The Effects of *Eucalyptus globulus* on Soil Physicochemical Property and Erodibility; Comparative Case Study in Wolmera District, Oromia Region

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ABSTRACT

Human alterations of land use and cover are responsible for different forms of soil degradation. Therefore, it is wise to explain exotic tree (e. Globules) monoculture plantation effects on land productivity. To investigate this process in depth, Oromia region special zone surrounding Addis Ababa Wolmera District, where excessive land use variations and erosion events have often occurred, was selected as the study area. The objective of the study was to determine the effects of eucalyptus plantation on soil properties, soil erodibility and investigate the relationships among soil properties and erodibility indices. Duplicate soil samples at three depths, 0-20, 20-40 and 40-60 cm, were taken using plastic bags and steel cylinders under eucalyptus plantation and Juniperusus stand from five pits for each stand. Soil particle size distribution, bulk density, moisture content, ph, cec, p, n, om, and clay ratio index were determined. Data were analyzed by using spss, pearson correlation analysis (at 95% and 99% significance level), mann-whithey u test at 95 % significance level and table of descriptive statistics using spss. According to study results, monoculture plantation of eucalyptus affects some properties of soils significantly. The study results showed that there were significant differences in soil ph, clay, and sand particles under Juniperus forest and eucalypt plantation ($p< 0.05$). Pearson correlation analysis results showed significant correlations among erodibility indices and certain soil properties such as organic matter, soil moisture, silt, clay and sand fraction of soils ($p< 0.05$ and $p< 0.01$). Indeed top soils were sensitive to erosion according to all clay ratio erodibility indices, the more sensitive soils were in eucalyptus plantation.

Key words: Eucalyptus, Juniperus, Soil Physicochemical Properties, Erodibility

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List of Acronyms

a.s.l.: above sea level

ANOVA: Analysis Of Variance

CEC: Cation Exchange Capacity

EMSE: Ethiopian Meteorological Service Agency

FAO: Food and Agriculture Organization of the United Nations

OM: Organic Matter

P ppm: Phosphorus in part per million

SPSS: Statistical Package for Social Science

USDA: United States Department of Agriculture

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Human alterations of land use and cover are responsible for different forms of soil degradation such as soil erosion, compaction, low organic matter, and loss of soil structure, poor internal drainage, salinity, and soil acidity problems.

In history, for one or other reasons, human society began to practice establishing artificial forest ecosystems. In Ethiopia, past decades (after 1970s) have experience introduction of *Eucalyptus* plantations in response to fuel and construction needs, without focusing on the impacts of exotic trees species on ecological services, such as habitat protection, biodiversity preservation, soil formation, nutrient recycling, and control of water and air pollution were rarely considered (Dixon and Sherman, 1991). *Eucalyptus* (Bahirzaf) is most commonly known exotic tree, which was intentionally planted throughout the country, however the prominent area of the introduction has been taking place in the Entoto mountain areas, (Davison, 2009; Gebremariam and Biru, 1998; and EWNHS, 1996).

Studies on the link between trees and the conservation of natural resources are, however, argue that plant physiology may positively or negatively contribute to soil conservation (Krutilla, 1967 Dixon and Sherman, 1991). Some studies attribute the positive contribution of trees to natural resources in relation to soil and water conservation. Faleyimu and Akinyemi (2010), for instance, considered the contribution of trees to soil conservation attached with reducing soil erosion, increasing soil organic matter, improving soil structure and assisting nutrient cycling. Trees can control landscape processes, even though it takes long time in comparison with others, like crops. Trees recycle nutrients by taking them from depth through their roots then depositing them biochemically throughout their biomass and later release them to the soil surface as litter, which then decomposes to form soil organic matter. Trees belongs family *Leguminosae* can even fix atmospheric nitrogen, in harmonization with soil microorganisms. By doing so, they play a non replaceable role for soil fertility.

In general, plants also have contribution to water conservation by increasing rate of percolation, by reducing the speed of surface flow and by reducing evaporation. But on the other hand they negatively affect soil water through evapo-transpiration, at different levels in accordance with vegetation type. According to Cheng and Shi (2004), research on different forest types, indicated that shrub forest had the best effect on water resource conservation and recharge while mixed broadleaf-conifer forest and broad-leaf forest had better effect and *Phyllostachys pupescens* forest had the worst effect.

On the other hand, plants also remove soil minerals in different amount from species to species and may negatively contribute to mineral economy of soil. This has led to the contemporary view that plant physiology and eco-physiology may positively or negatively contribute to soil conservation.

As far as nature is interactive, without doubt, the existence of water and wind causes soil erosion resulting in the movement of solid particles from one place to other (Julien, 2010). Hence, erosion is a natural process that causes breakdown of soil aggregates and accelerates the removal of organic and mineral materials (Gilley, 2005), but the extent is determined by prevailing natural and anthropogenic factors. One of the factors, which affect magnitude of erosion, is soil erodibility, represented by K, and defined as an estimate of the ability of soils to resist erosion, based on the physical characteristics of the soil (Gupta, *et al.*, 2006). However, according to Veihe (2002), the soil erodibility factor is affected by different soil properties beside to physical also chemical, biological, and mineralogical properties.

Eucalyptus, due to its fast growth rate and wide adaptability to prevailing environmental conditions, was planted without any concern about its impact on soil deterioration and harm to ground water. Moreover, there are no in-depth diagnostic studies or comparative case studies that assess the problems and consequences of *Eucalyptus* on soil and water conservation in Ethiopia, especially at Wolmera District. This study thus attempts to examine the effects of *Eucalyptus* on soil and water conservation in the Wolmera District, through examining soil physicochemical properties along soil profile, tree intervals and erodibility, and thorough looking the interactive relation between those parameters.

1.2. Statement of the Problem

From East Africa, Ethiopia is the prominent country which relatively has the largest land area occupied by *Eucalyptus* (Dessie and Erkossa, 2011). Teketay (2000) found out that there are about 55 species of *Eucalyptus* in the country from which *E. Globulus* is by far the most commonly used species. Therefore an in-depth investigation is needed to mitigate further expansion and deterioration.

Soil erosion is a major environmental problem worldwide. About 85% of land degradation in the world is associated with soil erosion, causing a 17% reduction in crop productivity (Oldeman *et al.*, 1990). Erodibility is among factors that determine rate and intensity of soil, with reference to inherent soil property. The texture (clay, silt, and sand content) of a soil derives from that of the true parent material, and has a major effect on the structure and drainage of the horizons below the topsoil. In the uppermost horizons the effects of texture and structure are generally modified to a greater or lesser extent by the presence of higher organic matter contents. Organic matter is one of most important soil parameters, which affects both physical and chemical properties of soil. The rate at which litter decomposes to organic matter is affected by the ratio of carbon to nitrogen in the soil (Faleyimu and Akinyemi, 2010).

Vegetative cover reduces detachment by intercepting raindrops and dissipating their energy. In addition, surface vegetation and residue act as dams that slow water flow and promote deposition, so vegetation and canopy structure are crucial for minimization of erosion. The author argues that impact of monoculture plantation on soil and water is not the only accountable but, also the nature of the plantings (whether in open mixed stands or in closed monoculture blocks), and how they are managed.

Fetene and Beeck (2004) came up with a conclusion that *Eucalyptus* is more efficient in water use than other tree species. Poore and Fries (1985) indicated that *Eucalyptus* transpires more water over the whole year than other trees. In case of water stress however the tree species react quite differently which results in other figures concerning the water use. It is also found that *Eucalyptus* must have more water otherwise they would die of water shortage during water stress situations. Fritzsche *et al.* (2006) showed that the effect of *Eucalyptus* on the water cycle seems to be mainly caused by its rooting system. However, it is not clear how much it impacts water availability for indigenous trees due to the competition they have over water.

Studies on the impact of *Eucalyptus* on the soil conservation focus on the nutrient composition, soil physical properties and deal in depth on soil erodibility.

A summarized list of arguments on *Eucalyptus* by Dessie and Erkossa (2011) shows, a few major points against the *Eucalyptus* which include: drains water resources; enhances soil erosion; suppresses undergrowth; depletes soil nutrients and introduces allelopathic effects.

The arguments supporting *Eucalyptus* include: 1) it is a fast growing tree 2) it requires minimum care 3) it grows in wide ecological zones and poor environments 4) it coppices after harvest 5) it resists environmental stress and diseases 6) the seeds are easy to collect, store and no pre-sowing treatment is required. In this connection, Davidson (1989), states that there is no evidence that *Eucalyptus* trees would be less effective in preventing nutrient and soil losses via erosion than other trees. Because there are no studies available that directly compare the effectiveness of different tree species on erosion reduction, especially E. globulus with other indigenous such as J. procera, the study also attempts to reveal this issue. By fare, very little information is available on the relationship of soil erosion index with various soil characteristics in the study area.

1.3. Rationale for the Study

The fact that the study is site-specific is believed to make it a valuable contribution to the much-needed but very scarce local-level understanding on the impact of *Eucalyptus* plantations on resource conservation in productive area of Wolmera. Species vary widely in their inherent nutrient requirements and use. According to FAO (1988), the nutrient removal of natural forest is 20 times lower than from a *Eucalyptus* plantation. Because *Eucalyptus* is fast growing tree, it has short life rotation; nutrient removal from the site is higher, because of frequent harvesting, than those tree species having long life time. Even though many researchers dealt over on the impact of plantations on soil nutrient economy and put there hypothetical assumption, for instance Lundgren (1978), from his comparative study on soil under conifer plantation and natural forest in Tanzania, generally argued that a reduction in soil nutrients possibly occurred due to nutrient drain through harvest removals of conifer plantation in 30 years rotation.

1.4. Research Question

The study tries to answer the following questions:

Are there differences on soil physical as well as chemical properties under *Eucalyptus* monoculture and *Juniperus* forest?

Do soil physicochemical properties significantly vary with depth under E. globules and J. procera?

Is there variation in soil erodibility indices under E. globules and J. procera?

Do soil erodibility indices have relation with soil physiochemical properties?

What will be the possible solution that can resolve the impact of *Eucalyptus* plantations on resource conservation?

1.5. Objectives of the Study

The major objective of this study is to assess the impact of *Eucalyptus* on soil property and soil erodibility in the highland area of Wolmera. In line with this general objective, the specific objectives are to:

- Examine the physicochemical properties of soil *Juniperus* forest, and *Eucalyptus* monoculture;
- Assess and quantify soil erodibility in the highland of Wolmera under those land uses in order to proof or disproof effect of *Eucalyptus* on soil erosion;
- Assess their impact along soil profile;
- Try to find out the relationships among soil physiochemical properties and erodibility indices;
- Forward possible solutions, if *E. globules* have a negative impact, which enables to resolve the challenges.

Chapter two

2. LITERATURE REVIEW

2.1. History of *Eucalyptus* Plantation in Ethiopia

In Ethiopia intention of establishing plantation using exotic tree, genus *Eucalyptus*, was triggered by resource limitation that resulted from overexploitation on indigenous tree species for the sake of fulfilling needs, fuel and construction wood, of increasing population in newly established capital city of Ethiopia, Addis Ababa. For the first time planting was done on Entoto Mountain, thorough decision of Emperor Menilek II (1868-1907), (Dessie and Erkossa , 2011). From that time onward planting *Eucalyptus*, without limit throughout the country, practice by private and governmental organizations, and facilitated by different donors. The rapid expansion of state forest established on Entoto reached Addis Ababa surrounding special zone, including the study site Wolmera District.

Indeed, *Eucalyptus* is not the only exotic species that was planted in Ethiopia but, also others such as *Cupressus lusitanica, Casuarina cunninghamiana, Pinus patula* and *Pinus radiata*. Some of the features that make *Eucalyptus* more preferable are its fast growth rate, capability of surviving on marginal environments and coppice regeneration from the stump after cut off. For those reasons the planting was rapid, according to Dessie and Erkossa (2011), *Eucalyptus* forest cover total area is 506000 ha in Ethiopia, which is a figure by far the highest in East Africa.

2.1.1. Challenges of *Eucalyptus*

The argument on *Eucalyptus* came from its irreplaceable socio-economic value and undefined impact on the environment. Many scholars dealt with the impact of *Eucalyptus* on environment, in relation to water resources, different research reports show that water use capacity (WUC), amount of water used to produce one gram of glucose, of *Eucalyptus* is relatively high (Zahid *et al.*, 2010). Annual amount of evapotranspiration, result achieved from measurement on *Acacia, Albizzia, Azadirachta* and *Eucalyptus*, show much greater water lost from *Eucalyptus*. Other studies indicate amount of water loss by these species vary depending on the availability of water and ages of plantation.

Figure 1 *Eucalyptus* plantation

According to Tilashwork (2009), in addition to lowering the soil moisture content both by its dense root system and by making the soil hydrophobic it reduces productivity of soil, enhances soil erosion, suppresses undergrowth, depletes soil nutrients and introduces allelopathic effects

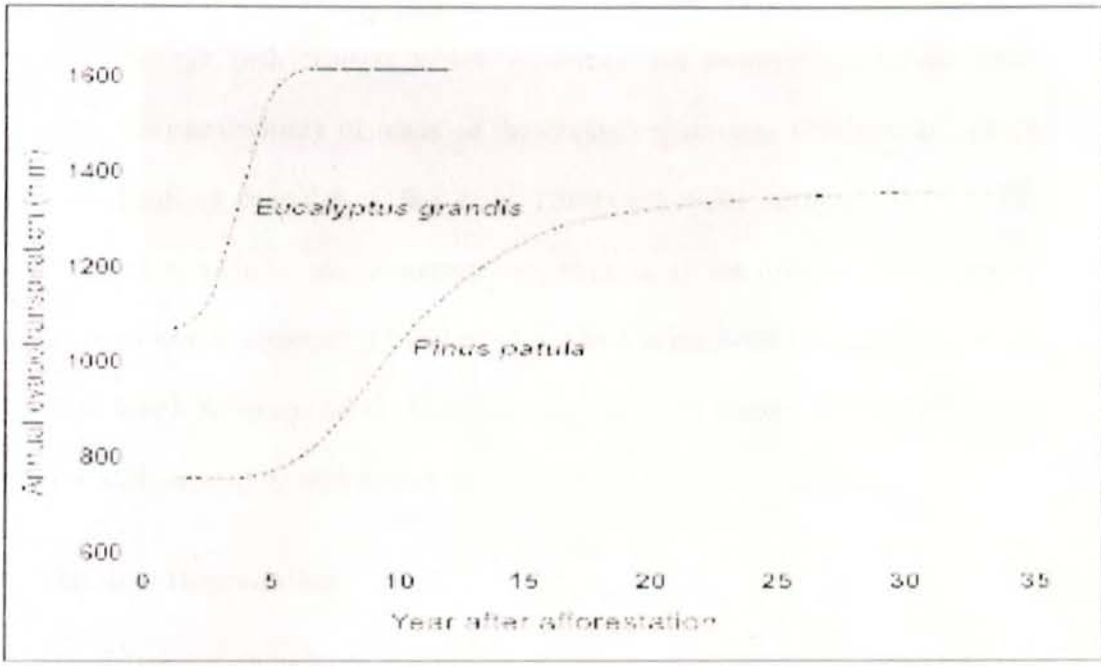

Figure 2 Water requirements of two evergreen species

2.2. Soil Physicochemical Degradation

Soil erosion is a process inherent in landscape evolution. The intensity of soil erosion is governed by numerous natural and anthropogenic factors. Natural factors include soil, climate, vegetation, relief and other eco-regional characteristics (Lal, 1996). Soils are more exposed to erosion for different reasons: inappropriate agricultural practices, deforestation, overgrazing, forest fires, and construction activities (Terranova *et al.*, 2009). Erosion process has both on-site and off-site consequences. On-site consequences results in the loss of productive topsoil and other physical and chemical consequences.

Furthermore, off-site problems, such as downstream sediment deposition in fields, floodplains and water bodies, are also very serious, with significant costs to society (Verspecht *et al.*, 2011). Land degradation may be defined as long-term adverse changes in soil properties and processes, leading to a loss of ecosystem function and productivity caused by disturbances from which land cannot recover unaided (Bai *et al.*, 2008; Palm *et al.*, 2007). Through such changes in soil properties and processes, soil degradation undermines the sustainability of many of the ecosystem services (Palm *et al.*, 2007). Among the kinds of degradation, Bai *et al.* (2008) list water erosion, wind erosion, nutrient depletion, salinity, and contamination, physical as the principal ones. Among them, water erosion is responsible by more than a half of the degraded land along world and also in South America. South American continent is a region with particular and expressive areas presenting high or very high vulnerability for water erosion.

2.2.1. Physical Degradation

Physical soil degradation includes degradation of soil structure, crusting, compaction, and erosion. One of the properties of soil whereby physical land degradation can be observed and studied in this research work is soil compaction (bulk density). Bulk density is a measure of the mass of soil per unit volume. When soil particles are pushed close together, increasing the mass per unit volume, the soil is compacted. The major problem for plants at high soil densities is difficulty in root extension, because plants do not readily push their roots through dense soil. Water flow through compacted soils is also restricted because the number of large pores is reduced. Soil compaction occurs when a weight on the soil surface rearranges the soil particles. The weight is transmitted through the soil to a depth at which the particles support the load. The total load and the load per unit area are the main factors influencing the soil behavior. The dominant soil factor influencing compaction is the soil water content at the time the soil is loaded. As the soil water content increases, the density of the compacted soil increases up to a maximum and then decreases. Dry soil particles do not readily slide or roll over one another. Water reduces friction and enhances movement. This does not continue beyond a maximum because water cannot be compressed; it takes up space. At water content near saturation, the particles are pushed completely apart by the positive pore water pressure, causing the soil to lose strength completely, (Woldegiorgis, 2007).

Table 1General relationship of soil bulk density to root growth based on soil texture.

Soil Texture	Ideal bulk densities for plant growth (g/cm3)	Bulk densities that restrict root growth (g/cm3)
Sandy	< 1.60	> 1.80
Silty	< 1.40	> 1.65
Clay	< 1.10	> 1.47

2.2.2. Chemical Degradation

Chemical degradation of soil includes acidification, salinization, and nutrient and fertility depletion of land. Organic matter improves soil nutrient content and structure. The amount of organic matter contributed by trees is affected by: the volume of foliage dropped; the quality of foliage dropped; the additions from the roots; and trees species.

The organic matter content in a soil affects the activities of microbes, which in turn have vital role in making nutrients available for plants. Moreover, organic matter content strongly affects the physical properties of soil including soil structure, bulk density, and percent pore space and water infiltration capacity. Soil organic matter is derived from the decayed tissue of plants and animals, and from animal excreta, particularly urine (Ngugi *et al.*, 1978). Soil organic matter has tremendous advantages in the improvement of soil physical, chemical and biological properties. Soil organic matter stabilizes soil structure, improves water holding capacity, lowers bulk density, increases CEC, acts as a pH buffer, ties up metals, supplies energy and body building constituents for soil organisms, increases microbial population and their activities, (Woldegiorgis, 2007).

Organic matter (humus) contained in the surface layer of a mineral soil usually varies between 1 and 10 %, depending on climatic and drainage conditions, (Ilaco, 1985). On average this organic matter contains 58 % carbon, 5 % nitrogen (C/N= 11.6), 0.5 % phosphorus, and 0.5 % sulfur. Thus, conversion of percent carbon to percent organic matter is, therefore, done with the empirical factor of 1.724, which is obtained by dividing 100 by 58. Organic matter content of a soil could also be roughly estimated from the total nitrogen content of soil by multiplying the percent total nitrogen by 20 by assuming organic matter contains 5 % nitrogen, (Sahlemedihin and Taye, 2000).

Cation exchange capacity is also crucial in the determination of soil fertility for two fundamental reasons (Olaitan *et al.*, 1996). The first reason is that the total quantities of nutrients available to plants as exchangeable cations depend on it.

The second reason is that it can influence the degree to which hydrogen and aluminum ions occupy the exchange complex, and thus affects the pH of soils.

Table 2 Rating of Organic Matter

Rating	Percent organic matter
Very High	>6.0
High	4.3-6.0
Medium	2.1-4.2
Low	1.0-2.0
Very low	<1.0

Source: Ilaco (1985)

2.3. Soil erosion

Soil erosion is a process of carried off soil particles by water or wind from a place of formation and deposited somewhere else. Soil erosion increased throughout the 20th century. About 85% of land degradation in the world is associated with soil erosion, most of which occurred since the end of World War II, causing a 17% reduction in crop productivity (Oldeman et al., 1990).

Soil erosion has accelerated on most of the world, especially in developing countries, due to different socio-economic, demographic factors and limited resources. For instance, Reusing *et al.* (2000) mentioned that increasing population, deforestation, land cultivation, uncontrolled grazing and higher demand for fire often cause soil erosion.

The impact of soil erosion can be worst in developing countries where farmers are highly dependent on intrinsic land proprieties and unable to improve soil fertility through application of purchased inputs. In Ethiopian highlands only, an annual soil loss reaches to 200 - 300 ton per hectare, while the soil loss movement can reach to 23400 million ton per year (FAO, 1984; Hurni, 1993).

Sheet and rill erosion are caused by: slope length and steepness; poor ground cover and surface roughness; poor tree and shrub cover; poor soil structure; poor infiltration; and intensity of rainfall.

2.3.1. Factors that determine the rate and magnitude of soil erosion

Soil erosion is a function of many factors as stated in the universal soil loss equation (USLE). These factors include rainfall factor, soil erodibility factor, slope length, crop factor, and control practice factor. This is represented in the universal soil loss equation as $A = R\ K\ LS\ C\ P$ (Renard *et al.*, 1997).

Soil erodibilty is defined as an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil and its factor varies spatially according to variations of some soil properties on the surface (Vaezi *et al.*, 2010). Studies also indicated that soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Among these factors tillage and cropping practices are usually causing poor soil structure and lower soil organic matter levels that contribute to increase in soil erodibility. On some sites, decreased infiltration and increased runoff might result in compacted subsurface soil layers that result in a soil crust. On the other hand, sand, sandy loam and loam textured soils will be less erodible than silt, very fine sand, and certain clay textured soils. The erodibility of soil is, thus, an effect of a number of reasons. The reasons may attached with the original soils may have poorer structure and lower organic matter.

2.4. Relation between soil erodibility and soil property

Topsoil properties and erodibility of soils provide very important clues for land use planning. The aim of this study is to determine the impacts of *Eucalyptus* on soil properties and to determine relationships between erodibility indices and soil properties.

Soils are generally composed of four main components; water, air, minerals, and organic matter. The organic matter content in a soil affects the activities of microbes, which in turn have vital role in making nutrients available for plants. Moreover, organic matter content strongly affects the physical properties of soils including soil structure, bulk density, and percent pore space and water infiltration capacity. This dominancy of OM in altering different soil parameters makes it most significant when regarding erodibility (Sahlemedihin and Taye, 2000).

Chapter three

3. Material and Methods

3.1. Study Area

3.1.1. Location of the Study Area

Wolmera District is one of the eight administrative units of Oromiya Special Zone Surrounding Addis Ababa, located 35 kms west of Addis Ababa.

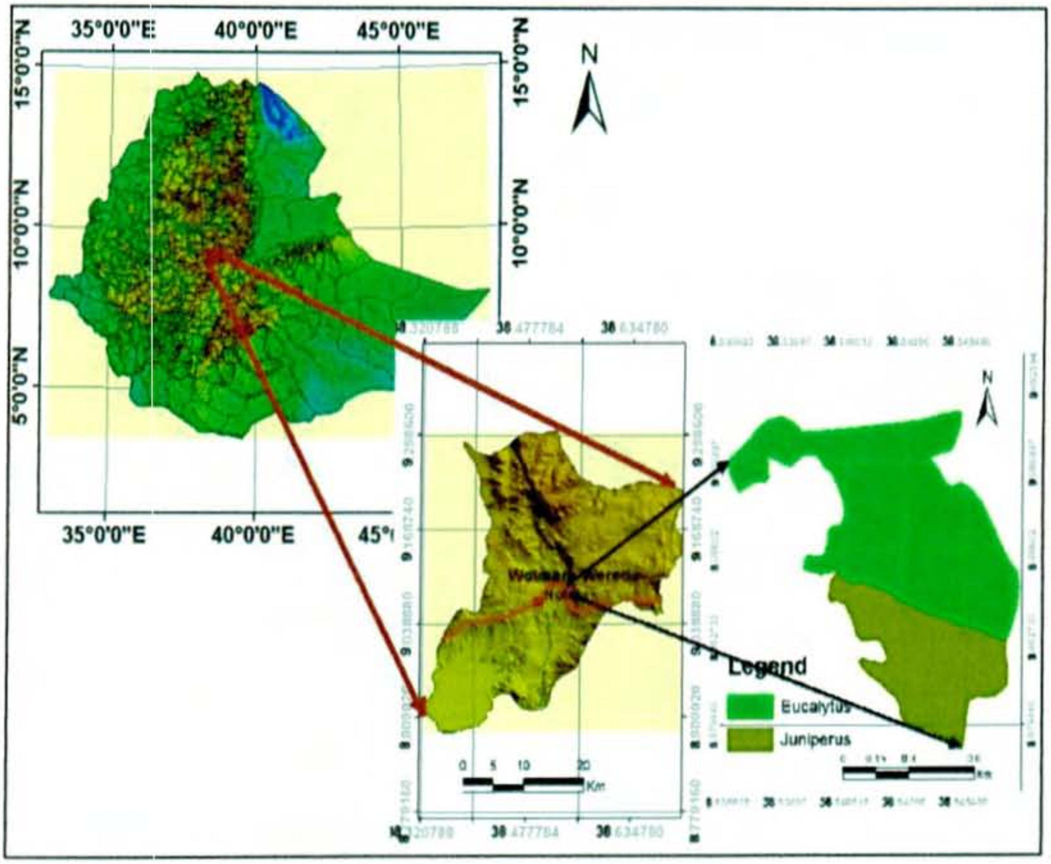

Figure 3 Location Map of the Study Area, (ETHIO-GIS data base).

Geographically, Wolmera is bounded from north to south by longitudes of 08°50′N to 09°15′N and latitudes of 38°25′E to 38°45′E, having total area of 755 km^2. Specifically plantation covers, at which the study was taken, total area of 88.85 km^2 approximately, from this area 60.71 km^2 is covered by *Eucalyptus* and the remaining area is covered by *Juniperus*. Where the major study area is located belongs to the Afromontane forest belt in the central highlands of Ethiopia. Formerly, indigenous trees such as *Juniperus procera*, *Olea europea* spp. *Cuspidata*, and *Podocarpus falcutus* were dominantly covering the area. Natural *Juniperusus-Podocarpus-Olea* forest which was once abundant on the area rapidly vanished due to an over exploitation of the indigenous trees (Pohjonen, 1989). The remnants of *Juniperus* and Olea trees in the area reflect elements of this vegetation. Currently, the dominating species in the area are *Eucalyptus* plantations on which this study focuses.

3.1.2. Soil Types of Study Area

In Wolmera District there are five different soil types; *Luvisols*, *Vertisols*, *Nitosos*, *Leptosols*, and *Cambisols*, but in specific to study area only *Humic Nitosols* was found as indicated in figure 4. According to FAO (1990) classification, *Nitosols* is topographically characterized by mountainous and gentle sloping landscape and it accommodates deep, well-drained, red, tropical soils. With diffuse horizon boundaries and a subsurface horizon with more than 30 percent clay and moderate to strong angular blocky structure elements that easily fall apart into characteristic shiny, polyhedric ('nutty') elements. Nitisols are strongly weathered soils but far more productive than most other red tropical soils.

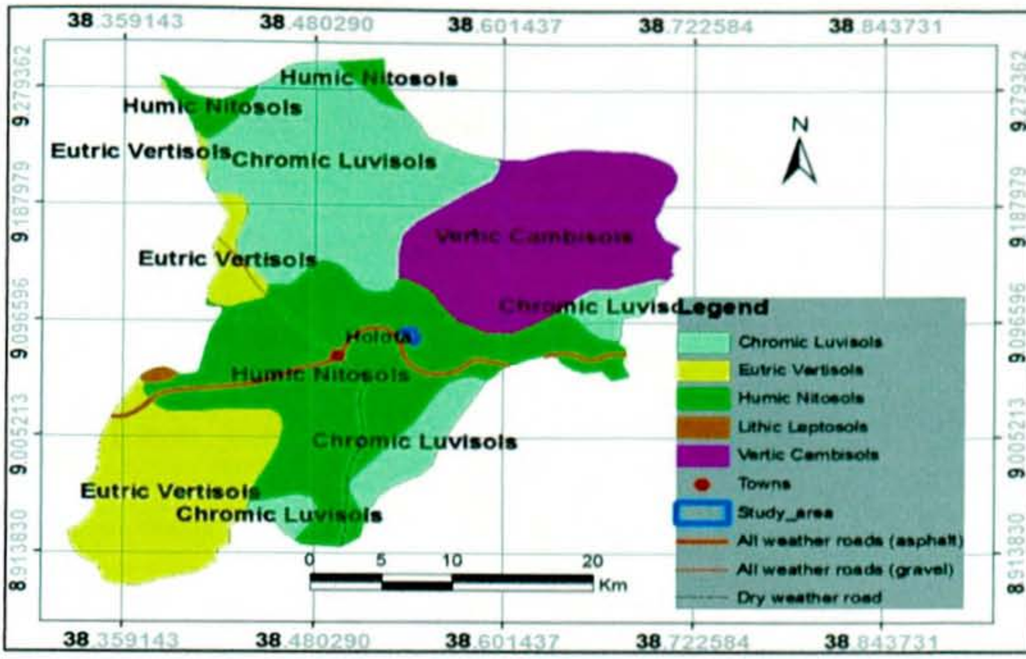

Figure 4 Soil Types in the Wolmera District (FAO).

The word Humic is a qualifier which indicates having, over a depth of 100 cm from the soil surface, more than 1.4 percent organic carbon (by weight) in the fine earth fraction in *Ferralsols* or *Nitisols*, having more than 2 percent organic carbon (by weight) to a depth of 25 cm in *Leptosols, or* having more than 1 percent organic carbon (by weight) to a depth of 50 cm in other soils (FAO, 2001)

3.1.3. Climatic Condition of the Study Area

The climatic zoning of the area is done based on the Ethiopian climatic classification after Chernet (1993) give below. The climatic regions of Ethiopia are summarized in the table 3.

Table 3 General Ethiopian climatic classification

Climatic Regions	Altitude of the region (m.a.s.l)	Mean Annual Temperature (^{0}C)	Presence in the study area
Alpine (Kur)	3300	10 and above	Absent
Temperate (Dega)	2300-3300	10-15	Absent
Subtropical (Weina Dega)	1500-2300	15-20	Present
Tropical (Qolla)	800-1500	>30	Absent
Desert (Bereha)	Less than 800	>40	Absent

Source Hydrogeology of Ethiopia (Cherinet, 1993)

The study area falls under the agro-ecological zone of "Weyina Dega" with altitude ranging from 1860 to 2060 m.a.s.l.

The climatic data from National Meteorology Agency about Addis Ababa and Holeta rainfall (1962-2004 and 1968-1995 E.C. years respectively) and temperature (1975-2004 and 1975-1998 E.C. years respectively) shown in table 4.

Table 4 Main Climate Elements of the Study area

Climatic station	Jan	Fab	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
						Mean Temprature							
Addis Ababa	15.7	16.6	17.7	17.6	18.0	16.6	15.5	15.4	15.7	15.6	15.1	15.0	16.2
Holeta	13.3	14.8	15.6	16.0	15.9	15.0	14.4	14.2	14.0	13.1	12.2	12.1	14.1
						Mean Rainfall							
Addis Ababa	17.0	43.0	67.0	89.0	83.0	121.0	254.0	284.0	175.0	37.0	9.0	7.0	1186.0
Holeta	16.1	56.1	69.0	82.5	70.7	103.0	251.3	276.5	140.0	14.2	3.9	9.1	1092.4

The area has a bi-modal rainfall with a short rainy season from March to May and with a long rainy season from June to September. The mean annual rainfall of the area varies from 730mm to 1100mm, while the average minimum and maximum temperature of the area is 12 ^{0}C and 30 ^{0}C, respectively.

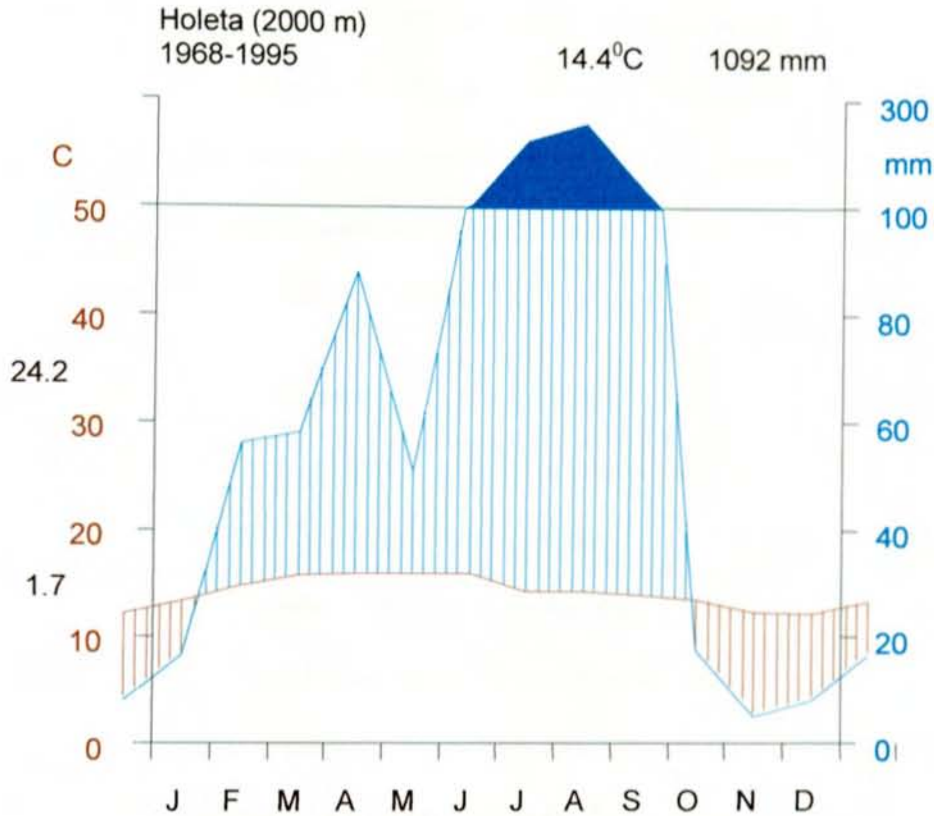

Figure 5 Rainfall patren of Holeta

3.2. Research design

This study is explanatory quantitative case study and it employed and single case study design. Explanatory quantitative case study would be used if you were seeking to answer a question that sought to explain the presumed causal links in real-life interventions that are too complex for the survey or experimental strategies (Yin, 2003).To select sampling points (under both stand) the study employed judgmental sampling, which is a non-probability sampling technique. All in all ten sampling points were selected where soils were sampled. Out of the ten five sampling points were located in *Juniperusus* (*Juniperusus procera)* forest, and five in eucalyptus *(eucalyptus globulus)* forests. The *Juniperusus* stand, indigenous to Ethiopia, was used as a benchmark in examining the impact of eucalyptus forest plantation on soil physicochemical and erodibility. Both stands were on the same area side by side in Wolmera District, so that both are somehow influenced by the same climatic conditions.

3.3.Data collection techniques

Firstly permission to dig soil pits in the forest plantations was sought from Finfinne Forest Enterprise. Before soil samples were collected first selected similar slope class in order to avoid slope dependent variation is needed so 1-5% slope was used and the pits were dug away from forest road and 10 meter from margin of the stands in order to minimize biased result. Then with an aid of a pick and a spade ten sampling pits in the sampling points measuring 1 m length, 1 m width and 1 m depth excavated, measuring tape were also used. The samples were collected from the bottom to the top of the soil pit to avoid sample contamination. Total of 30 total samples, from each stand 15 samples will be taken. From each stand five pits were dug out and from each pit samples were taken from three depths interval (0-20, 20-40, and 40-60cm), and from each depth interval two sample sets, disturbed and core soil, were taken. Disturbed soil sample were taken using polythene bags which were then tied with cotton strings and undisturbed soil samples for bulk density analyses were taken using cylindrical steel (metallic core ring with 5 cm height and 2.5 cm radius). The core ring was driven into the soil surface using a hand sledge and a block of wood. It was then removed by careful lifting after removal of excess soil around the edges using a flat-bladed knife. Then all samples were labeled and taken to the laboratory for chemical and physical analyses.

3.4. Laboratory analysis

For laboratory experiments, soil samples were taken from two forest stand, *Eucalyptus* plantation and *Juniperus* dominated regenerated natural forest that are found in Worlmera District to check the effects of *Eucalyptus* monoculture on soil physical properties, such as texture, bulk density, and moisture content. Laboratory experiments were undertaken at Holota Agricultural Research Center, Plant and Soil Analyzing Laboratory. In order to determine soil chemical properties, first soil samples were air dried, homogenized and sieved to remove large particles in order to examine chemical properties. In addition, soil organic matter content, pH, and some nutrients such as total nitrogen and available phosphorous were estimated. The soil samples were ground then after passed through 0.5mm sieve, organic matter content was calculated from organic carbon using Walkley Black Method, then 1g of soil was weighed and added to 500ml conical flask. Exactly 10ml 1.0N $K_2Cr_2O_7$ was added and swirled the flask gently to disperse the soil in the solution. Later 20ml of concentrated H_2SO_4 was added. The flask was then immediately and gently swirled until soil and reagents were mixed. The sample was then heated to 150^0C on a hot plate for 1 minute. The flask was then allowed to stand for 30minute and 200ml of distilled water were added. 5-6 drops of ferroin indicator were later added and titrated with 0.5N ferrous solutions. As the end point is approached, the solution took on a greenish cast and then changed to dark green. At this point, the ferrous sulphate was added drop by drop until the color changed sharply from blue to red (maroon color in reflected light against a white background). The conversion to derived %OM was based on the assumption that OM contains 58% organic carbon. Even though, as this proportion is not in fact constant, we prefer to report result as oxidizable organic carbon or multiplied by 1.724 as organic carbon. Organic matter has a major influence on soil aggregation, nutrient reserve and availability of moisture retention, and biological activity. Soil pH was measured, from the one to one ratio solution of soil and water, using pH meter.

Total nitrogen was extracted using 2 M KC1 and determined by the micro-Kjeldahl method. Available phosphorous was estimated using Olsen's solution (sodium bicarbonate) as an extracting agent.

Soil texture was determined using the textural triangle after the percentages of sand, silt and clay were determined after hygrometer analysis of soil particle size distribution (Bouyoucos, 1951). Other physical properties such as, bulk density and moisture content of soil were measured under those vegetation types. The soil samples that were taken from *Eucalyptus* monoculture and *Juniperus* forests were tested using gravimetric and volumetric soil moisture determination methods. Thus, these experiments will enable to compare and determine the moisture contents of both stands in light with its effects on conservation.

Soil erodibility can be measured through direct and indirect ways, the direct measurement of soil erodibility is costly and time consuming (Singh and Khera, 2007), efforts were made to predict indirectly form various soil properties. On this paper soil erodibility indices (K) will be calculated from the data, generated from laboratory analysis of soil physical properties, hydrometric test, using Bouyoucos (1935) equation.

Hydrometric test used to determine percent of silt, clay, and sand as follow;

$$\%Sa = \frac{Sw - r}{sw} * 100 \qquad \text{(eq.1)}$$

$$\%C = \frac{r}{sw} * 100 \qquad \text{(eq. 2)}$$

Where:

Sa is Sand, Sw is sample weight and r is reading after 40 second (for eq.1) and reading after 8 hours (for eq.2) and C is clay.

$$\%S = 100\% - (\%Sa + \%C) \qquad \text{(eq. 3)}$$

Where: S is silt.

$$C.R = \frac{\%sa + \%s}{\%c} \qquad \text{(eq. 4)}$$

Where: C.R is clay ratio expressed in percent.

3.5. Data Analysis

Mann-Whithey U test was performed to determine the effects of monoculture plantation of *Eucalyptus* on the chemical and physical properties of the soil, and comparative analysis done at 95%confidence level. Statistical analyses were performed using SPSS version 20. In order to determine relationship/ difference between soil parameters and soil depth Kruskal-Wallis independent sample test was used. Pearson correlation was performed at confidence levels of 95% and 99% to know whether the relationship is statistically significant (low probability of occurring in the sample if there was no relationship in the population) and how large the effect size (strength of the relationship) is.

Chapter four

4. Results

4.1. Soil physiochemical property variation in accordance with tree species and soil depth

4.1.1. Soil physical property variation

Even though, there is variation in soil particle size distribution among the two species as indicated in table 5, soil texture under both species belongs to clay soil according to USDA soil texture class analysis. Mean soil particle distributions for *Eucalyptus* and *Juniperususerus* are, 58.67, 31, 10.33, and 64, 29.67, 6.33 percent clay, silt and sand respectively (Table 5). Mann-Whithey U test shows significant variation of sand and clay between the groups (*Eucalyptus* and *Juniperus*) at 95% significance level (Table 7), which mean high clay particles were found under *Juniperus* relatively to the *Eucalyptus* stand and high sand particles were found under *Eucalyptus* than *Juniperus*. And also amount of clay and sand particles were significantly vary along depth under *Eucalyptus*, but not under *Juniperus* (Table 6a and b). High clay and sand particle were found at 40-60cm and 20-40cm depths, respectively (Fig. 6).

Mean percent soil moisture content under *Eucalyptus* and *Juniperus* were 17.04 and 18.19 respectively (Table 5), this figure is not statistically significant at 95% confidence level as indicated in table7, but under both groups it varied significantly along depth at 95% confidence level and moisture content is low at surface soil (0-20cm depth) as emphasis Fig. 6 and 7.

Table 5descriptive statistics for soil parameter variation along plantations

VegetationType		N	Minimum	Maximum	Mean	Std. Deviation
Eucalyptus	PH (1:2 water)	15	4.08	4.4	4.31	0.08
	P ppm	15	2.2	5	2.83	0.71
	%N	15	0.16	0.2	0.17	0.02
	CEC	15	17.06	24.2	19.55	2.3
	%OM	15	2.9	4.36	3.41	0.48
	%Claye	15	52.5	67.5	58.67	3.64
	%Silte	15	27.5	37.5	31	3.11
	%Sand	15	2.5	15	10.33	4.32
	BD	15	1.13	1.67	1.23	0.13
	%Moisture	15	11.48	20.8	17.04	2.5
	CR. Indices	15	0.48	0.91	0.71	0.1
juniperus	PH (1:2 water)	15	4.16	5.08	4.59	0.32
	P ppm	15	2	3.2	2.37	0.32
	%N	15	0.14	0.25	0.18	0.05
	CEC	15	15.92	28.26	21.18	4.12
	%OM	15	2.76	4.97	3.73	0.89
	%Claye	15	55	77.5	64	6.93
	%Silte	15	17.5	40	29.67	7.25
	%Sand	15	2.5	17.5	6.33	4.62
	BD	15	1	1.35	1.18	0.09
	%Moisture	15	12.76	22.7	18.19	2.67
	CR. Indices	15	0.29	0.82	0.58	0.16

As the result shows, there are little variation on mean bulk density (gm/ cm^3), under *Eucalyptus* and *Juniperus*, 1.23 and 1.18 respectively (Table 5), due to this, the variation resulted from tree species is not statistically significant at 95% confidence level (Table 7), also not significantly varies along soil depth (Table 8 and9).

4.1.2. Soil chemical property variation

Soil organic matter is derived from the decayed tissue of plants and animals, and from animal excreta, particularly urine and it has potential affect both physical and chemical properties. The amounts of Soil organic matter (OM) under *Eucalyptus* and *Juniperusus* did not have significant variations (Table 7), and they have mean values of OM 3.41 and 3.73 percent respectively. However under both stands there are significant variations along soil depths, 0-20, 20-40 and 40-60, %OM of 3.92, 3.37 and 2.94, and 4.86, 3.52 and 2.81, respectively.

The soil pH indicates the amount of acidity present in the soil solution and is one of the most commonly measured soil properties. It is considered as a standard and routine soil analysis. The result indicates mean soil pH under *Eucalyptus* and *Juniperus* are 4.31 and 5.59 respectively (Table 5), the difference between mean value of the vegetations are statistically significant at 95% confidence level (Table 7). And also mean value varies along soil depth under both stands (Table 6a and b); according to table 9 and 10 shows the variations are statistically significant at 95% confidence level. Soil acidity increase with depth under *Eucalyptus*, but opposite is true for *Juniperusus* as illustrated on figure 5 and 6.

Table 6 descreptive statstics for soil parameters variation along depth under both stands

Descriptive Statistics *Eucalyptus* at different depths						
Depth (cm)		N	Minimum	Maximum	Mean	Std. Dev.
0-20	PH (1:2 water)	5	4.24	4.33	4.28	0.05
	P ppm	5	3.20	5.00	3.56	0.81
	%N	5	0.19	0.20	0.19	0.01
	CEC	5	19.92	24.20	21.96	2.15
	%OM	5	3.62	4.36	3.92	0.41
	%Clay	5	52.50	60.00	57.00	3.26
	%Silt	5	27.50	37.50	31.50	3.79
	%Sand	5	10.00	15.00	11.50	2.24
	BD	5	1.16	1.27	1.21	0.04
	%Moisture	5	11.48	17.91	14.78	2.42
	CR. Indices	5	0.67	0.91	0.76	0.10
20-40	PH (1:2 water)	5	4.08	4.32	4.25	0.10
	P ppm	5	2.20	2.40	2.28	0.11
	%N	5	0.17	0.17	0.17	0.00
	CEC	5	17.52	21.14	18.43	1.57
	%OM	5	3.16	3.62	3.37	0.17
	%Clay	5	55.00	60.00	57.00	2.09
	%Silt	5	27.50	37.50	30.50	4.11
	%Sand	5	2.50	15.00	12.50	5.59
	BD	5	1.13	1.24	1.17	0.04
	%Moisture	5	15.36	19.99	17.98	1.83
	CR. Indices	5	0.67	0.82	0.76	0.06
40-60	PH (1:2 water)	5	4.34	4.40	4.38	0.02
	P ppm	5	2.60	2.80	2.64	0.09
	%N	5	0.16	0.16	0.16	0.00
	CEC	5	17.06	18.72	18.26	0.69
	%OM	5	2.90	2.97	2.94	0.04
	%Clay	5	60.00	67.50	62.00	3.26
	%Silt	5	30.00	32.50	31.00	1.37
	%Sand	5	2.50	10.00	7.00	2.74
	BD	5	1.17	1.67	1.29	0.21
	%Moisture	5	15.89	20.80	18.35	1.74
	CR. Indices	5	0.48	0.67	0.62	0.08

(b)

Descriptive Statistics *Juniperususs* at different depths						
Depth (cm)		N	Minimum	Maximum	Mean	Std. Dev.
0-20	PH (1:2 water)	5	4.89	5.08	4.97	0.10
	P ppm	5	2.20	2.40	2.24	0.09
	%N	5	0.17	0.24	0.21	0.04
	CEC	5	23.10	28.26	25.92	2.64
	%OM	5	4.69	4.97	4.86	0.15
	%Clay	5	55.00	62.50	58.50	3.79
	%Silt	5	30.00	40.00	35.00	3.54
	%Sand	5	2.50	15.00	6.50	5.18
	BD	5	1.08	1.35	1.23	0.11
	%Moisture	5	12.76	16.54	15.19	1.68
	CR. Indices	5	0.60	0.82	0.72	0.11
20-40	PH (1:2 water)	5	4.44	4.64	4.54	0.09
	P ppm	5	2.00	2.60	2.24	0.33
	%N	5	0.14	0.25	0.19	0.05
	CEC	5	15.92	21.82	18.18	2.44
	%OM	5	3.29	3.69	3.52	0.21
	%Clay	5	57.50	77.50	66.00	7.83
	%Silt	5	20.00	35.00	29.00	6.52
	%Sand	5	2.50	7.50	5.00	2.50
	BD	5	1.00	1.24	1.14	0.09
	%Moisture	5	17.72	22.70	19.61	1.99
	CR. Indices	5	0.29	0.74	0.53	0.17
40-60	PH (1:2 water)	5	4.16	4.34	4.26	0.09
	P ppm	5	2.40	3.20	2.64	0.33
	%N	5	0.14	0.17	0.15	0.01
	CEC	5	17.48	20.96	19.44	1.81
	%OM	5	2.76	2.90	2.81	0.06
	%Clay	5	62.50	75.00	67.50	5.86
	%Silt	5	17.50	35.00	25.00	8.10
	%Sand	5	2.50	17.50	7.50	6.12
	BD	5	1.11	1.21	1.15	0.04
	%Moisture	5	18.54	20.98	19.79	1.06
	CR. Indices	5	0.33	0.60	0.49	0.13

Cation exchange capacity (CEC) is the total nutrient fixing capacity of a soil. Result of this study shows mean values of CEC under *Eucalyptus* and *Juniperus* stand were 19.55

and 21.18 respectively (Table 5), and the difference in mean values are not statistically significant at 0.05 alpha level (Table 7). Mean values of CEC decrease with increasing soil depth (21.96, 18.43, and 18.26 cmol/kg of CEC for 0-20, 20-40, and 40-60cm soil depth respectively (Table 6a), statistical analysis shows that the variation along depth is significant at confidence level of 95% (Table 9).

Table 7 Mann-Whithey U test result for variation soil parameters between stands

Null Hypothesis (Ho)	The distribution soil parameter is the same across categories of depth (cm).										
Soil Parameters	CR	pH	P ppm	%Clay	%Sand	BD	% Moistu	%N	CEC	%OM	%Silt
Sig.	0.01	0.01	0.02	0.01	0.02	0.23	0.2	0.68	0.41	0.62	0.84
Decision	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Retain Ho	Retain Ho	Retain Ho	Retain Ho	Retain Ho	Retain Ho

Mean percent of total nitrogen (%N) under *Eucalyptus* and *Juniperus* are 0.17 and 0.18 (Table 5), variation of the mean values are not statistically significant at alpha level 0.05 as indicated in table 8. But the amount of nitrogen is inversely proportional to soil depth as show in table 6a and b and illustrated in figure 6 and 7.

Table 8 Independent-Samples Kruskal-Wallis test result for variation of soil parameters with depth under Eucalyptus, at significance level of 0.05.

Null Hypothesis (Ho)	The distribution of soil parameter is the same across categories of depth (cm).										
Soil Parameters	CR	pH	P ppm	%N	CEC	%OM	%Clay	%Sand	Moisture	%Silt	BD
Sig.	0.032	0.009	0.001	0.001	0.018	0.002	0.032	0.047	0.05	0.61	0.204
Decision	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Retain Ho	Retain Ho

Table 9 Independent-Samples Kruskal-Wallis test result for variation of parameters with depth under *Juniperus* at significance level of 0.05.

Null Hypothesis (Ho)	The distribution soil parameter is the same across categories of depth (cm).										
Soil Parameters	CR	pH	P ppm	%Clay	%Sand	BD	% Moistu	%N	CEC	%OM	%Silt
Sig.	0.01	0.01	0.02	0.01	0.02	0.23	0.2	0.68	0.41	0.62	0.84
Decision	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Reject Ho	Retain Ho	Retain Ho	Retain Ho	Retain Ho	Retain Ho	Retain Ho

The amount of available phosphorus was the soil under *Eucalyptus* is significantly higher than that of soil under *Juniperus* at alpha level of 0.05 (Table 8) and there means are 2.83 and 2.37 for *Eucalyptus* and *Juniperus* respectively, in the case of soil under *Eucalyptus*, highest amount of available phosphorus were found at the top soil or the first depth interval, but in the case of *Juniperus*, the distribution was relatively similar as indicated in table 7a and b.

4.1.3. Soil erodibility (clay ratio) indices

Result of this study indicates significant variation of erodibility indices between the two groups (Table 5), at confidence level of 95%, with mean erodibility indices 0.58 and 0.71 for *Juniperus* and *Eucalyptus* respectively. Furthermore erodibility indices vary along soil depth under *Eucalyptus*, but its variation is insignificant soil under *Juniperus*. However, soil of the study area is less prone to erosion because of its high proportion of clay, which help soil particle stick together.

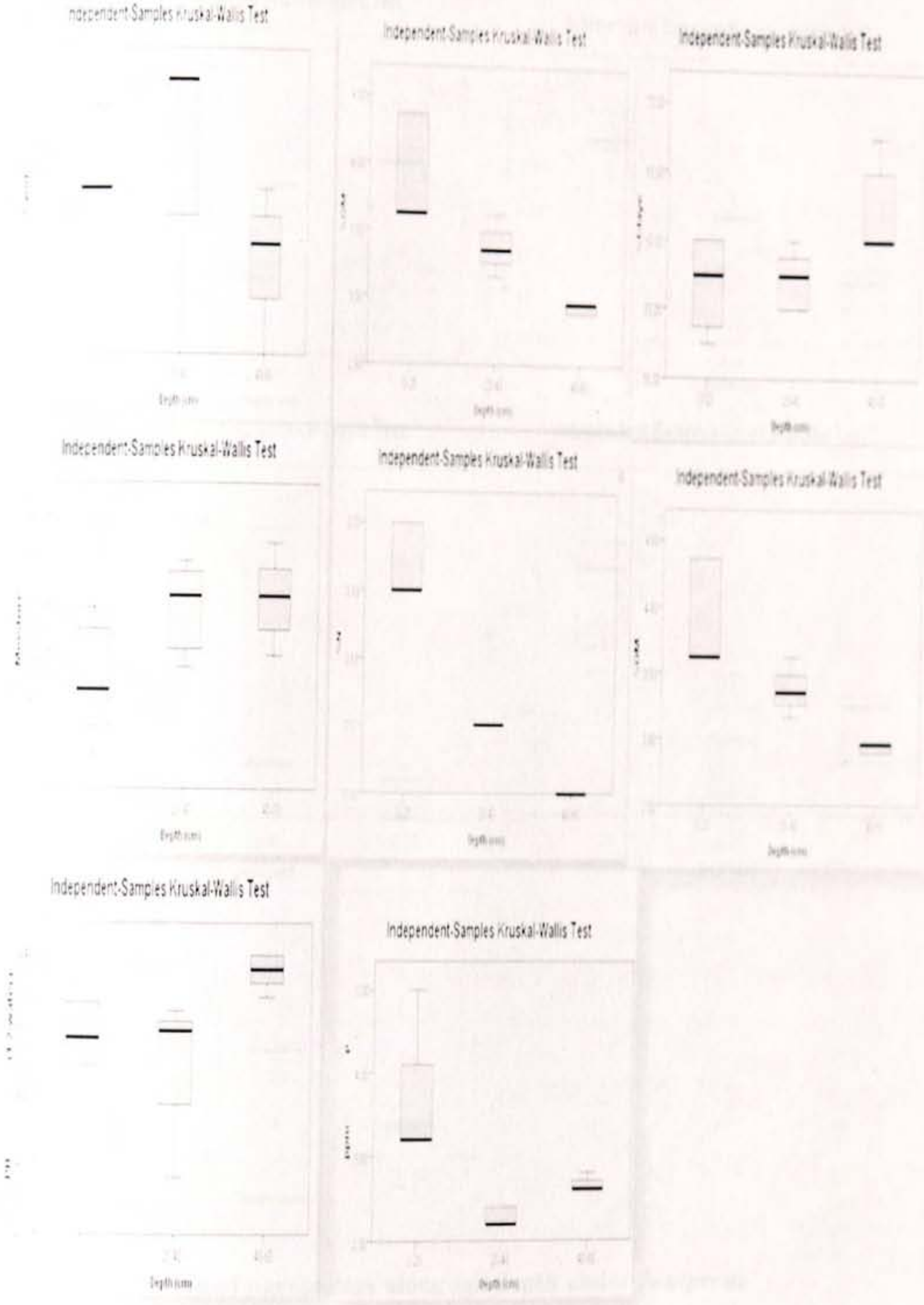

Figure 6Variation of parameters along soil depth under *Eucalyptus*

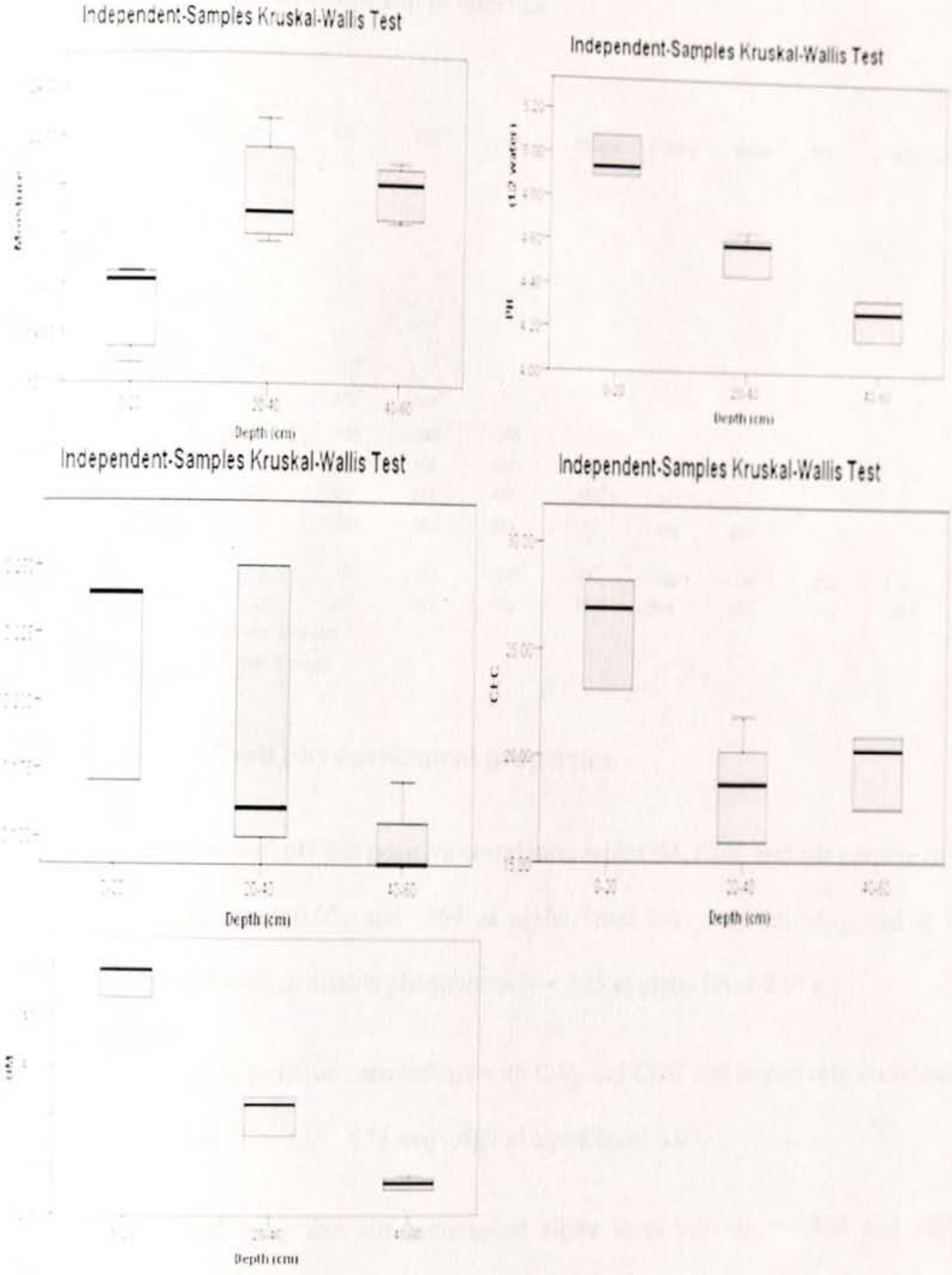

Figure 7 Variation of parameters along soil depth under *Juniperus*

Table 10 correlation of between soil properties

Pearson Correlation

	Depth (cm)	PH (1:2 water)	ppm P	%N	CEC	%OM	%Claye	%Sand	%Silte	BD	%Moisture	KIndix
Depth (cm)	1											
PH (1:2 water)	-.479**	1										
ppm P	-.184	-.395*	1									
%N	-.613**	.350	.135	1								
CEC	-.626**	.537**	.100	.519**	1							
%OM	-.873**	.770**	-.099	.575**	.783**	1						
%Claye	.478**	-.066	-.174	-.165	-.346	-.388*	1					
%Sand	-.150	-.338	.212	-.011	.102	.002	-.508**	1				
%Silte	-.395*	.369*	.005	.191	.292	.425*	-.656**	-.317	1			
BD	-.011	.096	.133	-.063	.064	.078	.111	-.151	.011	1		
%Moisture	.651**	-.253	-.167	-.487**	-.596**	-.563**	.471**	-.140	-.396*	-.059	1	
KIndix	-.507**	.061	.224	.217	.359	.402*	-.993**	.534**	.625**	-.119	-.467**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4.2. Correlation of soil physiochemical properties.

As shown in table 10, soil pH has positive correlation with OM, CEC and silt particle (r = .770, .537 at alpha level 0.05, and .369 at alpha level 0.01 respectively), and it is negatively correlated with available phosphorus (r =.395 at alpha level 0.01)

Total nitrogen also has positive correlations with OM and CEC and negatively correlates with moisture content (r = .519, .575 and -.487 at alpha level 0.05).

OM in correlate with clay and silt particles at alpha level 0.01 (r = -.388 and .425 respectively), and it also has positive correlation with soil moisture content at alpha level 0.05 (r = -.563).

Soil clay particles have positive relation with soil moisture content and negative correlations with sand and silt at alpha level 0.05 (r = .471, -.508, and -.656 respectively)

4.3. Correlation between physiochemical properties and soil depth

As shown in table 10, some soil physical and chemical properties are varies along soil depth. Moisture content and clay particles have positive correlation with soil depth (r = 0.651 and 0.478 respectively) at alpha 0.05, which indicate that they increase in accordance with increasing depth, in contrary to those soil depth has negative relation with some soil chemical properties such as soil acidity (pH), cation exchange capacity, total nitrogen and organic matter at alpha 0.05 and by far it has strong negative relation with soil moisture, at confidence level of 0.01 (r = 0.651). Indeed, when increase soil depth erodibility indices were decrease and this relation is confident at alpha 0.05.

4.4. Correlation between physiochemical properties and erodibility indices (clay ratio)

According to the findings of this study there are positive significant relationships between the erodibility indices with sand and silt particles (r = 0.534 and 0.625 respectively), and were significant at alpha level 0.05. Other parameter that has strong positive correlations with erodibility indices is OM, they are correlated at alpha level 0.01 and there (r = 0.402). On the other hand, clay content of soil has correlate negatively having (r = 0.993) at alpha level of 0.05. And it also negatively correlates with moisture content (r = 0.407 at alpha 0.05) (Table 10).

Chapter five

5. Discussion, conclusion and recommendations

5.1. discussion

The study area is categorized to highland of Ethiopia, in addition to population pressure there is prominently *Eucalyptus* were plantation, which is not indigenous and worldwide controversial tree (Dessie and Erkossa, 2011). Therefore, the findings of study indicate that *Eucalyptus* plantations have both positive and negative impacts on soil in comparison to *Juniperus*.

5.1.1. Soil physical property

The soil type of the study area is *Humic Nitosols,* typically clay dominated soil and profound in tropic. Farther more it is more productive soil type. The relevance of clay on the availability of nutrients in the soil has been acknowledged by researchers, for example, Aweto (1981) suggested that clay proportion in the soil strongly affects tree regeneration. The result of this study shows that amount of clay under *Juniperus* is by far greater than soil under *eucalyptus,* this indicate that, either due to the species or due to anthropogenic factor clay content were reduced, productivity of soil under *Eucalyptus* is relatively lower since clay is involved in almost every reaction in soils which affects plant growth. The amount sand is an indicator for soils drainage and aeration constituents and in this regard, soil under *Eucalyptus* was better.

Soil bulk density is a commonly measured parameter in forest soil studies to assess harvesting effects on forest soil quality such as compaction induced by logging or site preparation practices (Powers, 1999), the result shows that there was no significant variation that imposed by *Eucalyptus* trees. There is also no statistically significant effect long the soil depth in comparison with *Juniperus*, even though typically bulk density increases with soil depth since subsurface layers have reduced organic matter. Generally, mean values shows, soil under both stands were good situation under since the values below < 1.47 g/cm3, which is critical value for clay soil, above it restrict root growth.

5.1.2. Soil chemical property

In general, soil organic matter has tremendous advantages in the improvement of soil physical, chemical and biological properties. Some of detail advantages of OM are stabilizes soil structure, improves water holding capacity, lowers bulk density, increases CEC, acts as a pH buffer, ties up metals, supplies energy and body building constituents for soil organisms, and by doing so increases microbial population and their activities, (Woldegiorgis, 2007). Even though there was no significant variation on total amount of OM that resulted tree species (Table 7), but as to the result shown above in table 7a and b, at first soil depth interval OM under *Eucalyptus* and *Juniperus* is fall to categories of moderate and high OM class respectively according to Ilaco (1985) rating. This difference may came from improper usage of litter fall for fuel consumption or allelophatic exudates from *Eucalyptus* tree species resulted inhibiting effect on the undergrowth vegetation, regeneration and growth of understory, which indirectly decrease the amount necrotic plant tissue accumulation at soil surface.

The other influential soil chemical property is pH, which affects the solubility and availability of many elements as well as microbial activity (Marschner, 1995). An acid soil commonly has concentrations of Al or Mn that are high enough to be toxic to some plants. This study also verify the increasing effect of *Eucalyptus* plantation, soil acidity was high in comparison to soil under *Juniperus* plantation. Moreover, Zewdie (2008) come up with the change which takes place in the chemical status of the soil surface is because the litter layer and organic matter becomes dominated by one species. The high acidity in *Eucalyptus* forests is attributed to the fact that *Eucalyptus* leaves have phenolic acids tannin and flavonoids (Zewdie, 2008).

Soils with low CEC have little resilience and cannot build up stores of nutrients. The clay content, the clay type and the organic matter content all determine the total nutrient storage capacity (Woldegiorgis, 2007), *Eucalyptus* has no effect of with regard to CEC, since result shows the difference in mean values are not statistically significant at 0.05 alpha levels.

5.1.3. Soil erodibility (clay ratio) indices

Soil erodibility indices, clay ratio (C.R) in the case of this study shows high percent under *Eucalyptus* than *Juniperus* , this may resulted from difference of texture, soil texture determines the ease with which agents of erosion or destruction can detach a soil, and coarse textured soils are more easily detached than medium or fine textured soils (Wischmeier & Mannering 1969). Fine-textured soils that are high in clay have low erodibility values because the particles are resistant to detachment. This deduction is further more supported by Asiegbu (1980) and had reported that erodibility of the soil will increase with low values of clay particles. The same scenario was found during this study, comparative examination of soil erodibiliti under two different dominant species.

Beyond to this, soil particles distributions were determined by different chemical property, according to Evans (1980) opinion organic and chemical constituents of the soil are important because of their influence on stability of aggregates.

5.2. Conclusion

The fact that soil erodibility indices under *Eucalyptus* were greater than those under native forest of *Juniperus* indicates there is no sustainability of the environment, under *Eucalyptus*, regarding erosion. This may have resulted from variation of physicochemical properties.

Organic matter in the soil reduces erodibility because it produces compounds that bind particles together, increasing aggregation and reducing the susceptibility of the particles to detachment by raindrop impact and surface runoff. Also, organic matter improves biological activity and increases infiltration rates, which reduces runoff and erosion. Morgan (2001) suggested that soil erodibility decreases linearly with increasing organic content over the range of 0 to 10%. Variation of erodibility which occurs between *Eucalyptus* and *Juniperus* plantations may have resulted from organic matter of soil, and differences in OM may have affected quality of litter, rate of decomposition and human interference by removal of litter fall for fuel consumption.

Even though, the soil was developed from the same parent material, there are differences in percentage of clay and sand, which may occur due to root morphology of the plants. *Eucalyptus* is deep rooted plant, therefore its contribution of anchoring surface soil may be less when its compare to *Juniperus*.

Acidity of the soil is relatively high under *Eucalyptus* than *Juniperus*. On the other hand available phosphorus, by taking advantage of soil acidity, is higher under *Eucalyptus* than *Juniperus*.

5.3. Recommendation

In order to mitigate soil erosion first and foremost all the community need to be made aware what land productivity or soil quality is and what factors affect soil erosion.

Even though, *Eucalyptus* plantation has impact on soil erodibility, the magnitude of impact could be reduced using appropriate silvicultural methods. During planting *Eucalyptus* is practiced, one needs to think about spacing for the sake of reducing competition. By doing so it is possible to reduce amount of allelopathic chemicals that they produce.

Removing litter is also the other factor that is responsible for increasing erosion and reduces soil quality through affecting soil physicochemical properties. Therefore, it is important that the communities are restricted from daily removal of litter for fire consumption.

And if it is possible, replacing *Eucalyptus* using indigenous trees specially those having good quality on developing soil quality and reducing erosion, particularly in highland and sloppy areas, is advisable.

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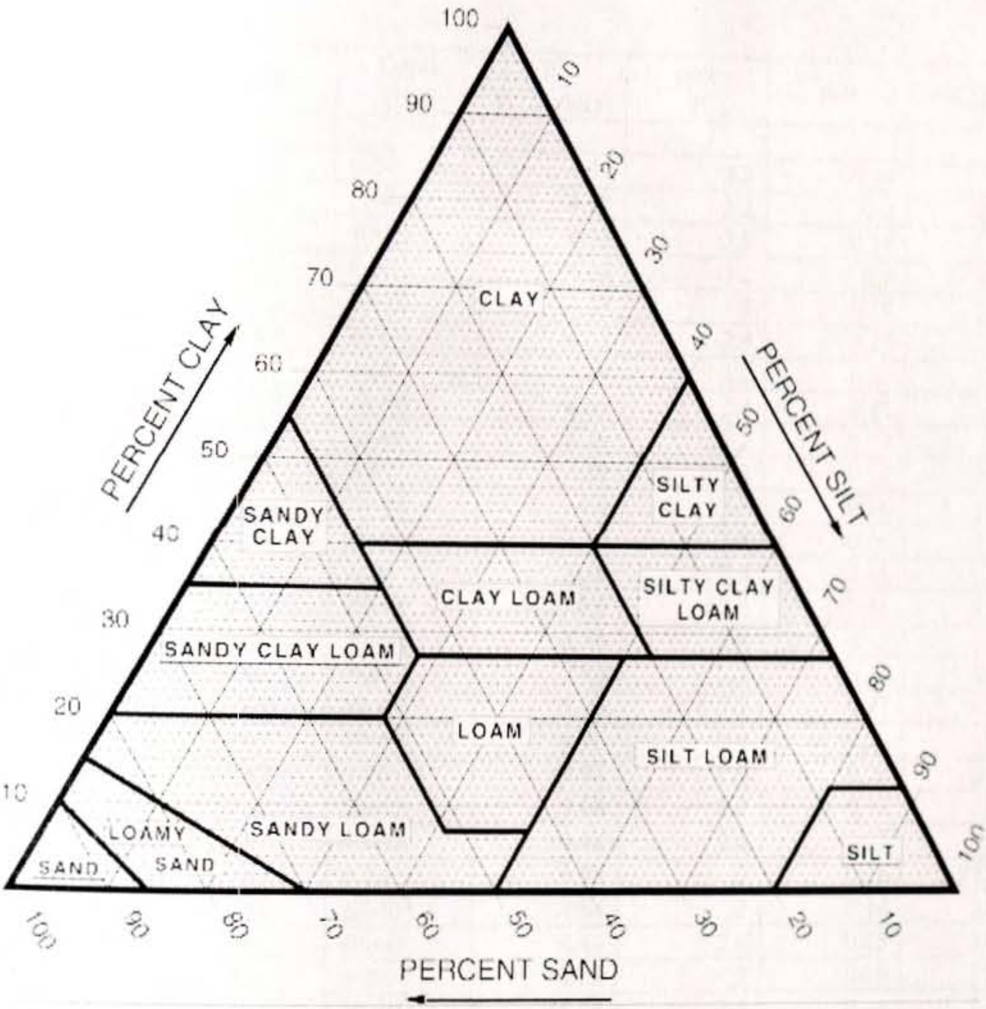
Appendix

Appendix 1:

The USDA soil texture triangle



Appendix2:

aboratory result

Holetta Agricultural Research Center

Soil and plant Analysis Laboratory

Result Delivery Sheet

Lab No	Filed No.	Depth (cm)	P^H (1:2 water)	ppm P	%N	CEC	%OC
10971	EV1	0-20	4.33	3.2	0.19	24.2	2.53
10972	EV1	20-40	4.24	3.2	0.2	19.92	2.1
10973	EV1	40-60	4.33	3.2	0.19	24.2	2.53
10974	EV2	0-20	4.24	3.2	0.2	19.92	2.1
10975	EV2	20-40	4.28	5	0.19	21.58	2.1
10976	EV2	40-60	4.32	2.4	0.17	18.44	2.1
10977	EV3	0-20	4.29	2.2	0.17	17.52	1.95
10978	EV3	20-40	4.08	2.4	0.17	21.14	1.83
10979	EV3	40-60	4.29	2.2	0.17	17.52	1.95
10980	EV4	0-20	4.29	2.2	0.17	17.52	1.95
10981	EV4	20-40	4.4	2.6	0.16	18.72	1.72
10982	EV4	40-60	4.34	2.8	0.16	17.06	1.72
10983	EV5	0-20	4.38	2.6	0.16	18.4	1.68
10984	EV5	20-40	4.4	2.6	0.16	18.72	1.72
10985	EV5	40-60	4.38	2.6	0.16	18.4	1.68
10986	Jn1	0-20	4.89	2.2	0.24	28.26	2.88
10987	Jn1	20-40	5.08	2.2	0.17	23.1	2.72
10988	Jn1	40-60	4.93	2.4	0.24	26.9	2.88
10989	Jn2	0-20	4.89	2.2	0.24	28.26	2.88
10990	Jn2	20-40	5.08	2.2	0.17	23.1	2.72
10991	Jn2	40-60	4.44	2.6	0.25	18.62	1.91
10992	Jn3	0-20	4.58	2	0.16	15.92	2.14
10993	Jn3	20-40	4.64	2	0.14	21.82	2.1
10994	Jn3	40-60	4.44	2.6	0.25	18.62	1.91
10995	Jn4	0-20	4.58	2	0.16	15.92	2.14
10996	Jn4	20-40	4.34	2.4	0.14	17.48	1.6
10997	Jn4	40-60	4.16	2.6	0.14	20.96	1.64
10998	Jn5	0-20	4.28	3.2	0.17	20.3	1.68
10999	Jn5	20-40	4.34	2.4	0.14	17.48	1.6
10988	Jn5	40-60	4.16	2.6	0.14	20.96	1.64

Result Checked by Alemayehu Tereffe

Signature ____________

Lab No	Filed No.	PSA		
		% Claye	% Silte	%Sand
10941	EV1	60.00	30.00	10.00
10942	EV1	55.00	30.00	15.00
10943	EV1	60.00	32.50	7.50
10944	EV2	60.00	27.50	12.50
10945	EV2	57.50	27.50	15.00
10946	EV2	67.50	30.00	2.50
10947	EV3	55.00	30.00	15.00
10948	EV3	57.50	27.50	15.00
10949	EV3	60.00	30.00	10.00
10950	EV4	52.50	37.50	10.00
10951	EV4	55.00	30.00	15.00
10952	EV4	62.50	30.00	7.50
10953	EV5	57.50	32.50	10.00
10954	EV5	60.00	37.50	2.50
10955	EV5	60.00	32.50	7.50
10956	Jn1	55.00	40.00	5.00
10957	Jn1	57.50	35.00	7.50
10958	Jn1	62.50	35.00	2.50
10959	Jn2	62.50	35.00	2.50
10960	Jn2	62.50	35.00	2.50
10961	Jn2	65.00	32.50	2.50
10962	Jn3	62.50	35.00	2.50
10963	Jn3	77.50	20.00	2.50
10964	Jn3	75.00	17.50	7.50
10965	Jn4	55.00	30.00	15.00
10966	Jn4	70.00	25.00	5.00
10967	Jn4	72.50	20.00	7.50
10968	Jn5	57.50	35.00	7.50
10969	Jn5	62.50	30.00	7.50
10970	Jn5	62.50	20.00	17.50

Result Checked by Alemayehu Tereffe

Signature ____________

Lab No	Filed No.	Depth (cm)	BD	% Moisture
10911	EV1	0-20	1.16	16.14
10912	EV1	20-40	1.18	19.09
10913	EV1	20-40	1.17	18.46
10914	EV2	0-20	1.21	13.97
10915	EV2	20-40	1.15	19.99
10916	EV2	40-60	1.67	20.80
10917	EV3	0-20	1.27	14.38
10918	EV3	20-40	1.24	18.49
10919	EV3	40-60	1.18	18.47
10920	EV4	0-20	1.21	17.91
10921	EV4	20-40	1.13	16.97
10922	EV4	40-60	1.24	18.13
10923	EV5	0-20	1.22	11.48
10924	EV5	20-40	1.16	15.36
10925	EV5	40-60	1.19	15.89
10926	Jn1	0-20	1.08	16.42
10927	Jn1	20-40	1.00	18.31
10928	Jn1	40-60	1.21	18.54
10929	Jn2	0-20	1.22	12.76
10930	Jn2	20-40	1.16	22.70
10931	Jn2	40-60	1.15	18.81
10932	Jn3	0-20	1.35	16.54
10933	Jn3	20-40	1.24	18.96
10934	Jn3	40-60	1.16	20.49
10935	Jn4	0-20	1.32	14.09
10936	Jn4	20-40	1.12	20.35
10937	Jn4	40-60	1.11	20.98
10938	Jn5	0-20	1.20	16.12
10939	Jn5	20-40	1.19	17.72
10940	Jn5	40-60	1.13	20.11

Result Checked by
Alemayehu Tereffe