POTENTIAL OF SMALLHOLDER FARMERS' CONSERVATION AGRICULTURAL PRACTICES IN ENHANCING SOIL ORGANIC CARBON STOCK AND OTHER SELECTED SOIL PHYSICOCHEMICAL PROPERTIES ,AT AKAKI DISTRICT, CENTRAL, ETHIOPIA.

M.Sc. THESIS

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A THESIS SUBMITTED TOTHE DEPARTMENT OF AGRO FORESTRY, WONDO
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IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE
DEGREE OF
MASTER OF SCIENCE IN (CLIMATE SMART AGRICULTURAL LAND SCAPE
ASSESSMENT)

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APPROVAL SHEET I

This is to certify that the thesis entitled ‘potential of smallholder farmers’ conservation agricultural practices in enhancing soil organic carbon stock and on other selected soil physicochemical properties’ at the Akaki district, central Ethiopia. Submitted in partial fulfillment of the requirement for the degree of master of sciences, in climate smart agricultural landscape assessment of the school of graduate studies Hawassa University Wondo Genet College of Forestry and Natural Resources. The thesis is a record of original research carried out by Addisu Wakayo Abamagal ID. No. MSC/CSAL/002/09, under our supervision and no part of the thesis has been submitted for any other degree or diploma. The assistance and help received during the courses of this investigation have been duly acknowledged.

Therefore, we recommend that, he can submit the paper to the department.

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Dr.Fantaw Yemir __________________ ___________________

Name of Co-Advisor signature Date

APPROVAL SHEET II

We, the undersigned, members of the Board of examiners of the final open defense by Addisu Wakayo have read and evaluated his thesis entitled potential of smallholder farmers' conservation agricultural practices in enhancing soil organic carbon stock and on other selected soil physicochemical properties at Akaki district, central Ethiopia and examined the candidate. This is therefore to certify that the thesis is accepted in partial fulfillment of the requirements for the degree of Master of Science.

Name of the Chairperson	Signature	date
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Name of External Examiner	Signature Date	date
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STATEMENT OF AUTHOR

I here, by declare that the thesis entitled potential of smallholder farmers' conservation agricultural practices in enhancing soil organic carbon stock and other selected soil physicochemical properties. The thesis has been submitted in partial fulfillment of the requirements for the degree Master of Science in climate smart agriculture landscape Assessment. It is my original work and has not been presented for a degree in any other university. All sources of materials used for this thesis are duly acknowledged and references are listed at the end of the main text.

Author's Name: Addisu Wakayo Abamagal

Place: Wondo Genet, Ethiopia

Signature_________________

Date of Submission march 2019

LIST OF ACRONYMS AND ABBREVIATION

C	Carbon
N	Nitrogen
SOC	Soil organic carbon
SOM	Soil organic matter
Tg	Tones gram
CO_2	Carbon dioxide
N_2O	Nitrous oxide
DAAO	Documents Akaki agriculture office
CA	Conservation Agriculture
GPS	Geographical position system
IPCC	Intergovernmental panel on climate change
SOCD	Soil organic carbon density
STN	Soil total nitrogen
BD	Bulk density
SOCS	Soil organic carbon stock
C: N	Carbon to nitrogen ratio
OC	Organic carbon percentage
STN	Soil total nitrogen
CV	coefficient variation
USDA	United states department of agriculture
SPSS	Statistical package for social sciences
SAS	Statistical analysis software
SD	Standard deviation
PH	Power of hydrogen
ANOVA	Analysis of variance
BD	Bulk Density
CEC	Cation exchange capacity

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ABSTRACT

Soil degradation and extensive use of agricultural lands have led to the decline in soil fertility. To reverse the nutrient deterioration of cultivated lands, farmers have started employing various conservation agriculture practices. This study was initiated to examine the potential of conservation agriculture (integrated practices such as inter cropping, crop rotation, residue retention and minimum tillage) for four years ago by smallholder farmers to enhance soil organic carbon stock and other selected soil physicochemical properties in Akaki district Bilbilo micro watershed. A systematic sampling method was employed for data collection. Totally 96 composite soil samples (8 plots x 2 treatments x 2 replication of site x 3 depth: 0-10cm, 10-20cm and 20-30cm) were collected for analysis. Results showed that soil bulk density (BD) was significantly ($p<0.05$) varied with practices and depth ($p<0.001$). It was lower in soil under conservation (0.78 g m^{-3}) than under conventional practice (1.48 gm^{-3}); and in the top layer 0-10 cm (1.21±0.05) than the rest depths. BD showed increasing trend with soil depth across the practices: lower on the top 0-10cm depth (0.78 ±0.03) compared with the rest. The pH was higher (7.28) in conservation than conventional (5.75) due enhanced SOM. The CEC was higher (14.6Cmol (+)/kg) in conservation practice than in the conventional (10.3cmol (+)/kg). Both pH and CEC had shown increase in the two practices and soil depth due to the leaching of base cation from upper to lower layers. The mean SOC stocks decrease with increasing soil depth about the significant variations with treatments and depth. The SOC stock was higher (110.6t c /h) in conservation practice than in conventional practice (50.22 t/ha). Similarly, total N stocks was also higher (19.5 t c/ha) in conservation practice than in conventional practice (17.4 t c/ha). SOC and total N in both practices had decreased with soil depth due to lower accumulation of organic residue in the lower layer. Likewise, C: N ratios had increases with depth due to similar reason the decrease the amount of soil organic carbon and TN pool (e.g. root biomass) with depth. However, the C: N ratio has higher value in conservation practice (6.51) than in conventional practice (6.05) due to fertility of soil improved. The higher variability in SOC stock across the farming practices and soil depths was due to human disturbance during cultivation and other activities. Such as the change in agricultural practice management can increase or decrease soil organic carbon. In conclusion, most of the measured soil properties were improved in CA aided followed by soil depth compared with conventional agriculture and at soil depth layers ones. The interaction of farming practice types and soil depth also significantly affected all parameters. Therefore, integrated land management and soil conservation measures especially (CA aided) are required in all land management types and soil depth to maintain soil properties.

Keywords, *Nutrient management, residue retention, crop rotation, soil depth, pH, soil bulk density.*

1. INTRODUCTION

1.1. Background

Agricultural activities are responsible for about one third of the world's greenhouse gas (GHG) emissions, especially in developing countries (Gupta *et al*., 2007). Certainly, smallholder agricultural systems are highly dynamic and heterogeneous environments that may have significantly contributed to GHG emissions from the past number of decades (Berry, 2011). The Human efforts to produce ever-greater amounts of food have to leave their negative mark on our environment. Such as soil, degradation is occurring in almost all terrestrial biomass and agro-ecologies, in both low and high-income countries. Still, its impact is most severe on the livelihoods of the poor; those heavily depend on natural resources (Nkonya *et al*., 2016). Even so, it is eroding crop yields and contributing to malnourishment in many corners of the globe. Despite the availability of improved varieties of increased yield potential, poor crop system management (Reynolds and Tuberosa, 2008) does not achieve the potential increase in production.

Persistent use of conventional farming practices of extensive tillage, and especially when combined with burning of crop residues, have magnified soil erosion losses and the soil resource base has been gradually degraded (Montgomery, 2007). Another direct because of farmer's persistent use of traditional production practices is rapidly increasing production costs agriculture-based technologies for production systems. Furthermore, these systems traditionally suffer from severe soil organic matter (SOM) depletion due to intense decomposition following soil ploughing, consider using most of this ground biomass during harvested, and the enhanced soil erosion inherent to those activities (Mann *et al*., 2011). The change in mindset not only by farmers, but also by scientists, extension agents, private sector partners, and policy makers may be the most difficult aspect with the development, transfer, and farmer adoption of appropriate conservation agriculture technologies. As such, the movements towards conservation agriculture based technologies normally comprise a sequence of stepwise changes in cropping system management to improve productivity and sustainability.

Conservation agriculture is promoted as an agricultural practice that increases agricultural sustainability, associated with a potential for mitigating greenhouse gas emissions (Paustian *et al*., 1997).Therefore, conservation agriculture (CA) aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as to enhanced and sustained agricultural production. It's can also be referred to as resource efficient or resource effective agriculture (Gustafsson, 2013). In Ethiopia, 85% of the population is directs supported by the agricultural economy (Karppinen *et al*., 2016). Agricultural sectors dominated by small-scale farmer's systematic practice rain-fed mixed farming by employing traditional technology, adopting a low input and low output production system .Such a system exposes the land to degradation and negatively affects the management of the natural resources, water, soil, plants and animals, and hence reduces agricultural production (Baylis *et al*., 2012). Today conventional agriculture is built on two related goals such as the maximization of production and the maximization of profit. Whereas, conventional farming systems are associated with a decline in soil structure and soil aggregation, a decrease in water infiltration and an increase in soil bulk density, nitrogen leaching and ground water contamination (Logsdon *et al.*,1993; McGarry *et al.*,2000).

Such types of agricultural systems were lead to a continuing degradation of soil resources, particularly from the chemical properties point of view, resulting in a loss of agricultural productivity reflected in lower yields and higher environmental problems (Kimble, 1998). The land degradation activity is aggravate to soil erosion leads to the breakdown of soil aggregates and clods into their primary soil particles due to this GHG emission and off turn worsens climate change (Berry *et al*., 2011). The residue gradually breaks down in the soil, increasing the amount of organic matter in the soil. However, ploughing damages the soil cultivation leaves the soil bare, exposing it to erosion and water loss through evaporation, which results on the capping of the soil surface, accelerated decomposition of soil organic matter and contributes to the destruction of soil structure. Repeated ploughing and cultivation at the same depth increases the risk of soil compaction and creation of hardpans at the working depth and mixing of the soil layers can severely harm soil organisms and reduce soil fertility (Leifeld, 2005). The soil organic carbon can be maintained or increased from most farming practice which are cropped every year in which crop residues are returned to the soil, and erosion is kept to a minimum as the result enhance carbon stock in a soil (Lal, 2004). Since the smallholder farmer, conservation agriculture is enhancing the selected soil physicochemical properties and soil organic carbon stock, this study is initiated to generate scientific evidence on their effectiveness on improving the soil carbon stock and other soil physicochemical properties.

1.2. Statement of the problem

One or more of human induced activities aggravate land degradation. It has declined the soil quality, resulting from improper farming practices (Mulu *et al*., 2016). In the study area (Akaki district), agricultural practices that did not consider soil care measures and continuous cultivation with minimum soil fertility enhancements were practiced for several years. These practices have resulted in loss of the biological and economic productivity of cropland, loss of organic matter and fertile soil. Moreover, it has resulted in a human induced soil erosion, deterioration of the physicochemical and biological properties of soil and long-term loss of natural vegetation in the site.

The conventional farming practices of extensive tillage, and especially when combined with burning of crop residues and forage have magnified soil erosion losses and the soil resource base has been gradually degraded. Responding to these problems, Akaki district agricultural offices had started collaborating with NGOs: Climate resilient green economy (CRGE) and Green foundation Ethiopia (GEF) since four-years to overcome the overgrowing soil fertility degradation reduce human induced soil erosion and GHG emission from agricultural sector.

Thus, an integrated conservation, agricultural practices for soil fertility improved: such as crop rotation, intercropping, residue retention, minimum soil disturbance, terrace construction, and tree planting were implemented by compensating the farmers of the locality. However, the information on those conservation agricultures towards the soil carbon stocks and physicochemical properties is limited. This study was designed to evaluate of smallholder farmer's conservation agriculture on soil organic carbon stocks and other selected soil physicochemical properties.

1.3. Objectives

1.3.1 General objective

To investigate potentials of smallholder farmers' conservation agriculture practices in enhancing soil organic carbon stock and improving other selected soil physicochemical properties compared to conventional practices at Akaki district, central, Ethiopia.

1.3.1.1. Specific objective

- ✓ To determine the conservation in reference to conventional farming practices on soil organic carbon stocks.
- ✓ To determine the conservation in reference conventional farming practices on other selected soil physicochemical properties.

1.4. Research Questions

- ✓ Is there is a difference of SOC stock improved between the two practices (Conservation and Conventional)?
- ✓ Does the conservation and conventional farming practices show variation on other selected soil physicochemical properties?

1.5. Significance of the study

The study will provide information on the potential of conservation agricultural practices on soil carbon stocks and on other selected physicochemical properties. It will hopefully inform benefits and challenges about conservation agriculture in the Akaki district central highland of Ethiopia. Moreover, the outcome of this study will generate information on effect of the conservation, agricultural practices improved soil properties for the Woreda agricultural and natural resource management. Therefore, that encouraging donors to support this long-term, applied, research with improved soil fertility as well as the enhanced crop productivity.

Generally, the research findings of this study will have the significance of various stakeholders by providing strong scientific evidences for the performance of conservation agriculture in improved fertility of cropland, and it will serve as a basis for future similar studies.

2. LITERATURE REVIEW

2.1. Concept of land degradation

The land degradation is primarily the result of vegetation degradation, water erosion, wind erosion, and salinization (Dregne, 1994). Therefore, land degradation is any reduction or loss of the biological or economic productive capacity of the land resource base (ELD and UNEP, 2015). Nowadays, about 2 billion hectares of global land is severely degraded, in some cases in irreversible. All these caused a severe damage to local ecologies as well as contributing a lot to climate change and its associated effects on the well-being of humanity (Alemu, 2016).

The degradation of soils and land, in this regard, poses significant challenges to the well-being and food security of all the people around the world (Nkonya *et al.,* 2016). Ever since human kind started agriculture, land degradation is a single largest threat to soil productivity and has remained so until the date. This was a major global issue during the 20th century and will remain high on the international agenda in the 21st century (Utuk and Daniel, 2015). The global land assessment of degradation (GLASOD), experts estimate that nearly 2 billion hectares worldwide (22%) of all cropland, pasture, forest, and woodland) degraded is since mid-century (Utuk and Daniel, 2015).

Africa and Latin America appear to have the highest amount of degraded agricultural land and Asia is the highest proportion of degraded forestland. About 5 to 10, a million hectares are being lost annually to severe degradation (Jie *et al*., 2002). Land degradation stretches to about (30%) of the total global land area and about three billion people exist in degraded lands. The annual global cost of land degradation due to land use/cover change and using land degrading management practices on static cropland and grazing land is about 300 billion USD. Sub-Saharan Africa (SSA) accounts for the largest share (22%) of the total global cost of land degradation. Only about (46%) of the cost of land degradation due to land use/cover change which accounts for (78%) of the US$300 billion loss is borne by land users and the remaining share (54%) is borne by consumers of ecosystem services offed to the farm (Nkonya *et al*., 2016). Land degradation in Africa continues to be a serious environmental challenge with significant economic and social implications (ELD and UNEP, 2015). For many countries and in particular for many African countries land degradations on agricultural land is posing substantial threats to sustainability, economic growth and the welfare of the rural population (Pagiola, 1999).

Land degradation, especially in the highland are identified as the most serious environmental problem in Ethiopia. The Hararghae highlands in Eastern Ethiopia, Tigray, Wollo and Semen Shoa highlands in the north and the Gamo-Gofa highlands and the Bilate River basin, which starts in eastern slopes of Gurage highlands and stretches through eastern Hadiya and Kembatta highlands are the seriously eroded/degraded land surfaces in Ethiopia (Mesene, 2017).

In the Ethiopian highlands, land degradation resulting from soil erosion and nutrient depletion is a serious environmental and socio-economic problem (Amsalu and Graaff, 2006). The major causes are rapid population increases, severe soil loss, deforestation, low vegetative cover and unbalanced crop and livestock production. Topography, soil types and agro ecological parameters are also additional factors affecting the land degradation processes in Ethiopia influenced by man (Gashaw *et al*., 2014). It is become a growing concern with the current increase in demand for arable land. Sustainable land management and land restoration practices are required to meet the demands to provide food and other services (Quillérou and Thomas, 2012).

Overall, soil is being lost from agricultural areas at 10 to 40 times faster than the rate of soil formation imperiling humanity’s food security (Pimentel and Burgess, 2013). Severe loss of soil and water not only has its disturbing effect on farming, forestry, stock-breeding and ecological environment of the area concerned, but also is the root of poverty for local people (Qiangguo, 2002). The amount and rate of erosion depend on soil properties, land topography, local climate cropping and management systems, and the presence or absence of runoff management and erosion control practices (Moldenhauer, 2016). Certainly, 1 mm of soil, easily lost in one rain or windstorm, is so minute that its loss goes unnoticed by the farmer and others. Yet this loss of soil over a hectare of cropland amounts to 15 t/ha (Pimentel and Burgess, 2013).

2.2. Dung and crop residues consumption

As rural populations grow and woodland is converted to cultivation, the use of dung and crop residues for fuel has become much more important (Berry, 2003). The organic content of soils is often low due to the widespread use of dung and crop residues for energy (Teketay, 2016). The soil fertility has been declining due to the limited recycling of dung and crop residue in the soil, low use of chemical fertilizers, declining fallow periods, soil and organic matter burning, and soil erosion. Although the farming system in the high lands is predominantly mixed crop-livestock, nutrient flows between the two is predominantly one sided, with the feeding of crop residues to livestock, but little or no dung being returned to the soil (Desta *et al*., 2000). Crop residues are increasing use of fuel rather than mulch. Dung is used as fuel rather than manure. All these factors lead to nutrient loss and increased erosion (Berry, 2002).

2.3. Soil physical degradation

Soil physical indicators are principally concerned with the physical arrangement of the solid particles and pores, and include texture, bulk density, porosity, aggregate strength and stability, soil crusting, soil compaction and topsoil strength (Mrabet *et al*., 2012). Soil physical degradation is a gradual process of many steps beginning from structural deterioration and ending in differential loss of finer particles through erosion (Omuto, 2008). Overpopulation, deforestation, and a large density of animals that trample the soil are contributing to faster degradation of the soil resources. The inherent nature of the soils like the low bulk density makes the soils highly vulnerable to water and wind erosion. Physical degradation may occur because of the movement of the soil away from its place, compaction, reduction in aeration and reduced permeability and sealing of the soil.

Such degradation accelerated largely by poor soil management practices or by the removal of soil covers by the land users or by over cultivation. Soil erosion is by far the largest process causing land degradation, in Ethiopia (Dubale, 2001).Bulk density has a strong relationship with organic matter. When the level of organic matter increases, the bulk density is getting low. Higher aggregate stability associated with higher levels of soil organic matter increases soil porosity, which results in a lower bulk density (Murphy, 2014). Factors affecting bulk density are porosity, texture and organic matter content.

Clay soils tend to have a higher total porosity than sandy soils. However, the relationship between texture and bulk density is tenuous and depends on a variety of factors such as organic matter content and depth in the soil profile (Chaudhari *et al*., 2013). Land use history can also affect bulk density through cultivation, the time since cultivation and the amount of rain since the cultivation and compaction by stock or machinery (Murphy, 2014). Changes in pore size distribution change the moisture and air regime of soils, affecting organic matter decomposition gradient and nitrogen mineralization. The higher the soil moisture contents of the compacted soils, the larger the negative impact (Mrabet *et al*., 2012). The bulk density was similar or lower with CA than with conventional farming. However, a natural consolidation and mechanical compaction in CA causing denser packing of top soil. Soil bulk density is a basic soil property influenced by some soil physical and chemical properties (Mrabet *et al*., 2012).

2.4. Types of Agricultural Practices

2.4.1. Conventional agriculture

Conventional agriculture is the major means of seedbed preparation and weed control and traditionally used for a given crop in a given geographical area (Bhattacharyya *et al*., 2012). However, conventional tillage with frequent tillage operations disturbed soil, and increase the effect of drying re wetting and freezing -thawing, which increase macro-aggregate susceptibility to disruption (Kumar *et al*., 2017). Enhanced C and N stabilization within the micro-aggregate-within macro aggregate fraction under permanent raised beds compared to conventionally till raised beds was related to the dynamic behavior rather than the amount of the micro-aggregates (Denef *et al*., 2002).

Higher mineralization and/or leaching rate has implicated for reduction in organic C and total N under tilled plot due to soil structure deterioration following tillage (Lal, 1997). A CEC and exchangeable Ca, Mg, and K, were significantly higher in the surface soil under CA compared to the repeated ploughed soil (Becker *et al*., 1994; Rahman *et al*., 2008). Typically, it includes a sequence of soil workings, such as ploughing, discoing, and harrowing, to produce a fine seedbed, and removing the plant residue from the previous cropping season (Hoogmoed and Derpsch, 1985). Therefore, conventional tillage systems are incorporates crop residues, lime, and fertilizer, which results in a mechanically mixed surface soil layer which are quite different from the relatively undisturbed surface soil under conservation farming practices (Komatsuzaki, 2007). It includes the uses of chemical fertilizers, pesticides and other input continually. A decline in soil structure and soil aggregation, a decrease in water infiltration and an increase in soil bulk density, soil salinity, nitrogen leaching, and ground water contamination (Logsdon *et al.*, 1993; McGarry *et al.*, 2000).

Therefore, conventional tillage was mainly practice implemented, which is the physical degradation of soil and increased soil erosion, labor, time, energy, and production cost. These have exacerbated the demand for water uses and affect soil fertility, threatening, long-term crop productivity by increasing soil degradation and causing water shortages (Quinton *et al.*,2010). In generally, conventional tillage practices disrupt soil aggregates, exposing more organic matter to microbial attack (Oades, 1984; Ladd *et al.*, 1985).

2.4.2. Conservation agriculture

Problems associated with tillage can be alleviated by implementing alternate tillage systems, such as conservation or minimum tillage that can improve soil structure, increase water storage and transmission, and enhance soil C and N content in the previous earlier plowed layer (Gantzer and Blake 1978). Therefore, conservation tillage is the collective umbrella term commonly given to no-tillage, direct drilling, minimum-tillage, to represent that the specific practice has a conservation goal of some nature (Gustafsson, 2013). Usually, the retention of 30% surface cover by residues characterizes the lower limit of classification for conservation-tillage, but other conservation objectives for the practice include conservation of time, fuel, earthworms, soil water, soil structure, and nutrients. Thus residue levels alone do not adequately describe all conservation tillage practices (Baker *et al.*, 2007).The conservation agriculture is the potential to sequester soil organic carbon by capturing atmospheric CO_2 because of the land management practices (Powlson *et al* ., 2011). The distribution of this SOC across the soil depth is varying;

its concentration is higher near the soil surface of conservation agriculture and lower at the deeper soil layer (Powlson *et al.*, 2012). The conservation agriculture is a base for integrated soil management, water and biological resources, and external inputs (Mupangwa *et al.*, 2013).

Management of soil carbon and nitrogen in agricultural lands such as crop residuals, conservation tillage, crop rotations, and integrated nutrient management in proper ways play positive roles for soil fertility, maintaining soil and environmental quality (Lal, 2004). This gives an opportunity to reduce erosion and increase organic matter in the soil surface and thus for climate change mitigation (Olson *et al.*, 2014). It attempts to achieve resource-efficient crop production by utilizing three farming practices are minimum soil disturbances, organic soil cover and diversified crop rotations (Gustafsson, 2013). The aggregate formation process of conventional agriculture is interrupting the soil by tillage with the corresponding destruction of aggregates, which increased wet aggregation. This can be improved by increasing the residue covers in conservation agriculture mainly on the soil surface (Verhulst, 2010).The soil organic matter accumulation in conservation agriculture is higher when compared to conventional agriculture; which is often associated with soil aggregation improvement (Baveye *et al.*,2011). In addition, the rotation of different crops with different rooting patterns combined with minimal soil disturbance with conservation systems promotes a more extensive network of root channels and macro pores in the soils that help with water infiltration with deeper depth (Kacemi, 1992).

The soil is disturbance by excessive tillage causes losses of soil organic carbon, physical and chemical soil properties. While in the CA is the crop residue, cover soil surface after planting which is used for soil carbon sequestrations and stabilizing atmospheric CO_2 concentration (Lal, 2003; Martinsen *et al.*, 2014). The difference crop root system is varied, soil carbon sequestration as compared to root penetrated conventional soil disturbed soil carbon loss and conservation tillage most soils undisturbed with in soil carbon stock in the soil depth across the crops (Baker *et al*.,2007). The SOC stock under conservation agriculture practice (combination of no-till and residue return) was greater than in conventional practice (Powlson *et al*., 2012). The soil chemical properties were more nutrient holding capacity in CA practice more exchangeable cation than convention agriculture practice, the reason of higher storage SOM in CA practices due to higher moisture and decomposition of plant residue faster than traditional agricultural practices (Blevins *et al.*,1977)

The higher soil organic carbon levels in CA is also related to high soil fertility; aggregate stability, the water retention capacity, the buffering of soil pH and the cation exchange capacity (Jat *et al*.,2012). The reduced tillage in CA reduces soil erosion and contributes for sustainable agriculture and improve soil quality (Matern *et al*.,2008).The conservation agronomical practice integrations such as cover crop, crop rotation, minimum tillage and intercropping are improve soil fertility and mineralization which release nutrient to the crop as compared to conventional farming (Sayre *et al*.,2007). In the conservation agricultures are soil aggregate, decomposition of SOM as the result reduced GHG emission in agricultural sector (Martinsen *et al*.,2014).

The SOM decomposition and stabilization of carbon and soil nitrogen through C and N mineralization is the result high formation of SOM (Hojberg *et al., 1994;* Sexstone.,*et al;* Sierra,1996). The cracks are between peds in undisturbed soils enhanced pore continuity in the un-tilled soils (Barnes, 1979). The residue remains on the surface has eighty-nine percent of surveyed organic farmers practicing conservation agriculture form into reduced tillage shallower than the standard conventional ploughing practice (Bàrberi, 2006). The CA practices are the cultivation of crops such as Maize, teff, wheat, bean, chickpea, lentil, and barley have been nutrients highly storage because of their deep root system which can longer get nutrient from the leached soil (Bàrberi, 2006).

2.4.3. Crop rotation

The practice of growing a series of dissimilar or different types of crops in the same area in sequenced seasons. It is done so that the soil of farms is not used for only one set of nutrients. It helps in reducing soil erosion and increases soil fertility and crop yield. The soil organic carbon stock and other soil physical properties are higher in crop rotation system than the continuous monocultures farming (West and Post, 2002). Increased biomass production and input from the different crops are through altering diversifying rooting pattern and rooting depth (luo *et al*., 2010).The crop rotation enhances the soil fertility and enriches nutrient supply to subsequent crops that leading to increased crop yield. Improved fallows are generally the deliberate planting of fast-growing species usually legume crops that produce easily decomposable biomass and replenish soil fertility (Bationo, 2000).

Therefore, crop rotation helps in maintaining the fertility of the soil because it makes easier to the leguminious plants to convert atmospheric nitrogen into a soluble form. The monoculture of wheat with N fertilization accumulated 50 g C m-^{2} y-^{1} compared to 150 g C m-^{2} y-^{1} with the corn-wheat clovers rotation with manure and N fertilization (Buyanovsky and Wagner, 1998). When fallow is removed and wheat is grown continuously, SOC is stored at a rate of 15± 6g Cm-^{2} yr-^{1}.The effect of crop rotation on carbon sequestration can be due to increased biomass C input, because of the intensified production, or due to the changed quality of the residue input (West and Post, 2002).

However, in the rotations with vetch planted as a winter green manure crop, soil C stocks were approximately 17 mg ha^1 higher under conservation agriculture practice than under conventional farming. The contribution to N_2 fixation by the leguminous green manure (vetch) in the cropping system was the principal factor responsible for the observed C accumulation in the soil under zero tillage, and that most accumulated C were derived from crop roots. The recommended of crop rotation strategies such as producing large amounts of biomass and residue for soil protection and incorporation in the soil, maintaining a continuous sequence of living vegetation (Govaerts *et al*., 2009).The perennial crops in the rotation, and diversifying the rotation to include nitrogen-fixing legumes (Kane,2015).

Altering crop rotation can influence soil organic carbon by changing the quantity and quality of organic matter input and thus has the potential to alter soil aggregation (Govaerts *et al*., 2009). Monoculture of winter wheat or barley resulted in greater aggregate stability than did winter wheat and vetch rotation, but the effect was only significant in some size fractions. Crops can affect soil aggregation by their rooting system because plant roots are important binding agents at the scale of macro-aggregates found significantly more large macro-aggregates in a soil under a wheat crop than in a soil under a maize crop (Six *et al*., 2002). Wheat has a more horizontal growing root system than maize and the plant population of wheat is higher, resulting in a denser superficial root network. This denser root network could positively influence aggregate formation and stabilization (Denef and Six, 2002).

An increased moisture conservation related to conservation agriculture practices, which as growing an extra cover crop after the harvest of the main crop (Sayre *et al*., 2007). Cover crops enhance soil protection, soil fertility, groundwater quality, SOC concentration, soil structure and water stable aggregates, build soil organic matter and improve the water balance, leading to higher yields. The replacement of fallow with legume ‘green manures’ such as lentils appears to bean effective C storage practiced with rates of C storage of 15±11 g C m-^{2} yr-^{1} (Blanco *et al.*,2009).

Therefore, water management practice in agricultural land was achieved by reducing water loss, harvesting water, managing excess water, and maximizing water storage such as the terrace on steep slopes and cross-slope barriers helps in reducing surface runoff (Blanco *et al.*,2009). Therefore, rotations with leguminous crops have the potential to increase the level of nitrogen in the soil through biological nitrogen fixation (Giller, 2001).such as an improves soil structural stability, increases crop water use efficiency, and increases soil organic matter levels and improves nutrient use efficiency (Gosling and Rayns, 2005).

2.4.4. Residue retention

The retention of crop residues is an essential component of CA for increasing or maintaining soil organic carbon. An increase crop yields are increase the amount of residue available and potentially soil carbon storage (Dolan *et al*., 2006; Wilhelm *et al.*, 2004; Paustian *et al*., 1997). Therefore, retention of crop residue on the soil surface as mulch is an essential component of CA intended to increase carbon inputs and enhance ecosystems benefits such as soil fertility, improved soil water relations, and biological properties (Palm *et al*., 2014). Higher SOC and total N have been in CA systems with crop residue retained as surface mulch than conventional tilled systems with incorporated residue retention (Verhulst *et al*., 2011; Govaerts *et al*., 2009). The fertility management is the single most important factor to increase residue production and ultimately increase soil carbon storage incorporates crop rotations (Giller *et al*., 2009; Dolan *et al*., 2006). The rate of decomposition is about 5.55 t ha^{1} with residue retention in comparison with the removal of all crop residues (Dersch and Bohm, 2001). The composition of residues are left on the field the soluble fraction, will determine its decomposition.

Soybean the residues are decompose faster than corn and wheat residues (Wagner, 1998). The belowground crop or weed root biomass is efficiently enhances SOC in the soil through its contribution to organic materials. The crop residue is dependent on the quantity and quality of the residue applied, soil properties, and the management practices followed (Singh and Lal, 2001). Crop residues refer to fibrous plant tissue left on the field after harvest and include stems, leaves, roots, and other plant parts (Pennock, 1995). Those protecting soil from acidification is by returning the crop residues to the soil (Miyazawa *et al*., 1993).

Such as the lower pH in CA was attributed to accumulation of organic matter in the upper few centimeters under CA soil causing increases in the concentration of electrolytes and reduction in pH (Rhoton, 2000). Retention of crop residue on the soil reduced the bulk density, enhanced organic carbon and EC but reduced the pH of the soil (Jat *et al*., 2004). The high organic matter contents are at the soil surface, under conservation agriculture, can increase the CEC of the topsoil (Kumar *et al*., 2015; Duiker and Beegle, 2006). Residues are contain large amounts of N, P and K. The positive effects of supplying residues are back into agricultural areas adding the nutrients to the soil, increasing SOM concentration, enhancing soil structure, influencing soil moisture and temperature regimes (Pennock, 1995). Therefore, the presence of mineral soil N available for plant uptake is dependent on the rate of C mineralization. The impact of reduced tillage with residue retention on N mineralization is lacking. However, a lower N availability because of greater immobilization by the residues left on the soil surface (Bradford and Peterson

2000, Rice and Smith 2004). Effects of conservation agriculture higher total N under CA compared to conventional tillage (Govaerts *et al.*,2007).

Therefore, the crop residues are input reducing volatilization and leaching losses, increasing root-soil interaction with nutrients, and increasing SOM concentration, which in turn improves intensity and capacity of water and nutrients in the soil (Gupta Chaudhary *et al*., 2014). Residue mulch changes the intensity and capacity of soil moisture by decreasing runoff and evaporation rate (Lal,2003). Replacing nutrients removed by crops with residues is equally whereas, more important in low-productivity subsistence farming (Potter *et al*., 1998; Pennock ,1995).

2.4.5. Intercropping

The practice of cultivating two or more crops in the same space and at the same time is a common a combination of an intercropping system to smallholder farmers involves cereals, legumes as compared to mono-crop (Ijoyah, 2012; Waddington *et al*., 2007). The cereal and legumes crops are combination of farmer due to legumes ability to combat erosion and raise soil fertility levels (Matusso *et al.*, 2014). Thus, a wide range of an intercropping has been developed because of significant increases in productivity compared with monocultures (Li *et al.*, 2007). Therefore, the nutrient inputs in organic systems are around 42.5 % on average lower plant soil than in conventional systems (Mader *et al*., 2002). The soil SOC, TN, and microbial biomass activities in minimum soil disturbance were significantly higher than conventional systems across 5 years (Alvear *et al.*, 2005).

The intercropping is a sustainable land management option compared to sole cropping since intercropping contributed to the long-term immobilization of nitrogen (N), with the potential to reduce nitrification and nitrate leaching. Reduced soil nitrification rates also moderate nitrous oxide losses, causing intercropping to mitigate the contribution to this greenhouse gases to global climate change (Cong *et al.,* 2015). An intercropping could potentially affect the rate of decomposition of organic matter in soil by greater diversity and quantity of the root litter added to the soil and through changes in the abiotic or biotic components of the decomposition environment (Lithourgidis *et al*., 2011).

Furthermore, the differences in the litter quality and the amount of litter deposited in the tree row of the intercropped space are expected to generate spatial heterogeneity in the SOC pool (Lithourgidis *et al*., 2011). An intercropping system such as maize/soybean, maize/cowpea, wheat/bean, wheat/chickpea and maize/faba bean, which significantly enhanced total N and P by over 50 % compared with monoculture (*Li et al.,* 2011).

2.5. Effect of tillage on bulk Density

The upper soil layer (0-7 cm) had low bulk density by reducing compaction due to rearrangement of soil particles and aggregates by various processes mainly the residue and mulch (Horn, 2004). The effect of tillage on soil bulk density is remains unchanged in deeper soil layers while in deeper soil layers, soil bulk density is generally similar in CA and conventional till (Gal *et al*., 2007). However, a plough pan has formed by tillage immediately underneath the tilled soil, causing higher bulk density in this horizon (Dolan *et al*., 2006 and Yang and Wander, 1999). Under CA, a more stable and porous structure can be formed and newly formed pores and rearrangement of soil particles preserved (Horn, 2004).In general, incorporation and/or retention of crop residues in to the soils reduced bulk density, and compaction of soils (Bellakki *et al*., 1998). Straw management had a large impact on bulk density in the surface layer (0-10 cm) but not significant in the 10-20cm depth. The bulk density under the high-mulch treatment was 58% lower and that under the low-mulch treatment was 19% lower than the bulk density under the un-mulched treatment for the 0-3 cm depth. In the 3-10 cm depth, bulk density under the high-mulch treatment was only 36% lower and that under the low-mulch treatment was 9% lower than under the control (Blanco-Canqui *et al*., 2006).

Crop residues have improved soil quality in terms of organic carbon and biotic activity (Karlen *et al*., 1993). Residues and organic carbon that are lighter in weight (Logsdon and Karlen, 2004), decomposition product promote more aggregation, root activity in the surface is increased due to better soil moisture in the surface due to this bulk densities lowered particularly near the soil surface in the no-till system (Shaver,2010).

When the level of organic matter increases, the bulk density is getting low. Higher aggregate stability associated with higher levels of soil organic matter increases soil porosity, which results in a lower bulk density (Murphy, 2014).Changes in pore size distribution change the moisture and air regime of soils, affecting organic matter decomposition gradient and nitrogen mineralization (Mrabet *et a*l., 2012). However, the relationship between texture and bulk density is tenuous and depends on a variety of factors such as organic matter content and depth in the soil profile (Chaudhari *et al*., 2013). The CA is a higher bulk density of the soil and consequently greater soil strength (Verhulst *et al.,* 2010). However, in other studies, the bulk density was similar or lower with CA than with conventional farming. However, a natural consolidation and mechanical compaction in CA causing denser packing of top soil. Soil bulk density is a basic soil property influenced by some soil physical and chemical properties (Murphy, 2014). 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. A normal range of bulk densities of clay is 1.0 to 1.6 mg/m$^{3.}$ A normal range of sand is 1.2 to 1.8 mg/m^3 with potential root restrictions occurring at ≥1.4 mg/m^3 for clay and ≥1.6 mg/m^3 of sand (Aubertin, 1965).

2.6. Soil pH (H_2O) and cation exchange capacity

Soil chemical properties that are usually affected by tillage systems are pH, CEC, exchangeable cations and soil total nitrogen. Soil chemical properties of the surface layer are generally more favorable under the CA practice than under the tilled soil (Lal, 1997).Soils with a pH of 6.0-7.0 have been high concentrations of available nutrients. Extremes in soil pH (<4.5 and > 8.5) can make some nutrients toxic and others unavailable to plants. At low pH levels (<4.5), aluminum, iron, and manganese are very available for plant uptake (Kushla, 2006 and Negassa *et al.*,2001). At high pH levels (>7.5), calcium and potassium are over abundant. In these situations, many plants will take up too much of these nutrients, while absorbing insufficient amounts of the others (Kushla, 2006 and Negassa *et al.*,2001).The cation exchange capacity (CEC) was increased due increases SOC stocks (Kumar et al., 2015). The cation exchange capacity (CEC) of a soil is a measure of the quantity of negatively charged sites on soil surfaces that can retain positively charged ions (cations) such as calcium (Ca2+), magnesium (Mg2+), and potassium (K+), by electrostatic forces. Cations retained electro statically are easily exchangeable with cations in the soil solution so a soil with a higher CEC has a greater capacity to maintain adequate quantities of Ca2+, Mg2+ and K+ than a soil with a low CEC. A soil with a higher CEC may not necessarily be more fertile because a soil's CEC occupied by acid cations such as hydrogen (H+) and aluminum (Al3+). However, when combined with other measures of soil fertility, CEC is a good indicator of soil quality and productive. Cation exchange sites found primarily on clay minerals and soil organic matter (SOM) surfaces.

Soil OM will develop a greater CEC at near-neutral pH than under acidic conditions (pH-dependent CEC). Thus, addition of an organic material will likely increase a soil's CEC over time. On the other hand, a soil's CEC can decrease with time as well, through natural or fertilizer-induced acidification and/or SOM decomposition gradient (Apanovich and Lenssen 2018). Different soils types have different optimum levels of nutrients and the CEC helps us to identify these different soil types can be establish optimum levels. The soil texture and CEC relationship described as; sand 0-3 Cmol (+)/kg, loam sandy to sandy loam 3-10 Cmol (+)/kg, loam 10-15 Cmol (+)/kg, clay loam 30cmol (+)/kg and clay >=30 (depends on type of clay) (Mohanty *et al*., 2015).

The highest CEC increased conservation agriculture practice as compared to conventional agriculture practice. The large loss of aggregate stability of the conventional agriculture is an improved the increased aggregate stability of surface soil under conservation agriculture (CA) is due to surface residue, crop rotation and other practice (Hammer beck *et al*., 2012). The retention crop residues are at significantly increased the CEC in the 0–5 cm layer of permanent raised (Govaerts *et al.*,2007).Human-induced acidification of agricultural soils is primarily associated with removal of base cations and loss of soil buffering capacity or increases in nitrogen inputs (legume pastures fertilizer inputs, atmospheric deposition). Soils with low pH buffering capacity and high aluminum content are most established when they have a low content of weather able minerals (Bruinsma, 2017). An acidification occurs simultaneously to conditions, including eroded topsoil and depleted organic matter, depleted nutrients, and alternating drought stress and high rainfall (Ben-Moussa, 2010). In high rainfall areas, excessive rainfall coupled with unfavorable temperature and precipitation is high enough to leach appreciable amounts of exchangeable basic cations (Mesfin, 2010).Its severity is extremely variable due to the effects of parent materials, landform, vegetation and climate pattern. In moisture-stressed areas, acidification can also be cause by continuous application of acid-forming chemical fertilizers (Ben-Moussa, 2010).

2.7. Soil Organic C, Total N and C: N ratios

Nature and frequency of tillage, farming management practices had significant effects on nutrient content, its distribution and transformations (Galantini *et al*. 2000). The nutrient distribution, availability on soil in CA is similar to the SOC content and distribution as increased nutrient availability on and near soil surface as compared to conventional tillage (Duiker and Beegle 2006).Soil organic C is an important index of soil quality because of its relationship to crop productivity (Lal *et al*., 1997). Therefore, decomposition rates of soil organic matter are lower of minimal tillage and residue retention, consequently organic carbon content increases in time (Gwenzi *et al.,* 2009). Farming practices are influence the distribution of SOC in the profile with higher soil organic matter (SOM) content with surface layers with CA than with conventional tillage ((Chivenge *et al*., 2011).

Improvement of SOM is a desirable aim as it is associated with better plant nutrition, crop performance and soil physical properties (greater aggregate stability, reduced bulk density, improved water holding capacity, enhanced porosity). SOC of surface soil is considered as a primary indicator of soil quality (Reeves, 1997) because it is vital horizon that received the much of seeds, fertilizers and other chemical applied (Verhulst *et al*., 2010).Frequency and intensity of tillage had significant influence on disintegration and decomposition of organic matter including residues (Singh and Ladha, 2004). Minimum soil disturbance resulted in higher SOC content in surface layers and sharp decline with depth (Alverez *et al*., 1995) but higher SOC content in the deeper layers in case of conventional tillage with residue incorporation (Jantalia *et al*., 2007 and Thomas *et al*. 2007).

Minimum soil disturbance had 3.86-31% higher organic matter as compared to conventional (Machado and Silva, 2001 and Balota *et al*., 2004).Significantly higher SOM in 0-10cm soil depth under Minimum soil disturbance, but it was lower in the 10-15 cm depth compared to conventional system (Jat *et al*., 2012). However, some studies have reported increase in carbon content with CA even up to depth of 40 cm compared to conventional (Balota *et al*., 2004).

Generally in CA system where soil destruction is reduced and residues are present in surface or near surface resulted higher SOM than the residue incorporated into the soil as in case of conventional tillage. The effect of tillage on SOC concentration was significant in the surface (0 – 10cm) soil layer but not in the deeper (10 – 30 cm) layers (Mazzoncini *et al*., 2011). The higher amount of SOC in surface soil layer in CA might be due to higher accumulation of crop residue that derived carbon and lesser exposure of previous crop roots even after the crop harvest that reduced the oxidative losses of roots (West and Post, 2002). While conventional tillage cause the grater incorporation of residues in the soil, its physical breakdown, overturning of soil and increase aeration, improve soil residue contact and disruption of soil aggregates that leading to oxidation of SOM and erosion which lowers SOC content in the surface soil (Six *et al*., 2002; Roldan *et al*., 2003 and Grant, 1997).

Conventional tillage incorporates residue into moister environment where decomposition is fast as compared to residues left in soil surface (Halvorson *et al*., 2002). The rate of decomposition of residue also depends on amount and composition of residue and soil characteristics where residue applied (Trinsoutrot *et al*. 2000).Nitrogen is one of the major nutrients required for the nutrition of plants. Nitrogen (N) in soil is found in quite heterogeneous chemical species, although it predominates in the organic form, varying from low molar mass compounds up to complex decomposition resistant substances (Bhatt and Sapra, 2015).

The accumulation of SOM, thereby enhancing the availability of Nitrogen, favored vegetation covers and the growth of plants, especially leguminous plants might have retarded the loss of N from the system resulting in higher TN. Soil organic matter holds 90 to 95 % of the nitrogen held in soils and the N nutrient cycle is closely tied in with the soil organic matter and the soil microbial population. The remainder occurs as ammonia, nitrates and nitrites (Murphy, 2014). Nitrate nitrogen (NO_3-N) most commonly measured in standard soil tests because it is the primary form of nitrogen available to trees or crop and, therefore, an indicator of nitrogen soil fertility. However, soil concentrations of NO_3-N depend upon the biological activity and may fluctuate with changes in soil temperature, soil moisture, and other conditions. Nitrate is also easily leached by rainfall (Ayars, *et al*., 2010).

Total nitrogen was recorded under minimum soil disturbance and permanent raised beds compared to conventional till (Govaerts *et al*., 2007). The total N of 10 cm depth under minimum soil disturbance was 21% higher than for conventional till (Thomas *et al.*,2007). The total nitrogen content was correlated with amount of residue applied (Graham *et al*., 2002).Mineral nitrogen uptake by plants is also depends on decomposition and mineralization. Lower nitrogen mineralization (Silgram and Shepherd, 1999) and greater immobilization is observed when residues left on and near soil surface in case of no till (Rice and Smith, 1984) which reduced nitrogen availability. Greater immobilization in CA practices had demand the higher initial N fertilizers requirements but this initial rate can be decreased over time because of reduced losses by leaching, surface run off, erosion and build-up of a larger pool of mineralized organic N (Schoenau and Campbell, 1996).

Tillage increases aggregate disruption, better soil and organic matter contact that increased microbial decomposition of SOM (Six *et al*., 2002b) and nitrogen mineralization (Kristensen *et* *al*., 2000). The incorporated residues decompose 1.5 times faster than surface placed residues (Balota *et al*., 2004). CA practices like no till, minimum till and permanent raised beds with residue retention resulted in more stable aggregates (Lichter *et al*., 2008) and more initial nitrogen immobilization. Greater immobilizations of nitrogen can lower the crop yield and nitrogen fertilizers recovery in initial years but benefits crop yield and lower nitrogen losses through leaching, surface runoff and denitrification (Randall and Iragavarapu, 1995). Total nitrogen is (0-30 cm) soil layer initial years are improved by 21.3% on no till with straw cover. While it decreased by 11.9% on traditional tillage with straw removal, total nitrogen under no tillage with straw cover was increased, as compared to traditional tillage with straw removal, while in the 5 -10 cm layer total nitrogen was increased in 10-30 cm layers (Wang, 2008).

The C: N ratios of cereal crop residues, reduce the available N in the soil due to N immobilization and could result in lower crop production, while residues with high N contents. Low C: N ratio is the case with many legume residues and legume cover crops, increase soil N availability and high crop production (Powlson *et al*., 2012). The ratio of carbon to nitrogen (C: N) in arable soils usually ranges between 8:1 and 15:1, with the median being between 10:1 and 12:1(Brady and Weil, 2008).However, a ratio of about 20:1 is generally considered as the approximate threshold between net mineralization and net immobilization of soil nitrogen (Weil, 2008).

A low C: N ratio (< 25) implies that soil organic matter is accumulating slower decomposing that there was net mineralization of N in the soil (Zhao *et al*., 2015;Weil *et al*., 2009). A C:N ratio lower than indicates that less organic matter was being merged into the soil (Saikh *et al*.,1998; Kim *et al*.,2007).In addition, the topsoil layers 0–10 cm had greater soil C: N ratios than the subsoil or deeper soil because the litter layers released more nutrients into the topsoil (Li *et al*., 2016). The higher soil organic carbon storage is in conservation agriculture than conventional agriculture to the addition of legume intercrops or cover crops in the rotation (Boddey *et al*., 2010). The slower decomposition of residues, lower mineral N in conservation agriculture compared to conventional agriculture result from higher root to shoot ratios, and below ground, C input with conservation agriculture (Boddey *et al*., 2010).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study site is located in the Akaki district of the special zone surrounding Finfinnee, the Oromia region, Ethiopia. It is located at 37km southeast of Addis Ababa. Geographically, it lies between 8º 49'0" N and 8º 43'30" N latitudes and between 38º 43'00" E and 38º 48'30" E Longitudes. Akaki district bounded by Ada'a district in the East, Sebeta Hawas and Kersa Malima districts in the West, Liben Zukala district in the South and Finfinne, Ginbichu and Barak districts in the North (Bekele *et al.*, 2012; Hailu *et al*., 2017).

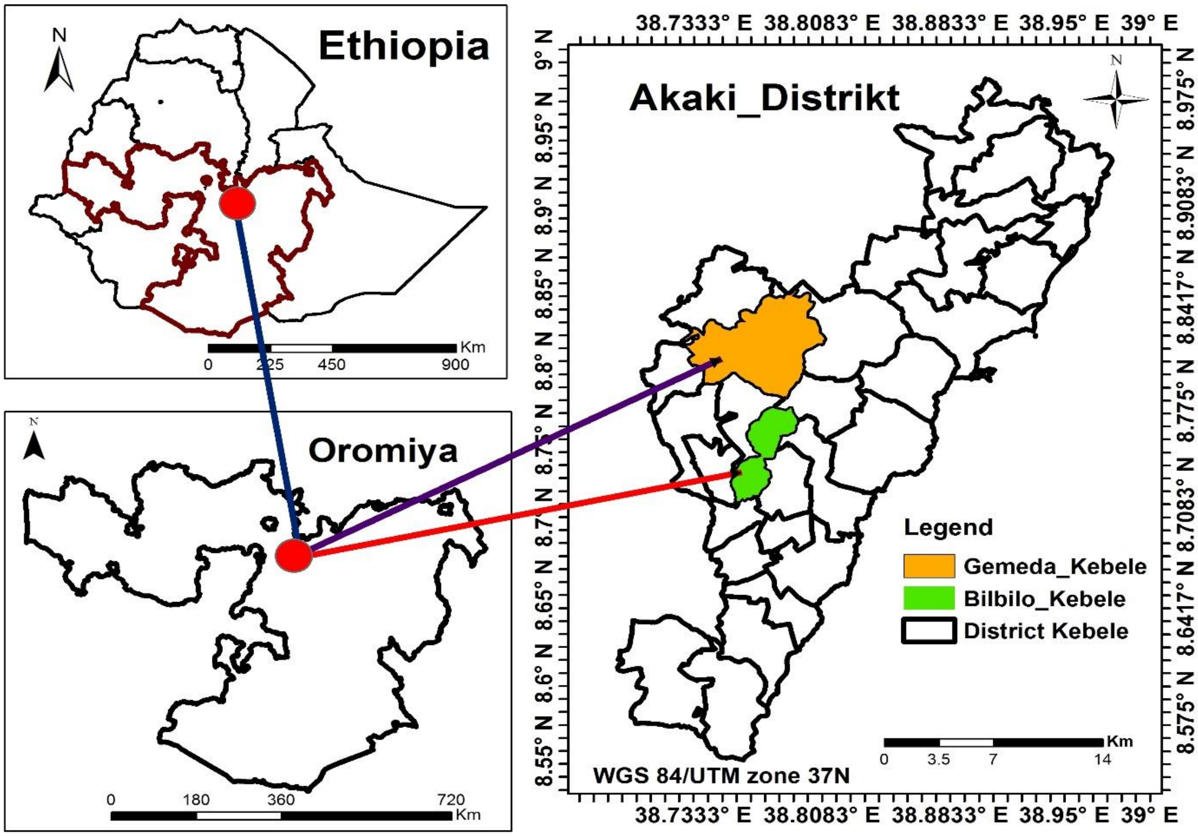

Figure 1: Map showing Akaki District in Oromia.

3.2. Topography and climate

The altitude of Akaki district ranges from 1500 to 3100 meters above sea level. Mount Yerer, on the border with Ada'a district, was the highest point in Akaki. It is characterized by 56% plain, 36% mountainous and 17 % hilly topography. The district is lies into two agro-ecological zones: highlands (2%) and mid-highlands (98%) (Bekele *et al*., 2012). In Akaki district, the highest temperature is observed during the spring (March, April, and May), while the lowest temperature was occurring during the autumn (October, November, and December). District the temperature larges between 15-27°C with the mean annual temperature of 21°C. Rainfall ranges between 800-1800 mm with the mean annual rainfall of 900mm.There were two rainy seasons in this area signifies the winter extends from June to half September, which was the main rainy season for the most economically important crop production.

The small wet season usually occurs during the first two months March to April. However, rivers including the Akaki Dukem, and Awash Dukem River are seasonal while, Akaki and Awash are Perennial River, even though the volume of water decreases substantially to the dry season. The farmers, living around Akaki and Awash Rivers uses them for irrigation and livestock consumption (Bekele *et al*., 2012; Hailu *et al*., 2017).

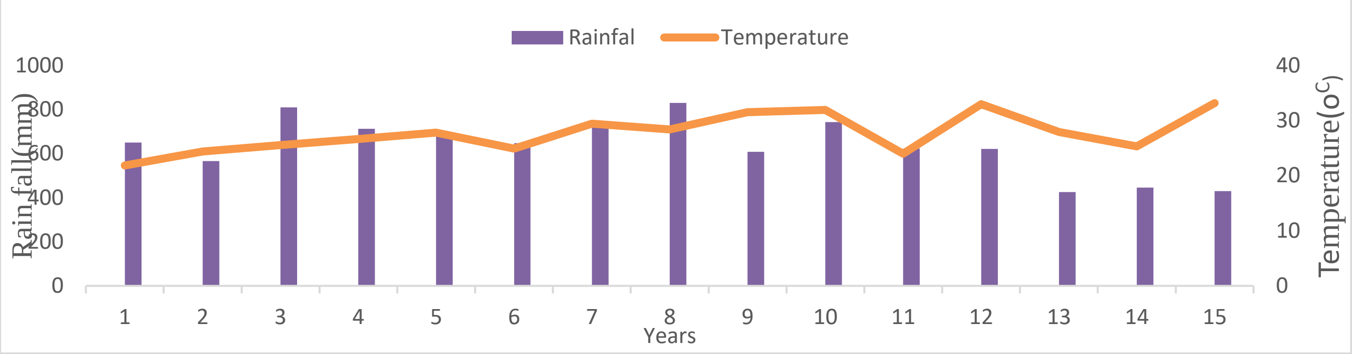

Figure 2: Mean temperature and rainfall distribution in the study area

(Bishoftu Research, center institution daily-recorded data from 2003 to 2017).

3.3. Geology and soil of Akaki district

This part is outcropped at Daleti, Abasamuel Dam, Akaki and Dukem area. The parent rock is coarse-grained porphyritic olivine basalt. It is vesicular basalt and at places, the vesicles are filled by carbonate minerals. It is consisting of scoria and spatter cones with associated lava flows. Both the basalt and scoria is quarried for construction around Akaki and Dukem area. The thickness of this unit around Akaki is 202m (exploration drilling data). The age of the Akaki basalt is 2.9-2.0 Ma (Chernet *et al.*, 1998; Morton *et al*., 1979). The dominant soil in Akaki district is vertisols (Bekele *et al*., 2012; Hailu *et al*., 2017). Vertisols are a group of heavy-textured soils, which occur extensively as Dark Clays, Black Earths, Black Cotton soils, Dark Cracking soils, Grumusols and Regurs in other classification systems (Dudal, 1965). The major factor contributing to the productivity of Vertisols environments is their high water-holding capacity; in areas of uncertain and variable rainfall, sometimes too much and often too little, the ability of a soil to store sufficient water to carry crops through droughty periods is of great importance.

3.4. Land use and land covers

The land of district covers a total area of 41,341ha; with different land uses: Cropland (29848.2ha), pastureland (3141.916ha), woodland/Forests (1819.004ha), and other lands (6531.878ha). Important forests include the government-protected Yerer and Addis Baha forests. Vegetation coverage of the district includes shrubs around hillside and some mother trees scattered on farmlands. The tree species found on farmland was most are acacia species such as Acacia albida, Acacia tortilis and Acacia Abyssinica that used randomly as Agroforestry and preferable by local farmers for soil conservation and soil fertility improvements. The long history of agriculture and high population around, vegetation cover was very low. The land use and land cover in percent of district were an indicated in (fig.3).

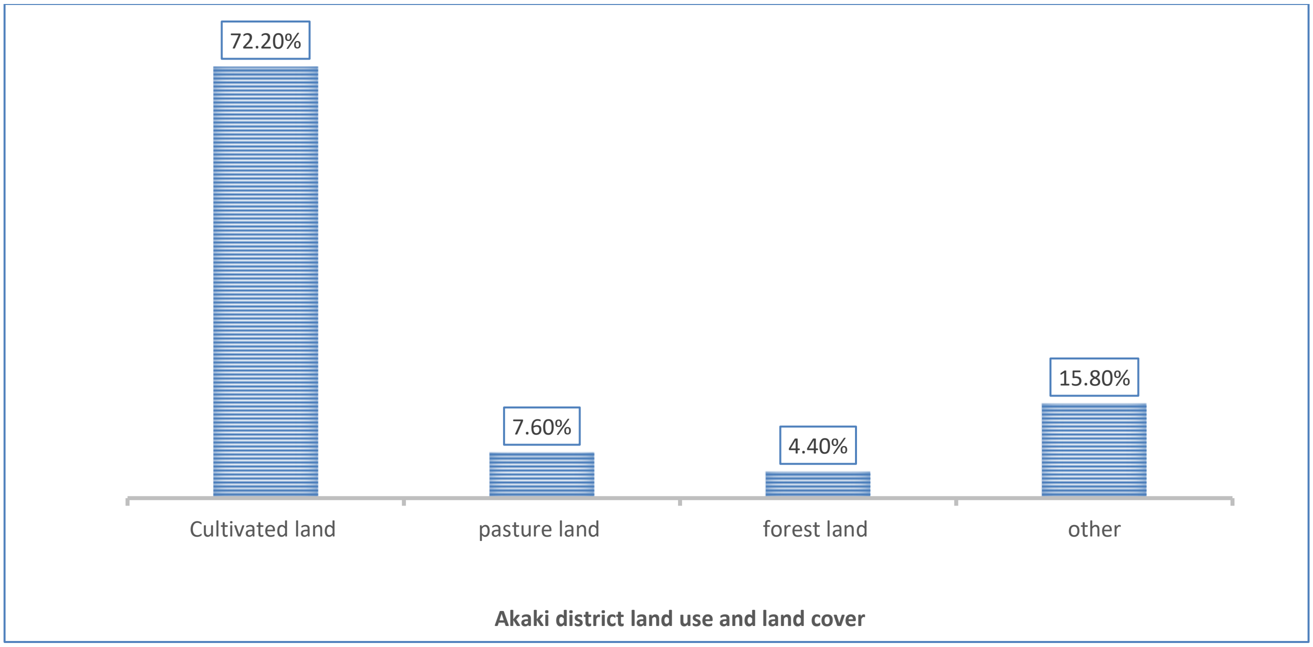

Figure 3: Land use and land cover type in Akaki district

(Akaki district agriculture office, 2017)

Additionally, Eucalyptus trees are widely planted around homesteads for different purposes such as, for construction, firewood and sometimes for extra income generation (Bekele *et al*., 2012). The district is the most important agricultural area in the central highlands of Ethiopia. Agriculture is the main economic activity, which includes crop farming and livestock production. Cropping patterns in the district is rainfall based agricultural practices. Tef, wheat, chickpea and lentil are the dominant crops with regard to area coverage while tef is the leading crop. Many other crops are also grown, but economically less important. Livestock production is important in the farming system of the district. The animals are used for draught power, source of food and income. Among the domestic animals raised, cattle population ranks first which is followed by goats, sheep, donkeys, horses and mules. Nowadays, the district has become poor in livestock production due to scarcity of grazing lands and their conversion to farmlands and other land use types as a result of human population pressure, expansion of urbanization and investments, as well as imbalance between animal population, grazing land and productivity (Bekele et al., 2012).

3.5. Methods

3.5.1. Sources of data

A preliminary field survey was conduct before the actual survey to get a general overview on the physical condition of the area such as the land management system and topography.

3.5.1.1. Primary and secondary data sources

For this study, both primary and secondary data sources have been used. Primary data sources were collected from conservation agriculture and conventional agriculture practices by categorizing each into three soil depth layers. These were 0-10, 10-20 and 20-30cm depth. Secondary data sources also have been acquired from review documents and reports (2017) on Akaki district, of agricultural office and Bilbilo and Gemeda kebele administrative office. Rainfall and temperature data were collected from Bishoftu Agricultural Research Center.

3.6. Study site selection and characterization

The study sites were selected purposely; since the soil sample was taken from selected site categorized in to CA (10.12ha) identify activities like (integration of acacia species distribution in farming land, crop rotation, intercropping, minimum tillage and residue retention) and the conventional agriculture (10.12ha) where no management practices were applied and freely accessed were used grazing after harvesting. The farm management practice an integrated not separated to identify activities such conservation practices in study area. The criteria for the field site selection were due to recent application of conservation agriculture practice as compared with traditional farming practices improved soil carbon stocks and soil properties. The climate conditions were similar at all sites with a mean annual temperature of about 21°C and mean annual precipitation of about 900 mm. Since, the conservation and conventional agriculture practices were found adjacent to each other; the Green Foundation of Ethiopia (GEF) and climate resilience green economy (CRGE) of the Bibilo and Gemada kebele beginning from 2013 to 2017 GC four years CA practices fund it. The conservation site was the project area supported by CRGE project farmers an integrated agronomical soil and water conservation implemented and conventional agriculture no management practices other farming practice without project area. The conservation agriculture and conventional agriculture Bilbilo site replicated into the Gemade site the same practice. The conservation agriculture management practices follows ; the crop residue management practices was mainly surface retention, especially leguminous residues such chickpea, bean, faba bean and cereal crops such wheat, maize, barely, teff should be selected to composition of residues are left on field a minimum adverse effect on the environment. Additional, crop residues refer to fibrous plant tissue left on the field after harvest and include stems, leaves, roots, and other plant parts. The crop rotation system was leguminous crop such bean chickpea faba bean and lentil with rotation with wheat, maize, barely and teff in general leguminous crop rotation with mono cropping. Another hand, crop rotations with or without legumes are essential to maintain high production levels. A mono cropping is the repetitive growing of the same crop on the same land. The practice of monoculture became popular when it was evident that mineral fertilizers and pesticides are a substitute for crop rotation although mineral fertilizers and pesticides generally only partly compensate for the yield depression associated with monoculture economic considerations have made this practice a common phenomenon. Sequential Cropping are a growing two or more crops in sequence on the same field per year. The succeeding crop is planted after the preceding one has been harvested. Crop intensification is only in the time dimension. Farmers manage only one crop at a time. Such a double cropping system implemented with wheat and barley are harvesting for September than chickpea planted.

The fertilizer applications are broadcast fertilizer application refers to a uniform distribution of material on the soil surface. When applied after planting, a broadcast application is often referred to as a top-dress application and in other broadcast incorporated system into the soil during crop planted. In General the integration conservation agriculture practices are four years ago.

3.7. Sample size determination

The number of plots required to estimate SOC stocks in each defined plot depends on the chosen precision, of the mean at 95 % confidence level. On the other hand and for the case of a given area ancillary variables, the number of plots required could be determined using a slightly modified relationship (Araujo *et al*. 2005; Aynekulu *et a*l. 2011). Such as the numbers of required sample, plots were decided using statistical approach by the following formula (Tubiello, 2013; Aynekulu *et al*., 2011; Eggleston *et al*., 2006).

$$n= \frac{(N*S)^2}{\frac{N^2*D^2}{t\alpha_2}+N*S^2}=32\text{plot}\ldots\ldots\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{equation1}$$

Where: n = total number sample plots

N = Number of sample plots in the study area

t_α =Student's t with degrees of freedom at 95% probability level

D = are the standard deviation.

S=sample variance

3.8. Soil sampling and analysis

3.8.1. Soil sampling design

Totaling 96 composite soil samples (2 site replicates * 2 farming practices * 8 sample plots *3 depth) were collected from the specified soil layers (0-10, 10-20 and 20-30) cm. On average, the soil sample plots were laid at a distance of 80m from each plot for both farming practices. To avoid the effect of disturbances the first and the last transects line were laid at a distance of 150m from the edges. To collect the required soil sample from 4 site, totally 8 transect lines (4 for each sites) which having 540m length of each were laid parallel to each other by the spacing of 55m between them. The plot of appropriate size areas 0.1025ha was created depending upon the area under a study; which represents a single plot size. Systematic random soil sampling techniques were used from conservation versus conventional agriculture practices. At each site, soil samples were collected from 24 sampling points in February 2018.

For this study, circular shape sample and plots were selected due to their tendency to include more of the heterogeneity within-plot and a plot fit natural patch sizes in the field. Thus, it is more representative than square or rectangular plots of the same area (Tubiello *et al.*, 2013;Tittonell *et al*., 2013).

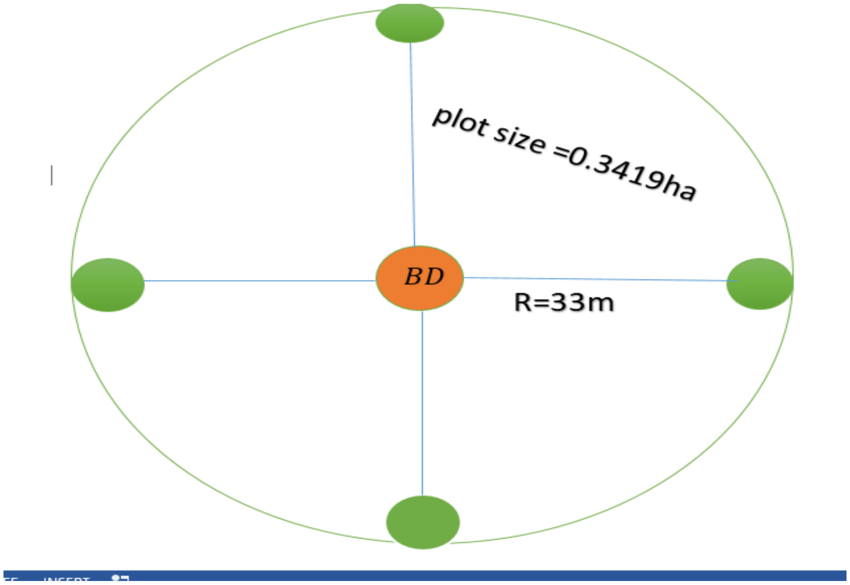

Figure 4*:* Circular plot design for soil sample collection.
(Siebenhuner, 2003).

Soil samples were collected from the two farming practices conservation and conventional agriculture at the specified three soil layers of the two treatments. Conservation agriculture the soil bulk density (Bd) samples were taken for the different depth intervals following the core method (Blake and Hartge, 1986).Totally 96 undisturbed soil samples were taken from to determine soil bulk density.

3.10. Soil laboratory analysis

Soil particle size distributions were determined by Bouyoucos hydrometer method (Beretta *et al.*, 2014).The soil organic C fraction was determining following (Walkley and Black ,1934) method. Total nitrogen was analyzed using the Kjeldahl method (Bremmer and Mulvaney, 1982). Soil pH was measured potentiometrically in the supernatant 1:2.5 soil: liquid mixture of water using a pH meter pH-H_2O (Reeuwijk**,** 2002). Cation exchange capacity was analyzed using Ammonium acetate by (Chapman, 1965) method.

The bulk density of 96 of soil samples was oven dried at 105°C for **48** hours and the rock fragment correction was done. Soil bulk density of the soil sample was calculated using (equation 2). After the oven dried soil mass identified the rock fragment (>2mm) size was again dried for then mass rock fragments and fine soil bulk density was measured (Don, 2013; Henkner *et al.*, 2016).

$$\text{BD-fine soil}=\frac{\text{Oven dry weight}}{\text{volume sample}-\frac{\text{Weight of rock fraction}}{\text{P rock fragment}}}\ldots\ldots\ldots\ldots\ldots\ldots\text{equation2}$$

Where: BD=Bulk density, P = a rock fragment mass (ρ rock fragments) of 2.65g/cm^3 (Don *et al.*, 2007).In the laboratory the soil was air-dried and weighed. A sub sample was then oven-dried, and gravimetric water content was calculates to establish the oven-dried weight of the total sample.

3.11. Soil organic carbon and total nitrogen stock estimation

The soil organic carbon and TN by volume (C kg m^{-2}, N kg m^{-2}) for individual profile soil layers was calculated using (equation3 and 4) adopted from (Smith *et al.*, 2008; Siebenhuner, 2003; Morisada *et al.*, 2004) as follows:

$$\text{SOC d/ (kg/m}^2\text{)} =100\text{x (OC}_i \text{ x Bd}_i \text{ x D}_i \text{ x (1-p}_i\text{)}\ldots\ldots \text{ Equation 3}$$

$TN\ d/\ (kg/m^2) = 100x\ (TN_i \times Bd_i \times D_i \times (1-p_i)$… Equation 4

Where: SOCd is the Soil organic carbon density,TNd is the total nitrogen density (kg m^2, N kg m^2), Bdi is the bulk density of layer i, OCi is the concentration of organic carbon(C %) in layer i, Di is the thickness of this layer (cm), and p_i is the volume of the fraction of fragments >2mm. Since the soil, particles were mostly above 2mm, this fragment fraction was calculated by (equation 2).Soil organic carbon stocks(t/ha) were primarily calculated by multiplying measured soil organic carbon (SOC) values (g $soil^{-1}$) with bulk density (g/cm^{-3}) and the depth of the sampled soil and also expressed in kg per mg of soil. The SOC (kg m^{-2}) density was calculate according to (Morisada *et al*., 2004). The representative values of the soil organic carbon density were average and converted to soil organic carbon stock in tons per hectare (t C ha-1) for each farming practices.

The SOC storage per farming practice type was obtains by combining the estimated SOC with the area estimates for the respective farming practices. The SOC stocks for the entire study area was compute by combining the average SOC stocks for all the farming practices with the total area estimate for the study area. The soil carbon stock was calculated using the equation by (Zhang *et al*., 2008; Baruah *et al*, 2017; Aynekulu *et al*., 2011).

$$SCS = \frac{SOCd*(test\ crop\ Area)}{100} \text{…...........................Equation 5}$$

$$TNS = \frac{STNd*(test\ crop\ Area)}{100} \text{…..........................Equation 6}$$

SCS (total) = ∑SCS…..… ……………………. Equation 7

TNS (total) = ∑TNS ………..…………………..Equation 8

Where: SCS is the soil carbon stocks (T/ha) or TNS is the total nitrogen stocks (T/ha), SOCd is the soil organic carbon density (kg/m^2) or TNd is the soil total nitrogen density (kg/m^2). (Area) were the SOC or TNS stock (Tons/ha), the SOC or TN density (kg/m^2) and the area (m^2) for agricultural land of each farming practices situation. SCS or TNS was the sum of the SOC or TN Sock of all land cover types at layer (0–10 cm, 10–20 cm and 20–30 cm).

Soil organic carbon stock or TN stock each layer of the dominant CA and conventional agriculture was calculated by multiplying the SOC or TN density obtained from equation 3 by the total area covered by a particular farming practices. Subsequently, SOC density or TN density in each soil layer thickness was summed up to determine soil organic C and TN stock contained up to 30 cm depth for each farming practices.

All soil physicochemical analysis was carried out at Bishoftu Agricultural Research Center (BARC) and Hawassa University, Wondo Genet College Forestry and Natural Resource following standard analysis procedures.

3.12. Statistical analysis

The soil carbon stocks and other selected soil physicochemical properties were subject to analysis of using (SAS.V.9.3, SPSS 23 version) software program. Two-way ANOVA was employed by ‘t’ independent method, to analyze the interaction effects and mean values of selected soil properties within and among the two farming practice types and three soil depth at $p<0.05$ significance level. Test for normality by similar to Shapiro-wilk of the distribution of all dependent data was verified prior to analysis. Pearson’s correlation coefficients were also computed to examine the relationship between soil carbon stocks and other soil physicochemical properties. All statistical analyses were performed at $P \leq 0.05$.

4. RESULTS

4.1. Soil Physical Properties

4.1.1. Soil particle fractions and bulk density

The soil textural class across the farming practices was clay (Table 1). The result showed that the dominant clay mineral of the vertisols in the study area. The result showed that soil bulk density (Bd) varied significantly with treatments, depths and the interaction effects ($p<0.0001$, Table 2). It was lower in soil under conservation (0.78 g/cm^3) in the top (0-10cm) surface soil than in the rest of the depths under the CA and conventional practice (Table 1).

The soil Bd showed an increasing tendency with depth across the treatments (Table 1), soil Bd at bottom layers of conventional agriculture increased by 47.29%, the extent of the implement compared to the conservation agriculture (Table 1). In conventional agriculture, the bulk density at 0-10cm soil layer was higher (35.53%) than the 0-10 cm soil depth as well as in the conservation agriculture. Whereas, the conventional agriculture, the Bd of the soil layer, 20-30cm was significantly ($P<0.05$) higher (24.32%) than in that of the soil depth 20-30cm conservation agriculture (Table 1).

The conventional agriculture was also significantly ($P<0.05$) higher (1.34g/cm^3) than CA (0.95 g/cm^3) (Table 1). In terms of the soil depth, the highest Bd (1.48g/cm^3) was recorded at the lower soil depth (20-30cm) under conventional agriculture higher than the bottom layers (20-30cm) of conservation agriculture (1.12 g/cm^3) (Table 1). The mean bulk density for total depth 0–30 cm across the two farming practice was increased from 0.95 g/cm^3 under conservation agriculture to 1.34 g/cm^3 in conventional agriculture. Nevertheless, the total Bd at the lower layer of soil depth was increased by 23.46% (20-30cm) soil depth higher conventional agriculture than the soil layer (20-30cm) CA practice (Table 1).However, the Bd in the CA was significantly ($P<0.05$) lower as compared with conventional agriculture across the farming practices and vertical soil profile. The lower end of Bd were more significant than at the high end of Bd because low Bd was associated with higher soil organic carbon content.

Table 1: Soil textural fractions and soil bulk density (Bd) in relation to farming practice and soil depths.

Variables	Depth(cm)	Farming practice type	
		Conservation Agriculture	Conventional Agriculture
Sand (%)	0-10	16 ± 4^{b}	25.6 ± 3^{a}
	10-20	21 ± 6^{b}	24 ± 5^{a}
	20-30	17 ± 4^{c}	26 ± 8^{b}
	Overall	18 ± 4.6^{b}	25 ± 5.3^{a}
Silt (%)	0-10	24 ± 4^{b}	28 ± 6^{a}
	10-20	25 ± 5^{b}	26 ± 6^{a}
	20-30	30 ± 11^{a}	25 ± 7^{b}
	Overall mean	26.4 ± 6.6^{b}	$26\ \pm6.3^{b}$
Clay (%)	0-10	60 ± 4^{a}	47 ± 9^{b}
	10-20	54 ± 6^{ab}	50 ± 7^{b}
	20-30	53 ± 12^{b}	50 ± 12^{bc}
	Overall mean	55.6 ± 7.3^{b}	49 ± 9.3^{c}
Bd (g/cm3)	0-10	$0.78\ \pm0.03^{c}$	1.21 ± 0.05^{d}
	10-10	$0.95\ \pm0.05^{b}$	1.35 ± 0.04^{b}
	20-30	1.12 ± 0.13^{ab}	1.48 ± 0.04^{a}
	Overall mean	$0.95\ \pm0.07^{b}$	1.34 ± 0.04^{b}
TL	0-10	Clay	Clay
	10-20	Clay	Clay
	20-30	Clay	Clay

Similar superscript letters were shown in the column for the same parameter indicate no significant difference at 0.05 where, Bd=Bulk density (g/cm^3), TL=Textural class.

Table 2:Two-way ANOVA results for soil bulk density and soil texture

source of variation	DF	Sand (%)		Silt (%)		Clay (%)		BD(g/cm3)	
		MS	P	MS	P	MS	P	MS	P
FP	1	5.3	0.216	3.39	0.0235	1.47	<.0001	0.292	<.0001
D	2	3.18	0.398	4.3	0.5102	0.58	<.0001	0.155	<.0001
FPXD	2	11.48	0.039	1.57	0.1834	0.02	0.0457	0.04	<.0001
Error	89	3.41		63.9		0.0057		0.0028	

DF Degree of freedom, FP Farming practice, D soil depth, SE standard error of the mean

4.2. Soil Chemical Properties

4.2.1. Soil pH (H_2O) and CEC

The results showed that the mean values of pH (H_2O) were significant at ($p<0.05$) the two farming practice and in all soil layers (Table 4). Similarly, the pH of the CA in all soil layers (0-10, 10-20 and 20-30cm) was higher by 24.42%, 21.82% and 17.23% than the conventional agriculture at the same soil layers (Table 3). The Soil pH (H_2O) under CA was increased by 21.01% as compared with conventional agriculture practices.

Whereas, the conventional agriculture, pH was varied by 9.24% and 10.38% at soil depth 10-20 and 20-30cm respectively.

Together, the higher mean value of pH was recorded in CA by the variation in 8.38% to 34.63% at the middle soil layers (10-20 cm) and lower soil layer (20-30 cm) respectively. This study indicated that the mean values of pH under CA were at $P<0.05$ significant higher (7.28) than the mean values of the conventional agriculture (5.75) and the highest mean value of pH was recorded at the lower soil layers (Table 3). Thus, showed that soil pH influenced by the land management and soil depth (Table 3)

Table 3: Soil chemical properties in relation to farming practice and soil depths

Variables	Depth(cm)	Farming practice type	
		Conservation Agriculture	Conventional Agriculture
$pH(H_2O)$	0-10	6.92±0.58^{a}	5.23±0.45^{c}
	10-20	7.33±0.10^{b}	5.73±0.53^{d}
	20-30	7.6±0.20^{a}	6.29±0.65^{b}
	Overall mean	7.28±0.29^{ab}	5.75±0.54^{abc}
CEC(Cmol/kg)	0-10	13.12 ±0.99^{b}	8.50± 2.84^{d}
	10-20	14.28±1.09^{b}	9.99±2.16^{c}
	20-30	16.4 ±1.67^{a}	11.92±3.28^{ab}
	Overall mean	14.6±1.66^{b}	10.13 ±2.76^{c}

Overall means within rows and columns followed by the same letter are not statically different at $p \leq 0.05$ with respect to soil depth and farming practice, Where PH= pH of soil, CEC=cation exchange-capacity (Cmol (+)/kg).

The mean values of CEC under CA increased by 27.31% than conventional agriculture. Similarly, it increased by 35.21%, 30.04% and 27.31% under the soil depth 0-10, 10-20 and 20-30cm CA then conventional agriculture (Table 3). Moreover, the higher mean values of CEC were recorded at in all soil layer (0-10, 10-20 and 20-30 cm) of the CA than the conventional agriculture of the same soil layers, respectively (Table 3).

The total mean CEC in the study area ranges from 10.13 to 14.6 Cmol(+)/kg) two the farming practice (conventional and conservation agriculture) with in all soil layer. The CEC at the upper soil layer of the CA practice was increased by 35.21% than at the same soil layers of conventional agriculture (Table 3).

Consequently, the main effect of the two farming practices (conservation and conventional agriculture) on CEC was significant .i.e; the CEC of the CA was greater than the CEC of conventional agriculture by 30.61%. Likewise, the CEC showed increments significant

($p<0.05$%) with the increase in the soil layer (0-10, 10-20 and 20-30 cm) (Table 3). As noticed from this finding; the higher CEC were found in conservation agriculture compared to conventional agriculture.

Table 4 Two-way ANOVA results for soil pH and CEC.

source of variation	DF	PH (H_2O)		CEC (Cmol(+)/kg)	
		MS	P	MS	P
FP	1	12.8	<.0001	29.91	<.0001
D	2	6.82	<.0001	3.37	<.0001
FPXD	2	11.1	0.0304	0.24	0.0352
Error	89	0.005		5.31	

DF, Degree of freedom, FP farming practiced, D soil depth, SE standard error of the mean, MS Mean square, PH soil pH or soil reaction, CEC, cation exchange capacity.

4.2.2. Soil organic carbon and TN content

The mean values of soil organic C and TN content of the soils showed much variation among the two farming practices and soil depth (Table 5). The soil organic C and TN content of upper soil layers (0-10cm) of the conservation agriculture (CA) increased by 36.3% and 43.75% as compared to soil layers (0-10) of conventional agriculture practices (Table 5). Similarly, the soil organic carbon and TN content in CA under 20-30cm soil depth increased by 28.39% and 9.09% as compared with 20-30cm soil depth of conventional agriculture.

With further variability (11.21% to 27.97%) was recorded at the top soil layer (0-10cm) of the two farming practices (conservation and conventional agriculture) with the lower range of soil disturbance in conservation agriculture and higher range of soil disturbance in the conventional agriculture.

There was higher SOC and TN content (1.68%, 0.32%) at 0-10cm at soil layers, and the lower (1.07%, 0.18%) at 0-10cm of CA and conventional agriculture (Table 5). With increasing the soil depth, both SOC and TN was decreased in both farming practice (conservation and conventional agriculture); while, the SOC and TN in conservation agriculture (CA) was higher than in the conventional agriculture. It is also clearly visible that as the soil depth increases the SOC and TN content decreased continuously in both farming practices (Table 5). Soil organic C concentration in the total soil layers was higher (1.19%) in CA than the conventional agriculture (0.78%) at $P<0.05$ significant.

An overall total N for the CA was increased by 35% higher than the conventional agriculture at significant ($P<0.05$) (Table 6). An effect of farming practices by soil depth of TN was significantly higher (0.32%) at 0-10cm surface layer of the conservation higher than in the surface of the conventional agriculture (0.10%) (Table5). The higher (1.68%) SOC was recorded at the top soil layer of the CA than the conventional agriculture (0.72%).

Table 5: Soil chemical properties relation to the farming practice and soil depths.

Variable	Depth(cm)	Farming practice type	
		Conservation Agriculture	Conventional Agriculture
SOC (%)	0-10	1.68±0.47^{a}	1.07±0.12^{b}
	10-20	1.1±0.22^{b}	0.72±0.09^{c}
	20-30	0.81±0.25^{ba}	0.58±0.12^{d}
	Overall mean	1.19 ±0.31^{c}	0.78±0.11^{a}
TN (%)	0-10	0.32 ±0.04^{b}	0.18±0.03^{c}
	10-20	0.17 ±0.03^{b}	0.13±0.02^{c}
	20-30	0.11 ±0.01^{ab}	0.10±0.02^{d}
	Overall mean	0.2±0.02^{a}	0.13±0.023^{a}
C:N	0-10	6.23 ±2.7^{c}	5.5 ±2.5^{cb}
	10-20	6.38±1.01^{b}	6.04 ±1.3^{ba}
	20-30	6.93 ±2.4^{a}	6.62 ±1.23^{ab}
	Overall mean	6.51±1.01^{ac}	6.05 ± 1.03^{cb}

Overall means within rows and columns followed by the same letter are not statically different at $p\leq0.05$ with respect to soil depth and farming practice, Where SOC=soil organic carbon content (%), TNC=total nitrogen content (%), C: N=carbon to nitrogen ratios.

4.2.3. C: N ratios

The mean value of C: N at 20-30cm layer of the soil of conventional agricultural was significant ($p<0.05$) lower than in the 20-30cm of conservation agriculture (CA) (Table 6). Mean value of C: N ratios in the CA increased by 4.47, 5.32 and 11.71% than the conventional agriculture at the soil layers: 0-10, 10-20 and 20-30cm (Table 5). This effect causes the lower nitrogen concentrations in both practices and bottom soil depth. C: N ratio of surface and subsurface layers increases with depth, with values ranging from 6.62 to 6.93 at 20–30cm soil layer and 6.04 to 6.38 at soil layers 10–20 and 5.5 to 6.23 at soil layer 0-10cm in both conventional and conservation agriculture respectively (Table 5). At depths of 0–10, 10–20 and 20-30cm the C: N ratio was greater in conservation agriculture (CA) than under conventional agriculture due to improved soil fertility as residue retention on soil surface. The C: N ratio was highly variable, especially lower in the soil depth due to influenced soil disturbed by cultivation. The C: N ratio differed between CA and conventional agriculture at any soil depth. Mean C:N ratios in vertical soil depth was significantly two agricultural practice with increase soil depth in the lower layers of soil depth 20- 30cm increases than the upper layer soil profile at significance level (Table 5). The C: N showed an increasing tendency with depth across the treatments (Table 5), C: N an overall soil layers of conservation agriculture increased by 7% as compared to the conventional agriculture (Table 5).

Table 6:Two-way ANOVA results for soil SOC, TN and C: N.

Source of variation	DF	SOC (%)		TN (%)		C:N	
		MS	P	MS	P	MS	P
FP	1	3.2599	<.0001	11.75	<.0001	309.5	<.0001
D	2	3.1848	<.0001	5.483	<.0001	92.34	<.0001
FPXD	2	0.0372	0.048	0.856	0.043	0.66	0.046
Error	89	0.0548		0.026		5.423	

DF =Degree of freedom, SE standard error of the mean, FP=farming practice, D= soil depth, MS=Mean square, SOC= soil organic carbon content, TN= Total nitrogen content, C: N= carbon to nitrogen ratios.

4.3. Estimation of soil organic carbon and total nitrogen stock

The mean values of soil organic carbon and Total N stocks of the soil showed significant variation across sampled farming practices and in all soil depths (Table 7). The average differences in soil carbon stocks in CA and conventional agriculture in the soil depth 0-10cm layer varied between 37.59 CT/ha and 1.54 NT/ha whereas, the average difference in soil depth 20-30cm soil carbon stock varied from 27.52 CT/ha and 2.39 NT/ha. This means the carbon concentration of SOC and TN stocks decreased with increasing soil depth for both CA and conventional agriculture treatments.

The carbon stock was a conservation agriculture for the 0-10cm depth layers significantly ($p<0.05$) higher than conventional agriculture for the 0-10cm soil depth layers. This means the SOC and total N stocks in the CA practice were increased by 54.59% and 9% than the conventional agriculture at significance level (Table 7). The SOC stock in all soil layers (0-10, 10-20, and 20-30 cm) were also higher by 47.61%, 57.75% and 61.15% than in the conventional agriculture of the same soil layer at ($P<0.05$) significant level.

Table 7: SOC and TN stocks in relation to the farming practice and soil depths.

Variables	Depth(cm)	Farming practice type	
		Conservation Agriculture	Conventional Agriculture
SOC stock (T/ha)	0-10	133.3 ± 37.6^{a}	69.83 ± 1.55^{c}
	10-20	109.4 ± 26.7^{bc}	46.22 ± 1.84^{b}
	20-30	89.1 ± 27.5^{c}	34.61 ± 2.39^{d}
	Overall mean	110.6 ± 7.65^{ad}	50.22 ± 0.79^{a}
SOC density (kg/m^2)	0-10	13.1 ± 3.5^{a}	6.86 ± 0.24^{b}
	10-20	10.75 ± 2.4^{b}	4.54 ± 0.12^{c}
	20-30	8.76 ± 2.5^{c}	3.4 ± 0.15^{d}
	Overall mean	10.87 ± 3.6^{ab}	4.9 ± 0.17^{a}
TN stock (T/ha)	0-10	27.03 ± 3.24^{a}	20.27 ± 2.6^{a}
	10-20	17.65 ± 2.44^{b}	16.72 ± 1.3^{b}
	20-30	13.83 ± 3.10^{c}	15.22 ± 1.7^{c}
	Overall mean	19.5 ± 2.92^{ac}	17.4 ± 1.86^{ab}
TN density (kg/m^2)	0-10	2.48 ± 0.3^{a}	0.86 ± 0.14^{d}
	10-20	1.62 ± 0.22^{b}	0.54 ± 0.12^{b}
	20-30	1.27 ± 0.3^{c}	0.4 ± 0.15^{c}
	Overall mean	1.79 ± 0.27^{ab}	0.6 ± 0.13^{d}

Similar superscript letters shown in the column for the same parameter indicate no significant difference, not significant at 0.05. SOCd, soil organic carbon Density (kg/m^2) SOCS,soil organic carbon stocks (T/ha), TNd, total nitrogen density (kg/m^2),TNS, total nitrogen Stocks (T/ha).

In terms, of the main effect of the farming practices, soil organic carbon and total N stocks were 110.6 CT/ha and 19.5NT/ha under conservation and conventional agriculture practices respectively (Table 7). Whereas, conventional agriculture had 50CT/ha and 17.4 NT/ha the comparison between the management system (Table 7) showed a significant decrease in the SOC stocks of conventional agriculture. Among the two farming practices and soil depths, the lowest mean soil organic carbon stock (0.58% or 34.61 t/ha) was observed in the lower layer of conventional agriculture while the highest SOC stock (1.68% or 133.3CT/ha) was recorded at the upper soil layer of conservation agriculture practice (Table 7). The soil organic carbon and TN stock was showed a decreasing tendency with depth across the treatments at significantly ($P<0.05$) (Table 7).

According to an analysis of the result CA were showed at significant ($p<0.5$) variation in soil organic carbon stocks under 0-30cm soil depth as compared to conventional agriculture (Table 7). Similarly, the TN stock of the CA at the upper and middle soil layer (0-10 and 10-20 cm) were higher by 25.5% and 26% than the conventional agriculture of the same soil layer. However, the TN stocks of CA at the subsoil layer (20-30cm) become lower by 10.5% than the conventional agriculture of similar soil layers (Table 7).

Table 8: Two-way ANOVA results for soil SOC and TN stocks

source of variation	DF	SOC stock (T/ha)		TN stock (T/ha)	
		MS	P-Value	MS	P
FP	1	625.5	<.0001	11.75	<.0001
D	2	18.1	0.0808	5.483	<.0001
FPXD	2	12.6	0.01723	0.856	0.0433
Error	89	56.29		0.2633	

DF, Degree of freedom, FP Farming practice, D soil depth, SE standard error of the mean, MS mean square, and SOC soil organic carbon stocks, TN, Total nitrogen stocks.

4.4. Correlation of relationship soil Properties

Pearson correlation (*r*) showed that the relation among the five variables ranged from − 0.77 to 0.62 value (Table 9). With respect to pH and CEC with, they correlated positively with SOC and TN content at significant level (Table 9). Total N showed a positive correlation (r = 0.62*) with SOC (Table 9). A positive correlation was also found with available pH (r = 0.51*) and CEC (r = 0.57*). However, the BD (r = -0.68*) each had a negative correlation with this plant nutrient. A negative correlation (r = -0.68*, where * indicates the correlation was significant at the 0.001 probability level) was observed between the Bd and SOC content, in this study, negative correlations of some other soil properties with Bd were also observed (Table 9).

Variables	**SOC**	**PH**	**TNC**	**CEC**	**Bd**
SOC	1	0.60*	0.62*	0.54*	-0.68*
PH		1	0.56*	0.57*	-0.77*
TNC			1	0.51*	-0.67*
CEC				1	-0.71*
Bd					1

Table 9 Pearson correlation (r) analysis matrix in selected soil properties

*, Significant at 0.05, ns = not significant, where, SOC= Soil organic carbon (%), TN= Total Nitrogen (%), pH (H_2O) (1:2.5) =Power of Hydrogen, CEC= Cation Exchange Capacity (Cmol (+)/Kg/soil), Bd=Bulk density (g/cm^3).

5. **DISCUSSION**

5.1. Soil Physical Properties

5.1.1. Soil particle fractions and Soil bulk density

The, similarity in textural class with the two farming practices shows the fewest impacts of the on the soil forming processed as parent materials could not be changed shortly, since the duration of the agricultural practices was four years. Thus, was in line with (Brady and Weil, 2007) in which the textural class of a soil did not change by the management practice.

Inline, Denef *et al*. (2002) also reported that the dominant clay mineral in most, of the Vertisols appears to be montmorillonite. Thus, plus the high clay content, looks to be the main reason for the high water-holding capacity of vertisol's thus low activity clay soil. Driessen *et al*. (1991) also added that low activity clay soil (LAC) had greater amount of water stable aggregates and the amount of water stable aggregates was less related to soil organic carbon content.

The highest soil bulk density of the conventional agriculture could be due to land degradation; high soil erosion and compaction of soil particles resulting in higher bulk densities reduced soil fertility. However, the fine soil particle has transported by soil erosion and compaction by livestock. The higher clay content is possible that the particles have compressed and compact soil particles resulting in low fertility and higher bulk densities of conventional agriculture practices. The compaction resulting from intensive cultivation of conventional agriculture system might have caused the relatively higher bulk density values in the surface soil layers than the respective soil depths of the conservation agriculture.

In line with this study, Jewitt *et al.* (1979) reported that the bulk density of vertisols varies greatly from their swelling and shrinking nature with changes in soil moisture content. Similarly, Jewitt *et al*. (1979) added that the soils have high bulk density when these are dry and low values when in a swollen stage. Such as variations at the lower end of BD are more than at the highly ending of BD because low BD is associates with organic soils (high C org) and a change from say, 0.78 to 1.48 g/cm3 leads to a doubling of SOC stock and mass. Murphy *et al*.(2004) also reported that the highest bulk densities was due to the land degradation and high soil erosion for compaction of soil particles as resulting of higher bulk densities of conventional practices.

The plots under conventional plowing system show relatively higher density in deeper layers due to the hard pan caused by livestock compacted and soil erosion, while the conservation agriculture system caused a relatively lower soil density in top soil, where it was reduced disturbed by conservation management. The results show a relatively higher amount of carbon in top layer. The increases in bulk density with increasing soil depth may be due to the decrease in SOC with depth.

The lowest BD in conservation agriculture was due to its highest soil organic carbon content that increases pore space as increases clay content, which as a result lowered bulk densities. Similarly, Enfors, *et al*.(2010); Gwenzi *et al*.(2009) ; Gicheru *et al*.(2004) from Tanzania, Kenya, and Zimbabwe, reported that there was a significant difference in soil bulk density under conservation farming practice than conventional agricultural practices within four and five years practices. So based on these findings, the soil bulk density may be affected or changed after practicing conservation agriculture at four years' of duration.

5.2. Soil chemical properties

5.2.1. Soil pH and CEC

The soil pH of conventional practice was generally lower from the early stages of management than conservation agricultural. Nevertheless, after four years of conservation practice the pH was increased. This study is in line with Ahmad (1986) ; Foth and Ellis (1997); Dudal (1965) in which lower soil pH was exhibited in conventional practice than the conservation practices. Such a result might be attributed to the depletion of organic matter in intensive cultivation/ conventional agriculture. Havlin *et al*. (2005) also added that root respiration and decomposition of organic matter produces carbon dioxide, which reacts and forms a weak acid, carbonic acid, and this can be a contributing factor to soil acidification in conventional agriculture farming practices. McKenzie *et al*.(2004) also reported that the fertility of soils decreases with decreasing pH which can be induced by acidifying nitrogen fertilizer, nitrate leaching and by conventional agricultural practice.

The higher CEC record in CA than the conventional agriculture could be due to the higher root biomass production of crop species (wheat, soybean, barely species, legumes crops etc.) and retention of crop residue on the soil surface that caused build-up of organic carbon responsible for greater CEC under conservation agriculture system. Soil CEC could be expected to increase up to 50 percent when the pH was changed from 4.0 to 6.5 and nearly double when the pH increased from 4.0 to 8.0. This study is in line with studies by Mengistu *et al*. (2017); Muche *et al*. (2015); Saikh *et al*. (1998) also reported the higher the CEC in CA than the conventional agriculture. Similarly reported by Govaerts *et al*. (2007) also reported increase the CEC in upper layers of soil the residue raised as compared residues was removed farming practice.

In addition in this study, the higher concentration of the CEC was recorded at deeper layer; while, the lower concentration of the CEC was obtained at the upper layer of the soil profile. This could be the result of leaching of basic cations and downward movement of CEC from upper soil layer to the lower layer through cation leaching process. The higher SOC stocked and clay contents observed at the upper layer soil profile could attribute to the higher CEC due to the direct relationship with nutrients. Similarly, Govaerts *et al*.(2007) also reported that increase the CEC in upper layers of soil the residue raised as compared residues was removed farming practice that attributed to the presence of high soil carbon content. Clay contents in the topsoil of conservation agriculture from which the organic carbon formed by improved land conservation practice underwent a complete decomposition crop residue as the CEC increases, the soil organic matter and clay content could be increased. Similarly, as land management types, soil depth layers also significantly affect the cation exchange capacity (CEC).

5.2.2. Soil organic carbon and TN content

The increasing result of SOC and TN in CA was consistent with another study that indicated SOC as affected by conservation agriculture within five years of practice when compared to conventional agriculture. Chivenge *et al*. (2011); Gentile *et al*. (2011); Gwenzi *et al*. (2009); West and Post (2002); Blevins *et al*. (1977) have reported that SOC was higher under conservation agriculture after five of years implementing the conservation agricultural practice. The increase in SOC concentration at 10cm soil depth in CA systems compared with the other depth could be due to the surface retention of crop residues (or stubbles in the case of no residue). Similarly Jat *et al*. (2014) reported higher plant biomass production leading to large amounts of root residues left in the system and a lower rate of organic matter decomposition due to minimum soil disturbance. In addition, higher SOC concentrations in surface soils under CA were reported as compared to conventional agriculture of northwestern India by (Gupta Choudhury *et al.*, 2014).The conservation agricultural practices proposed to increase carbon in the soil must be applied to be effective. Moreover, this type of management is more resource demanding than conventional methods of production; add to that the relatively long time of adopting this type of management before any evident change in carbon was achieve because this process takes years before showing its positive effects. These factors all act as barriers in the way of widespread adoption of conservative methods of crop production.

The low SOC content of conventional agriculture has been attributed to the reduced inputs of organic matter obtained from crop residues, frequent tillage which encouraged oxidation of organic matter. The reason has been due to intensive cultivation of the land and the total removal of crop residue for low conservation practice and high land degradation. Even though, the annual net carbon in soil input was the same for the conventional treatment, the CA system retained more of its soil carbon. In line, Brady and Weil (2002) reported that adding more N fertilizer increase total amount of crops; hence, production of more field biomass that has been also lead to more addition of C contents with the higher N level to the soil through more crop residues and a larger root biomass. Inline, Graham *et al*. (2002) also reported that increases in total N had been measured with increasing additions of crop residue. Similarly, reported with increasing Govaerts *et al*. (2007) also added reported that the amount of straw retained under permanent raised cropland increased total N. Following the rating of total N of > 1% as very high, 0.5 to 1% high, 0.2 to 0.5% medium, 0.1 to 0.2% low and < 0.1% as very low N status as indicated by (Negassa *et al*.,2001), conservation agriculture practices with the soil depth layers have medium content of total N.

Similarly, Malo *et al*. (2005) also reported that the low level of nitrogen in conventional agricultural practices may imply that the fertilizer additions have not replaced the total N lost due to the harvest and /or leaching. Similarly, Ben-Moussa *et al*. (2010); Enfors *et al*. (2010), also reported that the total N was significantly higher under five years of CA practices than conventional. It has been due to crop residue management, intercropping and crop rotation of the CA system.

5.2.3. C: N Ratios

In line, Stuedemannand Franzluebbers (2009) and Gal *et al*. (2007) also reported by the relatively narrow range of soil organic C: N throughout the soil profile and its general increases with depth. The ration C: N in conservation agriculture, soil was slightly higher than conventional agriculture soils. However, due to C: N lower in conventional agriculture affects the decreasing of N pool. Due to, thus, for conventional agriculture, soil the ratio of C: N showed the degradation rate of soil, which affects carbon storage influencing by cropping types. Handayanto *et al*. (1997) reported that a SOC with high C: N ratio is low in quality as compared to SOC with low C: N ratio due to the increased immobilization of N by microorganisms.

Jones (2003) added reported that the N released into the soil under the latter condition (C: N < 20:1) was available for plant uptake a greater C: N ratio of particulate organic matter with residue retention and improved soil fertility. However, conventional agriculture mono cropping was probably, caused by larger root biomass (continuous, long-lived rooting compared with short-term growth and death of annual crops) that might have been, exposed to drier soil by rapid soil water uptake throughout the year each time available. This result is similar to Yimer *et al*. (2006) report in which a very strong relationship between C and N were observed in the present study. Such as the C: N ratio was below 20 for all the soils in the study area, which indicates that there could be release of available form of N to the soil system through the mineralization soil OM. The observed values of C: N ratios may suggest that there was no N immobilization, which could significantly affect the availability of N for crop uptake. Similarly finding by Ahmad (1986); brandy and Weil (2002) also reported that C: N rations variations in the conserved farming system due moisture content, variation the fertility of the soil due to management practice.

A greater C: N ratio of particulate organic matter with CA than with conventional agriculture was probably caused by larger root biomass (continuous, long lived rooting compared with short-term growth and death of annual crops) that may have been exposed to drier soil because of rapid soil water uptake throughout the year every time available. Similarly finding by Baker *et al.* (2007); Blanco-Canqui and Lal (2008) a conservation agriculture management can store a greater quantity of C and N rather than simply redistribute them differently in the soil profile. Decomposition of perennial roots may have simply been more, delayed than of the annual roots. It was also known that conventional agriculture soil usually, they have lower C:N ratio than CA soils, In line by Zheng *et al* (1999) also reported that the underlying reason being that crop litter and its microbial decomposers have lower C:N ratios. C: N ratio in cultivated surface “A” profile horizons commonly ranges from 8 – 15 (median ~12) and was generally lower within soil depth. The C: N ratio was around 6.5 while, ratio over 30 was considered extremely high and can result in some soil nitrogen deficiencies. C: N was too high microbes search available N and thus, can lead to depletion of soil soluble N in different forms. In line by Brady and Weil (2010) because of that process N, deficiency can occur and decay of OM can be delayed.

5.3. Estimation of soil organic carbon and total nitrogen stocks

Soil organic carbon and TN stocks were influenced by farming practices and soil depth. Consistent with Yang *et al*.(2007); Gupta *et al*.(2014) also reported that higher SOC and TN stocks in the surface soils under conservation agriculture as compared to conventional; but, distribution down the soil depth was reduced. The SOC stocks varied from different farming practices, especially in the top layer where conservation agriculture both site and bottom layers where fluctuated due to human influence continues plowing as conservation and conventional agriculture areas were frequently eroded. Thus, is agreeing so reported by Morisada *et al*. (2004);

Woomer *et al*. (2004) also reported that the variation of SOC and TN stock among the farming practice and soil depth. Such management practices impact improving the soil physicochemical properties and SOC stocks. Furthermore, a low carbon stock in the conventional agriculture has been due to the crop uptake, leaching, and surface erosion losses. In line with the findings of Don *et al*. (2011) and Lemenih (2004) also added reported that inadequate land management, the crop residue removal and grazing after the harvest might have contributed to the low soil carbon storage in the cropland's topsoil and sub soil.

The lower TN stocks in the soil depth and across the farming practices were due to the reductions under the conventional system could related to topsoil soil layer (where in cultivators and hoes were used to weed and open pits), to no input of organic material and to increase topsoil exposure. Thus an indicated similarly Heinze *et al*. (2010); Perroni Ventura *et al*.(2010) ; Maia *et al*.(2008) also reported that reductions in TN stocks were aggravated by soil losses due to erosion leaching, ammonia volatilization because the decrease soils aggregate break downs which changed the soil temperature and water content. The presence of high soil nitrogen stocks in the conservation as compared conventional agriculture can be explained by a continuous various leguminous crop and crop residue (soya bean, lentil, leguminous crops other acacia species in agriculture field) could constitute the lion's share for the high soil OC and total nitrogen stocks conservation agriculture practice. The carbon and nitrogen fixed in the tissue of leguminous crops contributes to surface and subsurface soil in the form of nitrogen fixed similarly as indicated corresponds with the findings of Mohammed and Bekele (2014).

5.4. Correlation of relationship soil Properties

The highly negative correlation was found between the BD and SOC, which was corroborated by the report of Berhangoray *et al.* (2013). It was pointed out that BD was very specific to location and farming practices and it is unwise to consider BD as a single factor affecting storage of SOC because it relates to several soil properties such as particle size distribution, soil aggregate, moisture content. This result is similarities with the finding reported by Chaudhari *et al*. (2013) also indicated that there is strong negative correlation between soil organic carbon and bulk density of soil. Thus is because as the soil organic carbon increases the bulk density of soil decreases. Hillel (1980) cited in Chandel *et al.* (2015) reported that SOC is known to decrease bulk density for its abundance of pores and its tendency to increase porosity by aggregating soil particles.

It had shown a low relationship between organic carbon and total nitrogen. In line by Wong *et al*. (2008) also reported that, the contribution of organic carbon was significantly medium for nitrogen improvement. SOC in storing and supplying nutrients explains the significant correlation between SOC and soil nutrients. One of the effects of organic carbon is to hold cations and protect them from leaching and removal of nutrients by runoff. The study done by McCauley *et al*. (2017) described that soil organic carbon (SOC) serves multiple functions in the soil, including nutrient retention, water holding capacity and soil aggregation and is a crucial indicator of soil quality.

6. CONCLUSIONS

The conventional farming practice that involves intensive and continuous cultivation is the cause of the lower SOC stock and other soil physicochemical properties showed in the cultivated land without any conservation measures. Furthermore, soils under these conventional farming practices had lower SOC stocks and on other selected physicochemical properties than in the conservation agricultural practice due to crop residues are being grazed, removed and sometimes incorporated by the plough, and intensive tillage and mono cropping; that is causing the soil fertility depletion. The soil depth is also influencing these soils physicochemical properties regardless of the farming practices. Therefore, soil depth is increase with decrease soil carbon and TN content in both treatment.

Therefore, CA practices improve soil aggregation; reduce bulk density in long run due to carbon pool and improvement of soil structure. The higher amount of SOC in surface soil layer in CA is due to higher accumulation of crop residue, which also increases the availability of mineral nutrition. Such as CA practice (Minimum tillage, inter cropping, crop rotation and residue retention) with appropriate soil management could result in carbon and nitrogen accumulation, stabilization, and sustainable use of soil resources. Crop and soil management systems that help improve soil health parameters (physical, biological and chemical) and reduce farmer costs are essential. Overcoming traditional mindsets about tillage by promoting farmer experimentation with this technology in a participatory way will help accelerate mitigation of climate change and improved livelihood of the community.

7. **RECOMMENDATIONS**

The potential role of conservation agriculture in sequestration carbon to reduce the buildup of greenhouse gases in the atmosphere is now well recognized. A number of alternative approaches to use integration conservation management for carbon sequestration applied. Therefore, conservation agriculture is only practiced in few areas; as many as a new approach and climate-smart agriculture perceive it. The following points should be seriously considered for managing the conservation agriculture resources.

- Although, this study was focused only the SOC stocks and other selected soil physicochemical properties at 30 cm soil depth due to time and budget limit. The other investigation that considers the extra soil depth.
- The Perception of farmers towards of the conservation, agricultural practice needs investigation to scaling up the good practice.
- Therefore, this study did carry out on the integrated practice of the conservation agriculture (Intercropping, Crop rotation, and Minimum tillage). Further investigations on the effect of the separate conservation practice.
- Adequate understanding on climate change issues make cost/benefit analysis of conservation agriculture-based GHG mitigation and livelihood improvement to define incentives for wide scale adoption of the protection of the properly land management should be implemented.

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APPENDICES

Appendices 1: Sample label details format

First soil layer______	Top (cm) __________	Bottom (cm):
Sample per plot	Number of analyses _______	______________
Second Soil Layer	Top (cm):	Bottom (cm): _____________
samples per plot:	Number of analyses:	
Third soil layer	Top (cm): _______________	Bottom (cm) __________
Samples per plot:	Number of analyses:	

Appendices 2: Bulk density data collection format

Number of bulk density tests per plot

First layer__________: second layer___________: third layer______:

Total: multiplies by number of plots to get total bulk density tests___________:

Unit costs quoted by soil lab:________________________________

Analysis____________: bulk density________________: sample prep_______________:

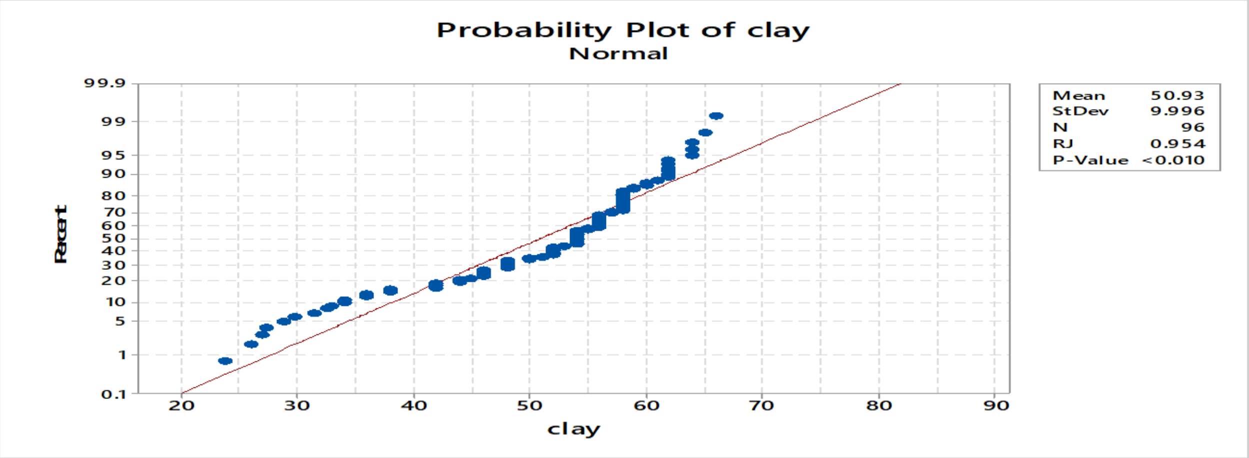
Appendices 3: Form for coordination point plot description

.ClusterNumber	Sample Id	Soil a Pit Numbers.	Coordinate point By GPS		Village/locality name
			X coord	Y coord	
Plot number					

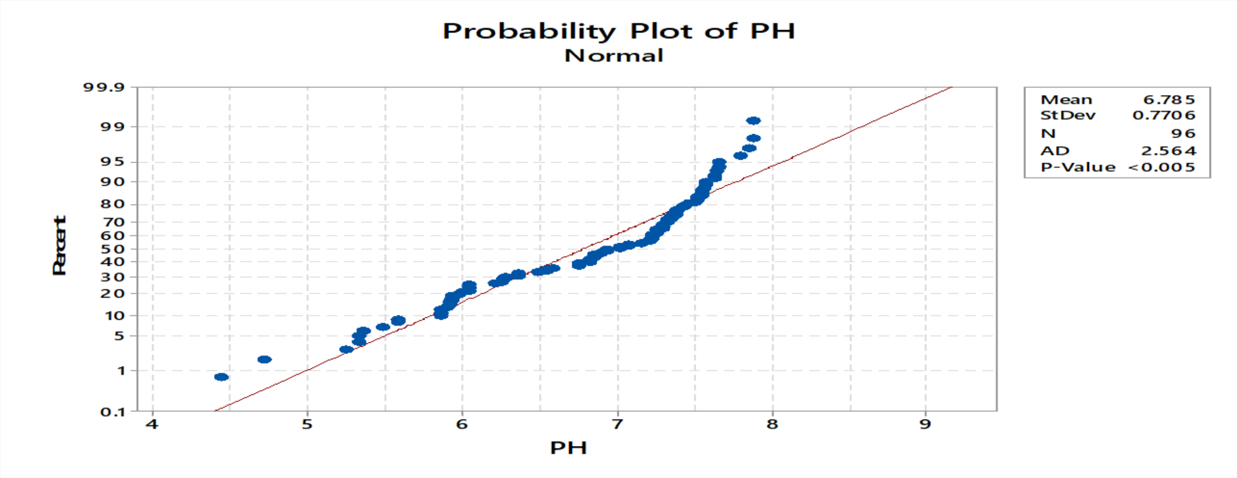
Appendices 4: coordination point a sample collection plot format

	Soil plot GPS Location		Farming practices	Plot numbers
GPS (Name, model)	UTM N (X)	UTM E (Y)	CA and CVA	
GPS60				

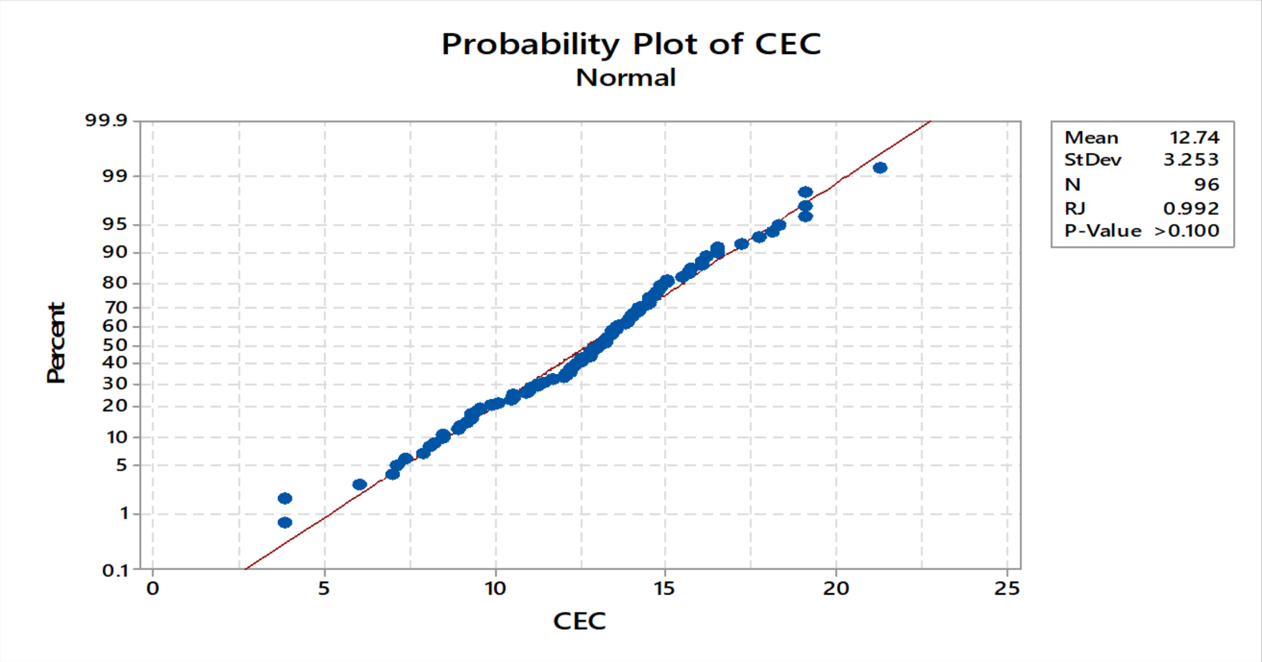
Appendices 5: Normality test for clay distribution farming practices in all soil profile



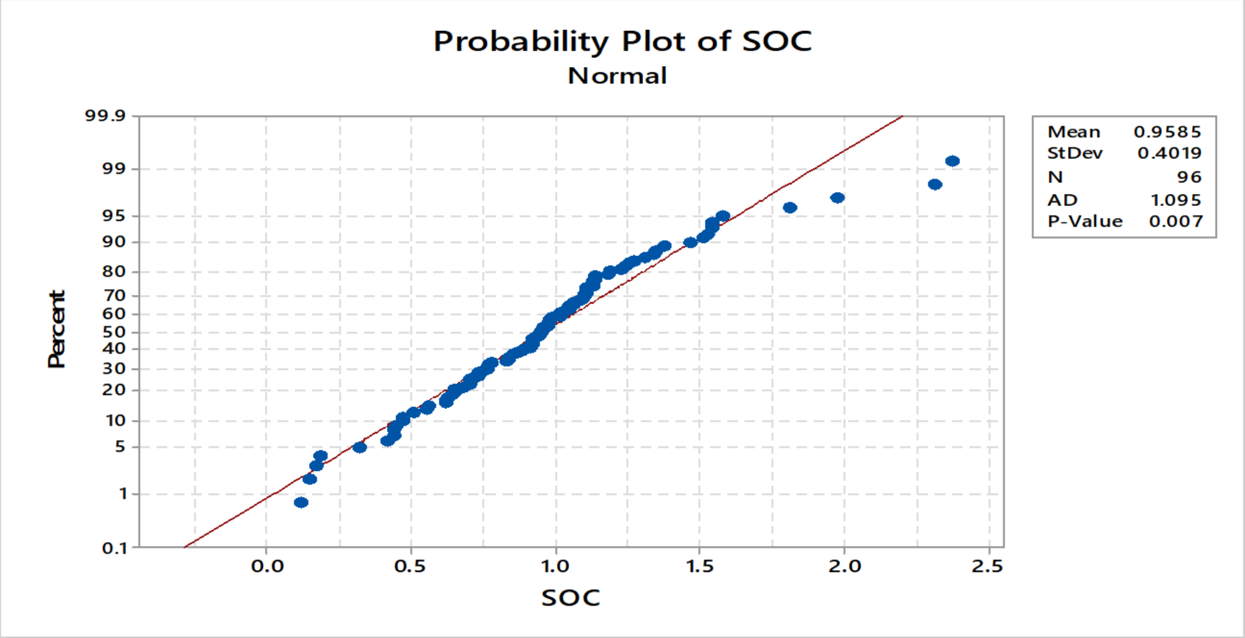
Appendices 6: Normality test for pH distribution two land use and three soil profile by Shapiro-wilk



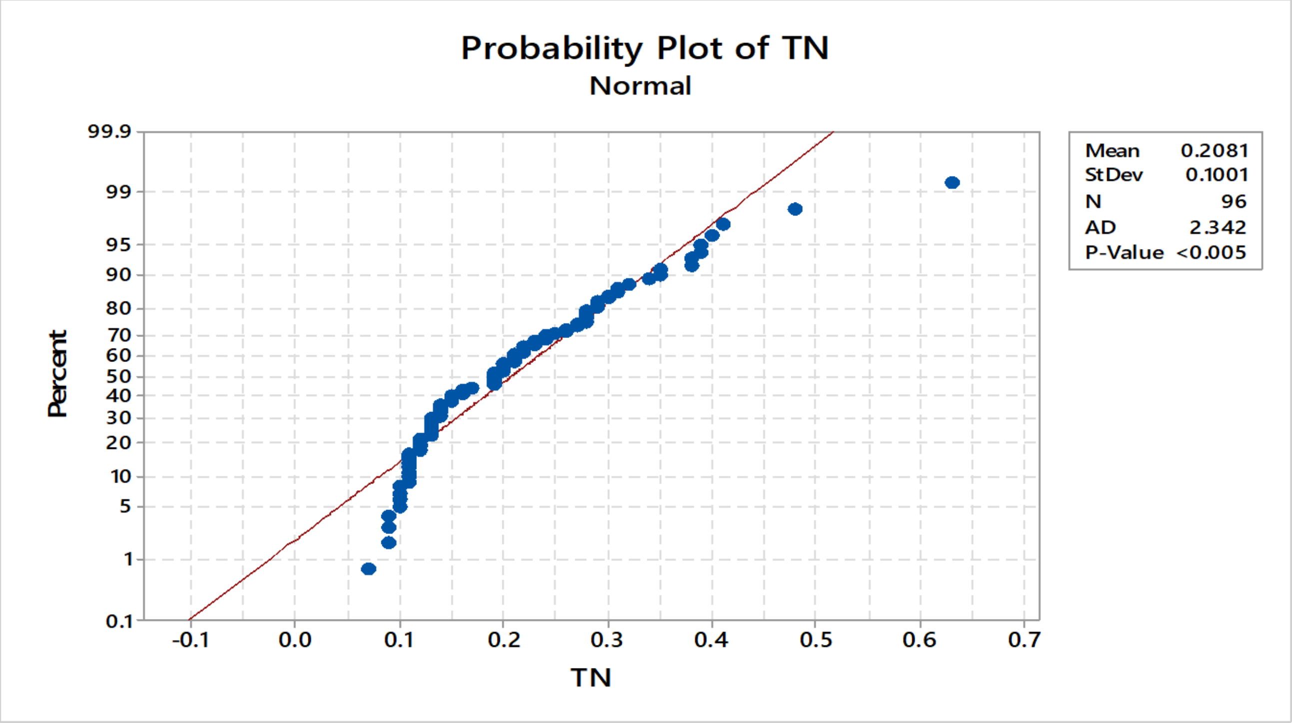
Appendices 7: Test for CEC distribution farming practices and in all soil profile by Shapiro-wilk



Appendices 8: Normality test for SOC distribution farming practices and in all soil profile by Shapiro-wilk



Appendices 9: Normality test for TN distribution farming practices and in all soil profile by Shapiro-wilk



BIOGRAPHICAL SKETCH

The author Addisu Wakayo Abamagal was born on August 18, 1985 G.C in North shoa zone, Mulo district and attended Elementary school education at Mulo Sagno Geba School, junior and high school at Bishoftu preparatory school. Soon after the completion of his high school education, he joined Mekelle University in 2005 G.C. and Graduated with BSc. in Natural Resource Management and Environmental protection stream Soil and water conservation in 2008 G.C. Then, he worked southwest Ilu Ababora zone in Bilo Nopha district Agricultural Office as expert for 4.5 years. In 2013, G.C joined Oromia special zone surround Finfinne at Akaki district Agricultural Office as expert. Then, in September 2016 G.C, he joined the Post Graduate Program of Hawassa University Wondo Genet College of Forestry and Natural to pursue his education leading for MSc. Degree in Climate smart Agricultural landscape assessment.

================ Thank you==================