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Effects of soil water conservation practices and slope gradient on selected soil physic chemical properties in Hawker watershed, Northwest Ethiopia

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BAHIR DAR UNIVERSITY
COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES
GRADUATE PROGRAM

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M.Sc. Thesis

By

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A THESIS SUBMITTED TO BAHIR DAR UNIVERSITY, COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES GRADUATE PROGRAM IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (M.Sc.) IN LAND RESOURCE MANAGEMENT

Department: - Natural Resource Management

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THESIS APPROVAL SHEET

As a member of the Board of Examiners of the Master of Science (M.Sc.) Thesis, Open Defense Examination, we have read and evaluated this thesis prepared by **Mrs. Meseret Ambachew** entitled "Effects of Soil and Water Conservation Practices and Slope Gradient on Selected Soil Physicochemical Properties in Kershewa Watershed, Northwest Ethiopia". We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Science (**M.Sc.**) in Land Resource Management.

Board of Examiners

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Name Chairman Examiner	Signature	Date

DECLARATION

This is to certify that this thesis entitled "Effects of Soil and Water Conservation Practices and Slope Gradient on Selected Soil Physicochemical Properties in Kershewa Watershed Northwest Ethiopia" is submitted in partial fulfillment of the requirements for the award of the degree of Master of Science (M.Sc.) in Land Resource Management to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by Mrs. Meseret Ambachew (ID No 207162R.) this is an authentic work carried out by our guidance. To the best of our knowledge and belief, the matter embodied in this project work has not been, submitted earlier to another university for an award of any degree or diploma.

Meseret Ambachew	______________	______________
(Name of student)	Signature	Date
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(Name of Advisor)	Signature	Date

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DEDACTION

I dedicate this thesis to my beloved family for their limitless support and inspiration in my complete academic career and life.

ABBREVIATION/ACRONYMS

ANOVA	Analysis of Variance
GDP	Gross Demotic Product
NGO	Non-Governmental Organization
PSWCP	Physical Soil and Water Conservation Practice
SPSS	Statistical Package for Social Science
SSA	Sub-Saharan- Africa
CSA	Central Statical Agency
DDARDO	Dehana District Agricultural and Rural Development Office
EPA	Environmental Protection Authority
MoFED	Ministry of Finance and Economic Development

TABLE OF CONTENTS

Table of Contents

LIST OF TABLES

Effects of Soil Water Conservation Practices and Slope Gradient on Selected Soil Physicochemical Properties in Kershewa Watershed Northwest Ethiopia

ABSTRACT

Evidence on effects of soil physicochemical properties under different soil water conservation practices and slope gradient is important for sustainable land resource management. However, the effects of soil water conservation practices and slope gradient on soil fertility has not been assessed as such.in the study area. This study was conducted in Kershewa watershed northwest Ethiopia to investigate the effects of soil physicochemical properties under different soil water conservation practices and slope gradient.. Two soil water conservation namely stone bound and beach terrace and three slope gradient (top, middle and bottom slope position) to determine soil physicochemical properties. A total of 36 composite soil samples were collected at two conservation structure and three slope position. The empirical data obtained from the soil result revealed that soil and water conservation and slope gradient effect on selected soil physicochemical properties in the study watershed site. Soil texture (sand, silt and clay), bulk density, moisture content, soil pH, organic carbon, total nitrogen, available phosphorus, cation exchange capacity and electrical conductivity were significantly ($p<0.05$) affected by both soil water conservation practices and slope gradients. . Thus soil water conservation and slope gradient had shown a great effect on soil properties. The highest clay (37.67-24.78%), moisture content (8.15-7.12%), soil pH (5.32-4.24), organic carbon (1.62-0.96%), total nitrogen (0.24-0.08%), available phosphorus (3.02-2.58ppm), cation exchange capacity (17.48-12.34 $cmolcg^{-1}$) and electrical conductivity (0.13-0.06ds/m) whereas the lowest sand and bulk density were observed under the treated stone bound. Conversely, the lowest observed under untreated bench trace from soil and water conservation practices. In case of slope gradient, the highest clay, moisture content, pH (5.33-4.10), organic carbon (1.72-1%), total nitrogen (0.27-0.12%), available phosphorus(2.99-2.65ppm), cation exchange capacity (16.78-12.15 $cmolcg^{-1}$) and electrical conductivity (0.12-0.06 ds/m) in addition to the lowest sand and bulk density were recorded in the bottom slope however the lowest under on the top slope position. In the study watershed unconserved structure and bottom slope position have a negative effect on soil physicochemical properties. Therefore, implementing appropriate soil water conservation practices to manage physicochemical properties of soils is important in the watershed

KeyWords : Soil structure; Stone bound ; Slope gradient ; Land management

Chapter 1. INTRODUCTION

1.1 Background and Justification

Agriculture contributes substantial role in the Ethiopian economy (MoFED, 2010). It creates employment opportunity for about 83-85% for the community and contributes 43-50 percent for growth and domestic products (GDP) and 90 percent of the total foreign exchange earnings. It also provides about 70 percent of the raw materials for different industries in the country to realize the agricultural-development-led industrialization strategy. Furthermore, the role of gender in agricultural system is critical, women contribute as much as 70 percent of on-farm labor (Awulachew Silesh *et al.* 2006). `

Land degradation and its related decline in the productivity potential of agricultural land are challenging the economic and social well-being of the current and future generations on earth (Nigussie Haregeweyn *et al.*, 2012). Soil erosion is the main cause of land degradation and a leading factor contributing to poor agricultural development in developing countries (Gemechu Eskinder *et al.*, 2016). Currently, soil resources are the main sources of livelihoods for most people of the world, such human exploitation being the foremost factor for soil degradation (MollaTegegn and Biniam Sisheber, 2017).

In developing countries, many people have been settled in the highlands due to favorable agricultural and ecological conditions, leading to high population densities and causing resource degradation (Nigussie Haregeweyn *et al.* 2017). Cultivation of marginal lands, forest degradation for farming, and overgrazing are the major causes of increasing vulnerability of agricultural land to soil erosion in Ethiopia (Adimassu Zenebe *et al.*, 2014). The slope steepness, long cultivation history with outdated technology, and overgrazing make soil erosion more severe in Ethiopia (Nyssen *et al.*, 2004). It has been identified as a major threat to the national economy (Hurni 1993) and among the main challenges influencing the sustainability of agriculture (MollaTegegn and Biniam Sisheber, 2017). As a result, two-thirds of the population of Ethiopia has been affected by soil erosion mainly associated with the conversion of forest to agricultural land (Hurni et al. 2015). This is indicated by a 0.4% increase in crop yields and a 5.7% increase in cultivated land from 1991 to 2003 (International Monetary Fund, 2005). The net soil loss increased from 130 to 182 million metric tons from 1995 to 2005 (Environment for Development, 2010). As part of the Ethiopian highlands, the Upper Blue Nile Basin experiences high soil erosion rate (0– 200 tons' ha−1 year−1) (Nigussie Haregeweyn *et al.*, 2017) and 131 million tons of soil loss annually because of poor land use management systems (Betrie et al., 2011). The Gumara watershed is part of this basin that is affected by high soil erosion (Belayneh Mengie *et al.*, 2019) and among the highest mean runoff portion in the basin (Nigussie Haregeweyn *et al.*, 2016).

Soil erosion is the main form of land degradation caused by the interacting effects of factors, such as biophysical characteristics and socio-economic aspects. Each year about 10 million hectares of cropland of the globe is being lost due to soil erosion (Pimentel and Burgess, 2013). In sub-Saharan Africa land degradation particularly, nutrient depletion is leading to a decline in crop productivity, and has been linked to hunger and poverty (Coxhead and Ygard, 2008). However, programs were targeted on areas frequently affected by drought in the northern and northeastern parts of the country aiming at social protection but not so much at resource conservation (Nigussie Haregeweyn *et al.*, 2015; Mekuriaw Asnake *et al.*, 2018). Active erosion and high annual runoff rates occur in the northwestern highlands of the country (Nigussie Haregeweyn *et al.* 2017), which are characterized by high and erosive rainfall and poor land management (Nyssen *et al.*, 2004).

The effectiveness of SWC measures was evaluated by several studies but most of them focused on the semiarid northern part of the country (Nigussie Haregeweyn *et al.*, 2016). Few studies were conducted in the northwestern highlands (Nigussie Haregeweyn *et al.*, 2015). The efficiency and effectiveness of SWC measures is subject to both the prevailing agro-ecology and the type of conservation measures implemented (Nigussie Haregeweyn *et al.*, 2015). This indicates the need for local and agro-ecologically based evaluation of the impacts of SWC measures in high potential northwestern highlands.

1.2 Statement of the Problem

Ethiopia is one of the most environmentally troubled countries in the Sahara belt. According to the Environmental Protection Authority (EPA, 2003), about 45% of the total annual soil loss in the country occurs from cultivated fields. To solve this problem, soil and water conservation (SWC) practices were initiated. The main committed of soil water conservation was to minimize erosion, restore soil fertility, rehabilitate degraded land, and increase agricultural productivity (Mekuria wolda *et al.*, 2007; Nigussie Haregeweyn *et al.*, 2012).

In the kershwa watershed, wagemera zone, Ethiopia like most north highlands, different SWC structures were implemented by farmers through community mass -mobilization but Soil erosion is widely represented as having a serious environmental, economic and social problem for both individual landholders and the wider community. Consequently, severe soil erosion continues to affect Sustainable development. Insufficient data on the effectiveness of SWC practices could lead to ineffective planning, progress, and realization of SWC initiatives. Hence, evaluating the impacts of SWC practices has been vital to learn lessons from its success and limitations of the initiative.

However, the effects of bench traces conservation practices on selected soil properties of the soil not still clearly investigated. There is no research which has been done with respect to the assessment the effect of soil water conservation on soil physicochemical properties in the watershed of the study areas. Therefore, aims this study assesses the effects of soil and water conservation practices and slope gradient on Soil physicochemical properties.

1.3. Objectives

1.3.1 General objective

The general objective of the study was to investigate the effects of Soil Water Conservation Practices and slope gradient on selected Soil Physicochemical Properties in Kershewa Watershed Northwest Ethiopia

1.3.2 Specific Objectives

To investigate the effect of soil water conservation structures on soil physical-chemical properties in Kershewa watershed, Northwest Ethiopia

To evaluate some selected physicochemical properties of soils under different slope gradients and soil-water conservation structures in Kershewa watershed, Northwest Ethiopia

Chapter 2. LITERATURE REVIEW

2.1 Soil Erosion and Land Degradation in Ethiopia

Soil erosion is a destructive process altering and changing the topsoil layer and soil carbon stocks through selective removal of fertile top soil along the slope (Olson *et al.,* 2016). In Ethiopia, soil erosion is one of a serious problem challenging the agricultural sector and economic development (Hurni *et al.,* 2016). It is severe in general and particularly in the highland areas where land highly degraded and exacerbates the prevailing of food insecurity in the country (Anteneh Belayneh and Tesema Zewdu*,* 2017).

The various studies conducted in the country point out that the loss of soil due soil erosion is at large rate. For instance, in Tigray highlands showed that the average rate of soil loss was about 14·8 t ha−1 yr−1 (Nyssen *et al.* 2008). Likewise, in Koga River the average annual soil loss rate was 30.2 t ha−1 yr−1which ranges from 12.1 t ha−1 yr−1 to 456.2 t ha−1 yr−1 for the outlet and the steep slope area of the watershed, respectively (Molla Tegegne and Biniam Sisheber, 2017). Similarly, in the north western highlands of Ethiopia, in the Geleda watershed of the Blue Nile basin, the soil loss in the steep areas of the watershed extends up to 237 t ha−1 year−1 (Temesgen Gashaw *et al.* 2017). This indicates that erosion rates exceed tolerable levels and affects the productive capacity of the soil system (Guerra *et al.,* 2017*).* Besides, the loss of soil also results in loss of water, nutrients, soil organic matter, and soil biota (Pimentel and Burgess 2013). These all indicate soil erosion exceed the generation of new topsoil which leads to decline in soil productivity, low agricultural yield; that need adoption of integrated soil and water conservation to reverse the problem. Thus, soil erosion control is being important under every type of land use (Kumar and

Pani, 2013).

2.1.1 History of Soil and water Conservation Practice in Ethiopia

In most areas of Ethiopia, new SWC technologies were introduced more than four decades ago. In the past, SWC policies tended to focus on the use of subsidies as an incentive for farmers to adopt environmentally sound production practices and conservation measures. Such policies are grounded in the belief SWC measures are inherently desirable and the benefits of their adoption outweigh the costs of their implementation and maintenance" (Anderson and Thampapillai, 1990). The adoption of SWC practices represents a decision by households to intensify their agricultural production to improve output per unit area through capital investment or an increase in labor inputs (Hailu Zegeyu and Metzger, 1993). In Ethiopia, significant SWC Practices were implemented during the 1970s and 1980s by mobilizing farmers through their peasant associations mainly in food for work programs. These SWC activities were implemented largely in the drought-affected areas including Wello focusing on both mechanical and biological measures. The major mechanical measures include construction of bunds, check dams, micro-basins, hillside terraces and the biological measures include enclosure protection of degraded land from human and animal interferences (enclosures), tree seedling production, planting of tree seedlings on farmlands (agro-forestry), afforestation, tree plantations around the homesteads and tree plantation in enclosures as enrichment to the natural regeneration (Girma Tadesse, 2001). The intention of the implementation was to reduce soil erosion, restore soil fertility, rehabilitate degraded lands, improve micro-climate, improve agricultural productivity and restore environmental condition (Vancampenhout, *et al.,* 2006; Mekuria Wolde *et al.*, 2007). In many parts of the Ethiopian highlands, current government has also been undertaking SWC through integrated and participatory watershed development approaches to improve rural livelihoods with sustainable natural resource management (MoFED, 2006)..

2.2 Soil and Water Conservation and Its Adoption in Ethiopia

Soil and water conservation is a key method in reversing land degradation in the country. To reduce soil erosion and land degradation, various soil and water conservation measures have been adopted throughout the country (Wolka *et al.,* 2015). The indigenous agricultural system in Konso zone is characterized by stone-based terraces and well-integrated Agroforestry practices. It has existed for at least four hundred years.

The strength of the system is expressing culture and its institutions that contribute to this kind of agriculture (Tesfaye Beshah, 2003). The survey result reveals that there are various indigenous and adopted soil conservation practices in Darimu and Chewaka Woredas of Illu Ababora Zone. Among these, fallowing, manure, contour plowing, crop rotation and waterways are indigenous soil conservation practices and terracing, soil bund, fayna juu, grass strip, grass and elephant grass are some of the adopted soil conservation practices in the area (Anteneh Belayneh *et al.,* 2017).

In Ethiopia, adoption of large-scale soil and water conservation techniques on farm lands was dated back in the early 1970's (Wolka *et al.,* 2015). For instance, soil bunds were introduced in Wolaita zone to conserve both soil and water in an experimental catchment in the early 1980s, which have shown moisture and nutrient conservation effects (Beshah, 2003). Introduction of soil and water conservation technology strongly reduces runoff production and soil loss. Stone bunds building lead to soil loss reduction of 58 to 66% in rangeland while the reduction rate ranges from 43 to 50% in cropland in central Tigray, northern Ethiopia (Aklilu Taye *et al.,* 2013).

Indigenous soil conservation techniques alone became less efficient when compared to modern technologies of conservation measures. Modern methods of soil and water conservation were unsustainable due to unpopular top-down policies and lack of community participation that leads past efforts of the modern intervention programs to being ineffective. Hence, to cope up with the problems, indigenous techniques of soil and water conservation needs improvement and the modern ones also needs adaptation to the environment and involving the community at all levels is vital (Osman, 2013).

2.2.1 Soil Conservation and Its Importance in Ethiopia

Ethiopia is a country where soil degradation is prevalent at a tragic rate. The average annual rate of soil loss in the country is estimated to be 12 tons/ hectare/ year, and it can be even higher on steep slopes and on places where the vegetation cover is low. The amount of yield reduction because of the loss of topsoil each year is increasing substantially. This makes the issue of soil conservation not only necessary but also a vital concern if the country wants to achieve sustainable development of its agricultural sector and its economy at large (Abera Birhanu, 2003).

The issue of resource conservation has been given due attention by the Ethiopian government, its development partners and NGOs. Indeed, various interventions have been crafted at both national and local levels to address what is believed by many to be Ethiopia's critical development challenge. Yet, is appears that such intervention should consider the added dimensions of secure resource entitlement and collective action to harmonize the environment-society relationship (Ayalneh Bogale, 2006).

2.3 Effectiveness of Soil and Water Conservation

Soil and water conservation measures interventions take various forms throughout the country to reduce soil erosion and land degradation problem based on the agro-ecology of the area (Yonas Ademe *et al.,* 2016). According to Mekuria Wolde, *et al.* (2007) stated that the constructed stone bund was trapped 76% of the total soil loss in the study conducted in northern Ethiopia. Similarly, the study conducted in the Jawe-gumbura watershed had reported a 28% annual runoff and 47% soil loss reduction. These are therefore used as evidence for the effectiveness of soil bund in reducing of runoff and soil losses. Consequently, soil bund has reduced losses of soil nutrients and organic carbon associated with conserved soil. On the other hand, the construction of soil bunds takes out the cultivable area out of production by 8.6 percent as compared to control, which is needed to compensate by integrating with biological conservation and increasing yield obtained from conserved land (Adimassu Zenebe *et al.,* 2017).

The farmers have several criteria to select soil and water conservation practices. The economic benefit is the one given top priority to choose the structure. Therefore, strengthening participatory planning with farmers and developing the best future alternatives that provide with immediate benefit along with the long-term benefit obtained from soil and water conservation investment is required (Adimassu Zenebe *et al.,* 2013).

2.3.1 Soil and Water Conservation Impacts on Selected Soil Physicochemical Properties

Soil and water conservation practice improves the soil properties through reducing runoff velocity, because in the absence of soil and water conservation, the soil is washed-out down the slope by erosion. Along with the loss of soil, it results in loss of water, nutrients, soil organic matter and soil biota. This severely harms the proper functioning of the soil system (Pimentel & Burgess, 2013). Soil erosion lowers base saturation and soil organic carbon (SOC) contents; as a result, it decreases the soil pH. The pH of the soil influences the availability of phosphorus, which is low for non-conserved agricultural land (Asmelash Fisseha *et al.,* 2016).

The study conducted in different parts of the country points out that cropland with soil and water conservation practice showed significant variation in soil physicochemical properties (Tigest Alemayehu and Getachew Fisseha, 2018). Similarly, Yonas Ademe *et al.* (2016) indicates that soil and water conservation improve the soil properties on conserved cropland (pH, K^+, available P, SOC, TN, CEC and clay content) than in the adjacent crop land that is without soil and water conservation measures. This indicates the positive impacts of soil and water conservation practices in improving the nutrient status of the cropland. In contrast to this Wolka *et al.* (2011) reported that the constructed soil bund had not affected most of the tested soil properties in cropland with soil and water conservation as compared to the non-conserved one.

2.4 Effect of SWCP on Soil Physio-Chemical Properties

2.4.1 Effect of SWCP on Physical Soil Properties

According to Mulugeta Demelash and Karl Stahr (2010), the non-conserved micro-watershed has highest bulk density than the micro-watershed treated with SWC measures. This could be attributed to the presence of higher organic matter as a result of biological conservation measures and higher accumulation of soil sediments that eroded from upslope in conserved watershed. Conserved soil with biological SWC measures has a better soil infiltration rate (the rate at which water move to soil vertically in a given period of time and depth) than the physical SWC measure due to the roots penetration effect and addition of soil organic matter from plant bodies through decomposition of the soil. This means, infiltration and bulk density has direct relationship.

The textural classes of top soils treated with SWC measures and that of the untreated lands have differences which were confirmed through statistical analysis of the soil laboratory data. The analysis revealed a significant variation of top soil texture in percent sand, silt and clay content due to effect of SWC measures. In general, bunds play a great role in reducing the incorporation of clay -dominated soil from the subsoil to the surface soil, which resulted from removal of topsoil and exposure of the subsoil by erosion (Mulugeta Demelash and Karl Stahr, 2010).

2.4.2 Effect of SWCP on Soil Chemical Properties

Soils with high organic matter content have a higher soil pH which favors better exchange of bases and increase availability of nutrients that are needed for the growth of plants in a given soil and ecology. Organic carbon can be attributed to the effect of SWC measures implemented. The age of bunds stabilized with vegetative measure have better affect in soil organic matter accumulation (Million Alemayehu, 2003). According to a study made by Bot and Benites (2005) soil organic matter accumulation support at foot or lower slopes of hills of non-conserved lands because of mid and upper slopes are wetter and organic matter would be transported to the lowest point of the landscape with runoff and soil erosion. Soil texture appears to have an important impact on the amount, distribution and chemical properties of soil organic matter (SOM) components. The analysis made using statistical methods revealed that the mean total nitrogen difference due to the impact of SWC measures was significant at p 0.05 (Million Alemayehu, 2003). However, Physical SWC measures stabilized with nitrogen-fixing plants designating the total nitrogen (N) is much higher compared with other biological measures (Mulugeta Demelash and Karl Stahr, 2010).

2.5 The Physical Soil and Water Conservation practice

Most of the PSWCP effort made in the area was directed in controlling soil loss from cultivated fields. These include stone faced soil bunds, soil bunds, water way, cutoff drain and Fanyajuu. However, it is not usual to see stone bunds due to scarcity of stone, which is attributable to geological feature of the study area (Addisu Damtew *et al.,* 2015).

Physical soil and water conservation practice may still be necessary as they have an important role in reducing soil loss by runoff control, particularly for annual crops and no steeper slopes. Despite all these efforts, many writers quoted that the SWC campaign was neither effective nor sustainable. For example, Aklilu Amisalu (2006) showed that PSWCP activities in the highlands of Ethiopia are faced with several challenges. Despite extensive conservation practice during the past decades, sustained adoption of the recommended measures by the farmers has not been as expected. Woldeamilak Bewket (2003) also noted that over the past few decades, the agricultural sector has failed to keep pace with growing demand for food. Generally, PSWCP can affect farm productivity positively in different ways. The major three methods are increasing farm yields per hectare through increased soil depth and water retention capacity, reducing input costs as PSWCP has the potential to increase the accumulation of SOM and increasing the productivity of factor inputs. Several other reasons also may play important role in soil conservation (Worku Hailu, 2017).

The overall intention of the interventions is to reduce soil erosion, restore soil fertility, rehabilitate degraded lands, improve micro-climate, improve agricultural productivity and restore environmental condition (Mekuria wolde *et al.,* 2007). According to Mulugeta Demelash and Karl (2010) the appropriate PSWCP can significantly improve chemical and physical properties of soil. It is possible to say that this way of implementation shows some changes in the country as a whole and specifically in Amhara Region. Physical soil and water conservation practice contributes to more effective rainwater harvesting, improve water retention and infiltration into the soil, increasing the amount of water available to plants and guaranteeing the harvest. Such an increase in available water in the soil profile will prevents the loss of rainwater under water-limiting conditions (Zougmoré *et al.,* 2014). Conserving water makes it available for crops, livestock and domestic use over a longer period. Controlling soil erosion improves crop and pasture yields, and conservation measures increase the value of the land (Sustainable Agriculture Information Initiative, 2010).

Chapter 3. MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location

The study was conducted in Biwul kidanemihret watershed situated at Dehana district Waghimra administrative zone Amhara National Regional State (ANRS) of Ethiopia in 2020/2021. The district is found in 78km away from West Waghimra Zone, 520 km North East of Bahir Dar (the capital of the Amhara Region) and 793 km North of Addis Ababa (the capital city of Ethiopia). The altitude ranges from 1205 to 3138 m.a.s.l. (DDADRO., 2021). The district lies between 12°10' and 12°39' North longitudes and 38°25' and 39°00' East to the west of Sekota town. It is bordered by Zequala Woreda in the north, north Wello zone in the south, south and north Gondar zone in the west and Sekota town in the east (Dehana District

Agricultural and Rural Development Office (DDARDO, 2021).

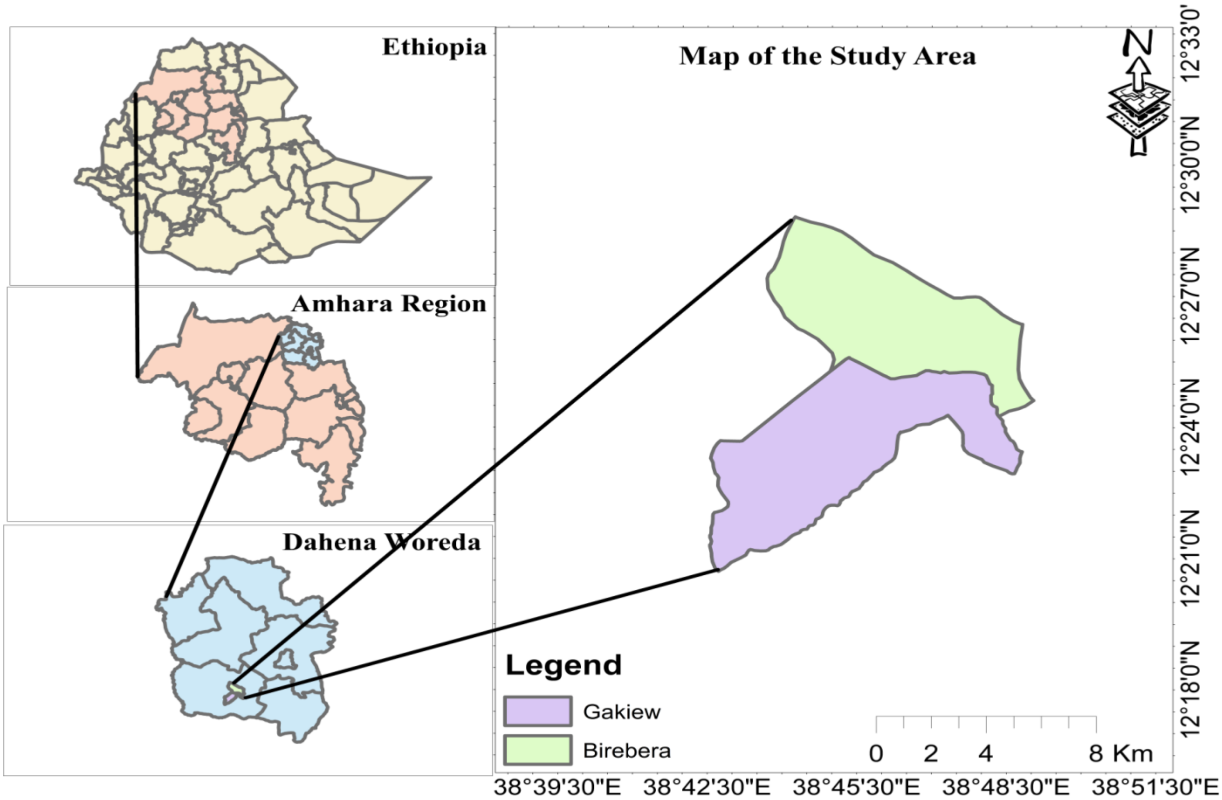

Figure 3.1: Location Map of the study area

3.1.2 Climate

The recorded annual mean temperature of the district ranges from 12^0C -28^0C in the highland and lowlands of *karshiwa* (parts of Dahana district), which is semi-arid kola. The highest rainfall in the district occurs during summer season which starts in the middle of June and ends up in the early September. Rainfall distribution in the region is characterized by high temporal and spatial variability with annual precipitation ranging from 400-450 mm (DWADO, 2021).

Karshiwa watershed covers 757.25ha in Dehana district. The soil of the watershed is characterized by Argosol, Aerosol and Leptosols (DDARDO, 2021). It has a uni-modal rainfall pattern; the main rain extends from late June to early September. The mean annual rainfall of the area varied from 500 to 700 and the mean minimum and maximum annual temperature are 18^0C and 26^0C. The watershed can be divided in to 3 agro-ecologies as kola (lowlands) which covers

20% of the area with relatively low rainfall and high temperature. Another is woinadega (middle highlands) which covers 44%with moderate amount of rainfall and temperature. Finally, dega (highlands) which covers 36% with somewhat higher rainfall and cold temperature. Around 857 household depend on Kashiwa watershed from 852 households, 517 are males and 335 are females. The main types of land use and land cover patterns in the watersheds are bush and shrub land (38ha or 5.01%), cultivated lands (417.25ha or 55.1%), forest land (94ha or 12.42%) and grazing lands (208ha or 27.47%).

3.1.3 Topography and soil types

The topography of Dehana district contains three main traditional divisions. The first is kola (lowlands) which covers 5.5% of the area with relatively low rainfall and high temperature. Another is woinadega (middle highlands) which covers 84.5%with moderate amount of rainfall and temperature. Finally, dega (highlands) which covers 9.8% with somewhat high rainfall and cold temperature (Dehana District Agricultural Office, 2021).

Argosol, aerosol and Leptosols are the soil types covering nearly 91% of the land in the district. Traditionally, fertility of the soils on the plains is believed to be fertile because of the silt coming from the adjacent mountains. The mountains in the eastern and northern parts of the valley are believed to be the major sources of alluvial soil because of relatively higher rainfall in these areas. However, previous studies by the district Project indicate that soil fertility is low. However, it is obvious that soil fertility is very poor as could be seen from the performance of crop production (Dehana District Agricultural Office, 2021).

3.1.4 Land use and farming system

The total area of the district is 71642.37ha. The main types of land use and land cover patterns in the district are bush and shrub land (27.12%), cultivated lands (23.9%), forest land (3.68) and grass lands (45.29%). Other forms of land use (built up area) cover account for 0.01% of the land mass (Dehana District Agricultural Development Office., 2021). Grass land is the dominant land use in areas of high population density. The natural forest resource of the district is overexploited and covers only about 3.68% of the total land area. Farming system in the area is typically mixed crop-livestock system of the high lands of the country, where livestock provide the drought power needed for farming operation and a good part of crop residue are fed to livestock. The main cultivated crops are sorghum, barley (*Hordeum vulgare*), wheat (*Triticum aestivum*), caw pea, teff (*Eragrostis tef*), pea (*Pisum sativum*), faba bean (*Vicia faba*) lentils, sunflower, safflower, potato (*solanum tuberosum*), tomato (*Lycoprsicon escluntum*), onion (Allium spp.), lettuce, mango, cabbage, and banana, pepper (Yiheyis Aemero *et al.,* 2012).

3.2 Soil sampling and analysis

Soil samples have been collected from each three plot of conservation and slope gradient. The soil physicochemical properties in different conservation and slope gradient of treated and untreated plots were taken. These composite soil samples have been collected from the top soils (0-20 cm) which are important for annual crops growth and development.

The soil samples were air dried, crushed and sieved through a 2mm mesh sieve for analysis. Then the soil properties considered in this study were texture, bulk density, soil compaction, Soil moisture content, Soil Organic carbon (SOC), Soil Organic matter (SOM), total nitrogen (TN), pH, available phosphorus (av. P), cation exchange capacity (CEC) and Electrical conductivity (EC).

Composite soil samples were air-dried, grinded, and sieved to pass through a 2 mm sieve to make it ready for lab analysis. The soil laboratory analysis has been done at Amhara National Regional State Agriculture Office, Sekota soil research and fertility improvement center. Selected soil fertility indicators such as soil texture, soil pH, bulk density, total nitrogen, organic carbon, available phosphorus, and caution exchange capacity were analyzed using standard laboratory procedures. For the analysis of total nitrogen and organic carbon content, the soil sample was further sieved by 0.5 mm sieve.

Soil bulk density (BD) was determined by core sampler method described in Black *et al.*, (1965). The determination of soil particle size proportions was carried out by hydrometer method suggested by Bouyoucos (1962). Soil reaction (soil pH) was determined by a 1:2.5 soil: water ratio using a pH meter as described by Van Reeuwijk (2002). The soil organic carbon (SOC) concentration was determined by using Walkley and Black rapid titration method as described in Haldar and Sakar (2005). Soil organic matter (SOM) was determined by multiplying percent organic carbon by 1.724 (Jones, 2001). Total nitrogen (TN) was determined by micro Kjeldhal methods as modified by Bremner and Mulvaney (1982). The available phosphorus (Av. P) content was determined using Olsen extraction method as described by Van Reeuwijk (2002). The exchangeable bases and CEC were determined by using ammonium acetate method (Sakar and Haldar, 2005). Soil electrical conductivity (EC) of a soil was measured with a conductivity meter in a soil water extract Sahlemedhin and Taye Bekele (2000).

3.4.1 Treatments and Experimental Design

After field observation a research was conducted in '*Kershewa'* watershed stone bund and bench terrace was done for about four years. For comparison purpose adjacent cultivated land without stone bund and bench terrace was considered. Three gradient levels (top, middle and bottom slope) were considered for soil physicochemical analysis. Soil samples at 0-20cm depth were randomly taken from each slope positions of the conserved and un-conserved cultivated land by using soil auger. In this experiment soil samples were collected from 12 treatments. Two factors were involved in the study, namely three slope classes (top, middle and bottom) and four classes of soil and water conservation measures (untreated stone bund cultivated land, cultivated land treated with stone bund, untreated bench terrace cultivated land, cultivated land treated with bench terrace). The experiments have a total of twelve (12) treatments that were arranged in 3*4 factorial combinations.

From each slope class 5 subsamples replicated 3 times were collected using zigzag method to have 20 composite samples for one slope class and, 60 composite samples for three slope classes and four SWC treatments were collected. A total of 36 composite samples (4 treatments (SWC) × 3 slope gradients×3 replications) were collected by using soil auger from a depth of 0-20 cm.

3.4.2 Statistical analysis

Mean and mean differences have been used as a descriptive statistical analysis method. One-way ANOVA have been used to test whether there is a significant difference in soil physicochemical properties between conserved and no conserved plots. Two-way ANOVA was applied to test whether soil properties are affected significantly due to the interaction effect of land uses and SWC treatment. In addition, bivariate correlation analysis was used to show the relationships between soil physicochemical properties. The statistical analysis has been manipulated and analyzed by using SAS 9.4.

Chapter 4. RESULTS AND DISCUSSION

4.1 Effects of soil and water conservation structures and slope gradient on soil physical properties

4.1.1 Soil texture

The results revealed that there was a numerical difference among the selected physicochemical soil properties across the different soil-water conservation structures(Table, 2). Soil texture (sand and clay) was statically significantly ($p<0.01$) affected by conservation practice and slope gradient. Whereas silt fraction none significantly affected both conservation practice and slope gradient (Table1). The highest (37.7%) mean value of clay fraction treated stone bound followed by treated beach trace and the lowest (24.4%) untreated stone bound followed by beach trace (Table 2). This could be soil weathering is a relatively slow process, texture remains constant and is not altered by soil conservation practice. However, the highest sand fraction was observed under untreated beach trace followed by untreated stone bund (Table 2). This might be the smallest fraction of clay soil is removed by erosion whereas sand fraction remains constant.

In case of slope gradient, the highest (48.25%) sand fraction was recorded under top slope gradient whereas the lowest (30.92 %) sand fraction was observed under the bottom slope gradient whereas the inverse is true for clay fraction (Table 2). Which might be the highest fraction couldn't be move easily by erosion to bottom slope. Variation was occurred in slope gradient and the mean value of sand fraction content declined down to the slope gradients. Similarly, Mulugeta Lemanih (2004), showed similar results that steep landscapes, transportation and translocation of fine particles are expected in the lower slope gradient, whereas coarse textural fraction remains at the upper slope gradient

Table 1. Mean square estimation for two ways of ANOVA on selected physicochemical soil properties under four-conservation practices and three slope gradient

arameters	Mean square for the source of variation

	)	(2)	slope (6)	(22)	)
(%)	6^{**}	8**	^{ns}	1	
)		6^{ns}	^{ns}	6	
%)	7^{**}	8**	^{ns}	9	
cm^{-3})		*		8	
%)	**	**			
$_2$O)		*			
)					
)			5^{ns}	3	
ppm)					
cmol$_c$g^{-1})	**	**			
s/m)	**	**	097^{ns}	07	

Where **= highly significant at P<0.01; ns =not significant; cmol$_c$g^{-1}=cent moles of charge per kilogram; ppm= part per million; BD= bulk density; pH=soil reaction; OC=organic carbon; TN=total nitrogen; Av. P=available phosphorus; CEC= cation exchange capacity; EC=Electrical conductivity; Ds/m= deciSiemens per meter.

4.1.2 Bulk Density (BD)

The highest (1.45 g/cm^3) BD was observed under untreated beach trace followed by untreated stone bund whereas the lowest (1.29 g/cm^3) BD was recorded under treated stone bond followed by treated beach trace (Table 2). Bulk density (BD) was statically significant (p<0.01) both conservation practice and slope gradient but non-significant effect on the interaction effect of both factors (Table 1). The lowest it could be high organic matter due to soil and water conservation management however the highest BD the lowest organic matter under untreated conservation practices.

The main effects of slope gradient, slope statically significant (p<0.01) affected by BD (Table 1). Then the highest (1.51 g/cm^3) BD was observed under the top slope and mid slope gradient whereas the lowest (1.20 g/cm^3) BD under the bottom slope gradient (Table 2). This could be high organic matter due to soil management practices that is soil water conservation. Therefore, high organic matters the low BD and highly significant and negatively correlated with organic matter. The study was in line with (Mulat Guadie *et al.,* 2019) stated that the higher BD in the untreated fields could be associated with the absence of SWCP that exposed the soil to erosion and consequently to the removal of organic carbon from the topsoil layer.

	icle size (%)		ral	
nents			ı$^{-3}$)	
	Silt	Clay		ó)
	Conservation practices			
ated stone bound	a	b		ı

ed stone bound	b		a		
ated beach trace	a		b		
ed beach trace	b		a		a
LSD (0.05)					
P-value					
SEM (±)					
		Slope (%)			
lope	a	b	c		
e slope	b	ba	b		
m slope	c		a		
LSD (0.05)					
P-value					
EM (±)					
CV (%)					

Table 2. **Individual effects of soil water conservation practices on selected soil physical properties**

Mean values within a column followed by different letters are significantly different from each other at **p<0.01 and *p<0.05; NS =not significant; CL= clay loam; MC= moisture content, LSD= least significant different; SEM= standard error of mean; CV=coefficient of variation.

4.1.3 Moisture content (MC)

The highest (8.15%) MC was observed under treated stone bound whereas the lowest (5.68%) MC was observed under untreated beach trace (Table 2). Moisture content (MC) was statically significantly (p<0.01) affected by both conservation practice and slope gradient however insignificantly affected by the interaction effect of both factors (Table 1). The highest MC under treated stone bound might be due to the rate of erosion is reduced by stone coverage and the sun doesn't contact directly on the soil.

In the case of slope position, the highest (9.26%) and the lowest (4.26%) MC was observed under the bottom and top slope position respectively (Table 1). The highest observed under the bottom slope position it could be due to erosion from the top position slope organic matter deposes to the bottom slope position that means high organic matter content indicates high MC *i.e* directly proportional (Table 4). The result of the study was in agreement with Melaku Alene *et al.* (2021) who reported that the highest MC was recorded under lower slope position due to high organic matter accumulation and low bulk density at lower slope position.

4. 2 Effects of soil and water conservation structures and slope gradient on soil chemical properties

4.2.1 Soil reaction (pH)

Soil pH (H_2O) was statically significantly (p<0.01) affected by both conservation practice and slope gradient position but insignificantly affected by the interaction effects of both factors (Table 1). The highest (5.32) soil pH was recorded under treated stone bound followed by recorded treated bench trace and the lowest under untreated bench trace followed by untreated stone bound (4.24) (Table 3). The highest pH under treated stone bund followed by treated beach trace it might be soils are undisturbed by erosion due to soil management. The soil pH ranges from 5.33-4.10 this is true that greater rainfall increases soil acidity and humid areas are more acidic than arid and semi-arid areas (Osman 2013). The study was agreement with Melaku Alene *et al.* (2021) showed that the highest pH was recorded under treated stone bund due high organic matter accumulation soils treated by stone bound since low soil erosion. Similar with Mengie Belayneh *et al.* (2019), showed that the mean pH of the soil in the study watershed was 5.77 and 5.66 in conserved and non-conserved land respectively. The acidity of the soil could be related with its sub-humid nature of the area and high amount of rainfall.

Within slope gradient position the highest soil PH was recorded from bottom to top slope position (5.33-4.10), respectively (Table, 3). The highest it might be soil nutrient deposited to from top slope position to bottom slope position due to high rain fall. The study result was agreement with Melaku Alene *et al.* (2021) showed that the highest soil pH was recorded under lower slope position compared with upper and middle slope positions.

4.2.2 Soil organic carbon (SOC)

The analysis of variance showed that SOC was significantly ($p<0.01$) affected by both conservation practice and slope gradient however insignificantly affected by the interaction effects of both factors (Table 1). The highest (1.62%) SOC was recorded under treated stone bound whereas the lowest (0.96%) SOC was recorded under untreated beach trace (Table 3). The highest SOC under treated conservation which might be due to conservation activity to minimizing erosion and plant and animal residues live on the place. Whereas the lowest under unconserved area to maximize erosion in this case plant and animal residues remove by erosion due to high rain fall. The result of the study was agreement with Melaku Alene *et al.* (2021) stated that high organic carbon was observed under conserved area than non-conserved.

In respect to slope gradient the highest (1.72%) SOC was recorded under bottom slope position followed by middle slope position where as the lowest (1 %) SOC was recorded under top slope position (Table 3). The highest SOC which might be due to erosion different animal and plant residues and soil nutrient deposited to the lower slope gradient. However, the top slope organic matter easily transported to the lower slope gradient. The study result was agreement with Muktar Muhammed *et al.* (2020) showed that high organic matter was recorded under lower slope gradient than the higher slope position.

4.2.3 Total nitrogen(TN)

The mean value of TN was higher (0.24%) under conserved practices of treated stone bound and the lower (0.08%) untreated beach trace (Table 3). The TN was significantly ($p < 0.01$) affected by both conservation practice and slope gradient whereas it showed insignificant ($p>0.05$) difference with the interaction effect of both factors (Table 1). The higher mean value of TN under conserved practices of treated stone bund which could be accumulation of organic matter reducing erosion by stone bund. However, the lower under untreated beach trace which might be low management soil organic matter easily removed by erosion. The study result was agreement with the study of Yonas Ademe *et al.* (2017) stated that that higher TN content was recorded in treated fields compared with untreated fields in southern Ethiopia. The correlation coefficient also revealed that TN significantly and positively correlated with SOC (r = 0.60 **) (Table 4). This is because SOC/SOM is the main source of TN.

Table 3. Main effects of conservation practices and slope on selected soil chemical properties

Treatments	pH (H_2O)	OC (%)	TN (%)	Av. P (ppm)	CEC ($cmol_{cg}^{-1}$)	EC (Ds/m)
Conservation practices						
Untreated stone bound	4.63^{bc}	1.13^{b}	0.10^{b}	2.85^{b}	12.34^{c}	0.08^{bc}
Treated stone bound	5.32^{a}	1.62^{a}	0.24^{a}	3.02^{a}	17.48^{a}	0.13^{a}
Untreated bench trace	4.24^{c}	0.96^{b}	0.08^{b}	2.58^{c}	12.36^{c}	0.06^{c}
Treated bench trace	4.82^{ba}	1.51^{a}	0.21^{a}	2.95^{ba}	15.50^{b}	0.11^{ba}
LSD (0.05)	0.68	0.33	0.07	0.18	1.88	0.04
P-value	**	**	**	**	**	**
SEM(±)	0.23	0.14	0.03	0.07	0.78	0.01
Slope (%)						
Top slope	4.10^{c}	1.00^{b}	0.12^{c}	2.65^{b}	12.15^{c}	0.06^{b}
Middle slope	4.84^{b}	1.19^{b}	0.19^{b}	2.90^{a}	14.34^{b}	0.08^{b}
Bottom slope	5.33^{a}	1.72^{a}	0.27^{a}	2.99^{a}	16.78^{a}	0.12^{a}
LSD (0.05)	0.53	0.26	0.05	0.14	1.48	0.03
P-value	**	**	**	**	**	**
SEM(±)	0.18	0.11	0.02	0.06	0.75	0.01
CV (%)	10.96	19.25	27.38	4.89	9.97	29.32

Mean values within a column followed by the different letters are significantly different from each other at **P<0.01 and *P<0.05; Ns= not significant; OM = organic matter; OC = organic carbon; Av. P=available phosphorus; TN=total nitrogen; LSD=least significant different; SEM=standard error of mean; CV=coefficient of variation; Ds/m= deciSiemens per meter.

In respect to slope gradient TN was decreased with increasing slope position then the higher (0.27%)TN was recorded under bottom slope position whereas the lower (0.12%) under the top position slope gradient (Table 3). The higher TN from the bottom slope position it could be the accumulation of organic carbon to the bottom slope position as evidenced the current study. In general TN was highly significant and positively correlated with OC (r=0.60**) (Table 4). The study result in line with the finding of Mulugeta Aytenew (2015) who showed that total N revealed an increasing trend from moderately steep to gently sloping gradient, which might be due to their downward movement with runoff water from higher slope gradient and accumulation there at the lower slope gradient.

4.2.4 Available Phosphorus (Av. P)

Available phosphorus was significantly (p<0.01) affected by both conservation practice and slope gradient whereas it was statistically insignificant (p>0.05) the interaction effect of both factors (Table 1). Considering the main effect, the highest (3.02 ppm) Av. P mean values were recorded in the treated stone bound followed by treated beach trace and the lowest (2.58 ppm) under untreated beach trace that is unconserved areas (Table 3). Low Av-P from untreated fields was due to continuous cultivation without SWCPs extractive crops biomass harvest, and soil erosion, as shown by Teressa Dejene (2017). As shown in Table 4 Av. P highly positively correlated with soil OC and TN (r=0.66**and 0.65**) respectively (Table 4).

In case of slope gradient, the higher (2.99 ppm) mean Av. P was recorded in the bottom slope gradients than in the top ones (Table 3), which might be due to the washing out of topsoil and organic matter from the top slope gradients and their subsequent accumulation at the bottom/deposition zone. The study results similar with Yonas Ademe *et al.* (2017) who observed that the higher Av. P was recorded under lower slope gradient than the top ones in Wenago district, southern Ethiopia.

4.2.5 Cation exchange capacity (CEC)

Cation exchange capacity was significantly (p<0.01) affected by both conservation practice and slope gradient but not (p>0.05) the interaction effects both factors (Table 1). The highest (17.48 $cmol_c kg^{-1}$) treated stone bound followed by treated beach traces mean a value of CEC was recorded and the lowest under non-conserved areas were recorded (Table 3). Soils in treated fields higher CEC than untreated fields (Table 3). Which might be due to the implementation of swcps which is increasing the accumulations of soil OM which is left on the land. The study was similar with Andualem Gizachew *et al.* (2014), Teressa Dejene (2017) showed that the higher mean CEC values were found in the treated than in the untreated fields in Adaa Berga district, central Ethiopia and the Weday watershed, eastern Ethiopia, respectively. In addition to this the study result was agreement with the finding of Mathewos Bekele *et al.* (2016) showed that the higher CEC was recorded under conserved land than non-conserved land in Menesibu District, West Ethiopia.

On the other hand, in slope gradient the higher (16.78 $cmol_c kg^{-1}$) mean value of CEC was observed under bottom followed by middle slope gradient and the lowest (12.15 $cmol_c kg^{-1}$) under the top slope gradient (Table 3). The slope gradient increased, the CEC value decreased (Table 3). This might be due to the removal of basic cations from the upper slope and accumulation in the lower slope positions stated by Mulat Guadie *et al.* (2020). Also similar with the report of Teressa Dejene (2017) stated as the higher CEC values in the lower slope position than in the upper slope positions in Adaa Berga district, central Ethiopia. CEC was positively correlated with pH, OC, TN and Av. P (r=0.73**, 0.63**, 0.77**, and 0.77**), respectively (Table 4) as evidenced the current study. The study was parallel with the finding of Mulugeta Aytenew (2015) at Dawja Watershed in Enebse Sar Midir District Northwest Ethiopia.

4.2.6 Electrical conductivity (EC)

Electrical conductivity showed statically significant ($p<0.01$) both conservation and slope gradient position however, not statically significant in the interaction effect of both factors (Table 1). Main effects of conservation practice the higher(0.13ds/m) mean value of EC was recorded under conserved areas of treated stone bound followed by treated beach trace (0.11ds/m) whereas the lower under unconserved areas (0.06ds/m) (Table 3). Since pH has positive correlation (r=0.49*) with EC, relative increasing of soil pH increases the value of EC as evidenced the current study (Table 4). The study result was parallel with Mathewos Bekele *et al.* (2016) who observed that the higher EC recorded under conserved land in Menesibu District West Ethiopia. Electrical conductivity of soil solution shows indirect measurement of salt content (Brady and Weil, 2002).

On the other hand, in the slope gradient the higher (0.12ds/m) mean value of EC was recorded under bottom slope position followed by middle slope position however the lower (0.06ds/m) under the untreated beach tracing (Table 3). As evidenced the current study indicated that from top to bottom slope position the EC revealed an increasing trend due to the increasing of soil pH. Which might be fertile soil with high amount of mineral compounds will have high conductivity while depleted soil with less minerals will have lower conductivity and soil conductivity also EC depends on types of mineral salts present. The study result was similar with the finding of Olarieta *et al.* (2008) showed that the mean value of EC increased from upper to lower slope position since soil pH has positive correlation with soil EC due to erosion and leaching of soluble salts from the upper slope and accumulation at the down-slope land positions.

4.3 Correlation among the Selected Soil Physicochemical Properties

Correlation analysis among physicochemical properties of soil indicated in Table 4. Sand fraction was highly significant and positively correlated with BD (r=0.72**) whereas negatively correlated with clay, silt, MC, pH, OC, TN, Av. P, CEC and EC (r=-0.88**, -0.60**, -0.53*, -0.69**, -0.68**, -0.77**, -0.69**, -0.77**, -0.60**) respectively (Table 4). Clay was negatively correlated with BD (r= -0.62**). However, positively correlated with other selected physicochemical properties of soil (Table 4). Soil BD was showed negatively correlated with all selected physico-chemical properties of soil except sand particle size (Table 4). Organic carbon was positively correlated with pH, TN, OC, Av. P, CEC and EC (r=0.53*, 0.60**,0.60*. 0.71**), respectively whereas negatively correlated with BD and sand friction (r=0.67** and 0.68**) respectively (Table 4). In general, all selected soil chemical properties such as pH, TN, OC, Av. P, CEC and EC positively correlated with each other (Table 4). Whereas soil physical properties including texture (sand, silt and clay), BD and MC were positively correlated except BD from other physical properties of soil (Table 4). The study result was agreement with Mathewos Bekele *et al.* (2016) in Menesibu District, West Ethiopia and agrees with Mulugeta Aytenew (2015) at Dawja Watershed in Enebse Sar Midir District Northwest Ethiopia.

Table 4. Pearson's correlation matrix between selected soil physico-chemical parameters, N=36.

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Where Av. P = available phosphorous; BD = bulk density; TN = total nitrogen; MC = moisture content; EC = electrical conductivity; CEC = Cation Exchange Capacity; OC = Soil organic carbon; Ds/m= deciSiemens per meter **, * the correlation is significant at $p < 0.01$ and $p<0.05$ respectively.

Chapter 5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study was investigated the effects of soil water conservation and slope gradient on selected soil physicochemical properties in Kershewa watershed, northwest Ethiopia. The empirical data obtained from the soil result revealed that soil and water conservation and slope gradient effect on selected soil physicochemical properties in the study watershed site. Almost all soil selected physico chemical soil properties were significantly ($p \leq 0.01$) and ($p < 0.05$) affected by both soil and water conservation practices and slope gradients. From this soil texture (sand, silt and clay), bulk density, moisture content, soil pH, organic carbon, total nitrogen, available phosphorus, cation exchange capacity and electrical conductivity. Thus soil and water conservation and slope gradient had shown a great effect on soil properties. The highest clay, moisture content, soil PH, organic carbon, total nitrogen, available phosphorus, cation exchange capacity and electrical conductivity. whereas the lowest sand and bulk density were observed under the treated stone bound. However, the lowest observed under untreated bench trace from soil and water conservation practices. In case of slope gradient, the highest clay, moisture content, pH, organic carbon, total nitrogen, available phosphorus, cation exchange capacity and electrical conductivity in addition to the lowest sand and bulk density were recorded in the bottom slope however the lowest under on the top slope position. Based on the study soil nutrient maintained on the conserved area than unconserved areas. Therefore, to conserve essential soil nutrients, it needs to produce sustained agricultural production.

5.2 Recommendations

Based on the findings and conclusions drawn, the following recommendations.

Responsible bodies and peoples in soil water conservation should raise awareness of the local people regarding benefits of soil water conservation by providing different soil water conservation practices to improve soil water conservation benefits.

There should be a harmonized and collaborated work among different responsible bodies to realize a common target of proper soil water management and reduction of soil nutrients.

Special consideration should be given to reduce the rate of soil erosion and erosion by implementing soil water conservation measures like stone bound and beach terrace for a sustainable soil resource management.

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Appendex

Author's Biography

The author, Meseret Ambachew, was born on Augest 1994 in Dhana woreda, Waghmra Zone of Amhara Region, Ethiopia. She attended her elementary and secondary education at Amdework from 2001 to 2010. She completed Preparatory School from 2012 to 2013 at Amdework General secondary school. In 2014, she joined Adama Science and Technology University and graduated in

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