ASSESSEMENT OF PHYSICOCHEMICAL PROPERTIES OF SOILS UNDER DIFFERENT LAND USE TYPES IN DEBELLO KEBELE, LIMU KOSSA DISTRICT, JIMMA ZONE, SOUTHWEST ETHIOPIA

ARESEARCH PAPER SUBMITTED TO SCHOOL OF GRADUTE STUDIES JIMMA UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIRMENT FOR THE DEGREE OF MASTER SCIENCE IN INORGANIC CHEMISTRY

By:

WAKSHOME TOLERA

ADVISORS:

1. GEBRU GEBRETSADIK (PhD Candidate)

2. TILAHUN WUBALEM (M. Sc)

OCTOBER, 2010/ 2017

JIMMA, ETHIOPIA

Table of contents

Contents   **Page**

LISTS OF TABLES

Table   **page**

List of figures

List of Tables in Appendix

Lists of figures in appendix

ACKNOWLEDGMENTS

LIST OF ACRONYMS AND ABBREVIATIONS

ARDO   Agricultural and Rural Development Office

Av.P   Available phosphorus

BD   Bulk Density

CL   Cultivated Land

CV   Cumulative Variance

CEC   Cation Exchangeable Capacity

DTPA   Diethylene Tri amine Penta Acetic acid

EC   Electrical Conductivity

EA   Exchangeable Acidity

FAO   Food and Agriculture Organization

FL   Forest Land

GIS   Geographical Information System

GPS   Global Positioning System

GL   Grazing Land

LUT   Land Use Type

LSD   Least Significant Different

LGM   Linear General Model

MAP   Mono Ammonium Phosphate

OC   Organic Carbon

PD   Particle Density

SOM   Soil Organic Matter

SAS   Statistical Analysis System

TN   Total Nitrogen

TEA   Tri Ethanol Amine

TSP   Triple Super Phosphate

.

Abstract

The study was conducted at the Debello Kebele, located in the Limu Kossa District of Jimma Zone in the Oromia Regional State. The purpose of the study was to determine the level of selected soil physiochemical properties of the three land use types (cultivated, graze and forest lands) based on the soil depths from 0-20 cm and 20-40 cm. The soil samples were collected from representative land uses with its replications then, finally eighteen total composite soil samples were collected from depths under six soil samples. Generally, comparisons between cultivated, grazing and forest land use types revealed a high significant difference on major soil fertility parameters. Soil texture (sand, silt and clay) studied was significantly affected ($P \leq 0.05$) by land use. In contrast, the other physical properties such as bulk density, particle density, total porosity were not significantly ($P > 0.05$) different. Among land use types, the highest mean clay (69.84%) and bulk density 1.32 g/cm^3 values were obtained in the cultivated land. Considering the land use types, the highest soil pH (H_2O) (5.13) and the lowest (4.5) were recorded in the subsurface soil layer of forest and surface soil layer of cultivated land, respectively. Moreover, the range of (4.5-5.13) soil reaction in the surface and subsurface layers of all land use types of the study area were strongly acidic with pH (H_2O) as well as pH (KCl).On the other, hand the highest average mean values of available P (9.13 mg/Kg), and SOM (6.79%) were recorded in the surface soil layer of the cultivated and forest lands. In addition, the highest mean values of available EA (4.13 cmo (+)/Kg), CEC (41.50)cmol(+)/kg) and TN (0.34%) were recorded in the surface soil layer of the cultivated land ,but TN in the forest land. The mean value of exchangeable bases (Na, K, Ca and Mg) were higher (0.24, 1.58, 8.67, and 5.75 cmol(+)/kg) on the subsurface of the forest land .The contents of available micronutrients (Fe, Mn, Zn and Cu) under the different land management practices were significantly different ($P \leq 0.05$) . The highest mean values Fe (27.42 cmol (+)/Kg),Cu (3.41 cmol (+)/Kg) ,Zn (2.99 cmol (+)/Kg)were obtained at surface layer cultivated land but, Mn(48.20 cmol (+)/Kg) obtained at surface layer forest land .

Key words/phrases: land use types, soil depth. Physicochemical properties and soil fertilit

1. INRODUCTION

Soil consists of a complex mixture of particulate materials derived from a biotic parent minerals, living biota and particulate organic detritus and humus substances. Soil is a complex ecosystem where living organisms play a key role in the maintenance of its properties[1]. It is a highly complex medium influence by environmental and physicochemical parameters, creating a varied habitat for a diverse range of soil microorganisms. Soil formation is influenced by climate (temperature and moisture), parental material, time, topography, and organisms, involve complex interactions between physical, chemical and biological processes [2]. In addition, soil texture (the relative proportion of particles of different sizes) and mineral constituents depend on the parent material (rocks) and the distribution of pores of various sizes that occur between soil particles are important factors which make soil complete resource [3].

Successful agriculture requires the sustainable use of soil resource, because soils can easily lose their quality and quantity within a short period of time for many reasons. Agricultural practice therefore requires basic knowledge of sustainable use of the land in ordered conserve soil fertility. Soil fertility is the quality of a soil to supply nutrients in proper amounts without causing toxicity, whereas soil productivity is the capacity of a soil to produce a specific crop or sequences of crops at a specific management system. Soil fertility and plant nutrition are two closely related subjects that emphasize the forms and availability of nutrients in soils, their movement to and their uptake by roots, and the utilization of nutrients within plants [4]. Therefore the monitoring of soil process studies in relation to crop growth and yield, as well as considerations on economic benefits arising from the use of these external resources seem to have been slightly decreased[5].

 Land use types that involve conversion of natural forests to farmlands and open grazing are widely practiced in the highlands of Ethiopia. The effects of such land use changes on soil resources of the country, particularly through soil erosion, have been reported in

many scientific literatures [6, 7, 8]. The massive soil loss in the country is caused by its' susceptibility to erosion due to the mountainous landscape coupled with mismanagement, intense rainfall and cultural practices of the farming community that leave the soil bear after harvest. The soil losses its physical and chemical properties due to erosion, vegetation removal, deforestation, leaching, and chemicals removed from industries as result of biological degradations (decline of soil humus content) [9,10]. Soil degradation refers to the reduction in soil fertility due to various human managements.

It is this variability of human activities (biomass burning, application of fertilizer, transfer of species, after clearing plowing the land *etc*.,). Studying the physicochemical properties of soil is important for sustainable management of the agricultural resources and economic growth. Physicochemical properties change is the main reasons for nutrient depletion as well as causes of fertility decline that affects crop production. Environmental degradation caused by inappropriate land use is a worldwide problem that has attracted attention in sustainable agricultural production systems.

Ethiopia is considered to be one of the developing countries where agriculture had always played a central role in the country's economy. Although agriculture has always been the mainstay of the economy, it is characterized by very low growth rate. The rapidly increasing population has led to a declining availability of cultivated land and a very high rate of soil erosion. It is apparent that soil is one of the most important and determinant factors that strongly affects crop production. Soil is the foundation resource for nearly all land uses, and the most important component of sustainable agriculture [11]. Therefore assessment of soil quality indicators (physical, chemical and biological soil indicators with respect to land use types, management practices and slope classes is useful and primary indicator for sustainable agricultural land management. Understanding the effect of these factors on soil physicochemical properties is useful for devising land management strategies [12]. Therefore this research was initiated to investigate the influence of different land use types on selected physicochemical

properties of the soil in Debello kebele, Limu Kossa District, Oromia regional Satate, Southwest Ethiopia.

1.1 Statement of the problem

This study concentrated on the assessment of soil physiochemical properties under different land uses based on depths. The types of land use that were considered under this study are: cultivated land, grazing land, plantation and the adjacent natural forests and its implications on sustainable soil resources management. Physicochemical properties of soil in the study area would be exposed by the land use change that can decrease soil fertility. Also high rain fall, erosion, intensive cultivation, and traditional farming were observed in the study area. Since all those factors can affect soil fertility which is closely related physicochemical properties that emphasize the health of soils [4]. Without maintaining soil fertility, one cannot talk about increment of agricultural production in feeding the alarmingly increasing population. To get optimum, sustained-long lasting and self-sufficient crop production, physicochemical properties soil has to be assessed and maintained through time. Therefore this research was initiated to investigate the influence of different land use types on selected physical and chemical properties of the soil in the study area.

This study may answer the following questions:

Which soil physical properties are more affected by land use, soil depth and the interaction of land use by soil depth?

Which soil chemical properties are more affected by land use, soil depth and the interaction of land use by soil depth?

Which land use types need improvement (treatment) of physicochemical properties in the study area?

1.2. Objectives of the Study

1. 2.1 .General Objective

To assess the selected physiochemical properties of soil under different land use types based on the depth in the study area.

1.2.2. Specific Objectives

To determine selected physicochemical properties of soil under different land use types in the study area.

To compare the selected physiochemical properties of soil among the three land use types and depth.

To identify which land use type most affected by physicochemical properties change and need treatment for productivity.

1.3 Significance of the study

The significance of the study was evaluating selected physicochemical properties of soil different land use types in the study area. The aim of this study was to provide information about physicochemical properties soil in different land use types based on soil depths. It may indicate land use type that needs improvement of soil physiochemical properties in order to maintain soil productivity. Studying physiochemical properties soil is important for sustainable management of the agricultural resources and economic growth. Finally, the result of this study can serve as reference point for the concerned bodies to know the capacity of selected physiochemical properties of the study area.

2. **LITERATURE REVIEW**

2.1 Land Use types

Soil has three important and interrelated physical, chemical and biological properties, which makes it functionally complete resources. The inherent characteristics of soil which are mainly the resultant of parent material and climate undergo subtle change due to different land management practices. Soil characteristics such as soil organic matter (SOM), aggregation and aggregate stability [13], bulk density, and water retention [14], pH and nutrient status [15], and soil biota [16] tend to change depending on land use, climate and vegetation.

Land use changes are operating over an immeasurably greater proportion of the globe's land area. Different time spans have been observed for the occurrence of these changes after sedentary agriculture was started. Some changes were very short and of an exploitative nature, while others were long and stable [17]. Indeed, changes in land use cover have significant effect on the amount and diversity of biomass returned to the soil, which also disrupt the richness of nutrient restored to the soil. It is perhaps a known fact that soil erosion intensity and amount of nutrient element loss varies depending on the vegetation type at a particular place and time. This is so because, the rate of nutrient element loss in both dissolved and sediment bound forms will depend on the ability of vegetation canopy to effectively intercept the direct impact of raindrops that strike the soil surface. In developing countries, including Ethiopia, the amount, rate and intensity of land use changes are very high. Human impacts upon the land are still very great and increasing [18]. Extensive deforestation and conversion of natural forests into agricultural fields is the most widespread change in land use system in Ethiopian ecosystems. In the past 100 years only, the total area of land covered by forest in Ethiopia has declined from about 40% to an estimated 2.4% in 1990 [19]. The rate of deforestation is estimated to be between 150,000 and 200,000 ha per annum [20] from which as a result one can see the scale of clearance has been massive. Destruction continued unabated especially in south

and the south western parts of the country where most of the remnant sub humid tropical forests are found [21].

Land use change is caused by a number of natural and human driving forces [22]. Natural effects such as climate change are felt only over a long period of time, while the effects of human activities are immediate and often radical. According to [23] changes are due to resource management strategies in terms of agriculture and livestock grazing, which significantly influence land use and in turn drives land use changes. Hence, changes in land use are, in most cases, reflections of the dynamics of socioeconomic development [24].

2.2. Soil Physical Properties

The physical properties of soils determine their adaptability to cultivation and the level of biological activity that can be supported by the soil. Soil physical properties also largely determine the soil's water and air supplying capacity to plants. Many soil physical properties change with changes in land use system and its management such as intensity of cultivation, the instrument used and the nature of the land under cultivation, rendering the soil less permeable and more susceptible to runoff and erosion losses [25].

2.2.1. Soil Texture

Texture refers to the relative proportions of particles of various sizes such as sand, silt and clay in the soil. The particles that make up soil are categorized into three groups by size sand, silt and clay. Sand particles are the largest and clay particles the smallest. Most soils are a combination of the three. The relative percentages of sand, silt, and clay are what give soil its texture. A clay loam texture soil, for example, has nearly equal parts of sand, slit, and clay. These textural separates result from the weathering process. Soil texture is one of the inherent soil physical properties less affected by management. The rate of increase in stickiness or ability to mould as the moisture content increases depend on the content of silt and clay, the degree to which the clay particles are bound together

into stable granules and the OM content of the soil [26]. Over a very long period of time, pedogenic processes such as erosion, deposition, eluviations and weathering can change the textures of various soil horizons [27, 28].Soil texture determines a number of physical and chemical properties of soils. It affects the infiltration and retention of water, soil aeration, absorption of nutrients, microbial activities, and tillage and irrigation practices [29]. It is also an indicator of some other related soil features such as type of parent material, homogeneity and heterogeneity within the profile, migration of clay and intensity of weathering of soil material or age of soil [30].

2.2.2 Bulk density

Soils are composed of solids (minerals and organic matter), and pores which hold air and water. The bulk density of a soil sample of known volume is the mass (or weight) of that sample divided by the bulk volume. The "ideal" soil would hold sufficient air and water to meet the needs of plants with enough pore space for easy root penetration, while the mineral soil particles would provide physical support and plant essential nutrients. Soil bulk density is a basic soil property influenced by some soil physical and chemical properties. Bulk density is influenced by the amount of organic matter in soils, their texture, constituent minerals and porosity [31].

Knowledge of soil bulk density is essential for soil management, and information about it is important in soil compaction as well as in the planning of modern farming techniques. Soil bulk density measurements are often required as an input parameter for models that predict soil processes. Such models often use bulk density measurements to account for horizon mass when aggregating soil data. Methods to measure bulk density are labor intensive and time-consuming. Thus, models have been developed to predict bulk density from soil physical and chemical data [32, 33]. Bulk density typically increases with soil depth since subsurface layers are more compacted and have less organic matter, less aggregation, and less root penetration compared to surface layers, therefore contain less pore space. Bulk density normally decreases as mineral soils become finer in texture. Soils

having low and high bulk density exhibit favorable and poor physical conditions, respectively. Bulk densities of soil horizons are inversely related to the amount of pore space and SOM [28, 29]. Any factor that influences soil pore space will also affect the bulk density. For instance, intensive cultivation increases bulk density resulting in reduction of total porosity. Bulk density can be changed by management practices that affect soil cover, organic matter, soil structure, compaction, and porosity. Excessive tillage destroys soil organic matter and weakens the natural stability of soil aggregates making them susceptible to erosion caused by water and wind. When eroded soil particles fill pore space, porosity is reduced and bulk density increases.

The study results of [11, 34] revealed that the bulk density of cultivated soils was higher than the bulk density of forest soils. Soil bulk density increased in the 0-10 and 10-20 cm layers relative to the length of time the soils were subjected to cultivation [11]. Similarly, Ahmed reported that soil bulk density under both cultivated and grazing lands increased with increasing soil depth [35] . On the other hand, [36] reported that bulk density was higher at the surface than the subsurface horizons in the abandoned and lands left fallow for twelve years. The changes in the physical soil attributes on the farm fields can be attributed to the impacts of frequent tillage and the decline in SOM content of the soil.

2.3 Particle Density

Particle density is the mass or weight of a unit volume of soil solids. It affects soil porosity, aeration and rate of sedimentation of particles. The mean particle density of most mineral soils is about 2.60 to 2.75 g/cm^3, but the presence of iron oxide and heavy minerals increases the average value of particle density and the presence of OM lowers it [37]. According to [35], the surface soil layer had lower particle density value than the subsoil horizons and the higher particle density (2.93 g/cm^3) was obtained at the subsoil horizons in different land use systems at different elevation. This is attributed to the lower OM content in the subsoil than in the surface horizons.

2.2.4 Porosity

Porosity is the fraction of the total soil volume that is taken up by the pore space. Thus it is a single-value quantification of the amount of space available to fluid within a specific body of soil. Being simply a fraction of total volume can range between 0 and 1, typically falling between 0.3 and 0.7 for soils. With the assumption that soil is a continuum, adopted here as in much of soil science literature, porosity can be considered a function of position [38]. A soil's porosity and pore size distribution characterize its pore space, that portion of the soil's volume that is not occupied by or isolated by solid material. The basic character of the pore space affects and is affected by critical aspects of almost everything that occurs in the soil: the movement of water, air, and other fluids; the transport and the reaction of chemicals; and the residence of roots and other biota. Porosity is often conceptually partitioned into two components, most commonly called textural and structural porosity.

The textural component is the value the porosity would have if the arrangement of the particles were random, as described above for granular material without cementing. That is, the textural porosity might be about 0.3 in a granular medium. The structural component represents nonrandom structural influences, including macro pores and is arithmetically defined as the difference between the textural porosity and the total porosity [39]. The texture of the medium relates in a general way to the pore-size distribution, as large particles give rise to large pores between them, and therefore is a major influence on the soil water retention curve. Additionally, the structure of the medium, especially the pervasiveness of aggregation, shrinkage cracks, worm-holes, etc. substantially influences water retention [40].

2.3. Soil Chemical Properties

Soil chemical properties are the most important among the factors that determine the nutrient supplying power of the soil to the plants and microbes. The chemical reactions that occur in the soil affect processes leading to soil development and soil fertility build

up. Minerals inherited from the soil parent materials overtime release chemical elements that undergo various changes and transformations within the soil.

2.3.1. Soil reaction (pH)

Soil pH is a measure of soil acidity or alkalinity. It is an important indicator of soil health. It affects crop yields, crop suitability, plant nutrient availability, and soil micro-organism activity which influence key soil processes. Soil pH can be managed by measures such as applying the proper amount of nitrogen fertilizer, liming, and cropping practices that improve soil organic matter and overall soil health. Soil reaction, or pH, is one very important property that has great influence on the growth of soil microorganisms and higher plants and on the soil management required for satisfactory crop production. Descriptive terms commonly associated with certain ranges in pH are extremely acidic (pH < 4.5), very strongly acidic (pH 4.5-5.0), strongly acidic (pH 5.1-5.5), moderately acidic (pH 5.6-6.0), slightly acid (pH 6.1-6.5), neutral (pH 6.6 -7.3), slightly alkaline (pH 7.4-7.8), moderately alkaline (pH 7.9-8.4), strongly alkaline (pH 8.5-9.0), and very strongly alkaline (pH > 9.1) [4].

 The pH of newly formed soils is determined by minerals in the soil's parent material. Temperature and rainfall control leaching intensity and soil mineral weathering. In warm, humid environments, soil pH decreases over time in a process called soil acidification, due to leaching from high amounts of rainfall. In dry climates, however, soil weathering and leaching are less intense and pH can be neutral or alkaline. Soils with high clay and organic matter content are more able to resist a drop or rise in pH (have a greater buffering capacity) than sandy soils. Although clay content cannot be modified, organic matter content can be changed by management. Sandy soils commonly have low organic matter content, resulting in a low buffering capacity, high rates of water percolation and infiltration making them more vulnerable to acidification [41,42].

Increasing soil acidity in crop production systems is caused by use of commercial fertilizers, especially ammonium (NH_4^+) sources that produce H^+ during nitrification;

crop removal of cat ion in exchange for H^+; leaching of cat ion being replaced first by H^+ and subsequently by Al^{3+}; and decomposition of organic compounds [43]. Fertilizer materials vary in their soil reaction pH. Nitrate sources carrying basic cat ions should be less acid forming than NH_4^+ sources. Phosphoric acid released from dissolving P fertilizers such as triple superphosphate (TSP) and mono ammonium phosphate (MAP) can temporarily acidify localized zones at the site of application. TSP will reduce soil pH to as low as 1.5, whereas MAP will decrease pH to approximately 3.5; however the quantity of H^+ produced is very small and has little long term effect of soil pH. Di-ammonium phosphate (DAP) will initially raise soil pH to about 8.0, unless the initial soil pH is greater than the pH of the fertilizer. Acidity produced by the nitrification of the NH_4^+ in DAP will offset this initial pH increase [44].

2.3.2. Electrical Conductivity

Soil electrical conductivity (EC) is a measurement that correlates with soil properties that affect crop productivity, including soil texture, cat ion exchange capacity (CEC), drainage conditions, organic matter level, salinity, and subsoil characteristics. In addition to overcoming some of the ambiguities of total dissolved salts measurements, the EC measurement is quicker and sufficiently accurate for most purposes [45]. Excessive accumulation of soluble salts convert soils to salt affected soils and the process leading to accumulation of salts are common in arid and semi arid regions where rainfall amount is insufficient to leach soluble salts. The electrical conductivity of soils varies depending on the amount of moisture held by soil particles. Sands have a low conductivity, silts have a medium conductivity, and clays have a high conductivity. Consequently, EC correlates strongly to soil particle size and texture. In addition to EC values separating variations in soil texture, EC has been shown to relate closely to other soil properties used to determine a field's productivity [46].

2.3.3 .Organic Matter

Soil organic matter is the fraction of the soil that consists of plant or animal tissue in various stages of breakdown (decomposition).Most of our productive agricultural soil has between 3 and 6% organic matter. Soil organic matter contributes to soil productivity in many different ways. In this fact sheet, we describe the various components of organic matter and the different roles organic matter plays in soil productivity. We also discuss field management practices that will help preserve or increase soil organic matter levels overtime. Soil organic matter is heterogeneous or non-uniform in nature and does not have any defined physical or chemical structure. It can be present in soils under various stages of decomposition from mineral associated partially decomposed plant material to fully decomposed humus [47].

 Soil organic matter (SOM) is the organic component of soil, consisting of three primary parts including small (fresh) plant residues and small living soil organisms, decomposing (active) organic matter, and stable organic matter (humus). Soil organic matter serves as a reservoir of nutrients for crops, provides soil aggregation, increases nutrient exchange, retains moisture, reduces compaction, reduces surface crusting, and increases water infiltration into soil [4]. Components vary in proportion and have many intermediate stages. Plant residues on the soil surface such as leaves, manure, or crop residue are not considered SOM and are usually removed from soil samples by sieving through a 2 mm wire mesh before analysis.

Soil organic matter content can be estimated in the field and tested in a lab to provide estimates for Nitrogen, Phosphorus and Sulfur mineralized available for crop production and adjust fertilizer recommendations. Soil organic matter impacts the rate of surface applied herbicides along with soil pH necessary to effectively control weeds. Soil organic matter impacts the potential for herbicide carryover for future crops, and amount of lime necessary to raise pH. The addition of organic matter to the soil usually increases the water holding capacity of the soil. This is because the addition of organic matter increases the number of microspores and macrospores in the soil either by "gluing" soil particles together or by

creating favorable living conditions for soil organisms. Certain types of soil organic matter can hold up to 20 times their weight in water.

Humus is the substance left after soil organisms have modified original organic materials to a rather stable group of decay products as is the colloidal remains of SOM [27, 41] has indicated that the distribution of SOM, expressed as organic carbon, is 38% in trees and ground cover, 9% in the forest floor and 53% is in the soil including the roots plus the SOM associated with soil particles. In most tropical environments, the conversion of forest vegetation to agricultural land results in a decline of the SOM content to a newer, lower equilibrium [24].

.Organic matter affects both the chemical and physical properties of the soil and its overall health. Properties influenced by organic matter include: soil structure; moisture holding capacity; diversity and activity of soil organisms, both those that are beneficial and harmful to crop production; and nutrient availability. It also influences the effects of chemical amendments, fertilizers, pesticides and herbicides [48].The total amount of OC in the soil can be considered as a measure of stored OM. In a sense stored OM is a mean OM store or standing stock of OM because it reflects the net product or balance between ongoing accumulation and decomposition processes and it is thus greatly influenced by crop management and productivity. Over the past few years, various attempts have been made to obtain both global and regional inventories of soil OM storage based on soil map units. Generally, sample generic soil horizons based on the effects of land use types and/or management practices provide a useful estimate of total soil carbon storage [49].

2.3.4. Total Nitrogen

Nitrogen is the seventh most abundant element in the universe. It's the single most common element in the earth's atmosphere, comprising about 78% (4,000 trillion tons) of the gas that makes up our atmosphere. Nitrogen is found in all soils, and is required by all living creatures. In plants, nitrogen is the nutrient required in the largest amounts. It is a key constituent of critical organic molecules such as amino acids, nucleic acids, and

proteins. Nitrogen is found in marine and freshwaters and is present in some minerals. In short, nitrogen is found in every ecosystem and in every part of the global environment. In the atmosphere, the predominant form of nitrogen is di nitrogen gas (N_2), which is relatively inert and must be converted into different forms to be utilized by most organisms.

There are several avenues for these conversion processes, collectively called nitrogen fixation, in which N_2 gas is converted to ammonium (NH_4^+). A small amount of nitrate (NO_3^-) is produced by high voltage electrical discharged in the atmosphere.[36] that there was a 30 and 76% depletion of total N from during lightning storms agricultural fields cultivated for 40 years and abandoned land respectively. Average total N increased from cultivated to grazing and forest land soils, which again declined with increasing depth from surface to subsurface soils [65] The considerable reduction of total N in the continuously cultivated fields could be attributed to the rapid turnover (mineralization) of the organic substrates derived from crop residue (root biomass) whenever added following intensive cultivation [66].

Moreover, the decline in soil OC and total N, although commonly expected following deforestation and conversion to farm fields, might have been exacerbated by the insufficient inputs of organic substrates from the farming system . The same author also stated that the levels of soil OC and total N in the surface soil (0-10 cm) were significantly lower, and declined increasingly with cultivation time in the farm fields, compared to the soil under the natural forest. Carbon (C) to nitrogen (N) ratio (C/N) is an indicator of net N mineralization and accumulation in soils. Organic matter rich in carbon provides a large source of energy to soil microorganisms. Consequently, it brings population expansion of microorganism and higher consumption of mineralized N. Dense populations of microorganisms inhibit the upper soil surface and have an access to the soil N sources. If the ratio of the substrate is high there will be no net mineralization and accumulation of N [67]. They further noted that as decomposition proceeds, carbon is released as CO_2 and the C:N ratio of the substrate falls. Conversion of carbon in crop

residue and other organic materials applied to the soil into humus requires nutrients [69] Plant residues with C:N ratios of 20:1 or narrower have sufficient N to supply the decomposing microorganisms and also to release N for plant use. Residues with C/N ratios of 20:1 to 30:1 supply sufficient N for decomposition but not enough to result in much release of N for plant use the first few weeks after incorporation. Residues with C/N ratios wider than 30:1 decompose slowly because they lack sufficient N for the microorganisms to use for increasing their number, which causes microbes to use N already available in the soil [68].

2.3.5 .Available Phosphorus

Phosphorus (P) is an essential element classified as a macronutrient because of the relatively large amounts of P required by plants. Phosphorus is one of the three nutrients generally added to soils in fertilizers. One of the main roles of P in living organisms is in the transfer of energy. Organic compounds that contain P are used to transfer energy from one reaction to drive another reaction within cells. Adequate P availability for plants stimulates early plant growth and hastens maturity. Although P is essential for plant growth, mismanagement of soil P can pose a threat to water quality. The concentration of P is usually sufficiently low in fresh water so that algae growth is limited. When lakes and rivers are polluted with P, excessive growth of algae often results. High levels of algae reduce water clarity and can lead to decreases in available dissolved oxygen as the algae decays, conditions that can be very detrimental to game fish populations.

Phosphorus (P) is known as the master key to agriculture because lack of available P in the soils limits the growth of both cultivated and uncultivated plants [4]. Following N, P has more wide spread influence on both natural and agricultural ecosystems than any other essential elements. In most natural ecosystems, such as forests and grasslands, P uptake by plants is constrained by both the low total quantity of the element in the soil and by very low solubility of the scarce quantity that is present [28]. It is the most commonly plant growth-limiting nutrient in the tropical soils next to water and N [50].

Erosion tends to transport predominantly the clay and SOM fractions of the soil, which are relatively rich in P fractions. Thus, compared to the original soil, eroded sediments are often enriched in P by a ratio of two or more [28]. Natural soil will contain from 50 to over 1,000 mg of total P per kilogram of soil. of this quantity, about 30 to 50% may be in inorganic form in mineral soils [4]. The main sources of plant available P are the weathering of soil minerals, the decomposition and mineralization of SOM and commercial fertilizers. Most of the soils in Ethiopia particularly Nit sols and other acid soils are known to have low P contents, not only due to the inherently low available P content, but also due to the high P fixation capacity of the soils [51]. Oxisols, Ultisols, Vertisols and Alfisols are generally low in total P while Andsols are generally high in P content [50].

2.3.6. Cation exchange capacity

Cation exchange capacity is the capacity of the soil to hold and exchange cations. The cation exchange capacity, or "CEC", of a soil is a measurement of the magnitude of the negative charge per unit weight of soil, or the amount of cations a particular sample of soil can hold in an exchangeable form. It provides a buffering effect to changes in pH, available nutrients, calcium levels and soil structural changes. As such it is a major controlling agent of stability of soil structure, nutrient availability for plant growth, soil pH, and the soil's reaction to fertilizers and other ameliorants. A low CEC means the soil has a low resistance to changes in soil chemistry that are caused by land use [52]. Cation exchange capacity is an important parameter of soil because it gives an indication of the type of clay minerals present in the soil, its capacity to retain nutrients against leaching and assessing their fertility and environmental behavior. The cation exchange capacity (CEC) of soils is defined as the capacity of soils to adsorb and exchange cations [28].Generally, the chemical activity of the soil depends on its CEC. The CEC of a soil is strongly affected by the amount and type of clay, and amount of SOM present in the soil [53]. Both clay and colloidal SOM are negatively charged and therefore can act as anions.

As a result, these two materials, either individually or combined as a clay-humus complex, have the ability to absorb and hold positively charged ions (cations).

Soils with large amounts of clay and SOM have higher CEC than sandy soils low in SOM. In surface horizons of mineral soils, higher SOM and clay contents significantly contribute to the CEC, while in the subsoil particularly where Bt horizon exist, more CEC is contributed by the clay fractions than by SOM due to the decline of SOM with profile depth [28].Soil Cations are positively charged ions such as calcium ($Ca^{2+),}$ magnesium (Mg^{2+}), and potassium (K^+), sodium (Na^+) hydrogen (H^+), aluminum (Al^{3+}), iron (Fe^{2+}), manganese (Mn^{2+}), zinc (Zn^{2+}) and copper (Cu^{2+}). The capacity of the soil to hold on to these cations called the cation exchange capacity (CEC). These cations are held by the negatively charged clay and organic matter particles in the soil through electrostatic forces (negative soil particles attract the positive cations). The cations on the CEC of the soil particles are easily exchangeable with other cations and as a result, they are plant available. Thus, the CEC of a soil represents the total amount of exchangeable cations that the soil can absorb. This property affects the availability of potassium, calcium, and magnesium to plants. The term used to report CEC is mill equivalents/100 grams (me/100g) of soil.

2.3.7. Exchangeable Acidity

Soil exchangeable acidity refers to the amount of acid cat ions, aluminum (Al) and hydrogen (H), occupied on the CEC. .Soil acidity occurs when acidic H^+ ion occurs in the soil solution to a greater extent and when an acid soluble Al^{3+} reacts with water (hydrolysis) and results in the release of H^+ and hydroxyl Al ions into the soil solution [28]. As soils become strongly acidic, they may develop sufficient Al in the root zone and the amount of exchangeable basic cations decrease, solubility and availability of some toxic plant nutrient increase and the activities of many soil microorganisms are reduced, resulting in accumulation of SOM, reduced mineralization and lower availability of some macronutrients like N, S and P and limitation of growth of most crop plants [54].

Aluminum is a predominant cation in many soils and can be a critical variable in establishing effective cation exchange capacity (ECEC) values. In exchange reaction sits characterization is complicated by the coexistence of complex multiphase Al components that make its measurement specific to a particular extract ant and potentially difficult to interpret. When the CEC of a soil is high but has a low base saturation, the soil becomes more resistant to pH changes. As a result, it will require larger additions of lime to neutralize the acidity. The soil is then buffered against pH change [4] stated that during soil acidification, protonation increases the mobilization of Al and Al forms serve as a sink for the accumulation of H^+. The concentration the H^+ in soils to cause acidity is pronounced at pH values below 4 while excess concentration of Al^{3+} is observed at pH below 5.5 [55]. In strongly acidic conditions of humid regions where rainfall is sufficient to leach exchangeable basic cations, exchangeable Al occupies more than approximately 60% of the effective cation exchange capacity, resulting in a toxic level of aluminum in the soil solution[56]. Generally, the presence of more than 1 parts per million of Al^{3+} in the soil solution can significantly bring toxicity to plants. Hence, the management of exchangeable Al is a primary concern in acid soils.

2.3.8. Exchangeable bases (K, Na, Mg and Ca)

The four major exchangeable cation bases in soils are K, Ca, Mg, and Na. All except Na are essential plant nutrients; however Na is included here because it plays an important role in soil physical properties. Soil Na level is needed for calculations of cation exchange capacity (CEC) and exchangeable. An ammonium acetate extract ant is used to extract exchangeable K, Ca, Mg, and Na from arid region soils, but it does not extract less plant-available forms. Some difficulty may be encountered in soils containing Ca or Mg carbonates (calcareous soils) because the ammonium acetate extraction may remove some Ca or Mg from these minerals along with the exchangeable forms. In these situations, the analytical results may indicate slightly elevated levels of these nutrients. Some laboratories adjust the pH of the ammonium acetate extract ant to 8.5 to minimize this error. However, this is not usually a large problem and K, Ca and Mg tests generally

provide excellent estimates of plant available levels of these nutrients. Exchangeable sodium (Na) alters soil physical and chemical properties mainly by inducing swelling and dispersion of clay and organic particles resulting in restricting water permeability and air movement and crust formation and nutritional disorders (decrease solubility and availability of calcium (Ca) and magnesium (Mg) ions) [57]. Moreover, it also adversely affects the population, composition and activity of beneficial soil micro organisms directly through its toxicity effects and indirectly by adversely affecting soil physical and as well as chemical properties.

In general, high exchangeable Na in soils causes soil so acidity which affects soil fertility and productivity. Soil parent materials contain potassium (K) mainly in feldspars and micas. As these minerals weather, and the K ions released become either exchangeable or exist as adsorbed or as soluble in the solution [38]. Potassium is the third most important essential element next to N and P that limit plant productivity. Its behavior in the soil is influenced primarily by soil cation exchange properties and mineral weathering rather than by microbiological processes. Unlike N and P, K causes no off-site environmental problems when it leaves the soil system. It is not toxic and does not cause eutrophication in aquatic systems [28].

[36] Reported that the variation in the distribution of K depends on the mineral present, particles size distribution, degree of weathering, soil management practices, climatic conditions, degree of soil development, the intensity of cultivation and the parent material from which the soil is formed. The greater the proportion of clay mineral high in K, the greater will be the potential K availability in soils [58]. Soil K is mostly a mineral form and the daily K needs of plants are little affected by organic associated K, except for exchangeable K adsorbed on SOM [59].described low presence of exchangeable K under acidic soils while [60] observed low K under intensive cultivation. Normally, losses of K by leaching appear to be more serious on soils with low activity clays than soils with high- activity clays, and K from fertilizer application move deeply [38].

Soils in areas of moisture scarcity (such as in arid and semi arid regions) have less potential to be affected by leaching of cations than do soils of humid and humid regions [61] Soils under continuous cultivation, application of acid forming inorganic fertilizers, high exchangeable and extractable Al and low pH are characterized by low contents of Ca and Mg mineral nutrients resulting in Ca and Mg deficiency due to excessive leaching [62]. Exchangeable Mg commonly saturates only 5 to 20% of the effective CEC, as compared to the 60 to 90% typical for Ca in neutral to somewhat acid soils [28]. Research works conducted on Ethiopian soils indicated that exchangeable Ca and Mg cations dominate the exchange sites of most soils and contributed higher to the total percent base saturation particularly in Vertisols [50]. Different crops have different optimum ranges of nutrient requirements. The response to calcium fertilizer is expected form most crops when the exchangeable Ca is less than 0.2mol (+)/kg of soils, while 0.5 cmol(+)/kg soil is reported to be the deficiency threshold level for Mg in the tropics [55].

2.3.9. Micronutrients (Fe, Mn, Zn and Cu)

The term micronutrients refer to a number of elements that are required by plants in very small quantities. This term usually applies to elements that are contained in plant tissues in amounts less than 100 mg kg_{-1}.

The four essential micronutrients that exist as cat ions in soils are zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn). Adsorption of micronutrients, either by SOM or by clay-size inorganic soil components is an important mechanism of removing micronutrients from the soil solution. Thus, each may be added to the soil's pool of soluble micronutrients by weathering of minerals, by mineralization of SOM, or by addition as a soluble salts [38]. Factors affecting the availability of micronutrients are parent material, soil reaction, soil texture, and SOM [28, 58] stated that micronutrients have positive relation with the fine mineral fractions like clay and silt while negative relations with coarser sand particles. This is because their high retention of moisture induces the diffusion of these elements. Soil organic matter content also significantly affects the availability of micronutrients.

According to [63] the presence of SOM may promote the availability of certain elements by supplying soluble complex forming agents that interfere with their fixation. [64] Stated that the main source of micronutrient elements in most soils is the parent material, from which the soil is formed. Iron, Zn, Mn, and Cu are somewhat more abundant in basalt. [28] Indicated that the solubility, availability and plant uptake of micronutrient cations (Cu, Fe, Mn, and Zn) are more under acidic conditions (pH of 5.0 to 6.5).

3. MATERIALS AND METHOD

3.1 Description of the Study Area

3.1.1. Location

The study was conducted at Debello kebel*e* in Limu Kossa District, Jimma Zone, Oromia Regional State, and Southwest Ethiopia. It is about 455 km away from the capital, Addis Ababa, and located in the South-west of Ethiopia and 8 km away from the District town, Limu Genet, to the East. Geographically with an elevation ranging 1250-2720 meters above sea level. It covers an area of about 800 hectares and shares commonly with Limu Genet town to the West, Liba Gonde Peasant Associations in the east, Cako Peasant Association in the south and Walake Sombo Peasant Association in the North. This Limu Kossa District shares boundaries in the West with Limu Shay and Didessa Districts, in the North with Limu Seka District, in the South Manna and Kersa Districts and East with Tiro Afeta District. This District possesses a total area about 250,000 hectares.
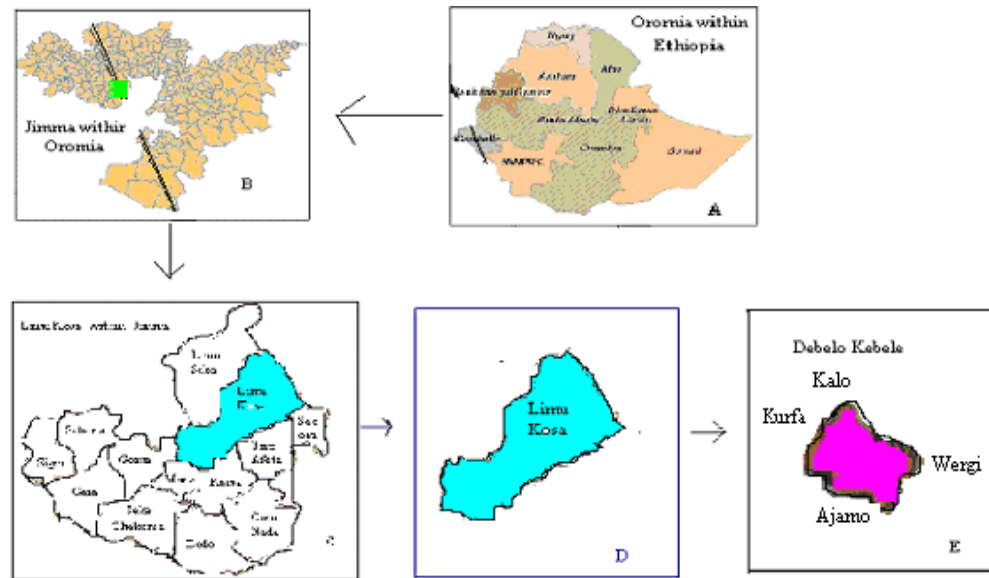
Figure . Location map of the study area**.**. A. oromia within Ethiopia B. Jimma within Oromia C. Limu Kosa within   Jimma Zone D. Limu Kosa District E. Debello Kebele (the study areas)

22

3.1.2. Climate

The average weather data recorded at the weather station located at Limu Genet town near the study area indicates that the study area has a uni-modal rainfall pattern with the average annual rainfall 1600-2200 mm. The rainy season covers the period from mid-April to October and the maximum rain is received in the months June, July and August. The annual average minimum and maximum air temperature is 11 ^{o}C and 27 ^{o}C respectively.

3.1.3. Soil type and vegetation

According to Agronomy department of the former Suntu Coffee Plantation Development (currently called Horizon Coffee Plantation), the soil of Limu area is well drained ,deep rich in humus content and characteristically suitable for coffee growth and other cereal crops. According to the district (ARDO, 2015), the vegetation of the area is exhibited to be complex, the montane moist forest is common. The main species of plants are broad-leaved and ever green. The natural coverage of vegetation in the area is declining from year to year because of farm land expansion and logging of trees for timber production.

3.1.4 .Farming system

Land is cultivated at the onset of the rainy season using a pair of oxen and traditional implements. The farming system is a typical coffee production and mixed crop-livestock system that is carried out on a subsistence scale. The main crops grown include maize, sorghum, vegetables and fruits. Cattle, sheep, goat, poultry, horse and donkey are among the common types of livestock.

3.1.5. Land Use

Limu kossa district consists of 23149 hectare natural forest land covers, manmade 10169 hectare, 38,386 hectare annual cereal crop coverage and 40,059 hectares area of coffee coverage (Agricultural and Rural Development Office, ARDO, 2007). The district

consists of 78 small rivers and two large rivers (Ghibe and Dedesa) in its drainage system. The total population of the district is reported to be 204,784. From this, 185,247 are rural residents while 19,501 are urban dwellers. Among these103, 350 are males while101,399 are females (Administration office population census ,AOPC, 2007).

3.2. Site Selection, Soil Sampling and Preparation

Representative soil sampling site was selected based on vegetation cover and cultivation history in the Debello kebele. Following this, three representative land uses (cultivated, forest and grass lands) were selected. Composite soil samples were collected from the depths of 0-20 and 20-40 cm. Each composite soil samples was made from 10-15 subsamples collected from within the respective area delineated as a replication of such land use types. Dead plants furrow, old manures, wet spots, areas near trees and compost pits were excluded during collection of samples minimizes difference. The soil samples were collected from representative land uses with its replications then air dried well mixed and passed through a 2 mm sieve for the analysis of selected soil physical and chemical properties. Separate soil core samples from the 0-20 and 20-40 cm depths were tooke with a sharp-edged steel cylinder forced manually into the soil for bulk density determination [52]. To make one composite soil sample the sub-samples were mixed well and about 1 kg of the mixed sub-samples is properly labeled. Finally eighteen of a total composite soil samples were prepared and packed in a polyethylene plastic and transport to soil testing centre for further analysis.

CL	GL	FL

Figure .Soil samples collected from the study area (Debello kebele)

24

Figure .A site(Debello kebele) where samples collected).

3.3. Soil Laboratory Analysis

The major part of the soil physical and chemical analysis was carried out at Jimma University College Agricultural and Veterinary Medicine in Soil Research Laboratory. Standard laboratory procedures were used for the analysis of the selected soil physicochemical properties in the study.

3.3.1 Analysis of soil physical properties.

A. Soil texture

Soil texture was determined by the Bouyoucos hydrometer method after destroying organic matter by hydrogen peroxide (H_2O_2) and dispersing the soil by using sodium hexameta phosphate [31, 32, 33]. Air dried and sieved soil of 50.0 g transferred to 500ml beaker. Then 20ml of distilled water followed by 20ml of H_2O_2 (30%) were added to the soil samples to destroy organic matter. Then 100 ml sodium hexa meta phosphate (dispersing agent) solution added and the sample bottle was shook for half an hour to homogenize solution. The dispersed sample solution was transferred to 1000 ml glass measuring cylinder and filled to the mark with water. If the surface covered by foam, one

25

drop of amyl alcohol was added. Measuring cylinder containing 1000ml sample solution covered at the top and shook energetically for 30 seconds. Then hydrometer immersed first in blank and next in the sample solution within 40 seconds, the hydrometer reading at 40 seconds and the temperature solution was recorded. This reading measures the percentage of silt and clay in suspension. After the first reading, the cylinder stand for two hours and the second reading was made in the same manner with the first. This second reading gave the percentage of clay in suspension.

B. Bulky density, particle density and total porosity

Bulk density was determined from undisturbed soil samples by using procedures in core sampler method. In this method cylindrical metal (core) of known volume was driven into the ground to the desired depth and carefully removed to preserve the known volume of as it existed in situ. The core sample containing moist soil was weighed and placed in an oven at 105 ^{0}c for about 24 hours .The dried defined volume of soil in an oven weighed [29,32]. Then bulk was calculated as the ratio of mass of oven dried soil to the volume of the sampling core. Diameter of core sampler = 5 cm, height = 5 cm. (Volume of core sampler),V = $\pi r^2 h$ where, π = 22/7, r = radius of the core sampler. V=π r^2h= 22/7 x (2.5 cm)^2 x 5 cm =98.125 cm^3 .

Soil particle density was determined using pycnometer method. A clean, dry pre weighed 100 ml volumetric flask was filled with water to the marked line and weighed again. Then, weight of water was determined by subtracting the weight of the flask from the weight of the flask plus water. Then, 25 g of soil was added to the flask containing water and shook gently to remove air bubbles, the mass of soil, water and flask was recorded. The weight of water in the flask containing soil determined, by subtracting the weight of soil and flask from the sum weight of the flask, water and soil. The difference in the weight of water in the flask with and without soil was recorded. The volume of water that was displaced by the soil (use the conversion of 1 g water = 1 cm^3 of water) can be

represent the volume of soil solids. Therefore, the particle density of the soil was calculated using the formula Dp = mass of dry soil/volume of soil solids.

While Percentage pore space was determined from the values of bulk density (BD) and particle density (PD) [28] as: Porosity percentage (%) = (1-BD/ PD) x 100.

3.3.2. Analysis of soil chemical properties

A. pH soil: The pH of the soil was measured potentiometrically with a digital pH meter in the supernatant suspension in the ratio of 1:2.5, soil: liquid mixture. In polyethylene, 10.0 g of soil sample and 25 mL of double distilled water or KCl solution mixed and shook on an automatic shaker for 30 minutes. The supernatant was transferred into another clean dry bottle .Buffer solutions pH 4, pH 7 and pH 9.2 were used to standardize pH meter. After calibration glass electrode was dipped into the bottle containing the soil water suspension, pH values were recorded and the electrode removed from soil suspension and cleaned the electrode with distilled water.

B. Electrical conductivity: Electrical conductivity (EC) was measured by digital conductivity meter from a soil water ratio of 1:2.5 socked for one hour. The soil water suspension of 10.0 g: 25.0 ml distilled water ratio prepared for the determination of pH can also used for conductivity measurement. After recording pH, the soil suspension in the bottle, settle for additional half hour. Calibration made and the conductivity cell was dipped in the soil water suspension of each sample turn by turn with cleaning the cell by distilled water [57, 58].

C. Soil organic matter: Soil organic carbon was determined by Walkley-Black wet oxidation method. In a 500 mL Erlenmeyer flask 0.5g of air dry soil (< 2 mm) was placed. Then, 10 mL 1 N $K_2Cr_2O_7$ and 20 mL H_2SO_4 were added the flask to destroy the organic matter [47]. After digestion, titration was carried by adding 0.5 N ferrous sulphate until the color flashes to green then continue to a light green end point observed. Diphenylamine indicator (DPAI) was used for titration. Soil organic matter contains 58%, then conversion

of carbon to organic matter can be done with the empirical factor of 1.724, which is obtained by dividing 100 by 58 (100/58) [47, 59].   %Organic matter =1.724x % carbon.

D. Total Nitrogen: Total nitrogen was determined by micro Kjeldah procedure (digestion, distillation and titration). Then 1 .0 g soil sample was added Kjeldah tube and placed in the fume hood for digestion using with 10 mL sulphuric acid (H_2SO_4) and 5 mL hydrogen peroxide (H_2O) with selenium as catalyst .The digestion was carried for 3 hours until the digest was colorless or pale yellow. The acid digested soil transferred into macro kjeldah flasks for distillation. Then, 20 mL of boric acid was measured from dispenser into receiver Erlenmeyer flask corresponding to the number of samples to prevent the loss of ammonia. The distillation flasks containing the digests, filled by75 mL of 40% NaOH and mixed gently.. After distillation, about 80 mL of distillate has been collected, removed the receiver flask. Finally a green receiver flask solution titrated with 0.1N H_2SO_4 until a pink color end point.

 E. Available P: Available P was analyzed using the procedures in the Bray-II method because of soil acidity. Extraction solution (Bray II) was prepared from the mixture of ammonium fluoride and hydrochloric acid to remove some phosphate ions from insoluble phosphates of iron and aluminum as well as to dissolve calcium phosphate. Also mixed reagent was prepared from sulfuric acid, ammonium molybdate, potassium antimony tartarate and ascorbic acid added to sample. Air dried soil (< 2 mm) of 2.0 g and 20 mL of extracting solution (Bray II) were transferred to bottle flask. After a mixture solution shook and filtered 8 mL of boric acid and 2 mL of mixed reagent were added. Finally available P in the sample solution was determined by Uv-spectrophotometer at a wave length of 882 nm [51].

   F. Exchangeable acidity: Exchangeable acidity was determined by saturating the soil samples with 1 M KCl solution [55]. Then 10 g fine soil transferred to a dry filter paper in funnel placed in a100 mL volumetric flask and added 10 portions of 10 mL 1M KCl solution with 15-minutes interval so that the percolation took about 2 1/2 hours. Then ,25 mL aliquot percolate pipette was added into a 250 mL Erlenmeyer flask with 5 drops of phenolphthalein solution and titrated by 0.02 M NaOH until the color turns just

permanently pink [64]. In addition, one of the sources of acidity, exchangeable aluminum was measured, separately by titrating solution with 0.02 M HCl until the pink color disappeared. In the titration process sodium fluoride (NaF) was added to the solution ,then the solution developed pink color and titrated with 0.02 M HCl until the end point was lasting long. Exchangeable acidity is the sum of exchangeable hydrogen and exchangeable aluminum.

Exchangeable H= Exchangeable acidity − Exchangeable aluminum

G. Cation exchange capacity (CEC): Cation exchange capacity (CEC) was determined by ammonium acetate saturation method [62]. Then, 5.0 g soil sample and100 mL of ammonium acetate 1M pH 7 solutions added to 250 mL beaker. The mixture was stirred instantly with stirring rod and allowed to stand overnight which involved soaking method. The next day the soaked samples transferred onto filter funnels placed on 250 mL volumetric flasks and washed the remaining soil with 50 mL and 25 mL turn by turn of 1M ammonium acetate pH 7.0 and removed the funnels; bring up the volume with distilled water. In next 25 mL ethanol about 2 to 3 times and 3 drops of Nessler's reagent was added with removing yellow precipitate by additional of ethanol. The saturated soil also washed with successive 20 mL sodium chloride (NaCl 10%) solution which is followed by distillation. Sodium chloride percolate of 75 mL and 10 mL of 1 N NaOH solutions were transferred to the Kjeldah flask over the 15 mL of 0.2 N H_2SO_4 in the 250 mL Erlenmeyer flask and connected immediately to the distillation apparatus. After the distillation, the distillate solution titrated with 0.1 N NaOH using methyl red indicators until color changes from purple to yellow.

H. Exchangeable basic cations: Exchangeable basic cations were extracted by 1M ammonium acetate (pH 7) method [62]. Air dried soil of 5.0 g and 100 mL of ammonium acetate 1M pH 7 solutions were added to 250 mL beaker, and stirred instantly with stirring rod and allowed to stand overnight which involved soaking method. The next day the soaked samples were transferred onto filter funnels placed on 250 mL volumetric flasks filtered and the remaining soil washed with 50 mL and 25 mL of 1M

ammonium acetate pH 7 turn by turn.. The aspirated original ammonium acetate leach ate and standard solution into flame and measured the transmittance of Na and K at wave lengths of 768 and 598 nm respectively. While Ca and Mg measured by AAS at the wave lengths 422.7 and 285.2 nm respectively.

 I. Micronutrients (Mn, Fe, Cu, and Zn) : Micronutrients (Mn, Fe, Cu, and Zn) of the soil were extracted by di ethylene triamine penta acetic acid (DTPA) [59]. DPTA extracting solution was prepared by dissolving 1.96 g DPTA, 14.92 g tri ethanolamine (TEA) and 1.47 g calcium chloride ($CaCl_2.2H_2O$) with distilled water in 1L of volumetric flask, then the final concentration was the mixture of 0.005M (DTPA) ,0.1 M TEA and 0.01 M $CaCl_2$. Then, 20.0 g air dried soil (< 2mm) and 40 mL of extractable DTPA were added in to 100 mL poly ethylene bottle. The mixture was shook for 2 hrs a length wise in horizontal position in a reciprocal shaker with a shaking speed of 150 rpm. Then, the sample solution was filtered and added 1 mL of 0.1 % La solution to it and homogenize. Finally, the concentration micro nutrients measured by AAS at their respective wave lengths.

3.4. Statistical Analysis

The general linear model (GLM) procedure of statistical analysis system (SAS) [69] was used for performing the significance of differences in soil parameters. A post the separation of means was done by least significant difference (LSD) test after main effects is found significant at $P < 0.05$. The soil analysis is performing for each land use types (cultivated, grazing and forest lands) in six combined treatments. Correlation analysis was carried out to determine associations between selected soil physicochemical properties.

4. RESULTS AND DISCUSSION

4.1. Soil Physical Properties

4.1.1. Soil texture (Particle size distribution)

The clay and silt fractions were significantly (P ≤ 0.05) different by land use, soil depth and the interaction of land use and soil depth. Similarly, the sand fraction was significantly (P≤ 0.05) different by land use and soil depth (Appendix Table 1).

Considering the interaction effects of land use and soil depth, the highest (73.0%) clay and (50.33%) sand contents were recorded at the surface layer 20-40cm and 0-20 cm depths of cultivated and grazing lands respectively. In contrast, the highest (25.67%) silt content was recorded at the subsurface layer of the grazing land, whereas the lowest (12.33%) sand content was observed in the sub surface layer of the cultivated land (Table 1). The increase in clay contents with depth under all land use types may be due to translocation of clay from surface to subsurface layers, which ultimately increase the proportion of silt contents in the surface soil layers. The current results are in agreement with the findings of [5] who reported an increase in clay content with depth under cultivated lands due to long period of cultivation.

The soil textural classes of both grazing and forest lands under surface layer (0-20 cm) were sandy clay loam and clay in cultivated land where as under sub layer (20-40 cm) of all land use types clay was observed.

Table . Interaction effect of land use and soil depth on soil physical properties of the in the study area.

LUT	Sand %		Silt %		Clay %	
	Soil depth (cm)		Soil depth (cm)		Soil depth (cm)	
	0-20	20-40	0-20	20-40	0-20	20-40
CL	15.33[a]	12.33[a]	18.0[b]	14.67[a]	66.67[c]	73.0[e]
GL	50.33[c]	29.33[d]	16.0[a]	25.67[d]	33.67[a]	45.0[b]
FL	46.00[b]	25.33[e]	21.33[c]	21,67[c]	32.67[a]	53.0[d]
LSD(0.05)	2.27		1.44		2.78	
SEM (±)	0.64		0.17		0.68	

Main effect means within a column followed by the same letter are not significantly different from each other at p ≤ 0.05 LSD = least significant difference; SEM = standard error of the mean LUT=land use type ; CL=cultivated land ;GL=grazing land; FL=forest land.

4.1.2. Bulk density

Bulk density value was not significantly (P ≥ 0.05) affected by land use, soil depth or their interaction effects (Appendix Table 1). Therefore, the highest (1.34 g/cm3) mean value of bulk density was recorded on the cultivated land and the lowest (1.26 g/cm3) mean value under the forest land (Table 2). This result from intensive cultivation might have caused relatively the higher bulk density values in the surface soil layers of the cultivated land than that of the respective soil depths in the grazing and forest lands. The reason for the relatively low soil bulk density on the grass and forest lands as well as surface soil layer could be due to the high SOM content and high clay content.

The average bulk density across the land use types did not also vary due to variation in soil depth and dominant textural classes could be sandy clay loams and clay. (Table2). However, bulk density increased slightly from 0-20 to 20-40 cm layer under the all land use types.

4.1.3 Particle Density

The particle density was not significantly (P ≥0.05) different only by soil depth. The particle density under the different land uses did not significantly vary with soil depth. The highest (2.60 g/cm3) mean value of particle density was obtained under the grazing land. (Table2). Considering the surface and the subsoil depths, the highest particle density values were recorded in the grazing land among the different land use types considered in the study (Appendix Table 1). The particle density under the different land uses decreased with increasing soil depth (Appendix Table 1), which was oppose to the findings reported by[35]. These higher particle density values on the surface soil layers might be due to the presence of heavy minerals of Fe and Mn in the surface soil as indicated by the higher Fe and Mn contents in the surface layer which is in agreement with past reports by [36,37].

4.1.4. Total porosity

Total porosity was not significantly (P > 0.05) different by land use, soil depth and the interaction of land use and soil depth (Table 2) .The average (surface and subsurface) total porosity percentages of the grazing, forest and the cultivated lands were 51.40, 50.77 and 48.96%, respectively (Table 2). Generally, total porosity of surface (0-20 cm) and sub surface (20-40 cm) layers of soil were recorded (50.59%) and (50.15%) respectively (Appendix Table1). Total porosity was inversely related the bulk density of the soils in the study area (Table 2).

Table .Interaction effect of land use and soil depth physical properties of the in the study area.

LUT	BD g/cm3		PD g/cm3		TP %	
	Soil depth (cm)		Soil depth (cm)		Soil depth (cm)	
	0-20	20-40	0-20	20-40	0-20	20-40
CL	1.30[b]	1.34 [b]	2.56[a]	2.59[b]	49.73[a]	48.2[a]
GL	1.27[a]	1.27[a]	2.60[b]	2.60[b]	51.53[c]	51.2[c]
FL	1.26[a]	1.27[a]	2.55[a]	2.59[b]	50.50[b]	51.04[c]
LSD(0.05)	0.013		NS		NS	
SEM (±)	0.012		0.017		0.005	

LSD = least significant difference; SEM = standard error of the mean; BD = bulk density; PD = Particle density; TP = Total porosity NS= not significant; LUT =land use type CL=cultivated land; GL=grazing land; FL=forest land

4.2. Soil Chemical Properties

4.2.1. Soil reaction (pH)

Soil pH values measured in a solution of soil to KCl ratio are less than a suspension of soil to water ratio. The pH (H_2O) or KCl value of the soils content was not significantly (P ≥ 0.05) different by all land use types and their interaction effects (Table3). The highest pH (5.13) in the surface (20-40 cm) and the lowest (4.50) in the surface (0-20 cm) of soil pH-H_2O values were recorded under the forest and the cultivated lands, respectively. Considering the two soil depths, the mean values of pH increased from 0-20 cm to 20-40 cm soil layers (Appendix Table2). Application of inorganic fertilizers and continuous cultivation practices, excessive precipitation, erosion could be some of factors which are responsible for the variation in pH in the soil [35]. Another reason may be reduction of Ca and Mg ions along soil depth which lowers soil pH from top to down the soil layers. Considering the two soil depths, the higher mean values of pH-H_2O (4.82) and pH-KCl (4.04) were observed within the surface (20-40 cm) soils. In general, the pH (H_2O) values observed in the study area were within the ranges of strongly acidic (4.5 - 5.13), and pH (KCl) values ranged from very strongly acidic (3.75 - 4.36) soil reactions as indicated by [4] (Table 3 and Appendix Table 2).

4.2.2. Electrical conductivity

Considering the main effects of land use types, the highest (0.07 dS/m) and the lowest (0.02 dS/m) EC of the soils were obtained under the forest sub layer(20-40 cm) and the grazing lands surface layer (0-20 cm), respectively (Table 2). Electrical conductivity (EC) of soils was not significantly ($P \geq 0.05$) difference by land use, their interaction and the soil depth (Table2 and Appendix Table 2). The highest EC value under the forest land might be due to its highest exchangeable Na content, whereas the lowest EC value under the grazing land can be with the loss of base forming cations (Ca^{2+} and Mg^{2+}) after deforestation and intensive cultivation. As indicated in Table 2, EC is positively and significantly correlated with pH (r = 0.70) , OM (r = 0.46), total N (r = 0.46) . On the other hand, EC is negatively and significantly correlated with exchangeable acidity and CEC. Relatively, higher EC values were recorded in the sub surface than in the top surface soils. Considering the interaction effect of land use by soil depth, the higher interaction mean value of EC (0.047 dS/m) was obtained in the subsoil (20-40 cm) layer , whereas the lower value (0.033 dS/m) was observed in top soil (0-20 cm) (Table 2 and Appendix Table 2). Based on the rating scale of EC range suggested by [70], then soil of the study area was ranged from the all land use types, in low EC(very less saline) (Appendix Table 2 and 7).

4.2.3. Soil organic matter

Soil organic matter content was not significantly ($P \geq 0.05$) different by land use, soil depth and their interaction (Appendix Table 7). The land use interaction effect of by soil depth, on the variability of SOM was significantly higher (6.80%) at surface layer (0-20 cm) of the forest land and lower (3.70.%) at subsurface layer (20-40 cm) of cultivated land (Table 3). The reason may be due to intensive cultivation of the land and the total removal of crop residues for animal feed and source of energy.

. Considering the two soil depths, the higher mean value of SOM (5.58%) and the lower (4.62%) were observed within the surface (0-20 cm) layer and the sub surface layer (20-40 cm) of soils respectively. Based on the rating scale of SOM ranges suggested by [70], the soils of the study area were ranged from medium in both forest and grazing lands,

35

where as ranged from low in cultivated land (Appendix Table 2 and 6). This result is in agreement with [43] who reported that SOM content is lower in cultivated soils than those under natural vegetations.

4.2.4. Total Nitrogen

The effect of land use by soil depth on total N the highest (0.34%) at the surface (0-20 cm) layer of the forest land the lowest (0.19%) in the subsurface (20-40 cm) layer of the cultivated land (Table 3). Total N content of soils was significantly ($P \leq 0.05$) different by land use, soil depth and the interaction of land use by soil depth (Tables 3, Appendix Table7). The average mean values of total N was (0.28%) under surface (0-20 cm) layer and (0.23%) under the depth (20-40 cm) land use types (Appendix Table 3). The mean N content decreased considerably from in the surface (0-20cm) to in the sub surface (20-40 cm) soil layers (Table 3).

The mean total N content of the surface soils of the study area was within the range of high in soils of cultivated and grazing lands, while very high in soils of forest land as per total N rating suggested by [70] (Appendix table7) .The very high total N content in soils of the forest land could be associated with the high OM contents of these soils. This is confirmed by the positive and highly significant correlation ($r = 1.0$), obtained these parameters (Table 3).

The carbon to nitrogen (C/N) ratio of the soils at the study area was not significantly affected by land use ($P \geq 0.05$) and by the interaction of land use with soil depth .Considering the interaction effect of land use by soil depth of C/N ratio values were recorded at the subsoil (20-40 cm) and surface (0-20 cm) layers of the all land use types in the study area almost similar to each other (Table 3). Accordingly, the C/N ratio of the soil across the study area may be considered to be within the optimum range in all land use types and soil depth. The narrow C/N ratio at the surface soil may be due to higher microbial activity and more CO_2 evolution and its loss to the atmosphere in the surface (0-20 cm) soil layer than in the subsurface (20-40 cm) soil layer.

Table . Interaction effects land use and soil depth on some chemical properties of soil in the study area.

	pH (H2O)		pH (KCl)		EC (sd/m)		OM %		TN%	
	Soil depth (cm)		Soil depth (cm)		Soil depth (cm)		Soil depth (cm)		Soil depth (cm)	
LUT	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
CL	4.50^a	4.58^a	3.75a	3.96^c	0.03^a	0.04^b	4.09^a	3.7^a	0.21^a	0.19^b
GL	4.65^b	4.76^b	3.82^b	3.86^b	0.02^a	0.03^a	5.85^d	5.2^c	0.29^b	0.26^a
FL	4.93^c	5.13^d	4.06^c	4.36^d	0.05^b	0.07^c	6.79^e	4.96^b	0.34^a	0.25^a
LSD	0.85		0.15		0.01		0.7		0.035	
SEM (±	0.096		0.09		0.007		0.46		0.022	

 LSD = least significant difference; SEM = standard error of the mean; EC = Electrical conductivity; OM = organic matter;

4.3.5. Available phosphorus

The available phosphorus (P) was not significantly ($P \geq 0.05$) different by land use, soil depth and the interaction of land use with soil depth (Table 3). Available P content in the cultivated land appeared to be higher than the other two land use types. According to the recorded data the interaction effect of land use with soil depth, the highest (9.13 mg kg-1) and the lowest (7.23 mg kg-1) available P contents were recorded at the surface soil (0-20 cm) layer of the cultivated and subsurface soil (20-40 cm) layer of the forest lands, respectively (Table 2). Considering the two soil depths, the higher mean value of av.P (8.42 mg kg-1) and the lower (7.76 mg kg-1) were observed within the surface (0-20 cm) layer and the sub surface layer (20-40 cm) of soils respectively.

 The cultivated land soils had higher content of available P due to continuous application of mineral P fertilizer for long time as indicated by different farmers in the area. The mean available P content of the soils of the study area was within the range of low in soil of all land use types as per available P rating suggested by [71] (Appendix table 7)

4.3.6. Exchangeable Acidity

The exchangeable acidity was significantly (P ≤ 0.05) affected by land use, soil depth and their interaction (Appendix Table 7). The highest (4.13 cmol$_{(+)}$/kg) and the lowest (1.01 cmol $_{(+)}$/kg) exchangeable acidity were recorded under the cultivated land surface (0-20 cm) layer and the forest land sub surface (20-40 cm) layer respectively (Table 4). These results show that intensive cultivation and application of inorganic fertilizers leads to the higher exchangeable acidity content under the crop field than the other land uses. The results of this study were in agreement with those reported by [36], who reported that inorganic fertilizer application is the root cause of soil acidity.

With regards, except the forest land which had the high content exchangeable acidity in both cultivated and grazing lands with two soil depths, exchangeable acidity values decreased from the surface (0-20 cm) to the subsoil layer (20-40 cm) under different land use types (Appendix Table3). Exchangeable acidity was negatively and significantly correlated with pH (r = -0.92) and EC (r = -0.73), and positively correlated with av.P (r = 0.39) and CEC(r=0.59) (Table 7). [72] reported that the concentration of the H$^+$ to cause acidity is pronounced at pH value below 4 while excess concentration of Al^{3+} was observed at pH below 5.5. However, the results of this study indicated that the pH of the study area was below 5.2 and acidic cations had occupied the site. Therefore, the concentration of exchangeable Al^{+3} might be caused Al toxicity in the area.

4.2.7. Cation Exchangeable Capacity (CEC)

The CEC values of the soils in the study area were significantly (P≤ 0.05) different by land use and the interaction of land use by soil depth and soil depth (Tables 4 and Appendix Table 3). Significant difference in CEC contents due to the interaction of land use and soil depth was observed in the study area as highest (41.50 cmol$_{(+)}$/kg) in surface soil (0-20 cm) layer of the cultivated land and lowest (22.52 cmol$_{(+)}$/kg) in subsurface soil (20-40 cm) layer of the grazing land. CEC values decreased from the surface (0-20 cm) to the subsurface (0-20 cm) layer under different land use types (Table 4).

Soils containing high clay and organic matter contents have high cation exchange capacity. Therefore, high clay content soils from the surface and the subsurface layer of the cultivated land had caused high values CEC in the study area (Table1). Based on CEC ratings developed by [73], the CEC content of soils of the study area was rated a high in both cultivated and forest lands while, medium in the grazing land their CEC (Appendix Table 7). Cation exchange capacity was positively and significantly associated with, available P, and EA, whereas it was negatively and significantly correlated with pH (H_2O) , TN and SOM

Table . Interaction effects of land use and soil depth on some chemical properties of soil in the study area.

LUT	EA(Cmol(+)/Kg		Av.P(mg/Kg)		C:N		CEC(Cmol(+)/Kg	
	Soil depth (cm)		Soil depth (cm)		Soil depth(cm)		Soil depth (cm)	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
CL	4.13[d]	3.76[c]	9.13[a]	8.77[a]	11.59[a]	11.59[a]	41.50[e]	35.50[d]
GL	3.44[b]	3.97[c]	8.61[c]	7.27[b]	11.59[a]	11.57[a]	28.52[c]	22.52[a]
FL	1.33[a]	1.01[a]	7.52[d]	7.23[b]	11.60[a]	11.60[a]	29.91[c]	25.73[b]
LSD(0.05)	0.78		0.45		NS		3.58	
SEM (±)	0.56		0.22		0.004		2.80	

LSD = least significant difference; EA =Exchangeable Acidity; TN = Total nitrogen ;

C/N= Carbon–nitrogen ratio and CEC =Cation exchangeable capacity NS= not significance;

Av.P = available phosphorus; LUT=land use type; CL=cultivated lanGL=grazing land;

FL=forest land

4.2.8 Exchangeable Bases (Na, K, Ca and Mg)

The content of exchangeable sodium (Na) was significantly ($P < 0.05$) affected by land use and the interaction of land use with soil depth but, it was not significantly ($P >0.05$) by soil depth (Appendix Table 5). Based on the data obtained in the study area, relatively highest (0.24 cmol(+)/Kg) exchangeable Na was recorded in subsurface soil layer of the forest land where as the lowest (0.13 cmol(+)Kg) obtained in the   surface   layer of cultivated land. (Table5).

According to the rating set by [73], the Na contents of soils in the study area ranged from low in all land use types (Table 5 and Appendix. Table 8).

Exchangeable K content was significantly (P <0.05) affected by land use and the interaction of land use and soil depth. On the other hand, it was not significantly (P > 0.05) affected by soil depth (Appendix Table 4). Considering the interaction effects of land use by soil depth, the highest (1.58 cmol(+)/kg) and the lowest (0.58 cmol(+)/kg) exchangeable K contents were recorded at the subsurface layers of the forest land and the surface layers of the cultivated land, respectively (Table 4). According to the rating set by [73], the K contents of soils in the study area were very high in forest land and high in both grazing and cultivated lands. (Appendix Table 8)

Exchangeable Ca was significantly different (P ≤ 0.05) from each other due to the interaction effects between land use types and soil depths. The highest (5.75 cmol(+)/Kg) and the lowest (3.62 cmol (+) Kg) exchangeable Ca were obtained in sub surface layer of forest land and surface layer of cultivated land respectively(Table 5). The rate of mean exchangeable Ca values observed in this study ranged from medium in both grazing and forest lands while low in cultivated land [38] (Table 5 and Appendix Table 8).

The content of exchangeable Mg was significantly (P ≤ 0.05) affected by land use and the interaction of land use by soil depth. However it was not significantly (P ≤ 0.05) affected by soil depth (Appendix table 4). The effects of land use by soil depth on exchangeable Mg was significantly high (8.67 cmol(+)/kg) under subsoil layer of the forest land and low (3.56cmol(+)/kg) under surface soil layer of the cultivated land (Table 5). According to the rating set by [73], the Mg contents of soils in the study area were ranged from high in all type land use types.(Appendix Table 8).

Table .Interaction effects of land use and soil depth on exchangeable bases of soils in the study area.

LUT	Na (cmol/Kg)		K (cmol/Kg)		Mg (cmol/Kg)		Ca (cmol/Kg)	
	Soil depth (cm)		Soil depth (cm)		Soil depth (cm)		Soil depth (cm)	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
CL	0.13^a	0.19^c	0.58^a	0.95^b	3.56^a	4.61^c	3.62^a	4.37^b
GL	0.14^a	0.20^c	0.95^b	1.04^c	4.89^d	5.50^e	4.96^c	5.21^d
FL	0.16^b	0.24^d	1.15^c	1.58^d	4.48^b	8.67^f	5.48^e	5.75^f
LSD	0.096		0.22		1.55		0.28	
SEM(±)	0.017		0.13		0.72		0.032	

LSD = least significant difference; SEM = Standard error of the mean; LUT=land use type; CL=cultivated land; FL=forest land

4.2.9 Micro nutrients (Fe, Zn, Cu and Mn)

The contents of extractable micronutrients (Zn Fe,Mn and Cu) were significantly (P ≤ 0.05) affected by land use, and the interaction of land use with soil depth, but there were not significantly (P ≥ 0.05) affected by soil depth (Appendix Table 8). Considering the main effects of land use, the highest contents of Fe (27.42 mg/kg), , Zn (2.99 mg/kg) and Cu (3.41 mg/kg) were recorded under the cultivated land where as Mn (48.83 mg/kg) under forest land (Table 6), while the lowest (16.36, 26.76 and 1.46 mg/kg) contents of Fe, Mn and Cu were observed under the grazing land, respectively, and Zn content was lowest (2.20 mg/kg) on the grazing land. The results of the study also indicated that the contents of all these micronutrients were higher at the surface (0-20 cm) layer than in the subsoil (Tables 6)

41

Table . Interaction effects of land use and soil depth on micronutrients of soils in the study area..

LUT	Fe(Cmol(+)/Kg)		Cu(Cmol(+)/Kg)		Zn(Cmol(+)/Kg)		Mn(Cmol(+)/Kg)	
	Soil depth (cm)		Soil depth (cm)		Soil depth (cm)		Soil depth (cm)	
	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
CL	27.42^e	23.50^d	3.41^e	2.68^d	2.99^e	1.72^b	48.20^e	35.11^c
GL	19.90^c	16.36^a	1.76^b	1.46^a	2.61_d	2.20^c	41.0^d	26.76^a
FL	20.66^c	18.13^b	2.61^d	2.38^c	2.02^c	1.36^a	48.83^e	29.36^b
LSD	2.44		1.96		1.49		8.84	
SEM (±)	1.62		0.28		0.24		3.82	

 Main effect means within a column followed by the same letter are not significantly different from each other at p ≤ 0.05 LSD = least significant difference; SEM = standard error of the mean; LUT= land use type

5 . Summary, Conclusion and Recommendations

5.1. Summary

The effect of the physicochemical properties of soil under different land use types in the study area would be determined based on the soil depths. The study assessed soil physicochemical properties under different land use types with the status of soil depths. . According to the study, the physical properties such as bulk density, particle density, total porosity were not significantly ($P > 0.05$) different, whereas soil texture was significantly affected by land use types and the interaction of land uses with soil depths. The mean of sand (35.67%) ,silt (20.89%) and clay(69.84%) were observed in the area from forest ,grazing and cultivated lands respectively.

The analysis of variance revealed that the soil pH was significantly affected by land use types. Numerically soil pH measured 1: 2.5 soil to water ranges from 4.5 in the cultivated land to 5.13 in the natural forest. The main reasons for the lowest value of soil pH in the cultivated land were due to poorly managed cultivation; inappropriate use of ammonium based fertilizers and accelerated erosions that implied the deterioration of soil quality. Similarly, the decrease in soil pH of the plantation forest could be due to prolonged uptakes of basic cations by tree root.

The mean values of exchangeable acidity (H^+ and Al^{+3}) 3.95 cmol(+)/Kg ,3.71 cmol(+)/Kg and 1.17 Cmol(+)/Kg were obtained in the area from cultivated ,grazing ,forest lands respectively. The highest values of exchangeable acidity in the cultivated and grazing land might be due to aluminum saturation.

Based on the land use type and soil depth the mean values of CEC 41.5 cmol(+)/Kg , 29.91 cmol(+)/Kg and 28.52 cmol(+)/Kg were determined in the surface soil layer of cultivated , forest and grazing lands respectively .

The highest amount of CEC (38.5 cmol(+)/Kg) was obtained in the cultivated could be because of the amount and nature of the clay particles content ,whereas the lowest (25.52 cmol$^+$/kg) recorded in the grazing land . The amount and type of clay mineral and organic matter are responsible factors for CEC in that both.

Soil organic matter (SOM) and total nitrogen (TN) content showed significant variation (p<0.05) under soils of different land use types with higher contents (5.88%, 0.3%) and lower (3.9 %, 0.2%) registered in natural forest and cultivated land, respectively. Besides, the mean SOM content value recorded in the cultivated land was lower than in the two remaining land uses. Further, the mean SOM content in the surface was greater than in the subsurface soil layers. The mean value of total N was greater in the surface forest land and lower in the surface layer of cultivated land.

Available phosphorus was not significantly (P≥ 0.05) varied between land use types. The level of accessible phosphorus on the soils of all land use types can be illustrated as a low in the study area. The highest mean of available P (8.42 cmol (+)/Kg) and the lowest mean (7.38 cmol(+)/Kg) were recorded in the cultivated and forest land respectively.

The mean exchangeable Na and K content of the soil were highly significantly affected by land use but not by soil depth. The highest mean values Na (0.24 cmol/Kg) and K (1.58 cmol/Kg) were recorded at subsurface soil layer of forest land. Similarly the highest mean values Ca(8.67 cmol/Kg) and Mg (5.75 cmol/Kg) were obtained at subsurface soil layer of forest land. The mean value of exchangeable Na, K, Ca, and Mg were relatively lower in the surface and higher in the subsurface soil layers. Generally, the value of exchangeable bases relatively increases with soil depths.

The contents of extractable micronutrients (Fe, Zn, Mn and Cu) were significantly (P ≤ 0.05) affected by land use, and the interaction of land use with soil depth. The highest mean values Fe (27.42 cmol (+)/Kg),Cu (3.41 cmol (+)/Kg) ,Zn (2.99 cmol (+)/Kg)and Mn(48.20 cmol (+)/Kg) were obtained at surface layer of cultivated land. Besides, the mean available Fe, Mn, Zn, and Cu were higher in the surface layers of all land use types.

5.2. Conclusion

The highest content sand (35.67%) ,silt (20.89%) and clay(69.84%) were observed in the area from forest ,grazing and cultivated lands respectively. The bulk densities of soils obtained in the study area were low, but which inversely related to total porosity.

The results revealed that soils in all of the land use types of the study area were generally strongly acidic (pH< 5.2).Cultivated land mostly affected by soil acidity (PH <4.6).Electrical conductivity of soil obtained in all land use types were low (0.02-0.07 dS/m) or very less saline. SOM in cultivated land was less than in both forest and grazing lands. SOM obtained in the study area were intermediate and it was not significantly affected by land use changes. The mean total N content of soils of the study area was within the of high in all land use types.

The level of accessible phosphorus on the soils of all land use types can be illustrated as a low in the study area (appendix table). The high values of exchangeable acidity in the cultivated (3.95 cmol(+)/ Kg) and grazing (3.71 cmol(+)/Kg) land. High exchangeable Al was observed in the study area that might be cause aluminum saturation which increase soil acidity.

The highest amount t of CEC (38.5 cmol(+)/Kg) was obtained in the cultivated could be because of the amount and nature of the clay particles content land type. Sodium content of soil in the study area ranged from low while potassium and magnesium contents high in all land use types. Calcium content of soil in the study area ranged in medium in both grazing and forest lands, but low in cultivated land. Besides, the mean available Fe, Mn, Zn, and Cu were higher in the surface layers of all land use types.

5.3. Recommendations

1. Soil pH is strongly acidic which significantly affected by land uses in the study area. Therefore, the concerned bodies or farmers should focus to improve or maintain soil acidity particularly cultivated land by: addition of lime, reducing the activities that can rise soil acidity and using an integrated fertilizers.

2. The level of available phosphorus in the soils of all land use types can be illustrated as a low due to high soil acidity in the study area. Then, it needs acceptable technologies for maintaining of available .P

3 .Generally the government and non government rural development strategies should emphasize: to conserve the soil physicochemical properties of the study area and to make up farmers capacity how to apply integrated soil fertility management techniques.

4. This study can serve as reference point for others researchers who further study on physicochemical properties soil under different land use types in the study area.

Table .Pearson's correlation matrix for various soil physicochemical parameters

pH	H2O	PHKCl	EC	OM	AV.P	EA	CEC	TN	CN	Sand	Silt	Clay	BD
PH H2O	1												
PH KCl	0.95	1											
EC	0.7	0.69	1										
OM	0.92	0.83	0.46	1									
AV.P	-0.53	-0.55	-0.36	-0.44	1								
EA	-0.93	-0.86	-0.74	-0.88	0.39	1							
CEC	-0.67	-0.57	-0.03	-0.84	0.35	0.59	1						
TN	0.92	0.83	0.46	1	-0.44	-0.88	-0.84	1					
CN	-0.64	-0.81	-0.39	-0.47	0.28	0.47	0.3	-0.46	1				
Sand	-0.46	-0.27	-0.05	0.77	0.51	-0.57	0.57	0.71	-0.47	1			
Silt	-0.39	-0.44	-0.15	0.63	0.49	0.21	0.65	0.74	-0.37	0.63	1		
Clay	0.58	0.41	0.33	-0.91	-0.67	0.34	-0.81	-0.93	0.64	-0.76	-0.82	1	
BD	-0.43	-0.46	-0.19	0.55	-0.22	0.37	0.43	-0.49	0.58	-0.42	-0.4	0.59	1
PD	0.23	0.19	-0.33	0.27	-0.57	-0.45	-0.34	-0.44	0.46	-0.51	0.49	0.72	-0.42
TP	-0.27	-0.22	0.33	-0.44	-0.37	-0.17	0.25	0.57	0.17	0.69	0.34	-0.7	-0.58
Na	0.39	0.37	0.12	0.23	0.03	-0.43	0.27	0.23	-0.2	0.72	0.31	-0.2	-0.41
K	0.11	0.09	0.07	-0.67	-0.04	-0.04	-0.78	-0.67	0.3	-0.7	-0.71	0.79	0.59
Ca	0.48	0.47	0.23	0.09	0.21	-0.31	0.57	0.09	-0.12	0.01	0.25	-0.1	-0.2
Mg	0.53	0.5	0.21	0.44	0.45	-0.46	0.65	0.44	-0.29	0.48	0.51	-0.5	-0.71
Fe	-0.74	-0.79	-0.45	-0.17	-0.07	-0.66	-0.52	-0.17	0.54	-0.13	-0.08	0.12	0.08
Zn	-0.61	-0.41	0.09	0.39	0.23	0.38	0.29	0.39	-0.39	0.44	0.32	-0.4	0.2
Cu	-0.75	-0.75	-0.34	-0.23	-0.74	0.64	-0.49	-0.23	0.39	-0.13	0.1	0.09	0.53
Mn	-0.83	-0.89	-0.41	0.22	0.68	0.68	-0.29	0.22	0.47	0.22	0.39	-0.3	0.33

SOM = soil organic matter; Total N = total nitrogen; C/N = carbon to nitrogen ratio; AvP = available Phosphorous; EA = exchangeable acidity; CEC = cation exchange capacity

47

Table 7. "Continued"

	PD	TP	Na	K	Ca	Mg	Fe	Zn	Cu	Mn
PD	1									
TP	0.47	1								
Na	-0.17	0.53	1							
K	0.43	0.22	-0.2	1						
Ca	0.56	0.31	0.46	-0.25	1					
Mg	-0.24	-0.37	0.69	-0.72	0.53	1				
Fe	0.71	-0.57	-0.64	0.27	-0.51	-0.68	1			
Zn	0.54	0.44	-0.41	0.01	0.38	-0.4	0.57	1		
Cu	0.34	-0.27	-0.38	0.43	-0.51	-0.73	0.9	0.63	1	
Mn	0.79	-0.64	-0.49	-0.17	-0.53	-0.51	0.93	0.54	0.85	1

BD = bulk density; PD=particle density; TP= total porosity

6. REFERANCES

[1]. Hlin, J. N. ; Balster, S.; Chapman, D.; Ferris, T. Thompson and T. Smith. Trends in soil science education and employment *SoilSci.Soc.Am.J.***2010,***74*:1429–1432. doi:10.2136/sssaj.0143

[2]. Jenny, H. *Factors of soil formation: A system of quantitative pedology Dover Publications*, Inc, New York. 1941.

[3]. D.E.; J.L. Kleinjan, W.A.; Tjentland, N. Kitchen, *Collecting representative soil Samples for N and P fertilizer recommendations [electronic resource]*. Crop Management *C.G.* Carlson. 2002.

[4]. Foth, H.D. and B.G. Ellis., *Soil fertility,* 2nd Ed. Lewis CRC Press LLC., USA. 1997 290p.

[5]. Shiferaw,B. Soil phosphorous fractions influenced by different cropping system Andosols and Nitsols in Kambata-Tenbaro and Wolaita Zones, SNNPRS, Ethiopia. M.S.c Thesis Submitted to School of Graduate Studies, *Alemaya University*; **2004**. 126p.

[6]. Hurni, H., Land degradation, famines and resource scenarios in Ethiopia.. World Soil Erosion and conservation. Cambridge University Press, Cambridge *In: Pimentel, D. (Ed.)*. **1993**. pp. 27–62

[7]. Hawando, T. Desertification in Ethiopia High Lands. Norwegian Church AID, Addis Ababa, Ethiopia. *RALA report*, **1997** No *200*. .

[8]. EFAP, II. *The challenge for development; Ministry of Natural Resources and Environmental Protection, Addis Ababa, Ethiopia*. Ethiopia Forestry Action Program 1994.

[9]. Eyasu, E. Farmers' Perceptions of Soil Fertility Change and Management. Addis Ababa, Ethiopia *Doctorial thesis SOS SAHEL & Institute for Sustainable Development*. **2002**.252pp.

[10]. Young, A. *Agro forestry for Soil Management*, *2nd ed.* CAB International, Walling ford.1997, 320pp.

[11]. Mulugeta. L. Effects of land use changes on soil quality and native flora degradation and restoration in the highlands of Ethiopia: Implication for sustainable land management. PhD Thesis Presented to Swedish University of Agricultural Sciences, *Uppsala* **2004** .64p.

[12]. J. Six, E. T. Elliott and K. Paustian. "Aggregate and Soil Organic Matter Dynamics under Conventional and No- Tillage Systems," *Soil Science Society of America Journal*, **1999,** *Vol. 63*, No. 5, pp. 1350- 1358. doi:10.2136/sssaj.6351350x

[13]. B. M. Shrestha, B. R. Singh, B. R. Sitaula, R. Lal and R. M. Bajarcharya, "Soil Aggregate- and Particle-Associated Organic Carbon under Different Land Uses in Nepal," *Soil Science Society of America Journal*, **2007** *Vol. 71*, No. 4, , pp. 94-1203. **2006**doi:10.2136/sssaj.0405

[14]. R. Lal, "Soil Erosion and the Global Carbon Budget," *Environment International*, **2003** *Vol. 29*, No. 4, pp. 437- 450. doi:10.1016/S0160-4120(02)00192-7

[15]. D. K. Benbi and J. S. Brar, "A 25-Year Record of Carbon Sequestration and Soil Properties in Intensive Agriculture," *Agronomy for Sustainable Development,* **2009** *t*, *Vol. 29*, No. 2, pp. 257-265. doi:10.1051/agro:2008070

[16]. K. R. Islam and R. R. Weil, "Land Use Effects on Soil Quality in a Tropical Forest Ecosystem of Bangladesh," *Agricultural Ecosystem and Environment*, **2000** *Vol. 79*,No.1,,pp.9-16. doi:10.1016/S0167-8809(99)00145-0

[17]. FAO, *Guidelines for the control of soil degradation*, Rome: United Nations Environment Programmed (UNEP) and Food and Agriculture Organization of the United Nations (FAO) 1983.

[18]. Rao, K.S. and R. Pant. Land use dynamics and landscape change pattern in a typical micro watershed in the mid elevation zone of central Himalaya, India. *Agriculture, Ecosystems and Environment*, **2001.** 86: 113-123.

[19]. Eshetu . Z and P. Hogberg Effects of land use on Natural abundance of soils in Ethiopian High lands. *Plant Soil,* **2000** **,** 222: 109-117.

[20]. EFAP,. *Ethiopian forestry action program*: the challenge for development Ministry of Natural Resources Development and Environmental Protection, Addis Ababa, Ethiopia. (Vol. I). 1993

[21]. Solomon, D., J. Lehmann, M. Tekalign, F. Fritzsche and W. Zech,. Phosphorus forms and Dynamics as Influenced by land use changes in the sub-humid Ethiopian highlands. *Geoderma* **2002** 105: 21-48.

[22] . W.B. and B.L. Turner II, *Changes in land use and land cover: a global perspective*. Cambridge University and employment. *Soil Sci. Soc. Am. J*. **2010** *74*:1429–1432. doi:10.2136/sssaj.0143, Press, Cambridge, UK 1994.

[23]. Reenberg, A., T.L. Nielsen and K. Rasmussen, Field expansion and reallocation in the Sahel: land use pattern dynamics in fluctuating biophysical and socio-economic environment. *Global Environment Change, 1998*. 8: 309-327.

[24]. Woldeamlak. B and L. Stroosnijder Effects of agro-ecological land use succession on oil properties in the Chemoga watershed, Blue Nile basin, Ethiopia.*Geoderma* **2003**. 111: 85- 98.

[25]. Sanchez; P.A *Properties and management of soils in the tropics*. John Wiley and Sons, nc., New York, USA. 1976; 618p

[26]. White; R.E *Principles and practices of soils science*: The soil is the natural resource Cambridge University Press, UK. 1997; 348p.

[27]. Foth; H.D. *Fundamentals of soil science*, *8th Ed*. John Wiley and Sons, Inc.New York, USA.1990; 360p.

[28]. Brady, N.C. and R.R. Weil. *The nature and properties of soils, 13th Ed*. Prentice-Hall Inc., New Jersey, USA.2002, 960p.

[29]. Gupta, P.K. Soil, plant, water and fertilizer analysis. Shyam Printing Press, Agrobios, India. 2004; 438p.

[30]. Lilienfein, J., W. Wilcke, M.A. Ayarza, L. Vilela, S.D.C. Lima and W. Zech,. Chemical fractionation of   Phosphorus, sulphur, and molybdenum in Brazilian savannah Oxisol under different land uses. *Geoderma.* **2 000**; *96*: 31-46.

[31]. Bouyoucos, G.J.Hydrometer method improvement for making particle size analysis of soils. *Agron. J,***1962.** 54: 179-186.

[32]. Day; P.R *Hydrometer method of particle size analysis.. In: C.A.   Black(eds.). Methods of soil analysis* . Agron. Part II, No. 9. Am. Soc. Agron. 1965**;** pp. 562-563

[33]. F.G. Calhoun, N.E. Smeck, B.L. Slater, J.M. Bigham, and G.F. Hall, "Predicting bulk density of Ohio soils from morphology, genetic principles, and laboratory characterization data," *Soil Sci. Soc. Am. Journal,* **2001 ,** Vol.65, pp.811–819.

[34]. Woldeamlak B and L. Stroosnijder,. Effects of agro-ecological land use succession on soil properties in the Chemoga watershed, Blue Nile basin, Ethiopia. *Geoderma,***2003**. 111:85

[35]. Ahmed H,. *Assessment of spatial variability of some physicochemical properties of soils under different elevations and land use systems* in the western slopes of Mount Chilalo, Arsi. MSc Thesis Submitted to the School of Graduate Studies, Alemaya University, Ethiopia 111p, 2002.

[36]. Wakene N,. *Assessment of important physicochemical properties of Dystric Udalf (Dystric Nitosols) under different management systems* in Bako area, western Ethiopia. MSc Thesis Submitted to School of Graduate Studies, Alemaya University, Ethiopia 2001; 93p.

[37]. Hillel; D *Fundamentals of soil physics*. Harcourt Brace Jovanivich Publisher, Academic Press, Inc. San Diego. 1980. 413p.

[38]. FAO (Food and Agriculture Organization).. Plant nutrition for food security: A guide for integrated nutrient management. FAO, Rome. *FAO, Fertilizer and Plant Nutrition* **2006a;** Bulletin 16.

[39]. Baver; L.D. *Soil permeability in relation to non-capillary porosity*: Soil Science Society of America Proceedings, 1938, v. 3, p. 52-56.

[40]. Burdine, N.T., Gournay, L.S., and Reichertz, P.P., , *Pore size distribution of petroleum reservoir rocks: Petroleum Transac-tions*, AIME, 1950, v. 189, p. 195-204.

[41]. Kamara, C.S., I. Haque and A.R. Soka. 1992. Soil Physics Manual. Plant Science Division Working Document No. B.12 (Revised) ILCA, Addis Ababa, Ethiopia, 106p.

[42]. McLean, E.O. *Aluminum.. In*: C.A. Black (Ed.). *Methods of Soil Analysis*. *Agron*. Am.Soc.Agron Madison,. USA 1965 pp. 978-998 , No.9. Part II.

[43]. Eylachew ;Z. Selected physical, chemical and mineralogical characteristics of major soils occurring in Chercher highlands, eastern Ethiopia. *Ethiopian Journal of Natural resource*. **1999**; 1(2): 173-185

[44]. Kamprath, E.J. and Fox, C.D. Lime fertilizer plant interactions in acids soils.

Fertilizer Technology and *Use. Soil Science Society of America, 1995, 92:54-58.*

[45]. USDA Soil Conservation Service.. Soil Survey Laboratory Methods and Procedures for   Collecting Soil Samples. *Soil Survey Investigations* **1982** Report No.1.

[46]. Doerge, T., N.R. Kitchen, and E.D. Lund. *Soil Electrical Conductivity Mapping*. Site- Specific Management Guidelines series is published by the Potash & Phosphate Institute   (PPI) SSMG-30.

[47]. Walkley, A. and I.A. Black, An examination of the Degtjaref method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci*. **1934**,37: 29-38.

 [48]. Chaney, David, Laurie Drinkwater and G. Stuart Petty grove. *Organic Soil Amendments and Fertilizers* UC Sustainable Agriculture Research and Education Program #2015. University of California 1992; 36p.

[49]. Carter, M.R., D.A. Angers, E.G. Gregorich and M.A. Bolinder, Organic carbon and Nitrogen stocks and   storage of profiles in cool, humid soils of eastern Canada. *Can. J. SiolSci*. **1997** 77(1-4): 205-206.

[50]. Mesfin A,. *Nature and management of Ethiopian soils*. Alemaya University of Agriculture, Ethiopia. **1998**,272p.

[51]. Bray, R.H. and Kurtz L.T.. Determination of total, organic and available forms of

phosphorus in soils. *Soil Science*, **1945**, 59:39-45.

[52]. Wilding, L.G. *Soil spatial variability*: *Its documentation, accommodation and*

implication to soil surveys.. In: D.R. Nielsen and J. Bouma (Eds.). Soil Spatial Variability

Proceedings of a Workshop of the ISSS and the SSA, Las Vega PUDOC, Wageningen

1985 pp. 166-187.

[53]. Day; P.R Hydrometer method of particle size analysis; In: C.A. Black (eds.).

Methods of soil analysis Agron. **1965** *Part II, No. 9*. Am. Soc. Agron.. pp. 562-563

[54]. Van Noordwijk, M., C. Cerri, P.L. Woomer, K. Nugroho and M. Bernoux,. Soil carbon Dynamics in the humid tropical forest zone. *Geoderma.* **1997,***79*: 187–225.

[55]. Rowell, D.L. *Soil science: Methods & Applications. Addison Wesley Longman* Singapore Publishers (Pte) Ltd., England, UK.; 350p , 1994 .

[56]. Peach, M.,. Hydrogen ion activity: In "Methods of soil analysis.''. (eds.) C.A. Black; D.D; Evans; J.L; White, L.E. Ensminger and F.E. Clark. Am. Soc. Agro. Monograph Madison, Wi. USA.**1965**, *No. 9.* pp. 374-390

[57]. Black, C.A.*Methods of soil analysis. Part I, American Society of Agronomy*. Madison, Wisconsin USA. 1965,1572p.

 [58]. Van Reeuwijk L.P. *Procedures for Soil Analysis*. 3rd Edition. International Soil Reference Information Centre Wageningen (ISRIC). The Netherlands. 1992. P.O. Box 353. 6700 AJ

[59]. Sahlemedhin ;S and Taye *Procedures for soil and plant analysis*. National   Soil Research Centre, Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia. 2000 110p

[60]. USDA Soil Conservation Service.. *Soil Survey Investigations,* **1984**. Report *No.1.*

 [61]. Thomas, G.W. and Hargrove, W. L.. The chemistry of soil acidity and Liming. *American Society of Agronomy*.**1984**, 50:3-56.

[62] .Van Reeuwijk L.P..*Procedures fo r Soil Analysis*. 3rd Edition International Soil Reference and Information Centre Wageningen (ISRIC). The Netherlands. 1993 P.O. Box 353. 6700 AJ Wageningen

 [63] . Hodgson, J.F. Chemistry of the micronutrients in soils. *Advances in Agron .***1963** *15*: 119- 149.

 [64]. Krauskof, K.B. *Geochemistry of micronutrients.. In*: J.J. Mortvedt, P.M Giordano and W.L. Lindsay (Eds.). *Micronutrients in Agricultur*e. Soil Sci. Soc. Amer. Madison, Wisconsin. 1972. pp. 7-35

 [65] .Nega E, *Land use changes and their effects on physical and chemical properties In Senbat Sub- watershed*, western Ethiopia. MSc Thesis Submitted to School of Graduate Studies, Alemaya University, Ethiopia. 2006;72p .

 [66]. McDonagh, J.F., T.B. Thomsen and J. Magid,. Soil organic matter decline and compositional change associated with cereal cropping in southern Tanzania. *Land Degradation and Development.* **2001** *12*: 13-26.

[67]. Mesfin, A. *The challenges and future prospects of soil chemistry in Ethiopi*a. Pp 78-96. 1996

[68]. Jordan, C.F. *Ecology of tropical forests.. In: L. Panxel (Ed*.). Tropical forestry hand book. 1993, pp.165-195

[69]. SAS (Statistical Analysis System) Institute,. The SAS system for windows, version .SAS Institute Inc. *Cary NC.,USA*. **1999** 8.1,*Vol.1*

[70]. Berhanu, D..The *physical criteria and their rating proposed for land evaluation in highland region of Ethiopia.* Land use planning and regulatory department, Ministry of griculture. Addis Ababa, Ethiopia 1980.

[71] . Olsen, S.R.; C.V. Cole; F.S. Watanable and L.A. Dean, Estimation of avariable phosphorus in soil by extraction with sodium bicarbonate. *USDA Circular*.**1954** *939:* 1-19.

[72]. Nair, K.M. and G.S. Chamuah, Exchangeable aluminum in soils of Meghalaya an management of Al^{3+} related productive constraints. *J. Indian Soc. Soil Sci.***1993** *4(1/2):* 331-334.

[73] .Landon, J.R. (Ed.),. Booker tropical soil manual: *A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics*. Longman Scientific and Technical, Essex, New York, 1991, 474p.

7. Appendix

Table1.1.Main effects of land use and soil depth on the selected physical properties of soils in the study area.

LUT	Sand%	Silt%	clay%	STC	BD (g/cm3)	PD(g/cm3)	TP%
				land use			
C L	18.83a	16.34a	69.84c	C	1.32b	2.58a	48.97a
G L	26.55b	20.89b	39.34a	SC	1.27a	2.6a	51.37b
F L	35.67c	21.50b	42.84b	SC	1.27a	2.57a	50.77b
LSD	9.21	2.76	7.1		1.81	NS	0.16
SEM (±)	4.86	1.67	3.6		0.16	0.015	0.017
				Soil depth			
0-20 cm	37.22b	18.48a	44.33a	SCS	1.28a	2.57a	50.59a
20-40 cm	22.33a	20.67b	57.01b	CS	1.29a	2.59a	50.15a
LSD	4.18	2.75	2.26		NS	NS	NS
SEM (±)	1.78	1.1	1.01		0.005	0.001	0.002

C= clay ; SC= sandy clay ; STC= soil textural classes;   NS= not significant

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

LUT	pH-H2O	pH- KCL	EC(Cmol(+)/Kg	SOM %	Av.P (ppm)
			Land use		
CL	4.45[a]	3.86[a]	0.035[b]	3.90[a]	8.95[b]
GL	4.71[a]	3.84[a]	0.025[a]	5.53[b]	7.94[b]
FL	5.03[b]	4.21[b]	0.06[c]	5.88[c]	7.38[a]
LSD (0.05)	1.63	0.56	0.056	2.33	1.14
SEM (±)	0.47	0.12	0.01	0.6	0.34
			Soil depth		
0-20 cm	4.69[a]	3.88[a]	0.033[a]	5.58[b]	8.42[b]
20-40 cm	4.82[a]	4.06[b]	0.047[b]	4.62[a]	7.76[a]
LSD(0.05)	1.27	0.67	0.56	0.57	0.72
SEM(±)	0.35	0.167	0.061	0.07	0.28

LSD =least significant difference; SEM = standard error of the mean; SOM = soil organic matter; AvP = available phosphorous; EC= Electrical conductivity.

Appendix Table . Main effects of land use and soil depth on selected chemical properties of soils in the study area**.**

Treatment	EA(Cmol(+)/Kg	TN%	C:N	CEC(Cmol(+)/Kg
			Land use	
CultivatedLand	3.95^c	0.20^a	11.59^a	38.5^c
Grazing Land	3.71^b	0.28^a	11.58^a	25.52^b
Forest Land	1.17^a	0.30^b	11.60^a	27.82^c
LSD (0.05)	4.1	0.37	NS	4.30
SEM ($\pm$)	0.89	0.03	0.006	3.99
			Soil deptjh	
0-20 cm	2.97^a	0.28^a	11.59^a	33.31^b
20-40 cm	2.91a	0.23^a	11.58^a	27.92^a
LSD (0.05)	4.15	0.36	NS	4.32
SEM ($\pm$)	0.03	0.025	0.005	2.70

LSD =least significant difference; SEM = standard error of the mean; C/N = carbon to nitrogen ratio; EA = exchangeable acidity; TN =Total nitrogen ; CEC= Cation exchangeable capacity

Appendix Table .Main effect of land use and soil depth on the selected chemical properties of soils in the study area**.**

	EB cat ions (cmol(+)/Kg)				Micro nutrients (cmol(+)/Kg)			
	Na	K	Mg	Ca	Fe	Cu	Zn	Mn
LUT	Land use							
CL	0.16^b	0.76^a	4.10^a	3.99^a	25.46^c	3.05^c	2.36^b	41.7^c
GL	0.17^b	1.00^b	5.20^b	5.08^b	18.13^a	1.61^a	2.41^c	33.9^a
FL	0.2^a	1.37^c	6.57^c	5.62^c	19.40^b	2.50^b	1.69^a	39.1^b
LSD	0.47	0.37	4.46	4.4	2.90	3.37	3.02	5.40
SEM ($\pm$)	0.022	0.18	0.71	1.48	0.26	0.49	0.23	2.90
	Soil depth							
0-20 cm	0.14^b	0.89^a	4.31^a	4.68^a	22.66^b	2.59^b	2.54^b	46.01^b
20-40 cm	0.21^a	1.19^b	6.26^b	5.08^b	19.33^a	2.17^a	1.76^a	30.41^a
LSD	0.23	1.46	4.17	4.90	2.96	3.35	3.02	5.56
SEM ($\pm$)	0.035	0.15	0.97	1.10	0.66	0.39	0.32	3.12

LSD = least significant difference; SEM = Standard error of the   mean; LUT= Land Use Type CL=Cultivated Land   FL=Forest Land   GL=Grazing Land

Appendix Table . Ratings of soil pH for 1:2.5 soils to water ratio suspension (Foth and Ellis, 1997).

No	pH	Rating
1	< 4.5	Very strongly acidic
2	4.6 – 5.2	Strongly acidic
3	5.3 – 5.9	Moderately acidic
4	6.0 – 6.6	Slightly acidic
5	6.7 – 7.3	Neutral
6	7.4 – 8.0	Moderately alkaline
7	>8	Strongly alkaline

Appendix Table 6. Ratings of organic matter (Berhanu,1980), total nitrogen (Berhanu,1980), CEC(Landon,1991), ava.P (Olsen,1954).

SOM%	TN %	CEC cmol(+)/Kg	Ava.P (cmol(+)/Kg	EC (cmol(+)/Kg	Rating
> 20	> 0.3	>40	>20	> 15	Very high
10-20	0.225 -0.3	26-40	15-20	8-15	High
4 -10	0.125 -0.225	13-25	10-15	4-8	Medium
2-4	0.05-0.125	6-12	5-10	2-4	Low
< 2	< 0.05	< 6	<5	< 2	Very low

Appendix Table 7. Rating of exchangeable bases (FAO, 2006a; Landon, 1991).

Exchangeable bases (cmol(+)/Kg)				Rating
Ca	Mg	K	Na	
>20	>8	> 1.2	> 2	Very high
10-20	3-8	0.6-1.2	0.7-2	High
5-10	1-3	0.3-0.6	0.3-0.7	Medium
2-5	0.3-1	0.2-0.3	0.1-0.3	Low
<2	< 0.3	< 0.2	< 0.2	Very low

Appendix Table 8.Rating of micronutrients (FAO,2006a; Landon,1991).

Micronutrients (cmol(+)/Kg)				Rating
Fe	Zn	Cu	Mn	
30.0	3.0	0.6	30.0	Very high
20.0	2.0	0.4	20.0	High
7.0	1.0	0.3	3.0	Medium
5.0	0.8	0.2	1.0	Low
3.0	<0.4	<0.1	<0.6	Very low

Appendix Table 9. Soil textural classes in the study area.

Land use type	Textural classes	
	0-20 cm	20-40 cm
Cultivated land	Clay	Clay
Grazing land	Sandy clay loam	Clay
Forest land	Sandy clay loam	Clay
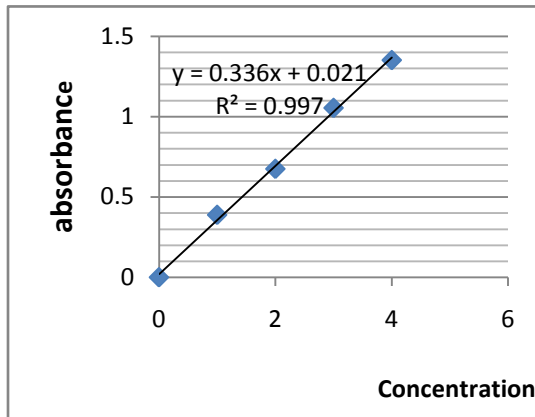
Appendix Figure . Calibration curve for determination of available P
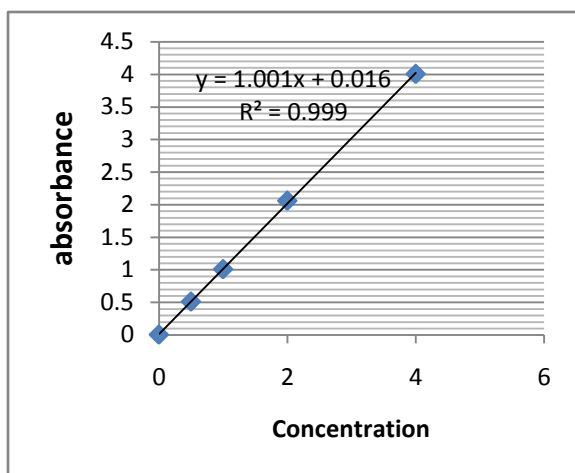
Na
          K
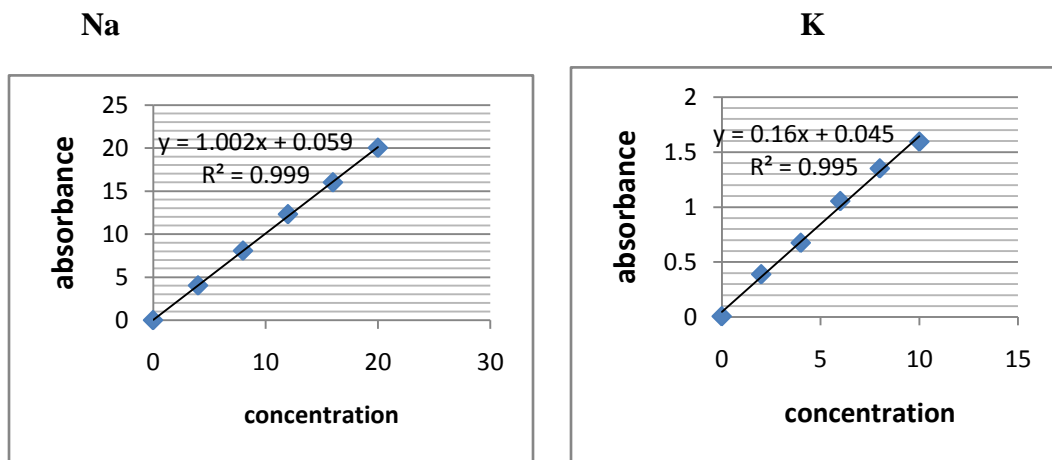
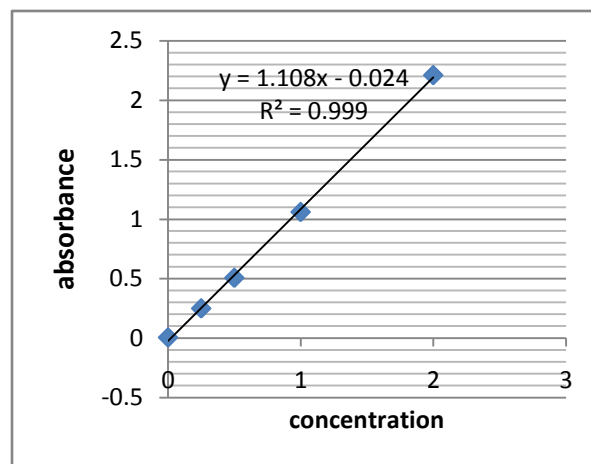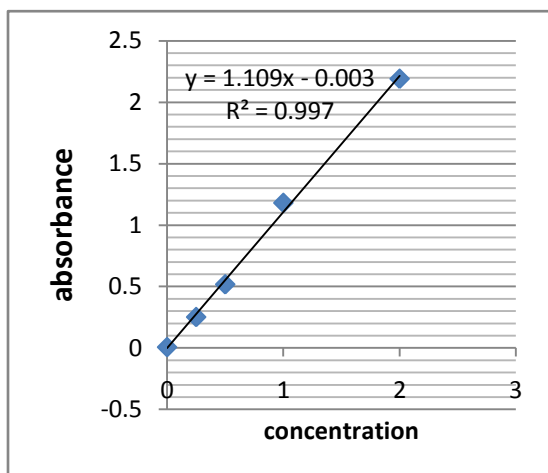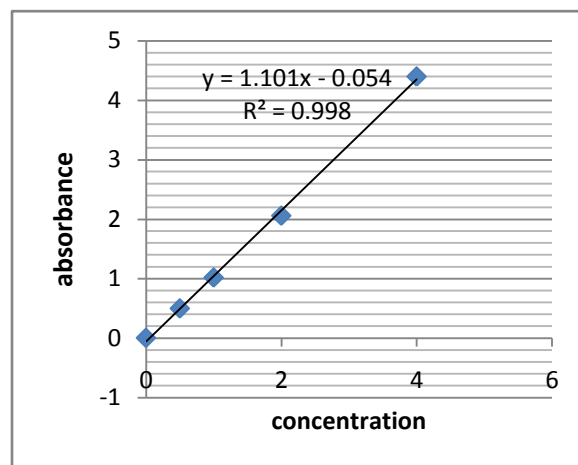Appendix Figure .Calibration curve for determination of Na and K

Ca
          Mg
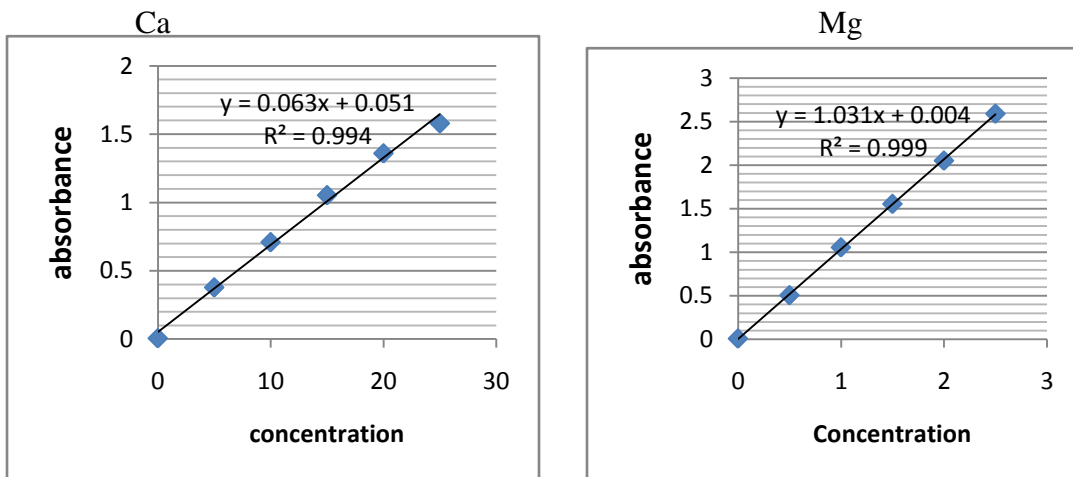
Appendix Figure . Calibration curve for determination of Ca and Mg

Fe

Zn

absorbance

y = 1.001x + 0.016
R² = 0.999

Concentration

absorbance

y = 1.108x - 0.024
R² = 0.999

concentration

Appendix Figure . Calibration curve for determination of Fe and Zn

Cu

Mn

absorbance

y = 1.109x - 0.003
R² = 0.997

concentration

absorbance

y = 1.101x - 0.054
R² = 0.998

concentration

Appendix Figure .Calibration curve for determination of Cu and Mn