 ± 1.80^{a}	0.17 ± 0.04	12.51 ± 0.81^{a}
CL	6.98 ± 0.24^{b}	0.08 ± 0.01^{b}	1.56 ± 0.32^{b}	2.87 ± 0.57^{b}	0.15 ± 0.03	12.20 ± 0.44^{ab}
P value	0.02	0.02	0.01	0.03	0.22	0.05
LSD(0.05)	0.22	0.03	0.78	1.46	0.05	0.65
			Soil depth			
0-15	7.13 ± 0.16^{a}	1.10 ± 0.05^{a}	2.40 ± 1.11^{a}	4.25 ± 1.82^{a}	0.17 ± 0.05	12.33 ± 0.78^{a}
15-30	7.05 ± 0.26^{a}	0.08 ± 0.01^{a}	1.86 ± 0.31^{a}	3.36 ± 0.83^{a}	0.13 ± 0.03	11.93 ± 0.36^{a}
P value	0.32	0.10	0.09	0.13	0.07	0.13
LSD(0.05)	0.18	0.02	0.63	1.19	0.04	0.53
CV (%)	2.55	20.94	19.63	18 .02	21.01	4.37

Main effect means within a column followed by the same letter are not significantly different from each other at $P \leq 0.05$; NS = not significant pH=Power of Hydrogen .

Along soil sample depth (0-15 and 15-30cm) pH was significant different ($P \leq 0.05$) between agro forestry and area enclosure. The interaction between land management practices and soil sample depths .Electrical conductivity (cmol(+)/kg): statistically significant difference ($P \leq 0.05$) was observed between AE ,AF and CL land management practices respectively . The highest EC was observed 0.12 (cmol(+)/kg under AE and lowest 0.08(cmol(+)/kg was observed under AF and CL. Along the sample depth, EC was non-significant variation ($P \leq 0.05$) was observed between AE ,AF and CL (Table 9). The interaction effects that the mean EC value under area enclosure was significant difference ($P \leq 0.05$).

Organic Carbon (OC %): organic carbon content of the soils was significantly difference ($P \leq 0.05$) between agro forestry practices and area enclosure (Table 9) .The highest mean values of soil organic Carbon (2.84%) at ($P \leq 0.05$) was observed in agro forestry practices and the lowest value (1.56%) recorded in cultivated land. The highest proportion of organic carbon in the agro forestry practices might be attributed to nutrient or organic matter recycling through litter falls from the scattered trees. This finding was similar with (Alemayew *et al*., 2010) reported that soil under agro forestry, show that high accumulation of organic matter can be found in the surface soil where large amount of root biomass and other plant remains found. On the other side, reason for low organic carbon could be explained for the significant difference in organic matter content for cultivated field was the removal of organic residues i.e. crop residues .The analysis of laboratory result revealed that there was no significant variation ($P \leq 0.05$) observed for organic carbon between soil sample depths (Table 9). The interaction effects of land management practices and soil sample depths showed significant difference for organic carbon in agro forestry practice when compared with rest of land use types. This finding harmonized with(Alemayew *et al*., 2010) reported complete removal of crop residues for animal feeds and fire wood lowers organic carbon content in cultivated land as compared to other land management/use type in the central highlands of Ethiopia.

Total Nitrogen (TN %): between the study different land use practices, and soil sample depths statically no significant differences ($P \leq 0.05$) was observed for total nitrogen (TN). However, there was numerical variation among the study land use types and soil sample depths. laboratory The combined effects of land use types with that of soil sample depth also showed that there was no significant difference on the mean value of total nitrogen at the ($P \leq 0.05$)(Table 9).

Available phosphorus (Avail. P ppm): available phosphorus was significantly different at the ($P \leq 0.05$) between agro forestry and area enclosure but no significant differen ce for cultivated land (Table 9). The highest mean value was recorded under agro forestry practices followed by area enclosure and cultivated land. The reason for this may be the height soil organic matter contents as result of plant residue, litter and mineralization of organic matter under agro forestry which contributed for AvP increment in the soil. The correlation analysis result (Appendix II) revealed that a negative and significant relationships between soil organic matter and AvP at ($P \leq 0.05$, $r=-0.06$). Cultivated land may be due intensive cultivation and high soil disturbance that cause for reduction of AvP in the study area. However, there was no significant variation observed on mean value of AvP for the two soil depth and interaction effects of land use by the soil depth at the p value 0.05 except land with agro forestry plantation (Table 9 and Table 10) respectively.

Table 10: The mean (±SD) interaction effects of land use by soil depth on pH, EC, OC, OM and TN

Land use types	pH		EC(cmol(+)/kg		OC (%)		OM (%)		TN (%)		AVP(ppm)	
	Soil depth											
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
AE	7.01±0.02.^{c}	7.02±0.14^{bc}	0.16±0.06^{a}	0.09±0.1^{b}	2.15±0.50^{b}	1.81±0.13^{bc}	3.70±0.87^{b}	3.60±1.33^{b}	0.15±0.08^{ab}	0.10±0.03^{b}	11.55±0.07^{b}	11.83±0.35^{b}
AF	7.26±0.07^{ab}	7.03±0.06^{a}	0.08±0.2^{b}	0.07±0.01^{b}	3.68±0.75^{a}	2.01±0.30^{b}	6.34±1.29^{a}	3.46±0.53^{b}	0.20±0.01^{a}	0.14±0.05^{ab}	13.17±0.21^{a}	11.85±0.55^{b}
CL	6.88±0.30^{c}	7.09±0.14^{a} ^{bc}	0.08±0.01^{b}	0.08±0.01^{b}	1.37±0.03^{c}	1.76±0.39^{bc}	2.71±0.53^{b}	3.03±0.67^{b}	0.16±0.04^{ab}	0.15±0.03^{ab}	12.29±0.67^{b}	12.12±0.18^{b}
LSD	0.24		0.04		0.63		1.57		0.08		0.79	
P value	4.15		5.95		0.0002		0.005		0.26		0.014	
CV (%)	1.93		23.83		16.35		22.72		22.00		3.59	

*Interaction means within a specific soil parameter followed by the same letter (s) are not significantly different from each other at $P \leq 0.05$; LSD = least significant difference; SEM = standard error of mean.

Cation exchange capacity (CEC cmol (+)/kg): the high mean value of CEC (31.84 cmol (+)/kg) was observed under agro forestry and the low mean value (26.77cmol (+)/kg under cultivated land and statically significant difference at the ($P \leq 0.05$) (Table 11). The reason for this can be the presence of high soil organic carbon and exchangeable cation under agro forestry has contributed for the improvement of CEC under agro forestry practices. The correlation analysis (Appendix Table 8) showed that there were a positive and significant relationships between the value of organic carbon, exchangeable base and CEC ($P \leq 0.05$; r=0.35).

The probable reason for this may be the leaching of basic cation due high rain fall in study area leads to bring significant variation in CEC of the soils.

Exchangeable bases: exchangeable calcium (Ca^{+2}) was highest (24.13) under agro forestry practices and lowest (20.19) under area enclosure and cultivated land (24.13, 22.02, 20.19), in 0 to 15 cm and 15 to 30 cm soil depths, respectively. Statically, there were no significance differences ($P \leq 0.05$) (Table 11).

Table 11: Main effects of land use by soil depth CEC, Ca, and PBS

Treatments	cmol(+)/kg		PBS (%)
	CEC	Ca	
	Land use		
AE	29.07 ± 1.12^{ab}	22.02 ± 0.91^{ab}	97.20±0.49
AF	31.84 ± 4.75^{a}	24.13 ± 2.82^{a}	97.54±1.14
CL	26.77 ± 1.06^{b}	20.19 ± 2.65^{b}	96.91±0.90
P value	0.013	0.026	0.45
LSD(0.05)	3.12	2.73	1.04
	Soil depth		
0-15	30.64 ± 4.29^{a}	22.91 ± 2.92^{a}	97.54±0.87
15-30	27.81 ± 1.51^{b}	21.32 ± 2.40^{a}	96.89±0.79
p value	0.03	0.15	0.12
LSD(0.05)	2.54	2.23	0.85
CV (%)	8.62	9.97	0.89

Main effect each other at $P \leq 0.05$; NS = not significant means within a column followed by the same letter are not significantly different from

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study results showed that AF practices contributed the highest net income for rural livelihoods as compared to cultivated and AE. This is due to AF providing cereal crops, fodders and fuel wood at the same time than others land use types. The respondents in the study area have positive response on contribution of *Croton macrostachyus* for the improvement of soil fertility states. Whereas majorities of the respondent have negative response towards *Eucalyptus globulus* trees plantation due to its high soil nutrient extraction that leads to the competition with annual and perennial agricultural crops.

The soil physico-chemical analysis result also revealed that there is significant variation was obtained in soil sand content, clay content, soil BD, SMC pH, OC, OM, AvP, CEC and Ca at 0.05 levels of significances. In addition the mean interaction effects and soil depth showed that there is significant difference in soil clay content, SMC, BD, pH, OC and OM. However, there is no significant difference in soil silt content, CEC and PBS at the p-value of 0.05. To this no significant variation was recorded on soil physico-chemical properties due interaction effects and difference in soil depth. When we compared the three lands use types the highest mean value of soil pH, OC, OM and AvP, CEC and Ca were recorded under AF practices and the lowest mean value was observed under AE next to CL. This indicated that AF practices enhance more soil chemical properties improvement in compared to AE and CL. Generally, both survey data analysis and soil laboratory analysis results indicate that AF practices played significant role for the rural livelihoods enhancement and soil physico-chemical properties improvement.

5.2. Recommendations

Based on the findings in this study, the following recommendation were for warded the accessible agroforestry practices and the farmers have used in managing these agroforestry practices in the study area are shows potential. Despite of these, there were no deliveries of appropriate extension services (no technical advices and provision of seedling for planting) from office of agricultural and rural development. Therefore, the *Lemmo woreda* office of agricultural and rural development and other concerned bodies should be providing suitable extension serves. The appropriate site selection or areas suitable for agroforestry farming need to be identified through detailed land use planning make a good awareness in the young people around local community in terms of agroforestry practice management and sustain such a local knowledge by encouraging scientific knowledge. Hence, farmers should be participating in local development programmer including decision and policy making, which may be substantial for the management and development of agroforestry practices.

In making intervention in livelihood improvement, there should be active participation of local people primarily farmers. This helps to integrate indigenous livelihood improvement with the new ones and enhance easy adoption and sustainable use of effective introduced practices. In addition, it is also essential to provide benefits to the local communities from area enclosed in sustainable manner which, in turn, increased the sense of one's resource.

In this study only limited socio economic data and selected soil macro nutrients were considered .So, further research is required on detail socio economic information, soil micro nutrients and biological soil fertility indicator .The study carried out on limited area of SNNPR of Ethiopia this is not sufficient to draw the conclusion on the role of AF practices over all of the regions. Due this further research is important to get reliable information on potential role of Agro forestry practices for soil fertility and rural community's livelihoods improvement.

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APPENDIX

APPENDIX I part I, Household Survey Questionnaire

General Information

1. Name of the numerator____

2. Date of the numeration____

3. Enumeration *kebele* ____

Part II. Personal Information

1. Name of respondent ____

2. Sex of the respondent 1, male 2, female

3. Age of the respondent ___________________________

4. Marital Status of the respondent, 1, single 2, married 3, divorced 4, widowed

5. Educational status of the respondent A, illiterate B, read and write C, 1st cycle (1-8) D, high school (9-12) E, college level

6. Wealth status of the respondent A. Rich B. medium C. poor

7. Family size 1 ≤ 6 2 .≥ 6

Part III. Economic Activities

1. What is your major economic activity? A, Crop production B, animal rearing C, mixed farming D, petty trade E, mixed farming and petty trade F, others (specify)

2. Do you have your own farm land? A, yes B, no

3. If your answer is 'yes', what is the estimated total size of your farmland? A, less than 1 ha B, 1-2 ha C, 3-4ha D, above 4ha

4. How do you see your current landholding to support the household? A. insufficient B. sufficient C. excess

5. If your answer is insufficient do you have any option of having additional land? A, yes B, no

6. If your answer is 'yes', what are the options? A. share cropping B, lease/contract land C, clearing forest and grazing land D, others (specify)____________________________________

7. How is the trend in your landholding size? A, increasing B, decreasing C, no change D, other (specify)

8. If your answer is ‘increasing’ what are the reasons behind the increase? (Multiple answers are possible) A, encroachment into forest area B, land reallocation C, cultivation of marginal land D, others (specify)

9. If your answer to Q No.7 above is ‘decreasing’, what are the root causes?(Multiple answers are possible) A, increase in human population B, increase in marginal land due to loss quality C, land redistribution D, land taken away by government E, others (specify)

10. Do you have your own livestock at present? A, yes B, no

11. If your answer is ‘yes’, what is the type and number of domestic animals you have? Others (specify)

Livestock Type	Number
Cattle Ox	
Cow	
Heifer	
Calf	
Goat **Sheep**	
Equines Donkey	
Horse	
Others (specify)	

12. What is the trend of your livestock holding? A, increasing B, decreasing C, no change

13. If your answer is ‘decreasing’, what are the reasons(Multiple answers are possible) A, Shortage of grazing land B, Lack of money to buy animals C, Prevalence of livestock disease D, Others (specify)

14. If your answer is ‘increasing’, what are the reasons?-A, Have enough money to buy animals B, sufficient of grazing land C. have no prevalence of livestock disease.

15 .How do you feed your livestock? A, free grazing on communal grazing land B. own grazing land C, cut and carry from communal pasture land D. crop residue E, others (specify)

16. How do you see the size of grazing land overtime? A, increasing B. decreasing C, remain the same

17. If your answer is ‘decreasing’, what are the reasons? (Multiple answers are Possible)

A, expansion of farm land B, grazing land distribution among people C, area closure

D, other (specify)

18. If your answer is ‘increasing’, what are the reasons? A, fallowing of farm land B, grazing land reserving among cultivating C, area closure

D, other (specify)

19. Which of the following agro forestry practices is leading or commonly practiced in your Locality? A. Woodlot B. Home garden C. Alley cropping /hedgerow intercropping D. Tree crop interaction E. Shelter belt/wind break F. Live fence G. Specify other

20. Describe management practices of AF that you are doing before but you do not practice now? A, communal forest B, hedgerow intercropping C, woodlot D, wind break.---------------
----
----

21. What are the major constraints to manage agro forestry practices? Solutions?

Constraints	Rank	Solution

Codes: Constraints: *c1=Drought; c2= Free grazing; c3=seedling shortage; c4=thief; c5=labor shortage; c6 =forest regulation ignorance; c7=other /specify /*

22. What are good opportunities in your managing agro forestry practices?

Opportunities	Rank

Code: Opportunities: *o1= market; o2=price; o3=water harvesting; o4= seedlings; o5=credit*

23. What type are your land use categories? A. AF land B. Cultivated land C. Area enclosure land D. AF land

24. What are the socio-economic benefits/uses you obtain from your agro forestry practices?

A, food for people B. for fire C. water harvesting D. timber production

25. What are selection criteria of tree species to incorporate into AF land, cultivated land, Area enclosure land and animals? A. Ability to increase soil fertility, B. Edible leaves by animals, C. Having low branch volume, D. Fast decomposing ability, E. Used for shade, F. Unpalatable by animals, G. Densely growing, H. Used for construction, I. Easy for microorganisms to decompose, J. Having sparse crown, K. Others (specify).

26. How about Agro forestry practices to improving livelihood? A .used for shade, B. Edible leaves by animals in Drought seasons, C. Ability to increase soil fertility,

27. Do you manage trees? 1. yes---------, 2. No---------

List the tree species managed under the coppice system?

Tree species 1----------2--------------3-------------4--------------5----------------6---

IV. Component interaction between trees and crops

A. Is there positive interaction between trees and crops? 1 yes, 2 no.

If yes, what are they? 1/ shading trees (stress reduction), 2/biomass contributions, 3/ water and soil conservation, 4/controlling runoff, 5/others (specify).

B. Is there negative interaction between trees and crops? 1 yes, 2 no. if yes, If yes, what are they? 1/ light competition, 2/nutrient competition, 3/water competition, 4/ allelopathy, 5/ others (specify) Is there positive interaction between trees and animal? 1 yes,2 no. If yes, what are they? 1/ shading, 2/manure deposition, 3/livestock feed, 4/others (specify).

C. Is there negative interaction between trees and animals? 1/ yes, 2/ no If yes, If yes, what are they?. 1/phytotoxins, 2, browsing damage, 3/ trampling, 4/disease (pest hosts)

D. Which type of trees has given high positive effect on crop yield increment in your area? 1/Acacia abyssinica, 2/Allophylus abyssinica, 3/Dodonea angustifolia,4/Croton macrostachys, 5/Olea Africana, 6/Grewwia mollis, 7/Ramnus prinodides, 8/Cordia Africana, 9/Dombia torride, 10/Bersama abyssinica.

E. Are trees/shrubs having negative interaction on crop production? A/Yes B/No.

F. What are they trees/shrubs have negative interaction on crop production? 1/Eucalyptus camaldulensis,2/ Eucalyptus globlus,3/junipers procera, 4/Rhamnus prinoides ,5/ Olea Africana, 6/cupress lustanica,7/Ficus vasta.

G. By what parts trees/shrubs have negative interaction on crop production? 1/Root, 2/Leaves/crowns, 3/Fruits, 4/Branches, 5/Steam.

II. Land management information

1. Total land holding size in hectares__________________

Land management types	Area (ha)
Agro forestry land	
Cultivation land	
Area closure land	

2. Land productivity by using input and without input;

Types of Crop	Productivity(kuntal/ ha using input	Productivity(kuntal/ ha without input	Input used(ku	Price of input (birr)	Crop price(kg/bir)
Barely					
Wheat					
Peas					
Beans					
teff					

3. How much production you produce in (kuntal)?
4. How much Production do you needed to support your family in (kuntal)?
5. Do you support your family at moment?
6. Do you have sufficient labor for Agriculture?
7. Do you food secured throughout the years?
8. How many months you feed your family from what you produce?

Annex II Questionnaire for key informant Interview

1. What is the average landholding of households? Is the current holding sufficient to feed the family?

2. What is the trend of land holding size over a period of time and what are the reasons?

3. What rights do farmers currently have on their land holding?

4. Do you think that this right affects farmers land management activities?

5. If there is a problem of AFP for land management, what are the indicators?

6. What are the contributing factors of AFP for land management?

7. What is the trend of productivity of land through time? Give justification for your response

8. What is the trend of livestock holding by the farmers in the area? Give reasons for your response--

9. Describe the major feed sources for livestock by order of importance----------------------------
----

10. What is the trend of these livestock feed? Give reasons for your response---------------------
----

11. How did you see AFP practice carried out in your area in the past? ----------------------------
----

12. What is the situation of the practice nowadays? ---

13. What interventions are there by government in the area with regard to AFP for land management? ---

14. What are the constraints to the sustainability of AFP for land management in your area?

A. Socio-cultural B. Policy/institutional C. Economic

15. What measures do you suggest for the AFP for land management in effective manner? ----
----

14. Why better soil physic-chemical properties are observed under Agro forestry practices? ---
----

Annex III Checklist for Focus Groups Discussions

1. What are the major economic activities of the community?

2. What challenges are there in undertaking these economic activities?

3. How about Agro forestry practices to improving livelihood?

4. What are the contributing factors if there is any change?

5. How do you describe the productivity of land overtime?

6. If there are changes, what are the contributing factors?

7. What mechanisms are used by the farmers to improve the productivity of land?

8. What are the major livestock feed in the area?

9. What is the trend in the availability of livestock feed?

10. If there is change, what are the major causes?

11 What is the trend in livestock holding by the community in the area?

12. What challenges are there in livestock production? If there are challenges, what are the causes?

13. How do you describe the status of AFP for land management in your kebele?

14. If there are problems of AFP for land management, what are the indicators for the problems?

15. What factors are aggravating the problems?

16. How did you see AFP for land management carried out in your area in the past?

17. How is the practice nowadays?

18. What problems being encounters in relation to AFP for land management?

19. What should be done to promote and sustain natural resource conservation in effective manner is your area?

20. What are the benefits that the local communities obtain from agro forestry Practices?

21. How agro forestry practices can contribute for sustainable land management

Appendix Table 1: HHs characteristics and their wealth status

HH characteristics	N	Min	Max	Mean	Valid percent
Age classes(no)	123	30	67	46.34	100
Family size(no)	123	1	2	1.73	100
Landholding size(ha)	123	1	3	4.23	100
Cultivated land	62				50.4
Agro-forestry	42				34.2
Area closure	19				15.4
Educational level	123				100
Illiterate	60				48.8
Read and write	33				26.8
1st cycle (1-8)	16				13.0
High school	10				8.1
College level	4				3.3
Wealth status	123				100
Medium	51				41.5
Poor	57				46.3
Rich	15				12.2

Source: Own Field survey, carryout in 2014

Appendix Table2. Different tree management of agro forestry practices in the study area

Tree and shrub species	Management practices of respondents in (%)			
	Coppicing	**thinning**	**pollarding**	**pruning**
Cordia africana	13.5	51.02	41.9	-
Croton macrostayus	20.9	39.62	34.1	19.24
Eucalyptus globules	60.3	-	18.6	24.6
Eucalyptus camaldulensis	70.8	-	16.7	22.5
Olea africana	9.0	46.42	42.3	18.78
Acacia abyssinica	27.2	48.12	26.2	-
Erithyrina brucei	20.7	38.52	38.3	-
Rhamnus prinoides	-	-	50.3	-
Average 10.64		**27.8**	**27.96**	**33.6**

Source: Field survey, Hayise and Lisana village in 2014

Appendix Table 3: Main effects of land use and soil depth on selected physical properties of the soils of study area

Treatments	Sand (%)	Silt (%)	Clay (%)	SMC (%)	BD(g/cm^3)	Textural classe
			Land use			
AE	22.34±1.62[b]	29.66±2.25	48.00±3.34[a]	32.61±2.11[a]	1.14±0.06[b]	clay
AF	24.66±3.01[ab]	31.67±2.25	43.67±3.72[ab]	28.74±1.21[b]	1.12±0.06[b]	clay
CL	27.00±2.52[a]	30.66±4.50	42.34±5.88[b]	23.24±0.56[c]	1.37±0.15[a]	Clay loam
P value	0.003	0.57	0.11	0.000	0.002	
LSD(0.05)	2.41	3.97	5.61	1.84	0.13	
			Soil depth(cm)			
0-15	26.11±3.37[a]	30.00±2.95	43.88±5.66[a]	28.31±4.73[a]	1.22±0.17[a]	clay
15-30	23.22±1.85[b]	31.33±3.27	45.44±4.12[a]	28.08±3.83[a]	1.20±0.13[a]	clay
P value	0.007	0.39	0.47	0.74	0.82	
LSD(0.05)	1.96	3.24	4.58	1.50	0.10	
CV (%)	7.89	10.45	10.15	5.28	8.67	

Main effect means within a column followed by the same letter are not significantly different from each other at $P \leq 0.05$; NS = not significant.

Appendix Table 4: Main effects of land use and soil depth on selected physical properties of the soils in the study area

Land use types	Sand (%)		Silt (%)		Clay (%)		SMC (%)		BD(g/cm 3)	
	Soil depth(cm)									
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
AE	22.33 ±[c]	22.33 ±[c]	28.66 ±	30.66 ±	49.00 ±[a]	47±[ab]	33.79 ±[a]	31.43 ±[ab]	1.13±[bc]	1.15±[bc]
AF	27±[ab]	22.33 ±[c]	30.66 ±	32.66 ±	42.33 ±[ab]	45±[ab]	28.15 ±[c]	29.34 ±[bc]	1.09±[c]	1.15±[bc]
CL	29±[a]	25.00 ±[bc]	30.66 ±	30.66 ±	40.33 ±[b]	44.33 ±[ab]	23±[c]	23.48[d]	1.42±[a]	1.32±[ab]
P value	0.0001		0.84		0.30		0.0001		0.02	
LSD(0.05)	2.98		NS		8.32		2.47		0.19	
CV (%)	6.66		11.34		10.23		4.8		8.8	

*Interaction means within a specific soil parameter followed by the same letter (s) are not significantly different from each other at $P \leq 0.05$

Appendix Table 5: Main effects of land use by soil depth CEC, Ca, and PBS

Treatments	cmol(+)/kg		PBS (%)
	CEC	Ca	
		Land use	
AE	29.07±1.12[ab]	22.02±0.91[ab]	97.20±0.49
AF	31.84±4.75[a]	24.13±2.82[a]	97.54±1.14
CL	26.77±1.06[b]	20.19±2.65[b]	96.91±0.90
P value	0.013	0.026	0.45
LSD(0.05)	3.12	2.73	1.04
		Soil depth	
0-15	30.64±4.29[a]	22.91±2.92[a]	97.54±0.87
15-30	27.81±1.51[b]	21.32±2.40[a]	96.89±0.79
p value	0.03	0.15	0.12
LSD(0.05)	2.54	2.23	0.85
CV (%)	8.62	9.97	0.89

Main effect each other at $P \leq 0.05$; NS = not significant means within a column followed by the same letter are not significantly different fro

Appendix Table 6: The mean (±SD) interaction effects of land use types by the soil depth on CEC, Exchangeable base and PBS

Land use types	cmol(+)/kg										PBS (%)	
	CEC		Ca		Mg		Na		K			
	Soil depth											
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
AE	29.28±0.58^{b}	28.86±1.63^{b}	21.64±0.90^{b}	22.41±0.91^{b}	2.85±0.24^{b}	3.27±0.33^{a}	0.08±0.01^{a}	0.07±0.01^{ab}	2.31±0.01^{b}	2.37±0.07^{b}	97.15±0.58^{ab}	97.26±0.50^{ab}
AF	35.90±2.40^{a}	27.78±1.16^{bc}	26.61±0.90^{a}	21.66±0.90^{b}	2.96±0.48^{b}	2.88±0.12^{b}	0.07±0.02^{ab}	0.06±0.01^{ab}	2.63±0.04^{a}	2.37±0.11^{b}	97.98±1.45^{a}	97.10±0.78^{b}
CL	26.76±0.93^{c}	26.79±1.40^{c}	20.48±^{b}	19.91±^{b}	2.88±0.12^{b}	2.84±0.23^{b}	0.05±0.02^{b}	0.02±0.01^{c}	2.45±0.13^{b}	2.42±0.03^{ab}	97.50±0.31^{ab}	96.32±0.94^{b}
LSD (0.05)	1.87		3.41		0.25		0.02		0.15		0.73	
P value	0.0001		0.016		0.02		0.004		0.026		0.011	
CV (%)	3.52		8.49		4.68		24.57		3.54		0.41	

Appendix Table 7: Pearson correlation matrix for the selective socio-Economic characteristic

	Selection criteria of tree species to incorporate into crops and animals	annual AF crops in your farm	Income get from annual AF crops in (ETB year -1)	Source of cash in cereals	Source of fodder for animals;	Family size	Estimated total size of your farm land	Your Current landholding to support the HHs
Selection criteria of tree species to incorporate into crops and animals	1							
Annual AF crops in your farm	-.048	1						
Income get from annual AF crops in (ETB year -1	-.114	-.065	1					
Source of cash in cereal	-.114	- .065	1.000**	1				
Source of fodder for animals;	.014	-.122	.065	.065	1			
Family size	-.028	-.149	-.043	-.043	.188*	1		
Estimated total size of your farmland	-.041	-.058	.034	.034	.136	-.021	1	
Your current and holding to support the HHs	.003	-.038	.024	.024	.079	-.048	.905**	1

*. Correlation is significant at the 0.05 level (1-tailed).

**. Correlation is significant at the 0.01 level (1-tailed).

Appendix Table 8: Pearson correlation matrix for the selected soil physicochemical properties

	MC	San	slit	Clay	BD	AvP	TN	pH	EC	CEC	OC	OM	Ca	Mg	Na	K	PBS
MC	1	-62$^{\times\times}$	.06	.54$^{\times}$	-.65$^{\times\times}$	.47	-.10	.19	.15	-.16	-.30	.26	.27	.25	.72$^{\times\times}$	-.35	.05
San		1	-.2	-.2	.4	-.01	-.36	-.45	-.44	-.11	-.15	-.52$^{\times}$	-.60$^{\times\times}$	-.10	-.55$^{\times}$	-.13	-.26
Slit			1	.13	-.2	.20	-.11	.34	.29	-.23	.17	.31	.20	-.33	.14	.06	.44
Clay				1	-.30	.50	-.39	-.13	-.16	-.41	-.37	-.01	-.01	.32	.39	-.37	.15
BD					1	-.80$^{\times\times}$	.30	.12	.12	.31	.49$^{\times}$	-.15	.09	-.01	-.44	.52$^{\times}$	.21
AvP						1	-.80$^{\times\times}$	-.09	-.05	-.23	-.36	-.06	-.22	-.13	.41	-.45	-.03
TN							1	.03	-.05	.06	.09	-05	.27	.21	-.21	.19	-15
pH								1	.96$^{\times\times}$	.51$^{\times}$	.52$^{\times}$	.85$^{\times\times}$	.68$^{\times\times}$	.31	.25	.52$^{\times}$	40
EC									1	.45	.50$^{\times}$	.86$^{\times\times}$	.66$^{\times\times}$	.36	.33	.51$^{\times}$	40
CEC										1	.58$^{\times}$	.35	.29	.02	-.07	.49$^{\times}$	.13
OC											1	.51$^{\times}$	.44	-.06	-.02	.91$^{\times\times}$	.59$^{\times\times}$
OM												1	.78$^{\times\times}$	.20	.41	.49$^{\times}$	.46
Ca													1	.16	.34	.39	.49$^{\times}$
Mg														1	.18	.19	-.31
Na															1	-.02	.37
K																1	.43
PBS																	1

$^{\times\times}$Correlation is significant at the 0.01 level (2-tailed)
$^{\times}$Correlation is significant at the 0.01 level (2-tail

Figure 1: *Eucalyptus camaldulensis*

Figure 2: Home garden and *Croton macrostachyus*

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