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Impact of Soil and Water Conservation Practices on Sediment Trap Ping, Soil Moisture Conservation, Slope Gradient Change ond Crop Yield in Dembecha District Gosho Watershed Northwest Highlands of Ethiopia

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BAHIR DAR UNIVERSITY

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES GRADUATE PROGRAM

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Msc Thesis

By

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March 2022
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THESIS APPROVAL SHEET

As member of the board of examiners of the master of sciences (M.Sc.) thesis open defense examination we have read & evaluated this thesis prepared by Mr.Yaregal Biadeglign entitled impact of SWCPs on sediment trapping, soil moisture conservation slope gradient change and crop yield at Dembecha district Gosh watershed north west highlands of Ethiopia. We hereby certify that, the thesis is accepted for fulfilling the requirements for the award of the degree of master of sciences (M.Sc.) in Land Resource Management.

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College of Agricultural & Environmental Sciences Department of Natural Resource Management

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DECLAR ATION

This is to certify that this thesis entitled"Impact of SWCPs on sediment trapping,soil moisture conservation slope gradent change and crop yieldat Dembecha district Gosho watershed west highlands of Ethiopia"submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in "land resource management" to Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by Mr. Yaregal Biadeglign (ID.No.BDU1207759) is an authentic work carried out by him under my guidance.The matter embodied in this project work has not been submitted earlier for the award of any degree; or diploma to the best of our knowledge and belief.

Name of the Student Yaregal Biadeglign

Signature ____________ date 11/03/2022

Name of Major advisor

1) _Mulatie Mekonnen (Major advisor)

Signature ____________ date 11/03/2022

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LIST OF ACRONYMS/ABBREVIATIONS

ANOVA	Analysis of Variance
ANRS	Amhara National Regional State
BD	Bulk Density
BPH	Barley plant Height
BSBM	Barley Straw Biomass
BYD	Barley yield
CL	Control
D	Depth
DA	Development Agent
DDAO	Dembecha District Agricultural office
DEM	Digital Elevation model
FAO	Food and Agriculture Organization of the United Nation
FB	Finya juu bund
FB+T	Fanya juu bund with treelucern
GIS	Geographical information system
GPS	Global Positioning System
MASL	Mater above sea level
MOA	Ministry of Agriculture
MOARD	Ministry of Agriculture & Rural Development.
NGO	Non-Governmental Organization
Ps	porosity
PSWCPs	Physical Soil and Water Conservation Practics
SB	Soil bund

SGCH	Slope gradient change
SMC	Soil Moisture content
SP	Slope position
SSA	Sub Saharan Africa
SWCPS	Soil and water conservation practices
USAID	United States Agency for International Development
WA	Average Width

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ABSTRACT

Land degradation in the form of soil erosion is a major global issues as well as Ethiopian concern given the strong negative impacts on crop productivity. To overcome the problem the government and non-governmental organizations have invested the resources and effort to promote soil and water conservation practices were implemented in every year. However the impact of soil and water conservation practices in trapping sediment and reducing soil transport, minimizing slope gradient,& improving crop productivity has notyet been studied well to understand the impact at particular study watershed.Hence this study was conducted to evaluate and draw conclusion on the effectiveness of the selected 8 years biophysical soil and water conservation practicse on sediment trapping,slope gradient change soil moisture conservation and crop yield and yield components in Gosh watershed north west highland of Ethiopia as case study.Using field experiment three treatments were designed field treated with fanya-juu fields treated with soil bund and fields treated with a combination of fanyajuu ridge and treelucern with three replications at three slope classes.A total of 54 composite soil samples from 20 cm depth were collected for soil moisture analysis and field measurement for grain yield,slope gradient change and sediment trapping samples from 27 locations were collected and analyzed by SAS software version 9.2.The result shows that sediment trapping, slope gradient change soil moisture content bulk density and porosity *have been significantly ($P<0.05$) influenced by soil and water conservation practices and land scape positions.Astatis tical;significant difference were observed from physical soil and water conservation practices compared to fanyajuu bund stabilized by treelucrn.The higher sediment stocked soil, moisture content, bulk density were obtained from integrated practices.in lower slope.On the contrary: slope gradient change and porosity were higher in the upper slope .Moreover untreated field showed significantly lower barley grain yieled & yield component,than the treated.From this study it was possible to conclude that soil water conservation practices tested the study water shed were appositive effect specially proper integration of physical soil & water conservation structure stabilizedby treelucern can be more productive. Therefore all physical soil & water conservations integrated with biological practices is better than physical alone.*

.***Keywords: Soil bund, Fanya-Juu ridge, Barley grain yield Slope reversing terrace, Sediment trapping and Soil moisture content***

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Chapter.1. INTRODUCTION

1.1 Background and Justification of the Study

Land degradations in the form of soil erosion is the major global issues as well as Ethiopian concern given strong negative impacts on crop productivity and food security,the environment and quality of life (Slegers, 2008;MoARD,2010). Land degradation has rendered vast areas of fertile lands in Ethiopia unproductive (Menale Kassie et al.,2010) particularly soil erosion by water (Zenebe Adimassu et al.,2018).

In Ethiopian highlands it accounts for nearly 43% of the country's total area and 90% of the regularly cultivated lands, are one of the world's major soil degradation hotspots mainly because of accelerated soil erosion by water (Hurni, 2015). At present more than 110 million people, growing at a rate of about 2% per year, inhabit the country mainly depend on rain fed smallholder agriculture that account for 80% of employment and 85% of export earnings (Vag en et al.,2013).However soil degradation resulting from population pressure and inappropriate land use for centuries is considered to be one of the major problems continuously threatening agricultural productivity in the country (Akililu Amsalu and de Graaff, 2007).

A study was undertaken to know the extent of soil erosion rate and confirmed that severity of the problem is expanding very fast but the extent& the rate of soil erosion is varying (Negusie Haregeweyn,et al.,2017).The review paper by Zenebe Adimassu et al,(2017) indicated that soil loss due to erosion in the Ethiopian highlands is between 42 & 175.5 t/ha/y. Other studies also confirmed that estimated rate of loss of fertile topsoil in the highlands also varied between 941 million t/ ha/ yr &1.5 billion t/ ha/ yr (Hurni et al.,2015).Recent estimates indicat e that annual deposits in the grand Ethiopian renaissance dam range from 250 to 319 million tons of soil (Hurni et al ., 2015).

To overcome the problems huge amount of soil & water conservation measures which include physical soil water conservation measures (PSWC), agronomic and vegetative that control land degradation, and enhance productivity and/or other ecosystem services has become practiced (MoARD, 2005; WOCAT, 2017). Based on recent published reports, the different SWCPs, the most commonly farmland terraces such as stone faced, soil and fanya-juu bunds/

terrace/and hillside management such as hillside terrace, area closure and moisture harvesting structures & gully rehabilitation activities have been implemented in the Amhara region over the past 15 years (1999-2014) (Zenebe Adimassu et al.,2018). According to Zenebe Adimassu et al,(2018), on average, 241,355 km of farmland terraces and 79,548 km of hillside terraces have been constructed in the region each year since 1998 and the annual rate of construction of farmland and hillside terraces was increased significantly after 2004.

There are study's to evaluate the implemented SWCPs in Ethiopia. Most of them confirmed the positive impacts of SWCPs on soil physic-chemical properties & crop yields. For instance SWCPs tested in Simada district northwest highland Ethiopia significantly improved the soil physic-chemical properties in which the clay content of soils showed a significant difference among the soil bund, stone bund and control fields (Mihrete Getenet ,2014).Similar result was also reported by Mulatie Mekonnen et al,(2020), aged SWCPs significantly reduced slope gradient as a result of the long year trapped sediment and man-made ridge lines made during construction.Farmers in Dijil watershed confirmed that an improved growth of the crops along the structures which was attributed to improvement in soil fertility due to a decreased the magnitude of soil erosion as a result of integrated conservation works (Woldeamlak Bewket, 2007).

Although most of the researchers confirmed the positive impacts of the implemented SWCPs on soil physic-chemical properties & crop yield. However farmers frequently destruct SWCPs constructed on their fields claiming that the practices didn't show a positive impact other than occupying their farmlands. According to Getachew Egedayehu et al,(2016) revealed that the farmers raised criticism on fanyajuu bund constructed on gentle slope (0.5%gradient & level) for the reason that since the ditch is below the embankment and the gradient was not enough to drain out the excess run-off, where water logging occurred resulting in yield reduction. Due to this reason, some farmers were forced to break the embankment to drain the collected run-off water. Some respondents criticized the exaggerated width of the embankment and narrow space between bunds since it reduces their small farmland.

Similarly, the majority of the surveyed farmers in Chemoga watershed confirmed that the fanyajuu bunds were evaluated as ineffective or even causing more erosion due to limited integration of fanyajuu bunds with other structures (Woldeamlak Bewket 2003).

1.2. Statement of the Problem

Gosh watershed is well-known by soil erosion and soil fertility depletion has been a major problem for the watershed.The underlying & direct cause of soil erosion in the study area were high population pressure, erratic and erosive rainfall, steep terrain deforestation, inappropriate land use, land fragmentation, overgrazing,weak management practices and also farmers'lack of information about appropriate alternative technology, Dembecha District Office of Agriculture report (DDOA,2021).The average annual soil loss of neighboring watershed of anjeni from the test plots without theconservation practices was reported to 90 t and110 t/ ha/1 yr/1on 12% and 18% gradients respectively (Herweg and Ludi, 1999). Gete Zeleke and Hurni (2001) also found the declining of natural forest from 27% in 1957 to 0.3% in 1995 at Anjeni and its surrounding. Thus clear evidences indicated that the width & depth of soil erosion are highly pronounced at Gosh watershed due to diversified reasons.The resulted consequences brought about reduction in food production and biodiversity and worsening poverty as well as malnutrition in the study area.

To overcome the soil erosion problem and soil fertility depletion in the study area the district supported by government and nongovernment organization like water and land resource center (WLRC)of Addis Ababa university aswell as development agents have invested aresources and efforts to promote conservation measures were implemented in the last eight to nine years ago. Among the interventions, the soil bund, fanyajuu and fanyajuu integrated; with treelucern is the conservation practice on cultivated land in the study watershed.From the implemented SWCP 213.9ha covered by Physical soil and water conservation practices the remaining 50.1ha was stabilized by treelusern and Gesho (DDOA,2021). However the impact of SWCPs in trapping sediment & reducing soil transport, minimizing slope gradient,and improving crop productivity has not yet been studied well to understand the impact at the particular study watershed. Thus this study is intended to explore the impact of SWCPs on reducing slope gradient change by trapping the eroded soil, improving moisture retention and increasing crop yield and yield component can be realistic and a warrant for farmers and policy makers if expressed in terms of understandable ways.

Therefor this study was focused on evaluation of the impacts of SWCPs by measuring and quantifies the amount of sediment trapped behind soil and water conservation practices its contribution for reducing slope gradient change and moisture retention together with crop yield increment.

1.3. Objectives of the Study

1.3.1 General Objective

The major objective of this study was to explore the impact of soil and water conservation practices on sediment trapping, slope gradient change, soil moisture conservation,&crop yield and yield components in Gosh watershed northwest highlands of Ethiopia

1.3.2 Specific objectives

- To quantify the amount of sediment trapped behind soil &water conservation practices on different slope position.
- To assess the effectiveness of selected soil & water conservation practices in reducing the slope gradient or landscape connectivity.
- To evaluate the role of selected soil and water conservation practices in trapping soil moisture conservation.
- To evaluate the effectiveness of selected soil conservation practices on yield and yield components of barley

1.3.3. Research question

- ✓ How much sediment is trapped by soil and water conservation practices?
- ✓ To what extent the implemented soil and water conservation practices reducing the slope gradient or land scape connectivity?
- ✓ Are soil and water conservation practices increasing soil moisture content?
- ✓ Are soil and water conservation measures increasing barley grain yield and yield component?

Chapter 2 LITERATURE REVIEW

2.1. Land Degradation and Soil Erosion

Land degradation through soil erosion is a serious problem in eastern Africa about 14 percent of its total area suffers from severe to very severe degradation. Almost all lands in Sub-Sahara Africa (SSA) are prone to soil degradation and Ethiopia is among the most affected countries (Vlek et al.,2008).Every year about10 million hectare of the croplands are abandoned globally and 6.5million hectare was in Africa (Mekonnen Kirubel andTesfahunegn Gebreyesuse,2011) because of erosion a minimum of 12 t /ha/ yr of soils in lost every year in Ethiopia. Economic impacts of this loss is estimated about $139 million which is 3- 4% of the agricultural growth domestic product (GDP) of the country (Mulugeta Demelash: karle,2010).Erosion affects soil physical conditions(e.g, reducing soil depth,waterholding capacity) and chemical properties (e.g,nutrient depletion) that affect agricultural production (Hurni *et al*,2010).In addition soil erosion causes negative effect on environment, agronomic productivity, food security and the overall life quality (Addisu Dametew et al.,2015).

Loss of arable land due to soil erosion is a widespread phenomenon in the highlands, which account for about 45% of Ethiopia's total land area and about 66% of the total land area of Amhara Region. On steep hillsides, soil losses of and exceeding 200 t/ha per year have been recorded the potential threat of land degradation to the country's fragile economy and food security has been emphasized by several publications (Hurni ,2016) .The threat is credible as about 90% of the population of the Amhara Region lives in the highlands and 90% of the regularly cropped land is found there.

Soil erosion by water is the dominant form of erosion. The areas that are severely affected can be found in waghemra and north wello followed by north and south Gonder, eastern parts of South Wello and northern parts of north Shewa zones. The soil depth in these places is very shallow (Leptosols) soil fertility is poor and farmers squeeze a living from pockets of shallow soils.Gullies are a frequent and permanent phenomenon everywhere in the region (Desta Gebr emichail, 2000).According to BoA,(2005),kobo, gubalafto & habru district (all of north wello) have lost 3700ha, of their 284,950ha the total land area changed to gullies. In addition to this reducing cultivable area, soil erosion, gully formation and expansion reduce the water holding capacity of the soil and, consequently, result in poor crop yields

2.2. Soil and Water Conservation Practices in Ethiopia

According to (Wogayehu Bekele and Lars,2003) Prior to the 1974 revolution, soil degradation did not get policy attention it deserves. The famines of 1973 and 1985 provided an in put for conservation work through large increase in food aid mainly using the imported grains and oil . Following these severe famines, the government launched an ambitious program of soil and water conservation supported by donor and nongovernmental organizations the use of food aid as a payment for labor replaced voluntary labor for conservation campaigns. The extent of conservation activities using food aid escalated tremendously and the conservation continued to grow arithmetically though the implementation could not keep pace with the plan. Up to 1986, food aid used for payment of conservation and related works as food-for-work payment accounted for approximately 29% of total food aid (71% of the food aid was distributed as emergency food). With this, Ethiopia became the largest food for work program beneficiary in Africa and the second largest country in the world following India (Desta Gebremichal ,2000) .Almost all the soil and water structures and practices were destroyed shortly after the construction in almost many place of the country. The project expected that the local people would bear all the costs of maintenance.Yet farmers had few incentives to maintain structures or continue within the practices (Woldeamlak Bewket,2003). During 1980s,the government of Ethiopia launched a massive program of soil and water conservation and rehabilitation. After 1989soil &water conservation practices have mainly been undertaken in the form of campaign and quite often farmers have not been involved in the planning process (SCRP ,2012).

Between 1976 and 1990, 71,000 ha of soil and stone bunds 233,000 ha of hillside terraces for afforestation 12,000 km of check dams in gullied lands, 390,000 ha of closed areas for natural regeneration 448,000 ha of land planted with different tree species, and 526,425 ha of bench terrace interventions were completed mainly through food-for work(FFW) program incentives (USAID,2000).

Nevertheless,the achievements fell far below expectations the country still loses a tremendous amount of fertile topsoil, and the threat of land degradation is alarmingly broadening(Berhanu

Gebremedhin,2004)The difficulties encountered by the programmers during their initial stage of implementation led to the realization of need for beneficiary's participation in the planning and implementation of conservation programmers and projects, including the adaptation of conservation technologies to local conditions (Biele,2014).

2.3. Soil and Water Conservation Practices in Amhara Region

Amhara region started to implement land rehabilitation measures through massive soil and water conservation (SWC) program in 1970s.The region has been realized the treatment of vast degraded areas (both cultivated land and hillside government lands of the highlands) thr-ough mass movement of the community in line with different project run by Governmental and Nongovernmental organizations. It comprises structural conservations measures (physical earth works like construction of terracing, cut off drain, bunds) followed by biological measur (plantation of grasses and forage plants to stabilize physical measures) that take place during the rainy season (Belay Assefa ,2010). Whereas, in 2010 the effort is very much strengthened and taken as the priority objectives within the political leaders and experts conducting SWCPs campaigns in every years,(BoA,2013).In those the campaigns, it has been observed that huge amount of resources (labor and finance) have been mobilized and large tract of land has been covered. At regional level, before the commencement of the SWC activities through public mobilization,the different preparatory works were conducted such as labor force organization, public awareness creations,capacity building and the local resource inventory. Compared with previous years, the past three year's community mobilization strategies were effective in the motivating collective action and involving all active labs our forces (elders, women, men and youth) that are expected to participate in catchment development activities as planned (BoA, 2013).The campaign gives due to emphasis for SWC measures which are to be constructed on communal lands, gully rehabilitation activity and drainage management such as cut-off drains, waterways and graded bunds, particularly in the highland areas where there is high rainfall and the drainage management structures have paramount importance (BoA ,2013).

2.4. Physical Soil and Water Conservation Practices

Physical soil and water conservation structures are permanent features made of Earth, stones or masonry, designed to protect the soil from uncontrolled runoff and erosion and retain water where needed. Physical SWC measures used to reduce surface run-off velocity trap water and sediment and thus control soil erosion. Bunds are simply embankment like structures made of soil and/or stone with basin at its upper side and constructed across the slope. Generally, it is used on cultivated lands with slopes above 3 % based on the soil type, intensity and amount of rainfall. In wet and the moist regions and where the permeability of the soil is low, the graded channel terraces are used with the purpose of draining the run-off from the arable land at non-erosive velocity to a site where it can safely be discharged (MOARD, 2005).

Among the PSWCPs Fanyajuu ridge,the Soil bund, Cheke-dames, Waterways, Cut-off Drains are soil bunds with a basin at its the lower sides made by digging a trenches along the contour and throwing the soil uphill to form an embankments. It reduces the velocity of the over lands flow and consequently the soil erosion. The embankments are stabilized within fodder grasses and in between cultivated portions. Over time the fanyajuu developing into the bench terraces. Useful in semiarid areas to harvest and conserve water.The measure is suitable for the soil too shallow for level bench terracing and moderate slopes below 20%. However, they are not thus applicable on stony soils (MOARD,2005).According to the studies conducted with the North-Western and North-Eastern highlands of Ethiopia. Soil loss estimates from soil Conservation Research Project experiments indicated that fanyajuu bunds, on average could reduce soil loss by 65 percent, or 25-72 t/ha/yr (MOARD,2005) .

Soil bunds /Contour bunds are ridges and ditches made of soil, dug across the slope along the contour. They are used to reduce run-off, to conserve soil and water, to reduce soil erosion, to increase the amount of water the soil can hold. They are constructing at within moderate slope (5-10%) with light or medium soil texture and less than 700 mm of rain per year. Soil contour bunds are simple to build; bunds conserve top soil and improves productivity, and in allowing chemical fertilizers to be used effectively. The dimension of the ditches and within bunds are determined by the maximum volume of sediment and run-off that should be on retained in the basin behind the bund. Soil bunds were constructed and the dimensions of the ridges and the spacing between the conservation structures were fixed according to the recommendation of the Soil Conservation and Research project (SCRP, 2012).The Soil bunds were constructed at a vertical interval of up to 2m according to the gradients of the area and the width of the ditch, and the height of the bund may be reaching 60 cm after compaction, base width 1-1.2 m and top width 30-40 cm and also the depth and width of the ditch are 50cm by 50cm and 50cm by 60cm depending on the soil type and rainfall amount of the area (BOA, 2013).

Check-dam is an obstruction wall across the bottom of the gully or within small stream for the purpose of reducing the velocity of run-off and preventing the deepening and widening of a gully channel. The check-dam that can be wooden, lose stones, gabions, plastics or sand filled sack Check dams or sediment storage dams trap large amounts of the sediments on eroded and transported from the upper catchment as well as within the gully itself and reduce downstream sedimentations within the sediment trapping efficacy of 67-74 %. The waterway is a drainage channel used to discharge excess run-off from the constructed, the graded SWC measure and or farmlands to rivers/ lakes.The waterways should be constructed one year before the graded SWC practices. The channel can have the gradient up to a maximum of 1 % with embankment height of 60cm after compaction. The base width ranges from 1 to 1.2m in the stable soils and 1.2-1.5m in unstable soils. It is a mistake to design waterway structures to discharge run-off if there is no suitable outlet such as a natural waterway, artificial waterway or grassed /forested areas (MOARD, 2005).

Cut-off drains are made across the slopes for intercepting the surfaces runoff and carrying it safely to an outlet such as a canal or stream. Their main purpose is the protection of cultivated land, compounds, and roads from uncontrolled runoff, and to divert water from gully heads (MOARD, 2005)

2.5. Biological Soil and Water Conservation Practices

Biological practiecs utilize the role of vegetation helps to minimize erosion. Soil management is concerned with ways of preparing the soil to promote dense vegetation growth and improve its structure so that it is more resistant to erosion. When deciding what conservation measures to employ preference is always given to agronomic treatment.These are usually less expensive and deal directly with reducing raindrop impact increasing infiltration reducing runoff volume and decreasing water velocities (MOARD, 2005).

Biological soil conservation measures include; vegetative barriers agronomic and soil fertility improvement practices which help in controlling surface runoff reduce soil losses & improve productivity.Agronomic measure are practiced as the second line of defense in erosion control exercise while mechanical measures are primary control measure and are often considered as reinforcement measures (MoARD,2005).Most of studies revealed that biological conservation measures are having significant role in the crop production. In a nut shell, it is to be noted that there were positive trends which all together should guide the soil and water conservation policy makers to identify important factors influencing the contribution of such a program and reconsider the design and implementation of the interventions (Yitayal Abebe and Adam Bekele, 2014).

The principle of the agronomic and vegetative practices is to maintain a high vegetative cover, which serves two purposes the production and protection. An improved crop management can involve improved seeds, appropriate varieties, diverse varieties, the optimal timing of planting appropriate spacing of plants, fertilization, the integrated pest and disease management, etc. In addition to improve the ground cover, the roots improve the soil structure, and thus aeration, infiltration and biological activity in the soil. Plant residues build up soil organic matter and thus improve the stability of the soil structure and aggregates. Mixed cropping, inter-cropping, sequential cropping, relay cropping agroforestry, cover crops, and last but not least fallow aim at an optimal plant cover over a longer period of time. The strip cropping, row cropping alley cropping, grass strips, hedgerows, and live fences reduce slope length and thus control runoff velocity and allow sediment in solution to accumulate. This process helps to decline the slope gradient & support terrace development. They naturally involve contour plowing and ridging to interrupt long slopes and thus help controlling runoff velocity. But there is the danger that farm implements and machinery increase erosion hazard because they involve compaction of the soil, which prevents infiltration (Mitiku Haile et al.,2006).

After construction of the stone bunds and soil bunds fodder grasses were planted on the emb-ankments of the bunds for stabilization and to compensate at least partially for the land taken out of production. The forage plants such as elephant grass, tree-lucerne, vetiver grass, bana grass and sesbania sesban were planted. The soil bunds and stone bunds stabilized by grasses and trees reduced soil losses, improved the availability of organic inputs for soil improvement ,and offered animal feed and consequent increase in cash income (Tilahun Amede,2003).

2.6. Impact of Soil and Water Conservation Practices on Sediment Trapping

On-site soil erosion and off-site sedimentation are natural phenomena in land scape formation. However human activities have accelerated natural erosion rates causing on & offsite problem with the soil degradation and sediment accumulation on undesirable location (Moregan,2005). Human induced off-site sedimentation is the products on-site soil erosion resulting ether from point sources like mining's and construction site or non-point source such as from agricultural area and grazing land gully and river bank erosion are important source of sediment (Hughes and prosser ,2012).

Water erosion plays a large role in transporting sediments from upstream catchments to down stream reservoirs.Although any slope & any place where water flows is potentially a sediment transfer pathway rivers, gullies & roads are the important sediment transfer pathway (Morgan, 2005).An increase in the density will increase sediment transport while the disconnecting of sediment transfer pathway reduces sediment transport and increases the sediment trapping of the area (Bracken et al., 2015).

Though physical soil and water conservation structures have great potential to reduce soil loss by decreasing over-land flow of water and increase the yield by reducing in moisture stress on plant growth through retention of rainwater that would otherwise lost to runoff. By reducing runoff and the need for chemical fertilizer inputs, downstream water quality improves it also helps to restore the capacity of soil to retain water along with nutrients and the organic matter farmers can dramatically reduce in agricultural water demand reduce vulnerability to climate extremes of drought and flooding and also increase soil carbon storage as well as productivity (Wagayehu Bekele,2003).

Moreover appropriate SWCPs can significantly improve soil chemical and physical properties soil organic matter, total nitrogen, available phosphorous, bulk density, and infiltration rate & soil texture by reducing the velocity of the runoff. Effective sediment trapping measures can disconnect landscape units from each other resulted in the decrease in runoff velocity and the sediment transport and subsequently reduced downstream sedimentation impacts (Mulugeta Demelash and Karl, 2010).Sediment trapped by soil and waterconservation structures in the minizr catchment from the sampled soil bunds & fanyajuu-ridges was 0•053m3 m1 y1or55kg m1y1,Sedimentation rate was measured with an average depth of 0•09m (Mulatie Mekonnen et al.,2014b).

The long-term impacts of SWC at Anjeni watershed, improved significantly the soil qualities and crop yields due to soil nutrients transported from the upper parts of the terrace are trapped by the conservation structures at the lower sides of the terraces and maintained there; making significant difference between the lower and the upper parts. In high rainfall areas of Ethiopia like Anjeni, nitrogen, and phosphorus and soil organic matter are the main limiting factors for agricultural production.Luckily these soil parameters have been significantly improved within the farm due to terraces, resulting better crop yield performances(SCRP, 2012).

2.7. Impact of Soil and Water Conservation Practices on Slope Gradient Change

The goal of SWC bunds as mechanical conserveation strategy is to change the natural length and steepness of the slope to benches and thereby to control runoff and soil loss(TilahunAmid *et al.*,2013).While the farmers have several criteria to select theSWCPs.The economic benefit is the one given top priority to choose the structure. Therefore to strengthening participatory planning with farmers and developing best future alternatives that provide with the immediate benefit along with the long term benefit obtained from soil and water conservation investment is required (Zenebe Adimassu *et al.* 2013).

The impact of the physical soil and water conservation measures can be classified into short- and long -term impacts based on the time needed to become effective against soil erosion the short term effects of the SWCPs are the reduction of slope length and the creation of on small retention basins for run-off and sediment by reduce the quantity and eroding capacity of the overland flow these effects appear immediately after the construction of SWC stractures and reduce soil loss the long term impacts of soil & water conservation measureswere reduce the slope gradient of farmland by forming bench terraces as a result of sediment accumulation; by considering the short and long term benefits of SWCP for the adoption and sustainabilityof the technology in the Ethiopian highlands (Bosshart,1997).The study conducted in different parts of the country points out that fanyajuu ridge at different slopes20year old fanyajuu form high sediment ridge lines because the trapped sediment have gradually converted them into bench terraces.This decreased aver age slope gradients by 2.7%. However,soil bunds do not alter the slope gradient largely because trapped sediment is buried inside the ditch instead of forming asediment ridge in front of structure (Mulatie Mekonnen,2020).Similar report was conducted in Maybar watershed. The result shows that most of the terraces have become bench terraces & grasses growing on the terraces have stabilized the structure.Measurements to estimate the slope gradient between the edges of terraces (lower and upper terrace) indicated nearly level conditions.The regular sedimentation and maintenance resulted in the development of higher terraces on steeper slopes due to great relief differences withi shorter distances.Terraces over 180 cm and as short as 40 cm were observed on the upper slope and the lower slope positions respectively SCRP (2012).

Moreover the slope gradients were reduced annually by 0.03% for the denber fields and 0.17–0.28% for the soil and stone bunds fields. (Shiro *et al.*, 2020) study's conducted in Semi-arid lowland areas of Ethiopia.Study's conducted in Koga catchment by (Walle Jembru *et al.*2017) indicated that most of the bund structures were in the process of benching and not stabilized accurately slope gradient measurements between the edge of the lower & upper embankments of five year old stone faced soil bunds were 10.7% to 28.4% slope obtained.

2.8. Impact of Soil and Water Conservation Measure on Soil Moisture Conservation

Water is the common medium for several life processes, lifecycle cease in the absence of water. For instance in plants mobility of necessary materials in the plant tissue is hold by soil water.Consequently water and soil is the primary requirements for the life and growth of plant .However, water availability in soils is restricted and therefore, its conservation and utilization turn into an indispensable issue (Gabriela,2019). The different land uses can influence the soil moisture distribution. This influence will provide scientific gist for rational utilization of soil water resource & the environmental construction in west. In the past because of the excessive utilization of soil water, the sustaining supply capacity of soil water declined, and the benefit of vegetation planting also reduced (Wang Li, et al., 2011).

To optimized the problem there are different types of the soil moisture conservation measures among this Straw terracing is indigenous moisture conservation practice in the form of by the farmers with letting of sorghum or maize stalk with the soil in the previous season.Trash line are created across the slope using previous seasons crop residues maize sorghum stalks&other dead vegetative organic materials to control surface runoff, soil erosion & enhance infiltration Besides stony with little straw is practiced by farmers as moisture conservation for cultivating crops in stone/rock dominated land (Fikre Ayana, 2018).The soil moisture also conserved by constriction of SWCPs.To ensuring this several studies have estimated the impacts of soil and moisture content measures in the Ethiopian highland for example Mulatie Mekonnen, (2020), the result shows that SMC was higher in recently constructed SB than aged SB. This was due the retention basin constructed on upslope of the SB which stored runoff water better during young ages.As the age of SB increasesSM decreases, because the retentionbasin was filled by sediment and its runoff water storage efficiency decreases.Unlike the SB in FB and FB+G as age increases the runoff water storage efficiency increases. SMC was higher in fields treated with FB+G than FB which was because roots of the grass increase the runoff water infiltration capacity of the soils.

Similar report was conducted by (Vancampenhout et al., 2006 and Mitiku Haile, 2006) found that, due to the retention of surface runoff behind the stone bunds the top soil on both sides of the stone bund has a higher soil moisture content compared to soil moisture content on farther away from the structure.This effect of SWC on soil moisture is even more important at greater soil depth (1to1.5m).

2.9. Impact of Soil and Water Conservation Practices on Barley grain Yield

In Ethiopia, a range of policies, strategies and institutional arrangements has been adopted to improve agricultural production; however, the sector still suffers with the detrimental effects of soil degradation which undermines potential soil productivity and requires enormous costs for reversing the degradation. Soil erosion an impact on soil productivity; most likely caused by deterioration in soil physical properties Inappropriate soil management intensify impact of erosion on soil productivity thus considered appropriate soil management for effective erosion control and maintaining soil productivity is crucial (Den Biggelaar et al.,2004).

Soil and water conservation reduces the removal of fertile topsoil and improves soil moisture that favors crop growth hence increase crop residue input which builds up soil organic carbon stock and plant nutrients on conserved cropland. Soil organic matter improves soil aggregate which influence total porosity of the soil that negatively affects soil bulk density (Oldfield et al., 2018).Soil bund of different age was able to improve soil properties that affect crop yield on conserved farmland in northern Ethiopia. The crop land with soil bund had improved the crop yield from 0.584 to 0.65 t ha/1/y which compensate the financial cost expends for the building of bunds (Nyssen et al.,2007).Likewise soil bund constructed at Absela site of Awi administrative zone located in the blue nile basin had improved yield of the crop as compared to non-conserved adjacent crop land. The average yield obtained from accumulation zone had increased crop grain yield by 29.8% as compared to loss zone this might be due to accumulati on of soil organic matter and fertile top soil above the bunds in the deposition zone of the bund. Furthermore, the use of soil bund had increased soil moisture content under plot with contour bund. On average 24.6% yield increment was reported this point out the contribution of soil and water conservation in conserving the soil productivity that enhances crop yield under the conserved plot of crop land than non conserved adjacent plot of crop land (Teklu Erkossa et al.2018).

This implies that soil bund reduce runoff velocity and hence soil erosion accordingly, the practice maintains the productive capacity of the soil. Due to this Soil erosion has decreased in many parts of the developed countries by means of good agricultural practices and SWC methods. As a result, these countries produce more food today than 50 years ago. In fact, many of the world's developed counties increased their food per capita in the last fifty years (Roetter and Keullen2008).Barley crop yield and yield component was significantly increased due to SWCPs. Fields treated with SB and SFSB showed a statistically significant positively correlation in barely grain yield, plant height, and straw biomass compared with the untreated fields.This means that SB &SFSB improved the fertility of the soil by reducing nutrient losses . Barley grain yield obtained from field treated with SB (22.22 q/ ha/yr) was high compared to the control (15.10q /ha/yr). Barley grain yield obtained on fields treated with SFSB (22.59q/ ha/yr) was also high as compared to the control. This means that barley grain yield was 34% higher on fields treated with SB and SFSB Mulate Gudie et al (2020).

The soil &water conservation structures revealed a significant effect ($p \leq 0.05$) on barely plant height,1000 seed weight and grain yield.Bunds stabilized by vegetation treated plots produced significantly higher ($p \leq 0.05$) barely crop yield than the yield recorded in the soil bund, stone bund treated plots & control plots. The soil conservation measures had resulted in a relatively high yield and good performance in the agronomic characteristics than that of the control plot. An increases in the grain yield of 42.44%, 24.47% and 22.18% were obtained from the bunds stabilized, stone bund and soil bund over the control plot respectively (Mihrete Getnet,2014)

Chapter 3.MATERIALS AND METHODS

3.1. Description of the Study Areas

3.1.1. Location

The study was conducted in Gosh watershed in the blue Nile basin, north west highlands of Ethiopia, located between 10°36'30" N to 10°38'30" North latitude and from 37°29'30"E to 37°30'30" East longitude with an elevation of 2217-2472masl and 367 km Northwest of Addis Ababa to the south of the Choke Mountains (DDOA,2021). As shown in (figure1).

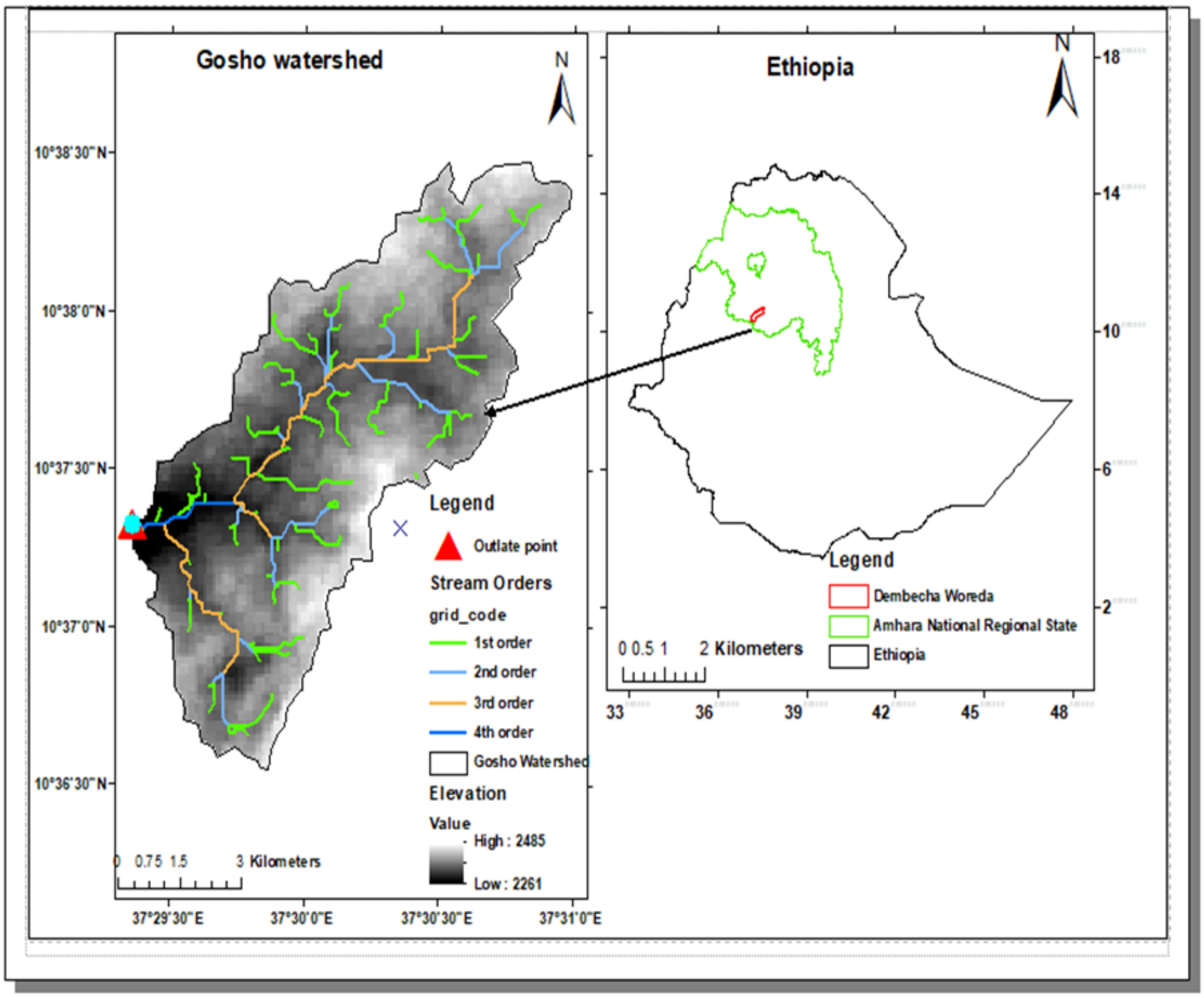

Figure 3.1: Map of the study area

2.1.2. Farming system and Population

The farming system of the watershed is a mixed farming system where crop production is the most important component of the livelihood of the farmers.The major crop grown in the study area are, Barley (Hordeum vulgare), maize (Zea mays),wheat (Triticum aestic vam tef (Eragro stis tef),lupine (Lupinu salbus),bean, pea and Niger seed etc, are the important crop cultivated. Livestock production is another component of the watershed mixed farming system. From the total Livestock production,cattle and small ruminants are the dominant in addition beekeeping is traditionally practiced in the watershed (DDOA,2021).The total household of the watershed is 458 which is 420 male and 38 female headed. The total population of the watershed is 1518 which is 710 male, and 808 female (DDOA,2021).

3.1.3. Climate and Soil

There is a meteorological station atAnjeni which is nearest to the study area.Based on10 years rainfall data analysis of this station, the watersheds are characterized by single maximum rain fall pattern with peaks in July and August and receives on average annual precipitation of 169 2.18. mm.About70-80% of the rainfall falls in the main rainy seasons (Kiremt) which starts in May and extends in August uptoSeptember.The watershed has a unimodal rainfall pattern.It is in this season that the major agricultural activities such as ploughing,sowing and weeding are performed.The dry months are between November and April known as (*bega*) occurs. In the watershed mean annual minimum and maximum temperatures are15.3 and 27.5 ^{0C}respectively .The elevation ranges between 2017-2272m.a.s.l.Thus the watersheds are under the category of Moist Woina-dega agro ecology zone (BMBO, 2021).

The prevailing soil in the watershed is Eutric Nitisol which have red color 335.9 ha (68.6%) and chromic Vertisols which have black color 154.1 ha (31.4%) (DDOA.2021).

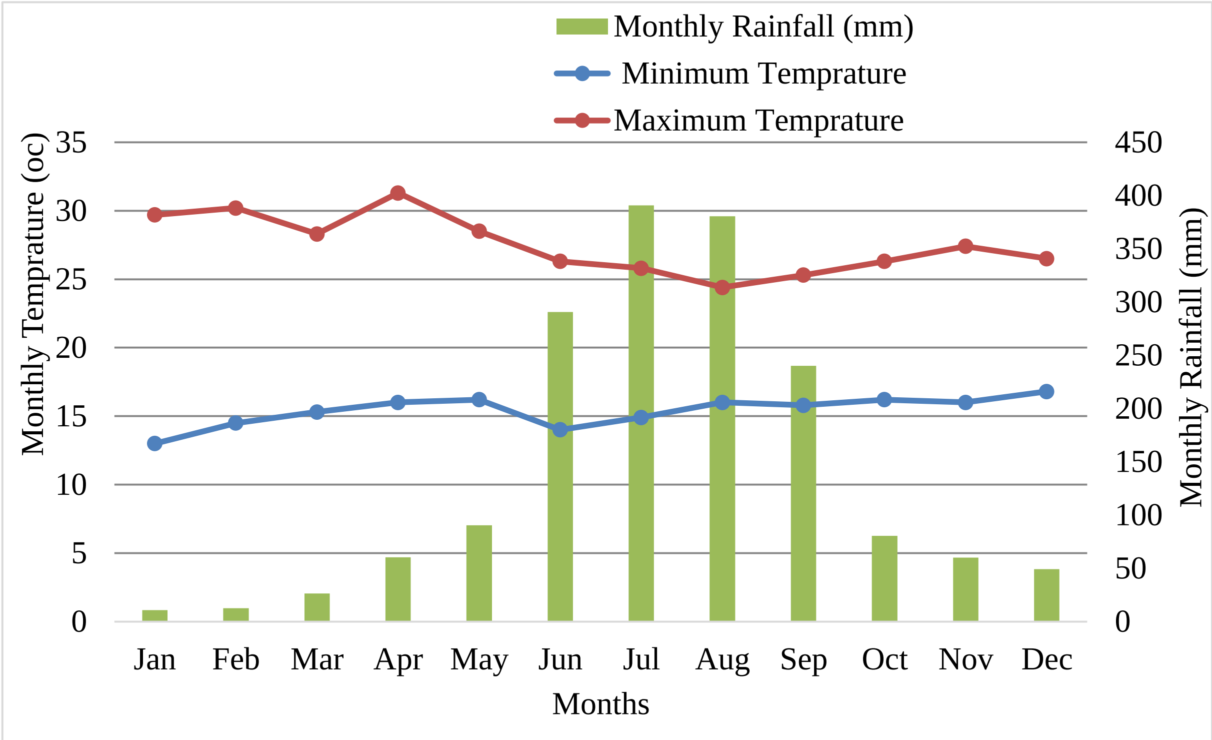

Figure 3 2.Average rainfall and Average Maximum and Minimum Temperatures at the Experimental area for the year (2011-2020).

3.1.4. Vegetation and Land use

In the study area several indigenous and exotic tree species are found even if their abundance was very limited. A few are found on some farmers' farmlands, river basins, around churches, homestead and the government forest.The most dominant tree species in the study area was Eucalyptus globulus. This is because it grows very fast and has high economic value such as house construction fuel wood and can also be sold on the market serve as cash crop.The land use pattern of the study watershed were cultivated land 324 ha forestland 54 ha, grazing land, 52 ha,area for settlement and unproductive land 24ha, bushland,36 ha a total area of the water shed is 490 ha (DDOA 2021).

3.1.5. Soil and Water Conservation practices

Land and water management activities were with underway in the Gosh watershed had been 2-3 decades.However the SWCPS is more focused & practice in 2012.The district agricultural office was carrying out the work with financial and material support from Water and the Land Resource project. The approach pursued in was an integrated watershed management (IWM) type where SWCPs was given acentral place.The component of the project includes the SWC promotion of afforestation and water harvesting activities. Soil bund (SB), fanyajuu (FJ),and FB+treelucern (T) and also Gesho(G) were among the SWCPs implemented in the watershed. The watershed where 264 ha covered with physical and biological SWC measures by water and land resource project and BOA programs.From the total area of PSWCPs 27% is covered by SB & 54 % is covered by FJ ridge and19% FJ ridge are integrated with different biological measures such as Treelucern and Gesho.

3.2. Experimental Design

The experiment was conducted in the 2021/2022 rainy season on farmers' fields under natural conditions. To investigate the impact SWCPs on sediment trapping, slope gradient change soil moisture conservation and crop yield and yield component.Three different SWCPs were used as atreatment.These include fields treated with soil bund (SB) fields treated with fanya-juu ridge (FB) and fields treated with fanyajuu ridge integrated with treelucern (FB+T) and the control treatment is only used to compare barley yield and yield components.Preliminary field survey within the watershed has been done inorder to secure a good representation of the treat ments having the ages of the SWCPs treatments were eight years old, slope of the farm land was (3-30%).The experiment was designed by classifying of the investigated SWCPs in three land scape positions lower slope <10%, middle slope10% -25% and upper slope > 25% each treatments replicated three times at each land scape position.

Totally 27experimental field that is nine field where slop>25% SWCPs constructed, nine field where slope between10%- 25% SWCPs constructed and nine field where slope <10% SWCPs constructed were selected. This experimental design is selected since it considers the natural farmers' fields as experimental: plots. Moreover, it is cost effective and better at representing the watershed scale environmental variables than the plot experiment that most researchers used for the last decades.

Table 3.1 Block, Treatments, SWCPs Replications of the Experiment.

Block	Slope position	Treatment SWCPs	Replication
Block 1	>25%	SB	3
		FB	3
		FB+T	3
Block 2	10% -25%	SB	3
		FB	3
		FB+T	3
Block3	< 10 %	SB	3
		FB	3
		FB+ T	3

Where: SB: is soil bund FB is fanya juu bund FB+:T is fanya juu bund integrated with Treelucern.

3.3. Method of data collection and sampling techniques

The data were collected from primary and secondary sources.The primary data which were collected from field measurement &laboratory analysis were made.During field measurement barley yield, plant height and plant biomass,vertical interval,horizontal distance, upslope and downslope measurement and also the amount of sediment trapping,the depth,width and length measurement were collected and evaluated furthernmore the primery data were collected from laboratory analysis of soil (physical properties) such as percentage of soil moisture content,the soil bulk density and soil porosity were analyzed.

Secondary data related to cropping pattern, information on soil and water conservation age in the watershed the typeof soil and water conservation measures major crop grown on the water shed were collected from Dembech District office of agricultural& kebele development agents

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3.3.1. Measuring the trapped Sediment by SWCPs

In Gosh watershed soil bunds, (SB) fanyajuu ridges (FB) and fanyajuu ridges integrated with treelucern (FB+T) have been widely implemented within the watershed on farmer's natural field. The volume of sediment trapped by such SWCPs was quantified using sediment pins for fanya-juu ridges and fanya-juu ridges integrated with treelucern and change in ditch/channel depth measurements of the deposited sediment for soil bund (Lakel *et al*.,2010).The deposited sediment was measured by measuring tape for the nine representatives soil bund (SB) nine representative fayna-juu ridges (FB) & nine representative fanyajuu ridge integrated with tree-lucern from three treatments replicated three times at each land scape position where selected before the rainy season 18 sediment pine (1sedement pine per ridge) were installed and also 9 ditch depth measurement (1ditch depth per bund) were measured by measuring tape.

The data collected from different sampling area where the deposited sediment depth behind soil bunds,fanyajuu ridges and fanyajuu ridges integrated with treelucern were measured and then the difference in sediment pins and ditch before and after the rainy season of 2021/2022 were collected while the average were taken to investget the sediment trapping evaluation.For sedimentation width measurement where taken at each depth measurement totally 18 width measurement were measured by measuring tape taken from fanyajuu ridge and fanyajuu ridge integrated with treelucern and the width of the sediment zone was also calculated as amean of the field measurements.To calculate the total volume of the traped sediment the average depth and width of sedimentation of the three treatments soil bund, fanyajuu ridges and fanyajuu ridges integrated with treelucern were multiplied by their total length.Direct field measureme nt was applied to gate the total length of SWCPs constructed on the study watershed appendix table (7.2) shows the detail field measurement. To calculate the total sediment trapped by the different types of SWCPS where

$$TS=DS*WS*LS \qquad \text{Equation (1)}$$

Where TS is the trapped sediment (m3); DS is the average depth of the trapped sediment by the three investigated SWCPs (m); WS is the average width of the trapped sediment by the three investigated SWCPs (m) and LS is total length of SWCPs constructed within the watershed (m

To convert the deposited sediment volume to dry sediment mass by using bulk density the detail of the bulk density analysis was done by laboratory analysis.

3.3.2. Slope Gradient Change Measurement

Slope gradient change measurement was done by 27 experimental samples from upslope and down slope of the investigated field of SWCPS. To calculate the slop by dividing the vertical interval by horizontal distance & multiplying by100 (BOA.,2015) The measurement was done 1.5 m upslope and downslope of the practices. About the 1.5 m upslope shows the area where sediment was deposited due to SWCPs& slope gradient was expected to reduce,whereas1.5 m downslope shows the area where there is no sediment deposition and no change in slope gradient, which could represent the slope gradient before intervention where measured by the following materials such as three (3) persons 11m string,the water level & 2m height ranging pole were used for measuring the vertical interval and horizontal distance for each upper and lower slope measurement. Finally, change in slope gradient was calculate as, slope (%) at B subtracted from slope (%) at A and change in slope gradient is compared between the investigating structures (Mulatie Mekonnen *et al.*, 2020). Slope of the watershed is the steepness of the slope. It is given as the height in percentage of length. It is calculated as

$$\text{Slope (\%)} = \frac{\text{vertical interval in (m)}}{\text{Horizontal distance in (m)}} * 100 \qquad \text{Equation (2)}$$

Changing in slop gradient in (%) A-B Equation (3)

3.3.3. Soil sampling for moisture content analysis

Soil moisture content was measured at the end of rainfall by considering the period ranging from September to November represents one critical spot for these season crops where higher amount of water were needed.The soil samples for soil moisture (SM) analysis were collected where barley grain yields were collected. At 20cm depth sampling was done 1.5m upslope of SWCPs assuming that sediment will be trapped and deposited up to this distance upslope of the structures (Zenebe Adimassu et al .,2014).From each experimental treatment ,three soil samples (replications) were collected and mixed thoroughly,and a single composite sample

(500g each)was taken for analysis.A total of 54 composite soil samples were collected for soil moisture analysis from September 13/09/2021up toNovember 03/11/ 2021,10days difference. Soil samples are taking by using an auger and stored in sealing plastics when taking out and weighed by sensitive balance. For bulk density analysis nine samples from the SB, nine from FJ and nine from FJ+T:were collected using an undisturbed soil core sampler 5cm in diameter &5cm height was used. Finally SMC and BD were determined in Deber Markose Soil Testing and Fertility Improvement Center by taking the sealing plastic and core sampler.

3.3.4. Barley Grain Yield and Yield Component Sampling

Barley(Hordeumvulgare) is one of the major cereal crop grown in gosh watershed during the main rainy season (May upto August) .Barley is the test crop to evaluate the crop response on SWCPs (treatments) SB,FB &FB+T.The crop was planted with package of recommendations agronomic activities were done properly in order to control yield reduction through the above factors. The data were collected from 36 experimental sites that is nine from untreated with soil and water conservation practices and twenty-seven from treated with SWCPs from the treated ,nine from SB, nine from FJ ridge and nine from FJ ridge +T were taken. By preparing a quadrat with 2m *2m area within the sediment deposition zone about1.5m up slope from the constructed SWCPs the sample were taken (Mulat Gudia *et al.*,2020).

For each treatments cropyield,dry biomass and plant height parameters were evaluated.Such as the biomass was evaluated by taking the sun dry weight which was exposed for about 10 days in the sun of the crop collected from each quadrant measured by sensitive balance with 0.1 gram precision the average was taken& convert to the total biomass in q/ha/yr.Plant height was measured from5 representative barley plants randomly selecting from each experimental quadrants before harvesting & measured by measuring tape their average was taken.And also barley grain yield was measured after threshing the seed yield from each of the quadrant and measured by sensitive balance with 0.1gram precision their average was taken and converts to q/ha/yr.

3.4 Laboratory Analysis

The physical soil analyses were conducted using the following procedures. To determine soil moisture content in the soil gravimetric method was adopted as described by (Abdullah,2014).

SM =Wet of soil- Dried soil (SM= WT-DR) Equation (4)

Percentage of Soil Moisture is worked out by:

(Wet-Dry) /Dry x 100 Equation (5)

The soil bulk density was determined from the oven dry at 105^{0}C for 24 hrs mass of soil in the core sampler & volume of the undisturbed soil cores using core sample method (Sahlemed hin Taye, 2000)).

$$Bd = \frac{\text{Mass of oven dry soil}}{\text{Volume of soil}} \quad \text{Equation (6)}$$

The total porosity of the soil was derived from bulk and particle densities using the following equation (Sahlemedhin, Taye, 2000)

P (%) =/ Pd(1)×100− Bd Equation (7)

Where P is total porosity (%), Bd means soil bulk density, and Pd means soil particle density with an average value of 2.65 g cm−1.

3.5. Statistical Data Analysis

The data on barley yield and yield component, trapped sediment mass and changing in slope gradient were generated from the field measurement and also laboratory analysis were subject ed to the analysis of variance ANOVAfollowing the general linear model(GLM) procedure of the statistical analysis system SAS Institute,1999).The least significance difference (LSD) test at 5% level of significance was used to separate significantly different treatment means using (Gomez & Gomez,1984).Finally the statistical results obtained from the different primary and surces quantitative analysis of the data was subject to presentation in the form of texts, tables and graphs.

Chapter 4: RESULTS AND DISCUSSION

4.1. Impact of Soil and Water Conservation Practices on Sediment Trapping

As showen in Table 4.1 the trapped sediment on the investigated soil and water conservation practices (SWCPs) such as soil bund fanyajuu ridge & fanyajuu ridge with treelucern in Gosh watershed.The total length of soil bunds, fanyajuu ridges and fanya juu ridges with treelucern constructed within the watershed was 131.7 km. In a one year the mean measured sediment on accumulation was 0.0187m3 m-1or 20.38kg m-1with an average sediment deposition depth of 0.035m.The total sediment deposited behind the SWCPs was found to be 2463 m-3 or 2685t with an average bulk density of 1.09 g/ cm3.

Table 4.1. Summary of Field Data on Sediment Trapping Measurement

Types of SWCPs	Land scape position	Average depth	Average width	Length (m)	1 year AST (m3)	1 year AST (kg/bulk density)
Soil bund	Upper	0.026	0.5	1	0.0133	15.0
Soil bund	Middle	0.03	0.5	1	0.015	16.5
Soil bund	Lower	0.04	0.5	1	0.02	21.4
Fanyajuu ridge	Upper	0.03	0.51	1	0.0155	17.37
Fanyajuu ridge	Middle	0.033	0.53	1	0.0175	19.37
Fanyajuu ridge	Lower	0.043	0.55	1	0.0241	25.78
Fanyajuu ridge+T	Upper	0.033	0.52	1	0.017	19.57
Fanyajuu ridge+T	Middle	0.033	0.53	1	0.0178	19.46
Fanyajuu ridge+T	Lower	0.053	0.56	1	0.029	31.57
Average		0.035	0.52	1	0.0187	20.38

As shown in Table 4.2 sediment trapping was statistically significant at ($P<0.05$) lower slope compared with middle and upper slope but no significant difference were observed between middle and upper slope position.While SWCPs at different slope position trapped for 17-26kg m-1yr-1 dry sediment and the different types of SWCPs trapped from17.6-23.6kg m-1yr-1 dry sediment, the highest sediment trapping was recorded from the lower slope and the lowest sediment was recorded from the upper slope because of aged SWCPs and luck of maintenance upper slope affected by over topping flow of water due to lack of bund ditch height to trap the eroded sediment results in high amount of sediment was accumulated in the lower slope.

The result was in line within different authors Kirubel Mekonen and Tesfahunegn Gebreyesus (2011). The result shows that the inclusion of some older stone bunds that do not have the capacity to accumulate sediment due to lack of free bund height could also reduce the annual rate of sedimentation. Similar result was conducted by Nyssen et al.(2007) who found that the Universal Soil Loss Equations P factor for stone bunds was estimated at 0.32m.This indicated that Sediment accumulation rates increase with slope gradient and bund spacing but decrease with bund age study conducted in Tigray high lands of northern Ethiopia.

In the case of the type of different SWCPs the result indicated that sediment trapping was a statistically significant difference ($p <0.05$) was observed in SWCPs stabilized by vegetation (FB+T) compared with physical SWCPS (SB and FB) in one hand and statistically significant difference also observed between physical strictures (SB and FB).While the highest sediment trapping was obtained from FB+T the lowest was obtained from SB. This result indicated that the physical soil and water conservation practices was less effective than biological soil and water conservation practices the possible reason was the integrated soil & water conservation practices was increase the resistance of soils to erosion and help improve soil permeability by increasing soil infiltration & thus decreasing runoff volume,thereby promoting sedimentation. This result was against the finding of Mulatie Mekonnen, (2020). The result showed that the highest sediment trapping was recorded from newly constructed SB compared with FB & FB +G in study's conducted in Koga catchment, in the northwest highland of Ethiopia. The main reason of the contradiction result might be age of the implemented SWCPs the researchers use as an investigation for aged SWCPs (8 years old).Hence soil eroded from the unstable newly constructed mainly first year structure ridges transported to the retention basin and increased the deposited sediment & also below the standard berm distance facilitates this type of erosion This type of erosion will not happen in old practices due the stability of the soil that was used to construct lines of soil ridges.

The current result was in line with, Desta Geberemecael ,(2005) and Kirubel Mekonen and Tesfahunegn Gebreyesus (2011) who found that SWCPs on cultivated land can accumulate much soil it was about 65.3t /ha/yr rough calculation to estimate the sediment accumulated in the stone bunds was carried out. And Vancampenhout et al,(2006) also found that stone and soil bunds can trap about 64% & 60%, respectively, of the inflow sediment a study conducted in the northern Ethiopia.

Table 4.2. Impact of SWCPs on Sediment Trapping. T/kg/Ha/Yr

Variable	slope position	SWCPs/Treatments			
Sediment trapping(kg)		SB	FB	FB+T	Overall
	Upper slope	15.0^{d}	17.37^{cd}	19.57^{cd}	17.3^{B}
	Middle slope	16.5^{cd}	19.37^{cd}	19.46^{cd}	18.4^{B}
	Lower Slope	$21.4b^{c}$	25.78^{b}	31.57^{a}	26.2^{A}
	Over all mean	17.65^{b}	20.82^{ab}	23.54^{a}	
	LSD(0.05)	2.1		3.19	3.19

Mean values followed by different small letters (a, b, c) along the same rows and capital letters (A, B, C) along the same column are significantly different at p <0.05. LSD is least significant difference

4.2. Impact of SWCPs on Slope Gradient Change

Slope gradient change: Slope gradient change showed a statistically significant difference (p< 0.05) were observed among the SWCPs stabilized by treelucern on (FB+T) compared with the PSWCPs (SB and FB).However no significant difference were observed between the physical strictures (SB and FB). On average slope gradient was reduced by1.7 %, 2.2 % and 3.5% on field treated with SB,FB and FB+T respectively Table 4.2.This implies that SWCPs stabilized by tree-lucern (FB+T) significantly reduced the slope gradient as compared to PSWCPs. The possible reasons were viewed by two ways, the 1st reason was the trapped and accumulated sediment behind the constructed SWCPs.The2nd reason was design and constriction difference during constructing FB ridges, were large amount of excavated soil was moved upslope to make lines of FB ridges while during constructing SB large amount of excavated soil moved downslope to make lines of SB thus its own contribution to reduce slope gradient on top of the accumulated/trapped sediment by SWCPs after construction.

The current result agreed with, Mulatie Mekonnen, (2020) the result showed that the type of SWCPs significantly ($p \leq 0.05$) affected slope gradient change with differently FB and FB+G significantly reduced slope gradient compared withSB moreover after construction the highest slope gradient change was recorded from FB+G ridges form the high sediment ridge lines and gradually form bench terraces which decreased the slope gradients by2.7% on average studies conducted in Koga catchment north west highland of Ethiopia.

Similarly the current study was in line with Shiro et al ,(2021), the result showed that on slope gradients were reduced annually by 0.03% grade for the denber fields and 0.17–0.28% grades for the soil and stone bunds fields in studies conducted in the catchments of Tebo and Geldia seasonal rivers in Semiarid highlands of Ethiopia .

And also Mulat Guadie et al,(2020) result indicate that the average inter terrace slope gradient showed a statistically significantly different ($p \leq 0.05$) between the treated and the untreated fields. The average inter-terrace of the slope gradient in the treated fields was found to be low as compared to the untreated fields. However, the average inter terrace slope gradient between soil bund and stone-faced soil bund didn’t show a significant difference.

With regarding to the type of soil and water conservation practices done with at the different slope position there was statistical significant difference were observed on the different slope position upper,middle and lower slope.While the highest SGCH was obtained from upper slop compared with middle & lower slope.This implies that which might be due to erosion increase as slope gradients increase hence SWCPs behind upper slope was a vantage place for traping more soil materials and debris on the upper position of bund causes a height increase of the bund year after year thereby reducing slope between two successive SWCPs than middle and lower slope.

The result was line with different authors a study’s conducted by Shimeles Damene, (2012), found that terraces on steep slopes are not only higher but are also made up of large boulders and stones walls that form thick stone this results in distinct terraces height differences were observed across the landscape terraces over 180 cm and as short as 40 cm were observed on the upslope and lower slope positions respectively and also closely spaced and taller structure are constructed on the steeps slopes however such structures are limited as the slope becomes very steep thus height difference were contribution of slope gradient change. Similarly, Desta Gebremichael et al,(2005) found that the rate of sediment accumulation by bunds is correlated with the soil loss by erosion because all the soil displaced by erosion remains in the deposited accumulation zone sediment accumulation volume was found to increase with slope gradient and bund spacing,but decreased with bund age.

And also, Nyssen et al, (2007), showed that Stone bunds constricted in steeper slope are also effective in reducing the slope gradient of the land between the bunds and in reclamation of steep land. Since sediment is accumulating behind the bunds, the original slope gradients of in the plots are reduced. The mean slope gradient of the 202 studied plots changed from 14.1% to11.2%, in 3-21 stone bund building years. The slope gradient of the plots decreases annually at an average rate of 0.33%in studies in Dogua-tembine district northern highland of Ethiopia

.The current result disagree within Gebeyehu Taye et al.,(2013) who found that with the same SWCT applied, for both rangeland and cropland soil erosion tend to decrease with increasing slope gradient mainly due to increase rock fragment cover this leads to reduce the amount of sediment trapping together with slope gradient change was lower in study’s conducted in Simi arid areas of the highland of Ethiopia.The possible reason within this negative result might be increase soil’s resistance to erosion (erodibility) due to an increasing rocks fragment cover in semiarid areas.

Table4.3.Impact of Different SWCPs on Slope gradient change (%)

Variable	slope position	SWCPs/Treatments			
Slope gradient change		SB	FB	FB+T	Overall Mean
	Upper slope	3.0^{b}	4.0^{b}	6.3^{a}	4.4^{A}
	Middle slope	$1.6d^{e}$	2.0^{cd}	$3.0b^{c}$	2.2^{B}
	Lower Slope	0.6^{e}	0.8e	$1.1d^{e}$	0.83^{C}
	Over all mean	1.7^{b}	2.2^{b}	3.5^{a}	
	LSD(0.05)	0.86		0.63	0.63

Mean values followed by different small letters (a, b, c) along the same rows and capital letters (A, B, C) along the same column are significantly different at $p < 0.05$. LSD is least significant difference

4.3. Impact of Soil and Water Conservation Practices on Soil Moisture Conservation

Water management includes understanding about the release pattern and storage of water by the soil. Soil moisture data can be used for water reservoir content and managing early advice of deficiencies irrigation planning, and crop yield estimation (Gabriela,2019).The easiest time for measuring soil moisture content were after harvest provided no late rainfall has distorted mainly don in the rain fall execs area like the highland of Ethiopia. The next critical time to measure is around late March prior to seeding up to the growing stage of the crop mainly rain fall stress area of the lowland.

The study was mainly focused on after harvest provided no late rainfall has distorted that is September 13/09/2021upto November 03/11/2021atotal of 54 composite soil moisture sample were collected six times at different days the result indicate that the different types of SWCP and SP were significantly ($p<0.05$) influenced by the soil moisture content (SMC).Astatically significant difference were observed between the treated SWCP while the highest SMC was obtained from fanya juu ridge stabilized by tree lucern (FB+T) the lowest SMC was obtained from soil bund as Table 4.4.The possible reason might be comes from different management activity of the land.According to Dagnew et al,(2016),indicate that design dimension affected soil management activities biological integration and maintenance strategies leads difference in stability of bunds this affected soil water storage and overall soil quality differences in the cultivated farm plots between successive bunds.

The current result is in line with Mulatie Mekonnen et al., (2020) the result shows that unlike the SB, FB and FB + G as age increased the runoff water storage efficiency increases.SM was higher in fields treated with FB + G than FB which was because roots of the grass increase the run-off water infiltration capacity of the soil. Similar result also found by Mulatie Mekonnen, (2016) the result shows that the grass roots increase the resistance of soils to erosion and help improve soil permeability & grasses with deep roots can access water deep below the surface, which increases infiltration.

Table 4.4, shows that the different SWCPs within different slope position resulted significant difference were observed lower slope compared to middle and upper slope position. While the highest SMC was obtained from lower slope & the lower SMC was obtained from upper slope This is to be expected. due to topographic influences soil water could be drained down the soil profile easily by gravity or high subsurface flow of water which might cause lower soil water content in relatively moderately steep and steep slopes (Flanagan; Johnson, 2005).The current result corresponds to (Walle Jumber, 2018),the result revealed that porosity, SMC, depths and infiltration rates showed significant difference between bunds on the lower, middle and upper slope classes. Soils in all fields with bunds on gentle and moderately steep slopes have higher soil moisture content than those on steep slopes.

From figure (4.1) indicate that the SMC influenced by day variation the slope gradient>25%, in different types of SWCPs the highest SMC (32.9%) was recorded by FB+T in September 13/09/2021 the lowest SMC(16%) was recorded from SB November 03/11/2021 respectively. Similarly slope between 10-25% in different types of SWCPs the highest SMC (36.05%) was recorded for FB in September 13/09/ 2021 the lowest SMC was recorded from SB (15.74%).

In addition the lower slope the highest and the lowest soil moisture content (36.7 &18.76 %) were recorded FB+T & SB at the similar sampling date of September and November. This is due to the fact that the soil moisture was reduced as the amount of rain-fall was also reduced while biological soil and water conservation measure was high amount of SMC than physical soil & water conservation strictures in almost all sampling dates. Because of plant roots were increase the infiltration and reduce the evaporation of the water in the soil results in SWCPs stabilized by vegetation hold greater proportion of soil moisture in a long period of time than others. However only one sampling date that is 13 /09/2021 in slope 10-25% the highest soil moisture content was observed in FB than FB+T the possible reason was might be the version of soil fertility of the sampled area and direction of the sun light contribute the highest SMC in FB than FB+T.

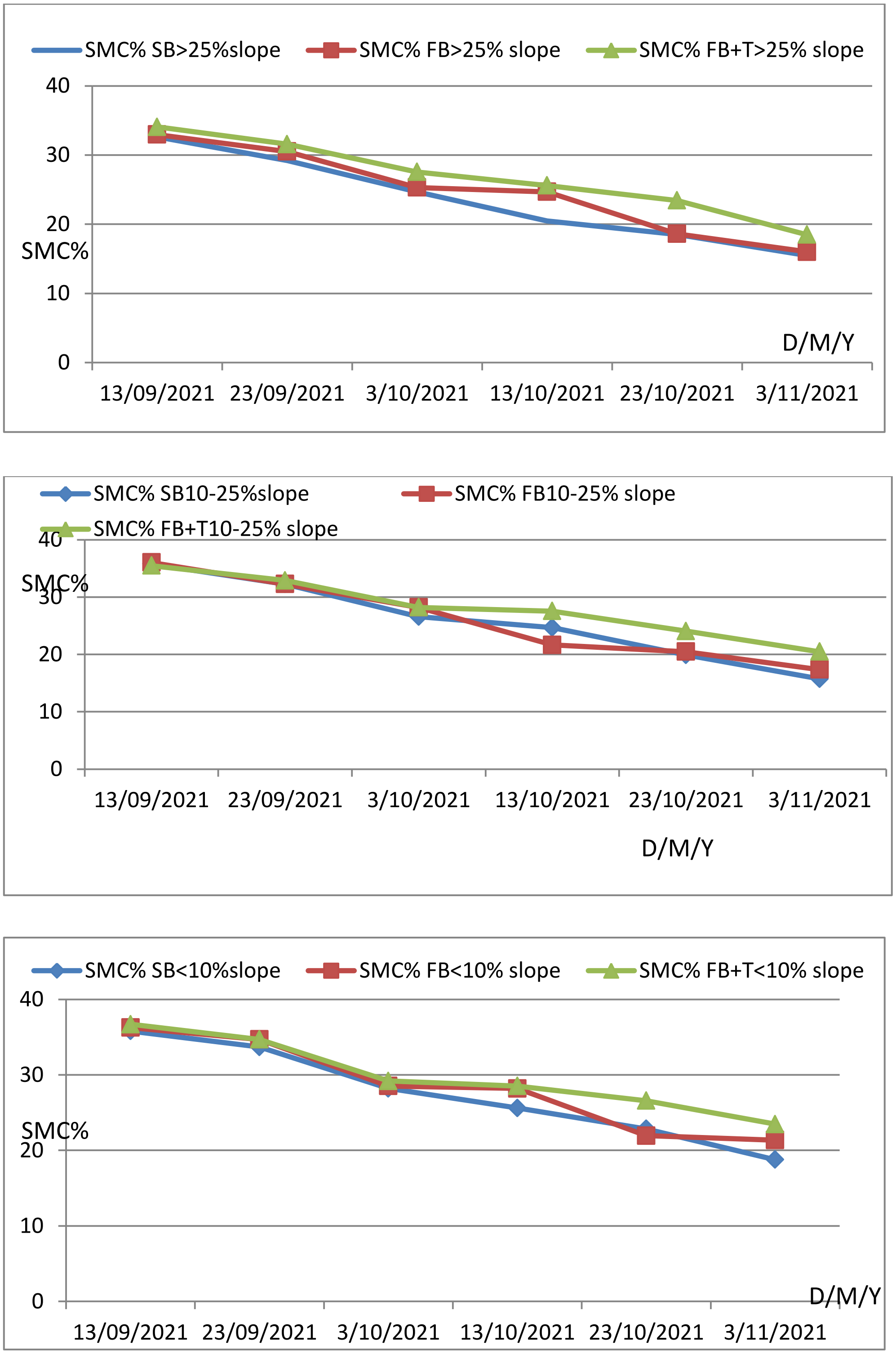

Figure 4.1 Impacts of SWCPs on SMC in different land scape position at different day

4.4 Impact of Soil and Water Conservation Practices on Bulk Density

As can be seen from Table 4.3 bulk densities showed a statistically significant difference at ($p < 0.05$) was observed SWCPs done with the different slope class. The lower bulk density was recorded in the lower slope compared with middle and upper slope class.The soil bulk density increase as slope gradient increase which might be attributed to the corresponding decline in soil organic matter content with the increase in slope gradient. The result agreed with different authors (LiY:Lindstrom,2001) who found that there is a decrease in bulk density on cultivated soils in the lower in the higher slope gradient. (Worku Hailu et al. 2012) also pointed out that the soil bulk density has a direct relation with slope gradients which might be attributed to the corresponding decline soil organic carbon content with the increase in slope gradient/steepnes .Similarly Mulat Guadie et al (2020) also reported that the bulk density showed a statistically significant variation ($p \leq 0.05$) at different slope positions. It was found to be lower in lower slope than in the upper slope positions study's conducted in Lole watershed.

In the case of soil and water conservation practices soil bulk density was significantly affected by (0.05) the different SWCPs. While there is a significant difference were observed between SB compared to FB and FB+T. Moreover the highest soil bulk density was recorded from the PSWCPs (SB) the lowest bulk density was recorded from the treated FB stabilized by treeluce rn. This could be attributed to the presence of significantly higher organic matter as a result of (FB) stabilized by treelucern implies that more roots of plants, higher organic matter and sediment are accumulated results in the reduction of soil bulk density. This result agrees with the findings of Yihenew Geberselasie et al. (2009), The non-conserved micro-watershed was found to exhibit significantly the highest mean value of bulk density than the micro-watershed treated with SWC measures.Similar result was reported by Mulat Guadie et al,(2020) soil bulk density was significantly influenced ($P<0.05$) by SWCPs while the soil bulk density showed a statistically significant difference were observed ($p < 0.05$) between the treated and untreated fields.

4.5 Impact of Soil and Water Conservation Practices on Porosity

The analysis of variance revealed the presence of significant differences in mean soil porosity values between lower slope as compared to middle and upper slope classes. The values of soil porosity decrease as the slope gradient increases. The lowest porosity was recorded from the upper slope while the highest porosity was recorded from the lower slope due to the low mean pore volume in upper slope class might be because soil had under gone structural degradation due to removal of soil organic matter and exposure of the subsoil by erosion. The upper slopes class (steep slopes) the soil is degrading severely than lower and middle slope class under similar cultivation history and all other management and cultural practices.

The current result in line with different authors Mulat Guadie et al.,(2020) the result indicate that soil porosity showed astatistically significant difference($p \leq 0.05$)at different slope position the values of soil porosity decreases as the slope gradients increases study's conducted in Lole watershed. Mulugeta Assefa (2015) also reported lower total porosity in steepest slope than in gentle slope fields as a result of high bulk density in the Dawja watershed, northwest Ethiopia.

Soil porosity is also significantly affected by soil and water conservation practices at ($p<0.05$) however no significant difference were observed between the treated SWCPs (SB, FB & FB+ T),while the lowest soil porosity was obtained PSWCPs from the soil bund (SB).This is might be due to the lower organic matter content of soil as a result of soil erosion that caused higher bulk density.The result in line with mulat Gudie et al (2020) the result show that a statistically significant difference ($p \leq 0.05$) was found in soil porosity between the treated and untreated fields.lower soil porosity (59.83 ±2.43) was found in the untreated fields than the treated field However no statistical significant different were observed between the treated SWCPs. This result also agrees with the findings of Yihenew et al. (2009) and Mulugeta and Karl (2010). The non-conserved micro-watershed was found to exhibit significantly the highest mean value of bulk density than the micro-watershed treated with SWC measures. The lowest (1.03 g cm^{-3}) and highest (1.20 g cm^{-3}) bulk density values were recorded at soil bund and control on lower slope gradient respectively

Table 4.4. Impact of SWCPs on SMC%, BD and porosity

Parameter	Slope position	SWCPs/ Treatments			
Soil moisture content (%)		SB	FB	FB +T	Overall mean
	Upper slope	23.49^{c}	24.67^{b}	26.77^{b}	24.97^{B}
	Middle slope	25.8^{b}	26.00^{b}	28.11^{ab}	26.66^{B}
	Lower slop	27.48^{ab}	28.49^{ab}	29.86^{a}	28.61^{A}
	Overall Mean	25.61^{b}	26.38^{b}	28.24^{a}	
	LSD(0.05)		1.8	2.1	2.2
Bulk density (Bd)	Upper slope	1.13^{a}	1.12^{a}	1.12^{a}	1.12^{A}
	Middle slope	1.10^{a}	1.10^{a}	1.09^{b}	1.096^{B}
	Lower slop	1.07^{bc}	1.06^{c}	1.06^{c}	1.060^{C}
	Overall Mean	1.10^{a}	1.09^{b}	1.09^{b}	
	LSD(0.05)		0.61	0.89	0.89
Porosity (P %)	Upper slope	57.40^{b}	57.74^{b}	57.74^{b}	57.6^{B}
	Middle slope	58.50^{ab}	58.50^{ab}	57.74^{b}	58.3^{B}
	Lower slop	59.60^{a}	60.00^{a}	60.00^{a}	59.0^{A}
	Overall Mean	58.5^{a}	58.74^{a}	58.49^{a}	
	LSD(0.05)		1.2	1.4	1.4

Mean values followed by different small letters (a, b, c) along the same rows and capital letter s (A,B,C) along the same column are significantly different at p <0.05.LSD is least significant difference

4.6. Impact of SWCPs on Barley Grain Yield and Yield Component

The result showed that barely yield, plant height and straw biomass significantly ($P < 0.05$) in fluenced by SWCP and SP (Appendix Table7.3,7.4 &7.5).Astatistically significant difference; ($p < 0.05$) was observed in barley plant height in upper middle and lower slope.The longest value of barley plant height was recorded in the lower slopes while the shortest was obtained from the upper slope position as the slope gradient decreased from 25% to 10%, barley plant height was increased as shown in the Table 4.4.The possible reason might be the sub-sequent effects of reduced soil loss and crop residue through erosion and addition of organic matter from plants contribute barley plant height increment than upper slope.The result was agreed with MulatGuadie et al.,(2020),the result shows that a statistically significant difference($p \leq 0.05$) was observed in plant height between lower middle and upper slope class.The longest plant height was recorded in the lower slope <9% than upper slope class>15% in the study's conducted in Lole watershed in the northwest highlands of Ethiopia.Similar result reported by Keesstr et al., (2016) a reduction in barley plant height, grain yield, and straw biomass as the slope gradient increases due to the loss of SOM, N, P, and K by erosion from steep slope areas.

As shown in the Table 4.4 the type of SWCPs astatistically significant differenceses (p <0.05) was observed in barley plant height between treated and untreated SWCPs.However no signifi cant:differenceses was observed between the treated SWCPs.The longest value of barley plant height was recorded from the SWCP fanyajuu bund stabilized by treelucern (FB+T) while the shortes was obtained from the untreated cultivated lands from control (CL).The longest plant height on the treated cultivated land stabilized by vegetation was recorded due to effectively trapping eroded soil & nutrient losses, and improved soil fertility than the untreated SWCPs.

The result agreed with different authores Mihrete Getnet, (2014),the result indicated that Plant height was significantly higher (p ≤0.05)on bunds stabilized by vegetation,stone bund and soil bund treated plots than the control plot.Average barley plant height was the highest on bunds stabilized by vegetation and the lowest was recorded on the control plot study's conducted in simada district south Gondar zone.Similar result was also reported by (Tesfaye Tanto;Fanueal Laekemariam,2019), the result indicate that SWC practices significantly influenced (p < 0.05) plant height of wheat.The longest plant was recoreded form SWCPs stabilized by vegetation with 5 years duration whereas the shortest plant was recorded from untreated cultivated land.

Barley plant straw biomass was also significantly affected (P<0.05) by the SWCPs and slope position.A statistically significant difference (p < 0.05) was observed in barley straw biomass in upper middle and lower slope the highest valu of barley straw biomass was recorded in the lower slope while the minimum was obtained from the upper slope as shown in table 4.4. The possible reason of barley biomass in the lower slope might be the subsequent effects of reduce soil loss and crop residue through erosion and addition of organic matter from plants contribut barley straw biomass increment than upper slope.

The result was line with Mulat Guadie et al,(2020),the result shows that a statistically significant difference ($p \leq 0.05$) was observed on barley straw biomass treated and untreated fields and at different slope positions barley straw biomass were found to be high on fields having lower slope and low on fields having upper slope study's conducted in Simada District, South gondar zone. Similarly Yihenew Gebereselasie et al,(2009)who found that reduction in straw biomass was recorded as the slope gradient increases due to the loss of SOM, N, P, and K by erosion from steep slope areas.

In case of the SWCPs a statistically significant difference (p <0.05) was observed in barley straw biomass between treated and untreated cultivated land.Among the three SWCPs and the control the highest barley biomass was recorded from SWCPs stabilized by vegetation(FB+T) the lowest barley biomass were recorded from the untreated cultivated land from the control as shown in Table 4.4.The possible reason was the longer the implementation year of SWCPs and corresponding stabilization of vegetation measures has resulted corresponding advantage for increasing biomass yield of Barley.

Similar result was reported by different authors for example (Mulat Guadie et al.,2020) who found that the highest barley straw biomass was recorded the treated soil water conservation strictures and the minimum was recorded in the control. Likeways (Yihenew Gebereselasie et al.,2009) result indicate that the higher crop straw biomass was recorded in treated fields as compared to un treated field.

Differences were also observed barley yield between the SWCPs & slope position in the case of slope astatistically significant difference ($p < 0.05$) was observed in barley yield in upper middle and lower slope.Barley yield was found to be high on fields having <10% slope and low on fields having>25% slope the possible reason for thus could be that erosion might have removed more top soil from the upper and deposited them at the lower positions which is most favorable for the crop yield increment.

The result in line with the finding of Nyssen et al,(2007) the result indicated that on plots with stone bunds of different ages there is an average increase in grain yield of 53% in the lower slope as compared to central and upper parts of the slope in study's conducted in Tigray high lands Northern Ethiopia.

Similar result was also reported by Mulat Guadie et al,(2020) The result show that a statistical significant difference ($p \leq 0.05$) was observed in barley yield between lower middle and upper slope position.The highset barley yield was recorder in the lower slope than upper slope class in study'sconducted in lole watershed in the northwest highlandsof Ethiopia.

In case of the SWCPs a statistically significance differenceses (p <0.05) were observed in the barley yield between treated and untreated cultivated land.However no significant difference were observed between the treated SWCPS (SB, FB and FB+T).Unlike the three SWCPs and the control the highest and the lowest barley yield were recorded from SWCPs stabilized with vegetation (FB+T) and the untreated cultivated lands control respectively.As compared to the contro l9.2q/h/y or 46.23% barley yield increment was recorded from the treated SWCPs how ever this yield increment is may not be related to the implementation of SWCPs rather it is an integrated response of many parameters is mostly difficult to relate it to any individual factors under field conditions.It is therefore difficult to establish aone to one,cause and effect relation ships between crop yield onone hand and soil erosion and erosion induced soil degradation on the other (Lal, 1988). SWCPs generally promote increased crop yield by reducing water soil and nutrient losses.

The result agreed with,Yihenew Gebereselasieet al,(2009),the result indicate that higher crop yield was recorded in treated fields as compared to un treated field in study's conducted in effect on upstream and downstream users of the Nile river Absela kebele, northwest Ethiopia. Similar report was conducted by Miheret Getenet (2014), the result should that the bunds stabilized by vegetation produced significantly higher ($p \leq 0.05$) barley crop grain yield than the yield recorded in the soil and stone bund treated plots and control plots.

Table 4.5. Effect of SWCPs on Barley grain Yield and Yield Component

Yield and yield component	Slope positions	SWCPs /Treatments				
		CL	SB	FB	FB+T	Overall mean
Barley yield(q/ha)	Upper slope	8.60^{e}	16.0^{c}	16.5^{c}	16.5^{c}	14.4^{C}
	Middle slope	11.5^{d}	19.5^{b}	19.5^{b}	20.0^{b}	17.6^{B}
	Lower slop	12.2^{d}	23.5^{a}	23.0^{a}	23.2^{a}	20.4^{A}
	Overall Mean	10.7^{b}	19.7^{a}	19.7^{a}	19.9^{a}	
	LSD(0.05)		1.0	0.58	0.5	
Plant height in (cm)	Upper slope	40.5^{f}	56.6^{c}	56.3^{c}	56.5^{c}	52.5^{C}
	Middle slope	42.5^{e}	67.0^{b}	67.3^{b}	67.8^{b}	61.5^{B}
	Lower slop	45.8^{d}	73.0^{a}	73.3^{a}	73.6^{a}	66.4^{A}
	Overall mean	42.9^{b}	65.5^{a}	65.6^{a}	66.0^{a}	
	LSD(0.05)		1.3	0.72	2.2	
Plant Biomass(q/ha)	Upper slope	28.6^{e}	36.6^{d}	37.0^{d}	42.0^{c}	36.0^{C}
	Middle slope	30.3^{e}	49.6^{b}	50.0^{b}	51.0^{b}	45.2^{B}
	Lower slop	41.0^{c}	56.0^{a}	56.8^{a}	57.2a	52.7^{A}
	Overall Mean	33.3^{c}	47.4^{b}	47.9^{a}	50.0^{a}	
	LSD(0.05)		3.7	2.2	1.8	

Mean values followed by different small letters (a, b, c) along the same rows and capital letters (A, B, C) along the same column are significantly different at $p < 0.05$. LSD is least significant difference.

Chapter 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The general objective of this study was to explore the impact of soil and water conservation practices on sediment trapping, the slope gradient change, soil moisture conservation and crop yield and yield components. The major fine digs of the study revealed that sediment trapping and in slope gradients changes were statistically significant for SWCPs and SP.The amount of sediment trapped bySWCPs were (17.6 upto 23.5kgm1) while the highest amount of sediment was stocked behind fanyajuu ridge stabilized by treelucern than physical SWCPs (SB & FB). On the other hand the slope gradients were reduced by 3.5% SWCP done with fany-ajuu ridge stabilized by treelucern.This implies that fanya-juu ridge integrated within tree-lucern (FB+T) reduced slope gradient and sediment trapping better compared with soil bund (SB) due to sediment ridge lines it forms on top of manmade ridges made during construction by throwing soils uphill.

As it was indicated in the finding the average soil moisture content was higher in the lower slope than upper and middle slope similarly the highest moisture content was recorded in the integrated soil and water conservation structures than physical soil and water conservation structures this indicated that soil moisture conservation were effective specially SWCPs done with fanya-juu ridge integrated with tree-lucern in the study watershed.

The findings also provide that significantly higher amount of bulk density and the lowest mean pore volume were registered on the upper slope SWCPs implemented by soil bund. On the other hand lower slope position SWCPs implemented by fanyajuu with treelucern, had the lowest mean bulk density value and the highest total mean pore volume were registered.

Further the results of analysis of variance showed that barley yield and yield component had significant variations with respect to soil and water conservation practices and slope position Fields treated with SB,FB and FB+T barely yield,plant height and straw biomass astatistically significant ($P<0.05$) influence was observed as compared to the untreated fields. This implies that SB, FB and FB+T improved the fertility of the soil by reducing nutrient losses due to erosion. Barley grain yield obtained on fields treated with the SB (19.7q/ ha/ yr) was higher as compared to the control (10.7q/ ha /yr.).Barley grain yield obtained on fields treated with FB and FB+T (19.7q/ha/yr and 19.9q/ha/yr) were also high compared to the control. This result is indicating that barley grain yield was 46.23% higher on fields treated with SB, FB and FB+T. From this study it can be concluded that the main effect of the tested SWCPs such as SB, FB and FB+T in Gosh watershed were found to be effective for increasing crop yield and yield component sediment trapping slope reversing and soil moisture content specially SWCPs with stabilized vegetation (FB+T) were more effective for physical structural change and increased crop yield and yield component.

5.2 Recommendation

Based on the findings of the study the following recommendations are forwarded.

- ✓ From the three types of SWCPs tested in the study area FB and FB+T were more effective for slope reversing than SB because of construction difference hence farmer's showed that constricting FB integrated with biological measures than SB in order to achieving the long term effectiveness of slope gradient change .
- ✓ Land degradation, particularly soil erosion by water on the cultivated fields, is a threat to agricultural production in the study area.SWCPs shows significant influence were observe in barley yield and yield increment by trapping of the eroded sediment was insured by this study. Thus, all stakeholders need to encourage farmers and the community at large in the adoption, implementation and maintenance of SWC measures at farmlands.

Based on the current result and conclusion the following suggestions were forwarded for future research

- ➢ Further studies should be made to get more information about the soil fertility status of the treated land and other related impacts on the farmers in the study watershed

Chapter 6. REFFERANCE

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APPENDIX SECTION

Table.1 Field Length Measurement of Soil and water conservation practices in the study area

No	Treatments	Ha	Km
1	SB	71.3	35.6
2	FB	142.6	71.1
3	FB+T	50.1	25
	Total	264	131.7

Table.2 Summary of ANOVA on the Impact of TSWCPs on Barley Height

				BPH					
Source	DF	Type III SS	MS	F	Pr > F	R-Square	CV (%)	Root MSE	GM
SP	2	1191.79	595.90	976.8	<.0001	0.9	1.3	0.7	60.0
TSWCP	3	3508.74	1169.58	1917.86	<.0001				
LSP*TSWCPS	6	164.49	27.41	44.93	<.0001				
Model	11	4865.02	442.2	724.7	<.0001				
Error	24	14.67	0.61						
C. Total	35	4879.69							

Table.3 Summary of ANOVA on the Impact of SWCPs on Barley Straw

	BSBM								
Source	DF	Type III SS	MS	F	Pr > F	R-Square	CV (%)	Root MSE	GM mean
SP	2	1672.72	836.11	169.25	<.0001	0.9	4.9	2.2	44.6
TSWCP	3	1583.47	527.82	106.01	<.0001				
LSP*TSWCPS	6	137.44	22.90	4.6	0.003				
Model	11	3393.6	308.50	62.44	<.0001				
Error	24	119.5	4.94						
C. Total	35	3513.13							

Table .4 Summary of ANOVA on the Impact of SWCPs on Barley Grain yield

	BYD								
Source	DF	Type III SS	MS	F	Pr > F	R-Square	CV (%)	Root MSE	GM
SP	2	189.84	94.92	262.93	<.0001	0.9	3.4	0.6	17.6
TSWCP	3	485.8	161.93	448.55	<.0001				
LSP*TSWCPS	6	27.98	4.66	12.90	<.0001				
Model	11	703.6	63.96	177.44	<.0001				
Error	24	8.66	0.361						
C. Total	35	712.26							

Table.5 Summary of ANOVA on the Impact of SWCPs on Slope Gradient Change

	SGCH								
Source	DF	Type III SS	MS	F	Pr > F	R-Square	CV (%)	Root MSE	GM
SP	2	58.07	29.03	71.27	<.0001	0.9	24.65	0.62	2.52
TSWCP	2	14.12	7.06	17.34	0.0009				
LSP*TSWCPS	4	6.7	1.67	4.11	0.0294				
Model	8	78.89	9.86	24	<.0001				
Error	18	7.33	0.4						
C. Total	26	86.22							

Table.6 Summary of ANOVA on the Impact of SWCPs on sediment trapping

	AST								
Source	DF	Type III SS	MS	F	Pr > F	R-Square	CV (%)	Root MSE	GM
SP	2	426.4	213	43.9	0.0000	0.8	15.7	3.2	20.67
TSWCP	2	156.3	78.15	16.11	0.0003				
LSP*TSWCPS	4	147.4	36.85	7.59	0.0066				
Model	8	730.1	91.2	18.8	0.0001				
Error	18	87.3	4.85						
C. Total	26	817.4							

Table.7 Summery of ANOVA on the Impact of SWCPs on Soil moisture content %

		SMC%							
Source	DF	Type III SS	MS	F	Pr > F	R-Square	CV (%)	Root MSE	GM
SP	2	1050	525	262	.0001	0.9	16.1	3.9	26.93
TSWCP	2	640	320	160	0.0002				
LSP*TSWCPS	4	159	39.7	20	0.019				
Model	8	1849	231	115	0.000				
Error	45	90	2.0						
C. Total	53	1939							

Table.8 Summary of ANOVA on the Impact of SWCPs on Bulk density

		BD							
Source	DF	Type III SS	MS	F	Pr > F	R-Square	CV (%)	Root MSE	GM
SP	2	0.015	.0075	1816	<.000	0.99	0.18	0.002	1.093
TSWCP	2	.0004	.0002	50	<.0001				
LSP*TSWCPS	4	.0001	.000027	653	<.0001				
Model	8	.016	.002	503	<.0001				
Error	18	.000075	.000004						
C. Total	26	0.01686							

Table.9 Summary of ANOVA on the Impact of SWCPs on Porosity

Source	DF	Type III SS	MS	F	Pr > F	R-Square	CV (%)	Root MSE	GM
				P (%)					
SP	2	22.17	11.08	1678	<.0001	0.99	0.13	0.08	58.58
TSWCP	2	0.29	0.145	21.96	<.0001				
LSP*TSWCPS	4	1.33	0.33	50.00	<.0001				
Model	8	25.66	3.20	484.8	<.0001				
Error	18	0.120	0.0066						
C. Total	26	1548.9							

Figure.1 Sample measurement of slope gradient change in the field

Figure 2 Sample sediment trapping depth and width measurement

Figure.3.Sample pictures of barley plant height measurement

Figure.4 Sampled pictures of Barley yield measurement

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The author was born in dembecha district west gojjame administrative zone of Amara national regional state and Ethiopia in September 1/1984.He attended his Elementary educationand his secondary school education in Dembecha elementary and secondary school. After completing his primary and secondary school he joined Burie technical vocational educational training college in September 2002 and graduated with diploma in natural resource management in July 19/2004.Following his graduation he served as development agent from August 2004 to September 2009 in Dembecha district at kebele level. He joined Bahir-dar university in 2009 to 2012 in B.Sc. program and obtained B.Sc.degree in natural resource management in regular program.Following his graduation heserved as head of department of job creation in Dembech district from November 15/2019.He joined bahir dar university in 2019 in the college of the agriculture and environmental sciences to specialize in land resource management.