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ORIGINAL ARTICLE

Effects of intgrated soil and water conservation on selected soil physico-chemical properties of lonke watershed, Sodo Zuria Woreda, Southern Ethiopia

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Background: Land degradation and nutrient depletion have been the major challenges in Ethiopia that directly affect soil fertility and crop productivity. With the aim of curbing land degradation problems, efforts are underway on the implementation of soil and water conservation (SWC) practices, but the performance of Soil and water conservation measures such as ISWC (Bench terrace with fodder species, grass species and deep trench) and physical SWC alone had been implemented to tackle soil erosion in the study area has not been well studied. Therefore, this research was conducted in Lonke Micro-watershed, Sodo Zuria Woreda,Wolaita Zone Southern Ethiopia to evaluate the effect of integrated soil and water conservation practice on soil physic-chemical properties and farmer's perception towards implementing ISWC practice.

Materials and Methods: The soil sampling was taken, 27 disturbed composite soil samples and 27 undisturbed soil samples were collected from sites treated with ISWC measures, SWC structures alone and non Soil and water conservation measures (NSWC) with the slope gradient 3-8%, 9-15% and 16-34 percent classification from each treatment site. A total of 81 Household heads were interviewed through close ended questionnaires to explore the farmer's perception on integrated soil and water conservation practices in Lonke watershed.

Results: The results of the experimental study showed that soil organic carbons (SOC), total nitrogen (N), soil pH and Bulk density (BD) were significantly ($p \leq 0.05$) affected by the integrated soil conservation measures but the effect of Av-P is highly significant($p<0.05$) but the physical soil and water conservation slightly affect above soil physicochemical properties. Sand, silt and clay soil texture significantly varied the site with integrated soil and water conservation measures, physical soil water conservation practice and non-conserved sites. 90.1% of respondents have positive opinion on its role in improving soil fertility based on their own indicators.

Conclusion: Farmers had a positive attitude towards the ISWC practice as they improve the soil physicochemical properties. Soil properties were in good conditions in the integrally conserved areas with higher SOC, total nitrogen (TN) and lower BD which are indicators of a fertile soil compared with the physical SWC alone and non-conserved plots. Biological supported conservation (Sesbania sesban and pigeon pea) were found to be effective in improving soil Physico-chemical properties in the study area.

Keywords: Integrated soil and water conservation, Physical soil and water alone, Non soil and water conservation, Farmers perception and soil physicochemical properties, Slope gradient.

Abbreviations: SWC: soil and water conservation, OM: organic matter; OC: organic carbon.

Introduction

The population of the world is dependent on land resource for food and other necessities. More than 97% of the total food for the world's population is derived from land, the remaining being degradation (UNEP, 2002). Globally, out of 22% of the land suitable for sustaining agricultural productivity, around 5 to 7 Million hectares are being lost annually due to land degradation, consequently, threatening food security of the world. Soil and water resources conservation and management is important for the welfare of the people (Lal, R., 2001).

Land including Soil is the most important natural resource all over the world. It is a place from which human beings are exploiting a number of resources. Almost all food production for the world population is derived from land and the need to produce more is increasing from time to time due to an increase in population. For increasing production, either area under cultivation must be expanded or its productivity needs to be increased. The decreased agricultural productivity, gradual decline of soil fertility, and vegetation cover are the major consequences of land degradation (Taffa, T., 2002).

The land degradation is one of the biggest problems in sub-Saharan Africa, threatening the lives of millions of people (Belay Manjur, et al., 2004). In Africa, the problem of soil erosion is estimated to cause damage of $26 billion annually to productive soils (Lal, R., 2001). According to Angima, S.D., et al., (2003) leads to 5 million grams per hectare of productive top soil being lost to lakes and oceans each year. These processes of land degradation contribute to the worsening poverty and further marginalization of rural people in sub-Saharan Africa. Land degradation in developing countries like Ethiopia, mainly in sub-Saharan Africa (SSA), is largely an outcome of the existing agricultural production system, which is a 'resource- poor' agriculture characterized by uncertain rainfall, low inherent land productivity, lack of capital, inadequate support services and poverty (Mekuria, W., et al., 2006).

In Ethiopia more than 85% of the population live in rural areas and derive their livelihoods from agricultural activities. Therefore, soil and water conservation in Ethiopia is not only related to improvement soil fertility and conservation of the environment but also it is a key factor for sustainable development of the agriculture sector and the economy of the country at large (Teklu, E., et al., 2018 ; Gete Zeleke, 2000). ISWC measures are benefiting by reducing soil erosion and changing the soil physicochemical properties for agricultural productivity.

Hence, it is worthwhile to investigate the effects of SWC practice on the main soil properties to evaluate the benefit of treating lands with bio-physical SWC measures. Physical SWC structures should be integrated with enclosure to enhance rehabilitation of degraded watersheds/landscapes. Integration of biological SWC measures that improve soil fertility was essential on the cultivated land of the watershed. Land degradation in developing countries such as Ethiopia has been a serious concern for its negative implications for the livelihood of the rural community and the environment on which they largely depend. Its immediate consequence is reduced crop yield, followed by economic decline and social stress (Greenland, D.J. 1994)**.** High seasonal rainfall intensity together with rugged topography and low vegetation cover caused by overgrazing and deforestation as well as low soil organic matter (SOM) content increases soil susceptibility to water erosion in the Ethiopian highlands (Hailesilassie, A., et al., 2005). Soil erosion and rapid soil degradation affect soil properties, undermine agricultural production and retard the economic development of the region. Moreover, other finding confirmed that soil degradation, especially soil erosion and associated soil nutrient depletion, is the major cause of the decline of agricultural production in Ethiopia (Nyssen, J., 2004).

Ethiopia to solve the problems of land degradation in the country, many efforts has been made since 1970s. Sustainable development and poverty reduction, socioeconomic performance and poverty profile of Ethiopia can be achieved by increasing the agricultural activity through integrated soil and water conservation practice (FDRE, 2002). Important strategic and policy reforms in Soil and water use planning are needed for the optimal use of land and other resources. Moreover, to conserve biodiversity for sustainable development, appropriate land use and management strategy is needed. To minimize the severity of the problem, soil and water conservation interventions with some new technologies were implemented in many parts of the country during the 1970s and 1980s. They were introduced in some degraded and food deficit areas mainly through food-for-work programs. The major types of conservation methods were structural type, and of these the most common were the funiajuu and soil (or stone) bunds and Hundreds of thousands of kilometers of funiajuu and soil (stone) bunds were constructed on croplands in Ethiopia (Belay, T., 1992; Herweg, K., Ludi, E., 1999). Soil and water conservation must therefore be central to strategies of agricultural, rural development and to reserve land degradation in sub-Saharan Africa. Soil and water conservation practice is the integrated use of land, vegetation, and water in a geographically discrete drainage area for the benefit of its residents, with the objective of protecting or conserving the hydrologic services the conservation structures reducing or avoiding negative downstream and groundwater impacts (Darghouth, S., et al., 2008).

Rehabilitation of natural resource mainly realized through integrated soil and water conservation practice (i.e., biological and mechanical soil conservation measures). In different particle of the countries of Ethiopia was a big problem in natural management because there is highly soil erosion problem, land degradation, deforestation etc. Even though a number of watershed management practices of soil and water conservation practice have been introduced in Wolaita zone including this study area and the above problem had been common feature.

Hence, integrated soil and water conservation (ISWC) measures in the country aim not only to control soil erosion but also to sustain agriculture and economic development of the country at large (Haregeweyn, N., et al., 2015). Different ISWCP implemented like bunds stabilized with grasses such as vetiver (V.zizanioides), C. palmensis, other leguminous plants and etc. brought changes on the nature of landscape. This signifies that, the integrated implementation of physical structures with biological/vegetative measures especially grasses are more effective in slope transformation. Stabilization of the micro-ecosystem as compared to other soil and stone bund stabilization techniques or non soil and water conservation land (Demelash et al., 2010).

In the Southern region, including Sodo Zuria woreda in Wolaita zone different types of integrated soil and water conservation measures (both biological and physical) are practiced, however, site suitability of measures has not been assessed. Knowledge of farmers' perceptions and attitudes toward land degradation is an important first step to tackling the problem. Land degradation is not a new phenomenon in the region as well as in this study area. It is often claimed that farmers do not fully understand the causes and consequences of land degradation. Nevertheless, farmers frequently undertake traditional methods of soil and water conservation such as simple diversion ditches across their fields to divert runoff and therefore prevent their land from becoming waterlogged (Lakew, D., et al., 2006).

In the area under the present study, there is long-lasting intensive cultivation. To reverse the problem, soil and water conservation practices are an influential tool which enables the productive potential of the soil. Farmers in the study area have been practicing, physical soil and water conservation structures were started in order to improve their land productivity through erosion reduction, implementing different physical soil and water conservation measures such as soil bunds, bench terrace, and trench have been practiced at Sodo Zuria Woreda in Gurumo Woyde lonke micro watershed as effective measures for continued soil problems (SZWAO, 2020).

The objectives of this research

- To evaluate the effect of integrated Soil and Water Conservation on physicochemical properties of soil.
- To explore the perception of the farmer towards implementation of integrated soil and water conservation.

Materials and Methods

Description of the study area

Soddo Zuria Woreda is one of rural Woreda administration in Wolaita zone (Southern Nations Nationalities Peoples' Region). The Woreda is located at a distance of 390 km (to the south) from Addis Ababa. Sodo Zuria woreda is bounded from north Damot-gale Woreda, south Humbo and ofa Woreda, east Damot-Woyde and West Kawo- Koysha and Damoti-sore woreda. The total land coverage of the woreda is 40805 hectares, of which 12269 Ha (35.75%) is allocated for crop production, 9067 Ha (19%) for fallow land while 12019 Ha (30.61%) for grazing land and 7450 Ha (15.02%) for forest land Sodo Zuria Woreda Agricultural and Rural Development (SZWARDO, 2020). The Woreda has 25 rural Kebeles administrative and Gurumo Woyde kebele is one of the rural administrative kebeble in sodo zuria woreda. The study was conducted in Lonke-watershed,in Gurumo-woyde kebele, sodo zuria Woreda, Wolaita Zone which is situated nearly 5 Km away from Wolaita Sodo town. It is geographically located at 6°57'20.035'' N Latitude and 37°46'31.279''E Longitudes. Lonke-watershed was divided into 3 slope class with total population of about 1525 Central Statistics Agency (2009). Lonke-watershed was selected for the research because of the widespread implementation of integrated soil and water conservation structures to control soil erosion.

Topography of the Lonke watershed

Topographically, the Lonke watershed lies within an elevation range of 2200-2850 meters above sea level. The land classification based on slope 3% is flat, gentle is 12%, undulating is 23%, and steeping lands is 62%. The slope in general declines East to West with all drainage being directed to the Waja River (SZWARDO, 2020).

Agro ecology of the study area

The agro-ecology of the study area is dominated by midland that covers about 57% of the total area, and the remaining 43% is highland with rugged mountains and slopes. Damota Mountain is the highest peak (over 2950 m.a.s.l) in the Woreda and is considered as the main water source to the surrounding communities Lonke-Watershed are located around the mountain of Damota. The altitude of the water-shed falls in the range of 2200 to 29500 m.a.s.l.(above sea level) (Fig.1.).

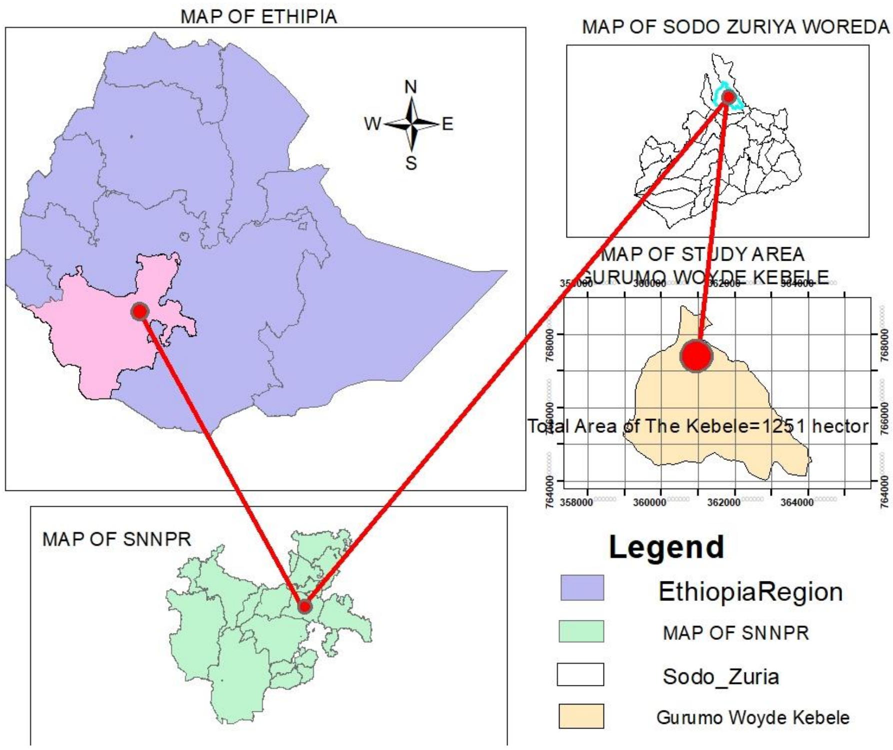

Fig. 1. Map of study area. Source (Adindan UTM Zone 37N WKD 2013 Authority:EPS).

Altitude

Based on the information from Woreda agricultural office, in most parts of the study area the topography is generally characterized by different land forms: such as flat, gentle sloping plains and steep slope to rolling plains with substantial proportion of low to moderate relief hills Wolaita Zone Agricultural and Development Office (WZADO, 2018). The variation in altitude varies from 1500-3200 meter above sea level.

Population

The total population of the Woreda is 144244 out of which 71,125, male and 73119 female Centeral stastistics agency. The population densities in the Woreda is 490 persons per square kilometer from the Wolaita Zone finance and economy development organization (WZADO, 2018). Majority of the population resides in the rural areas and their livelihood mainly depends on subsistence agriculture.

Climate

The study area mean annual maximum and minimum temperatures are 23°C and 15°C, respectively. The study area has annual rainfall of 1600 mm per annum, which is characterized by one long summer and one short spring rainy season and Soil types of the area are mostly sandy and sandy loam, Sodo soil laboratory center report. The long summer rainfall is mostly started mid-June and ended mid-October which is the main rainy season for crop production while the short rainy season which called 'Belg' is occurred between March and April.

There are two agricultural production seasons; meher (long rainy season) and belg (short rainy season). The meher rains start in June and extends up to mid September, while the belg rainy season lasts from March to May. The belg season contributes the highest share to the annual crop production, and about 87% of the farmers operate in this season.

Major agricultural practices and farming System

Rain-fed crop production during summer season is mostly practiced in the catchment area where intensive cultivation, sowing, weeding and other activities are performed. The livelihood of the community is mainly based on mixed farming. The dominant crops produced in the area are barley, wheat, teff (Eragrostis teff), potato, maize and others. Moreover, livestock production plays a significant role in the livelihoods of the people in the study area. Livestock is also a source of foods and cash as well as the major source of draft power, fuel and fertilizer for crop production. The major livestock manage in the study area include caws, Oxen, sheep and goat, donkey and poultry. Mule and horses found in small number.

However, the agricultural system is still traditional and is often characterized by low productivity. Farmers grow a variety of crops in the two seasons. Maize is the major food crop grown by all farmers as a main source for own consumption as well as for market. Haricot bean is often intercropped within maize field for own consumption and cash in the midland, while wheat and barley are the major crops grown in the highland area. Irish and sweet potato, enset/false banana/, cassava, taro and other root crops are also grown in the Lonke-watershed. Root crops play an important role in filling the gap in household food requirement particularly during the lean season.

Common conservation structures in the Lonke watershed

Among those physical soil conservation practices fanyajuu, Bench terrace and soil bunds and deep teranch are the most common in farm land and highly implemented in lonke micro watershed and biological measures like Plantation of cajanuscajan (pigeon pea), Sesbania sesban, Leucaena, elephant grass and desho grass on embankment has been done largely this data obtain from by field observation (WZFED, 2018).

Biological conservation practice

Biological soil conservation measures include; vegetative barriers, agronomic and soil Fertility improvement practices, which help in controlling surface runoff, reduce soil losses and improve productivity. Agronomic measures are practiced as the second line of defenses in erosion control exercise while mechanical/physical measures are primary control measure and are often considered as reinforcement measures (MoA, 2001). Strip cropping is a cropping practice where strips of two or more crops are alternately placed on the contour for erosion control. The practice is useful for controlling soil erosion which is integrated with physical strictures to control erosion with cropping system is dominated by row (sparsely populated) crops. Bench terraces are widely applied in the study area in modern conservation systems terracing may have developed in wolaita Zone, Sodo Zuria Lonke micro-watershed. Bench terrace and soil bunds are generally quite common in the Lonke micro watershed Sodo zuria woreda of the study area. They have been used for generations in Ethiopia as well as in this study area and where they are known conservation practice in this study area as well as Wolaita zone and in some parts of South Ethiopia.

Land use and vegetation

The Woreda has a total area 33,749.8 hectare. Most of which is a cultivated land 1826 hectare, while the remaining land use and covers include Range land 2740.5 hectare, forest land 8564.5 hectare,water covered parts 155.8 hectare, settlement 2927 hectare and other bare lands 333 hectares. The vegetation cover of the Woreda is composed of remnant forests, communal forests, homesteads plants, and natural vegetation in closed areas. The southern low land part of the Woreda is mostly dominated by Eucalyptus globules species. Mostly vegetation types found in the study site are native species such as Cordia africana, Ficus vaste and exotic species like Junipers procera. However, Cordia africana, and Eucalyptus globules are the dominant from foreign species of trees.

Household survey data collection

The sample of households from Lonke-watershed was selected by simple random sampling based on the available list to explor the farmers perception toward the implementation of soil and water conservation practices. Based on the size of households heads in watershed; the population proportionate samples were taken. On the formula provided by Kothari, C., (2004), the total sample size for the household survey is 81 as per the equation, to determine sample size with 95% confidence interval.

n= $\frac{z.^{2}\, p.q}{e^{2}}$ Where, n=sample size

z=the value of standard variety at a given confidence level
and to be worked out from table showing area under normal curve.
p=sample proportion
q=1-p
e=given precision rate or acceptable error (8%).

When the population size is finite, the formula for sample size determination was modified as under:

n= $\frac{z^{2}\, p.q.N}{e^{2}(N-1)+_{-}z^{2}.p.q}$ $n = \frac{1.96^{2}.0.5.0.5..252}{0.09^{2}(252-1)+\ 1.96^{2}.0.5.0.5}$

Where, N=252 total house hold head in water shade
z=1.96 (desired confidence level is 95% and value obtained from table)
p=0.5 (sample proportion).
q=0.5 {(1-0.5) i.e., 1-p}
e=8% or 0.08 (precision rate or acceptable error)

By putting the value, in positive Kothari, 2004 formula
n=$(1.96)^2.(0.5).(0.5).\ 252$
$(0.09)^2(252-1)+(1.96)^2.\ (0.5).\ (0.5)$ n=80.67 or 81,
n=81 sample households was taken large number of sample households.

According to the above formula, this study was carried out using a total of 81 sample households that was selected proportionally across the the Lonke watershed based on simple random sampling techniques the researcher select 81 household farmer Participants from the total household (N=252). These 81 household participant farmers were selected from the total section of the selected Lonke-watershed.

In each FGD, (old, young, male and female) from each group 8-10 members was select at each site to collect supporting data about the effectiveness of integrated conservation measures in the watershed. The watershed were purposive selected from different watershed. Sample households were selected through simple random sampling method by considering farmers understanding, participation in campaign work, and their involvement in different decision-making processes in the kebeles. The sex and age of farmers and their implementation level of ISWC measures were also considered in the selection process. The effects of ISWC measures were evaluated using adjacent integrated conserved, physical soil and water conservation alone and non-conserved plots in the study area Lonke micro-watershed in Sodo Zuria Woreda Wolaita Zone. The total area of watershed 595 hectare and the total 81 household heads were selected out of 252 total HH. The Sites having integrated soil and water conserved, physical soil and water conservation alone and non-conserved plot adjacently was identified through reconnaissance survey and transact walk survey. This is vital to make sample sites relatively similar in physical and environmental conditions for comparison and the variation could be due to ISWC structures. A combination of methods was used to collect relevant data. Primary data was collected during the study by using various techniques such as face-to-face interview by using interview schedule (close and open ended questionnaire), transect walk, direct observation, key informant and focus group discussion. In order to ensure the reliability and validity of the data collected; triangulation (i.e., asking same question to different people in different ways/using more than one, and often three, sources of information to cross-check responses of interviewees). These methods include observation, focus group discussion, and interview with randomly selected farmers and other key informants. As part of the primary data, information also was collected through structured questionnaire from woreda agricultural experts, Kebele leaders, SWC supervisors and DAs accordingly. Secondary sources of information employed in this study include published materials such as reports, plans, official records, project proposals and reports, research papers and websites and these sources were used carefully by counter checking for their validity. Selected watershed with three treatment and each treatment sites considering the three slope class. Slope of the watershed ranged from 3-34% and three slope classes are 3-8% (lower), 9-15% (middle), and 16-34% (upper) was considered during selecting the three treatment sites. The experiment was designed in three treatments: (1) sites treated with integrated soil and water conservation (ISWC), (2) sites treated with Physical soil and water conservation (SWC alone), and (3) sites without soil and water conservation practices (NSWC) in three replications with three slope gradients and better at representing the watershed.

Soil sampling procedure and analysis

Disturbed and undisturbed soil samples were collected from integrated soil and water conservation site, physical soil and water conservation alone site and non conserved site were soil sampling farm lands using auger and core sampler, respectively starting January 2020. The Soil samples were collected from each experimental fields treated with ISWC, fields treated with physical SWC, and fields without conservation (Non-conserved) at the depth of 0-30 cm, Five disturbed composite samples were collected based on five auguring points from the top 30 cm soil depth at each site. Five collected samples were mixed thoroughly and one composite sample was taken for each of five auguring points and 9 (Nine) composite soil sample were collected from each treatment site. The total 27 composite samples were collected. In addition, 9 core sampler of undisturbed soil samples were also collect from each site to determine soil bulk density (BD) using a core sampler at a depth of 0-30 cm. and total 27 core soil samples were collect from three sites (ISWC, SWC alone and NSWC) sites and with the three slope classes (Upper, Middle and Lower) in each treatment site. The top 30 cm soil sample was collected in the plastic bag and tagged separately in terms of its replication, Treatment site, and slope gradient. Then, the collected soil samples mixed together to form a composite sample of one kilogram of each treatment of soil sample and air dried and grinded, and sieved to pass through a 2 mm sieve to make it ready for laboratory analysis. The soil laboratory analysis were done at SNNPRS Agriculture Office, Wolaita Sodo soil laboratory research and fertility improvement center.

Selected soil fertility indicators such as soil texture, soil pH, bulk density (BD), organic carbon (SOC), available phosphorus (Av.P), Total Nitrogen (TN) and Cataion exchange capacity (CEC) in the soil were analyzed using standard laboratory procedures. The soil bulk density was determined by core sampler method described in Black, C.A., et al., 1965. The determination of soil particle size proportions were carried out by hydrometer method suggested by Sakar and Haldar (2005). Following this, the determination of soil texture and textural classification ware identified using equilateral triangle suggested by United States Department of Agriculture (USDA) and described by Mosman, K., 2013. Soil reaction (soil pH) was determined by a 1:2.5 soil: water ratio using a pH meter as described by Van Reeuwijk, L., 2002.

The soil organic carbon (SOC) concentration was determined by using Walkley and Black rapid titration method as described in Sakar and Haldar., 2005. The available phosphorus (av. P) content was determined using Olsen extraction method as described by Van Reeuwijk, L., 2002. To understand the effect of integrated soil and water conservation (ISWC) measures with and without integration of fodder tree species on Soil texture, SOCs, soil pH, av. Phosphorus, CEC of nutrients. Five disturbed composite samples were collected based on five auguring points from the top 30 cm soil depth at each site. Five collected samples were mixed thoroughly and one composite sample was taken for each of five auguring points. The total 9 composite sample was collected from each site(ISWC, SWC alone and NSWC).

In addition, 9 core sampler of undisturbed soil samples were also collect from each site to determine soil bulk density (BD) using a core sampler at a depth of 0-30 cm and total 27 core samples were collect from three sites (ISWC, SWC alone and NSWC) the slope gradient upper slope (15-34%), Middle slope (8-15%) and Lower slope (3-8%) respectively from each sites.

Data analysis

Soil data was subjected to descriptive analysis. To see the effect of soil and water conservation practices on soil physicochemical properties. Statistical Analysis of laboratory results of the soil samples were subjected to SAS software version 9.3 SAS, ANOVA was carried out using the General Linear Model (GLM) for soil physicochemical properties of ISWC practice, physical SWC and NSWC (Control). This model was used for comparison of treatment means performed using Tukey's Least Significant Difference test (LSD) at $P<0.05$ probability level.

Results and Discussion

Marital status

The marital status of respondents shows that about 77.7 percent of the respondents were married. Analysis of the data also indicates that 5.7 percent of the populations were unmarried, 4.9 percent were divorced and finally 11.1 percent of the populations were widowed. Majority of the respondents responded that the soil and water conservation practice were left for married household heads. Changes in the distribution of marital status have an important bearing on the size and structure of families and households (Table 1).

Table 1. The Marital status of household head.

Marital status	**Frequency**	**Percent**
Single	5	6.3
Marrid	63	77.7
Divore	4	4.9
Widow	9	11.1
Total	81	100

Source: Own survey, (2021).

Sex of household head

The total numbers of sample households used for this study were 81. The sex distribution of sample household heads was about 16% female and 84% male in Table 2. The great difference in male and female household heads in the present study clearly shows gender difference in the implementation of ISWC and physical SWC alone measures. As indicated in the survey results, most of the female household heads are not participated to implement integrated soil and water conservation practice or they have less attention to conserve integrated soil and water conservation practice and the male headed households are more and actively participated in practicing integrated soil and water conservation practice as well as physical soil and water conservation practice.

Table 2. The association between sex of household heads and SWC practice.

Characteristics of HHH	**Respondents**	
Sex	**Frequency**	**Percent**
Male	68	84
Female	13	16
Total	81	100

Source: Own survey, (2021).

The above table indicates that all respondents (84%) male have actively participated and perceived to practice integrated soil and water conservation practice in Table 1.

Educational status

This is attributed to the level of education of the household heads are important for the implementation of integrated soil and water conservation practice (Million Tadesse and Belay Kassa, 2004). Table 3 has indicated that (54.2%) of the total sample respondents have attended Illiterate implement ISWC practice, (19.7%) Grade 1-4, (18.4%) Grade 5-8, and (7.7%) where as above grade 9 in Table 3. However, the finding of this research shows that farmers participated in integrated soil and water conservation practice with lower class educational status. This again clearly indicates that the need for further training and extension services on integrated soil and water conservation practice to make the farmers positive perception of integrated soil and water conservation practices more effective on soil properties (Woldeamlak, B., 2005).

Table 3. Educational status households association between SWC practices.

Educational status of HH	**Frequency**	**Percent**
Illiterate	44	54.2
1-4	16	19.7
5-8	15	18.4
Above grade 9	6	7.7
Total	81	100

Source: Own survey result, (2021).

Age of household

Age is one of the demographic characteristics that influence the perception of farmers toward soil and water conservation practices. Farmers of the study area are classified under different age group. According to the Table 4, most of the household heads (80.3%) were in the age category from 20-50 years. Farmers in this age group are to have a good understanding of the problem of soil erosion. Due to this they are more interested in soil and water conservation practices. As explored through interview, farmers of these age groups to have a good understanding on the problem of soil-water conservation, and usually interested in implementing soil and water conservation practices than the other age group. The proportion of elderly people (over 60 years) and young farmers (Under ages 19 years) was an age group in which labor shortage can be a hindrance to practicing soil-water conservation measures.

Table 4. Farmers Perception on implementation of SWC practice and age of household heads.

Age category of HH	**Frequency**	**Percent**
20-40	52	64.3
40-50	20	16
50-60	5	6.2
>60	4	4.9
Total	81	100

Source: Own survey, (2021).

The findings of the present study are in agreement with that of Assefa, D., (2009) who found that most of the farmers between ages of 20-50 years actively participated in integrated soil and water conservation practice and physical soil and water conservation practices. This group of people seems to have better understanding for soil and water conservation practices. Moreover, this group of people is effective labor forces to implement soil and water conservation practices. Few elder people implement soil and water conservation practices through hiring laborers of young age group. This is because household heads with large number of family members may help to effectively adopted several SWC measures in their farm land either physical or biological soil and water conservation practice. These findings are generally supported by Ayalew, G., (2014); Kibemo, D., (2011) who found that household heads with medium and large family member have positive influences on practicing soil and water conservation measures. This means household heads with high working capacity may positively correlate with integrated soil and water conservation practices.

Household size

As shown in Table 1 the majority of the respondents (61.8%) were in the categories of 8-10 family members. The nature and size of family affects the degree of SWC. As clearly known soil and water conservation structure is labor intensive, households with larger household size make decision to maintain structures. According to the respondents view with resource person, large family size is very important for soil conservation measures because having a small number of children requires additional labor from out of family to construct and maintain soil conservation structures. Having large family size could result in demands more land for agriculture. This might be affect soil erosion due to increases disturbance of land for agriculture. The existence of large number of family members with limited resource could affect soil degradation due to increasing demand for food with limited land. Therefore, it is possible to perceive that family size has significant role in the construction of physical conservation measures and also biological soil and water conservation practice. This study conclude that integrated soil and water conservation practice that needs large family size to conserve different soil and water conservation practice.

Table 5. Farmers Perception on implementation of SWC practice by Family size.

Family Size	Frequency	Percent
Small(1-3)	10	12.3
Medium(3-7)	21	25.9
Large(8-10)	50	61.8
Total	81	100

Source: Own survey, 2021.

Table 6. Farmers perception on soil erosion and benefit of conservation practice.

Farmers perceptions on SWC Practice	Response	Frequency	Percent
The soil erosion is a problem for your farm lands	No	9	10.2
	Yes	72	81.8
	Total	81	92.0
The Occurrence of soil erosion is a problem of your farm land	No	23	26.1
	Yes	58	65.9
	Total	81	92.0
The ISWC more benefit than physical SWC alone	No	7	8.65
	Yes	74	91.5
	Yes	81	
Can soil erosion be controlled in your land after ISWC Practice.	No	13	16.1
	Yes	68	83.9
	Total	81	100

Source: Own survey, (2021).

The integrated soil and water conservation practice was the best practice in Lonke micro wa tershed in Gurumo Woyde kebele, sodo zuria woreda and the farmers was perceived 81.8% respondents 'recorded comfirm about soil erosion problems and occurance of soil erosion before integrated soil and water conservation, Table 5. Though farmers perceive Physical soil and water conservation practice is not much more benefit as integrated soil and water conservation practice (Table 5).

Framers perception on integrated swc practice and extent of soil erosion before and after

Generally, perception of soil erosion problem is an important factor to suggest possible solutions for farmers and makes decisions on conservation investments. The perception of farmers in Lonke micro watershed showed that soil erosion was perceived as a problem by more than 83% of the farmers before implementation of integrated soil and water conservation practice. All respondents recognized soil erosion as a problem in at least one of their plots, and were also able to identify indicators of the problem and to implement the different integrated soil and water conservation practice to increase soil organic matter (OM) and other soil properties. 89.9% of farmers perceived integrated soil and water conservation practice as important tool to increase soil fertility and

9.1% mentioned difficulty during plowing as indicators of soil erosion. Reduced productivity of land, declining soil fertility, formation of gully, and soil deposits on river bank were also indicated during focus group discussion. Participants of focus group discussions indicated that integrated soil and water conservation practice is not only used for improve soil propertice, because of its positive contribution for farmer's livelihood.

According to Table 6, it is understood that level of soil erosion and its severity is medium 73% with somehow high 27% but not at all low. This was attributed to the perception of local people and their engagement in soil and water conservation measures on their farm land and the entire watershed as it was supported or similar with Woldeamlak, B., Sterk, G., (2002). But, because of disparity and inconsistent follow up and guidance (Table 7) the result is indicating that local peoples are not fully engaged with all technical knowledge and expectations.

Table 7. Farmers Perception on effects of SWC practice association with the extent of soil erosion before and after intervention.

Issue	Response	Frequency	Percent
The Occurrence of soil erosion Intervention of ISWC Before and After	Yes	58	71.6
	No	23	28.4
	Total	81	100
Extent of soil erosion before ISWC you see	Severe	67	82.7
	Moderate	10	12.3
	Slight	4	5
	Total	81	100
Extent of soil erosion and soil organic after Intervention ISWC you see	Severe	5	6
	Moderate	9	13.5
	Slight	67	80.5
	Total	81	100

Source: Own survey, (2021).

Regarding the status of the soil erosion before and after introducing ISWC, most farmers had their own mechanisms to identify this status (severe, moderate and slight). Accordingly, if the farm land face high removal of top soil, high distribution of sand with shallow depth, less productivity and large gully formed in the farm, erosion is considered as severe then the land was non-conserved and/or before intervention of integrated soil and water conservation practice, if soil has better depth and better productivity with small gullies, farmers described it as moderate and land with deep depth soil with good productivity, soil fertility improvement and low removal of top soil, is considered slight this result is similar with Kirubel, M., Gebreyesus, B., (2011).

Out of total respondents 71.6% confirmed that the extent of soil erosion before the implementation of integrated soil and water conservation structures on their plots was severe and only 39.5% said that it was moderate (Table 8). Completely the current evaluation of integrated soil and water conservation practice in the study watershed was achievable. Indictors of non-conserved land was observed by different key informants, Focus desiccation group and different respondents are concluded that, there is soil fertility decline, Mass movement of top soil and soil organic matter decreases, 87.6%, 81.5% and 96.3% respectively (Table 10). This might be the reason why farmers need short-term benefit and less awareness of the effectiveness of ISWC(Bench terrace with peagen pea) measures. Because, the shortage of farming land, shortage of awareness creation and lack of training. Additionally, lack of proper design of structures and selection of structures that best fit with the weather condition of the area may also reduce the effectiveness of ISWC measure and leads to unconditional perception toward the structure by farmers. The result of the questionnaire survey indicated that most of respondents agreed with the presence of soil erosion problem under their field before the intervention of SWC practice, but now their land treated with Bench terrace, deep trench with bench terrace with fodder species and other ISWC structures (like Biological soil and water conservation practice). However, integrated soil and water conservation practice improve soil indicate that the farmers agreed in the soil fertility increasing after the intervention of ISWC. On the other hand the soil erosion in stutas their farm plots where as 80.5% and 13.5% and 6% of the respondent observe as slight moderate and sever respectively (Table 8).

Generally, awareness of soil degradation problems in Ethiopia is high and the farmer's perception increased, on integrated soil and water conservation practice. Participation in integrated soil and water conservation (ISWC) promotes a positive and significant effect on perception of farmers. Gebreselassie, T., et al., 2009, reported that participation of different stakeholders during strategy development, policy formulation and technology selection to sustain agricultural productivities helps to identify the interests of the different stakeholders and to choose more acceptable and appropriate management options.

Effects of soil and water conservation on soil physical properties

Soil texture

The ANOVA shows that, the general linear model (GLM) on the study soil's Clay, silt, and sand fractions were significantly affected (p=0.0001) in the practice of Bench terrace integrated with pea-gen pea and deep trench (ISWC), physical soil water conservation bench terrace (SWC alone), Control (NSWC) and slope gradients. The overall mean of sand fraction was found to be high in the upper (>15%), and low in the lower (<8%) slope positions. However, the silt and clay fractions were higher in the lower (<8%) slope positions. In general, sand content increases as slope gradient increases, and clay and silt content decreases as slope gradient increases. This could be due to the selective removal and transport of fine soil particles such as clay and silt by water erosion to the lower slope, leaving the coarser materials onsite in the upper slope positions. The result similar with the reports of Tekelu Erkossa, and Gezeahegn Ayale., (2003) that showed an increase in sand and decline in silt and clay contents with an increase in slope gradient in the Lonke watershed in Wolaita Zone Sodo Zuria woreda. According to Sharma, P.P., Gupta, S.C., (1995) sands are easily detachable but difficult to transport; in contrast, silt and clay are easily transportable although they are difficult to detach by runoff water.

The statistically significantly deference ($p \leq 0.05$) was found in clay, silt, and sand proportion between treated and untreated fields. The overall mean percentage of clay and silt content was significantly higher in the treated than the untreated fields, whereas the sand fraction was significantly lower in the treated than the untreated fields (Table 8). This might be due to the accumulation of fine-textured clay and silt fractions behind the soil and water structures constructed. The result similar with the findings of Kebede W, and Awdenegest M, (2011), in which higher clay and silt proportions were found in fields treated with SWCPs than the untreated fields.

Table 8. Tukey Mean difference of soil texture.

Soil Properties	**Slope Gradient**				**Soil Properties**	**Slope Gradient**
		NSWC	**SWC alone**	**ISWC**	**Overall Mean**	
	Upper Slope	46.00 ± 0.00A	35.33 ± 1.15^{C}	36.00 ± 3.4^{C}	39.11 ± 5.49^{A}	SL
Sand%	Middle Slope	34.00 ± 2.00^{B}	21.33 ± 1.15^{A}	21.33± 2.3^{A}	25.56 ± 6.54^{B}	SL
	Lower Slope	20.67 ± 2.31^{C}	17.33 ± 1.15^{B}	18.00 ± 0.0^{B}	18.67± 2.00^{C}	LS
	Overall Mean	33.56 ± 11.08^{A}	24.66 ± 8.25^{B}	25.11 ± 8.5^{B}		
	Upper Slope	10.00 ± 1.15^{C}	28.67 ± 2.31^{D}	28.00 ± 1.1^{D}	26.89 ± 2.67^{C}	SL
Silt%	Middle Slope	10.67 ± 3.05^{B}	38.33 ± 1.15^{B}	36.00 ± 2.00^{B}	34.00 ± 3.16^{B}	LS
	Lower Slope	21.67 ± 1.15 ^{A}	36.33 ± 1.15^{B}	36.67 ± 0.0^{B}	38.22 ± 2.11^{A}	LS
	Overall Mean	31.78 ± 7.51^{B}	39.78 ± 4.17^{A}	33.56 ±4.3^{A}		
	Upper Slope	17.33 ± 2.00^{B}	28.33 ± 3.46^{A}	43.66 ± 3.46^{A}	34.00 ± 4.00^{B}	SL
Clay%	Middle Slope	21.33 ± 4.62^{A}	41.66 ± 1.15^{B}	47.00 ± 3.05^{B}	40.44 ± 4.70^{A}	SL
	Lower Slope	24.00 ± 1.15^{A}	45.33 ± 2.31^{B}	52.00 ± 1.15^{B}	43.11 ± 3.62^{A}	LS
	Overall Mean	34.66 ± 4.58^{B}	41.56 ± 4.94^{A}	41.33 ± 4.8^{A}		

(Source: Laboratory Results, 2021). *Means within a columns followed by the same letter (s) are not significantly different at $P<0.05$; LS=Loamy soil, SL=Sandy loam.

Soil bulk density (BD)

Soil bulk density (BD) showed a statistically significant deference ($p \leq 0.05$) between the site treated bench-terrace with pea-gen pea and untreated fields and among different slope positions (Table 8). BD was found to be lower in fields treated with ISWC and SWC alone than the control. Higher BD in the untreated fields could be associated with the absence of SWCPs that exposed the soil to erosion and consequently to the removal of organic carbon from the topsoil layer. This finding was in line with those of (Abay, C., et al., 2016; Worku, H., 2017) which showed significantly lower BD values in the treated micro-watersheds than the untreated in Adaa Berga district, western Ethiopia, and Ambachia watershed, northern Ethiopia, respectively. Similarly, BD showed a statistically significant variation ($p \leq 0.05$) at deferent slope positions. It was found to be lower value in lower (3-8%) slope than in the upper (16-34%) slope positions in each treatment site. As slope gradient increases, BD increases, and also the slope position decreases, BD decreases which could be associated with low soil organic matter content, and associated with high organic matter contents.

Though there is highly significant difference ($p \leq 0.0001$) in soil BD among the conservation sites treated with Bench terrace-peagen pea and deep trench (ISWC) measures, the value recorded 0.91 with the lower slope position, 0.96 g/cm^{3} Middle slope position and the value recorded 1.15 in upper slope position. The values are recorded 1.02 g/cm^3 for the sites treated with Bench terrace (SWC alone), with lower slope, the value 1.11 g/cm^3 recorded in Middle slope and the value 1.2 g/cm^3 with upper slope position. In other hand the sites treated with NSWC measures the value recorded 1.33 g/cm^3 with lower slope, 1.4 g/cm^3 with Middle slope and 1.53 g/cm^3 upper slope position.

The result shown in Table 10. The lowest recorded value of BD 0.91 g/cm^3 in the conserved site Bench terrace-pea-gen pea and deep trench (ISWC) with lower slope position and the highest value of BD 1.53 g/cm^3 recorded in the site of Non-soil and water conservation (NSWC) with upper slope position, because there is high erosion and soil compaction. This findings similar with Kebede and Awdenegest, 2017. The lowest BD, of the conservation farm land site treated with ISWC measures, is due to the presence of fodder species of pea-gen pea which modify soil BD through increased addition of organic matter, and also to the increased soil porosity due to root actions, reducing soil erosion and deposing soil in lower slope.

Finally, the soil BD is significantly influenced by different soil and water conservation practice with slope gradient (Table 9).

Table 9. Effects of soil and water conservation practices (SWCPs) and slope on soil BD.

Soil Properties	Slope Gradient	Soil and Water Conservation Practice (Swcp)			
		ISWC	**SWC**	**NSWC**	**Over all**
BD	Upper Slope	1.15 ± 0.11^A	1.2 ± 0.07^B	1.4 ± 0.03^B	1.25 ± 0.07^A
	Middle Slope	0.96 ± 0.09^A	1.11 ± 0.09^B	1.33 ± 0.07^B	1.13 ± 0.09^A
	Lower Slope	0.91 ± 0.02^B	1.02 ± 0.11^C	1.15 ± 0.02^C	1.02 ± 0.11^B
	Over all	1.006 ± 0.06^A	1.11 ± 0.12^B	1.29 ± 0.09^B	

ISWC=INTEGRATED SOIL AND WATER CONSERVATION, SWC=SOIL AND WATER CONSERVATION ALONE, NSWC=NON-SOIL AND WATER CONSERVATION.

Effects of integrated soil and water conservation on soil chemical properties

Soil organic carbon

The soil OC significantly affected ($p \leq 0.0001$) by the conservation sites treated with Bench terrace-peagen pea and deep trench (ISWC) measures, Physical soil and water conservation (SWC alone) and Non-soil and water conservation (NSWC) with Lower, middle and upper slope gradient. The non-conserved in lonke micro-watershed was found to show significantly the highest mean value of bulk density than the treated with ISWC and physical SWC measures.

The value of soil organic carbon (SOC) was recorded in the site was treated with bench terrace-peagen pea with deep trench (ISWC) 8.38 g/cm^3, 4.25 g/cm^3 and 2.83 g/cm^3 with Lower, Middle and Upper slope gradient respectively. The value of SOC was recorded in the site was treated with bench terrace (SWC alone) 2.43 g/cm^3, 2.11 g/cm^3 and 1.68 g/cm^3 recorded in Lower, Middle and upper slope gradient respectively. The value of soil organic carbon (SOC) was recorded in the site with non-conserved (NSWC) 1.37, 0.74 and 0.51 g/cm^3 with Lower, Middle and upper slope gradient respectively in (Table 10).

Organic carbon (OC) value in the watershed

The ANOVA shows that, OC was significantly affected (p=0.0001) at 95% CI by the overall variables (Table 11). Whereas, this value does not indicate that all variable have influenced P-Value significantly, so that, independent and interaction effects were computed to understand the Specific influence of variables. Consequently, the treatment site (P=0.0001), slope gradient (p=0.0002), and have independently brought significant impact on the model at 95% CI. While, treatment site and Sampling slope position (0.0097) were statistically significantly affected interaction effects to the model at 95% CI (Table 11).

Table 10. The analysis of variances results for soil OC.

Source	DF	M S	F-Value	Pr>F	CV	Mean
(OC)					12.16	2.23
Model	8	1.85	25.10	<0.0001		
SLOPE	2	0.36	4.89	0.0020		
TRM	2	6.71	90.90	<0.0001		
Slope*TRM	4	0.17	2.31	0.0097		

DF=degree of freedom, Pr=Probability; F=F calculated, MS=Mean Squares, CV=coefficient of variance

The highest value of SOC 8.38 g/cm^3 recorded in the site integrated soil and water conservation practice with lower slope gradient and the lowest value of SOC 0.51 g/cm^3 was found in the site non-conserved (NSWC) with upper slope gradient. The SOCs in the soil of the land treated with ISWC was improved through appropriate soil and water conservation practices that integrated with fodder species with physical SWC (Bench terrace, trench with desho grass and bench terrace with peagen pea) measures, biological soil and water conservation practice. This integrated intervention also increased the conservation of SOM content through reduced erosion rates, which helps to sequester more carbon and plant nutrients and recycle them into the soil through decomposition of plant residues. In other hand soil organic carbon decreases with increasing slope and increasing soil erosion the site was non-conserved (Mulugeta Demelash and Karl Stahr, 2010). The soil organic carbon content under the integrated soil and water conservation practice was significantly higher than in the physical soil and water conservation alone and non conserved (Table 2). The result agrees with the finding of Feleke, S., Zegeye, T., (2006), who reported that soil organic carbon content in soils under three treatment sites were higher mean compared to non-terraced sites with similar slopes. Kebede Wolka, et al., (2011) also reported that non-conserved fields had significantly lower SOC as compared to the integrated soil and water conserved fields with different conservation measures and plant species.

Total nitrogen (TN) value in the watershed

The ANOVA table shows that, TN was significantly affected (p=0.000) at 95% CI by the overall variables (Table 12). The independent and interaction effects were computed to understand the specific variables' influences. Consequently, slope gradient (p=0.0001), and treatment site (p=0.0001) have highly significantly impacted on the model at 95% CI. Further, slope gradient and SWC treatment site interaction effect (P=0.0005) were statistically significantly affected, on the soil TN value at 95% CI.

Table 11. The analysis of variance result for soil TN.

Source	DF	MS	F- Value	Pr>F	CV	Mean
(TN)					105.94	0.48
Model	8	0.237	0.90	<0.005		
Slope	2	0.14	0.55	<0.001		
Trm	2	0.38	1.46	<0.002		
Slope*Trm	4	0.21	0.80	0.0005		

DF=degree of freedom, Pr=Probability; F=F calculated, MS=Mean Squares, CV=coefficient of variance, Trm=treatment.

Total Nitrogen (TN): TN showed a statistically significant deference (p ≤ 0.005) at deferent slope positions (Table 3). The value of soil total nitrogen (TN) was recorded in the site treated with bench terrace-peagen pea and deep trench (ISWC) 0.965, 0.84 g/cm^3 and 0.24 g/cm^3 with Lower, Middle and Upper slope gradient respectively. The value of TN was recorded the site was treated with bench terrace (SWC alone) 0.61 g/cm^{3,} 0.55 g/cm^3 and 0.45 g/cm^3 recorded in Lower, Middle and upper slope gradient respectively. The value of soil organic carbon (SOC) was recorded in the site with non-conserved (NSWC) 0.47, 0.28 and 0.12 g/cm^3 with Lower, Middle and upper slope gradient respectively.

The highest TN was recorded in the lower slope than in the higher slope gradients. This might be due to the removal of organic matter from the steep slopes the site does not conserved sites by soil erosion. Similar results were reported by (Haileslassie, A., et al., 2005). Similarly, TN showed a statistically significant deference (p ≤ 0.05) between the treated with (ISWC and SWC alone) and untreated fields respected with Lower slope, Middle slope and Upper slope gradient. The integrity treated fields showed higher TN values than the untreated fields (NSWC), which could be associated with the implementation of SWCPs that maintain soil fertility by decreasing the removal of SOC and TN through soil erosion. This finding is in line with Mulugeta Demelash and Karl Stahr, (2010), who found that higher TN content was recorded in treated fields by bench terrace, peagen pea and deep-trench compared with untreated fields with Lower and upper slope gradient respectively.

Table 12. Effects of SWCP and slope on soil chemical properties of TN and OC.

Soil Properties	Slope gradient	Soil and Water Conservation practice ISWC	SWC alone	NSWC	Over all
TN	Upper Slope	0.24 ± 0.00^b	0.45 ± 0.01^c	0.12 ± 0.01^b	0.27 ± 0.01^c
	Middle Slope	0.84 ± 0.0^b	0.55 ± 0.00^b	0.28 ± 0.01^a	0.55 ± 0.07^B
	Lower Slope	0.96 ± 0.03^a	0.61 ± 0.03^a	0.47 ± 0.06^c	0.68 ± 0.10^A
	Over all	0.68 ± 0.07^a	0.54 ± 0.09^b	0.29 ± 0.06^c	
OC	Upper Slope	2.83 ±0.16^b	1.68 ± 0.15^c	0.51 ± 0.06^c	1.67 ± 0.24^C
	Middle Slope	4.25 ± 0.31	2.11 ± 0.21^b	0.74 ± 0.19^c	1.78 ± 0.43^A
	Lower Slope	8.38 ± 0.30	2.43 ± 0.31^a	1.37 ± 0.30^c	3.32 ± 0.48^A
	Over all	5.15 ± 0.65^a	2.07 ± 0.47^b	0.87 ± 0.45^c	
	LSD 0.05		0.2157		

Source: laboratory results, 2021. ISWC=Integrated soil and water conservation, SWC=Soil and water conservation alone, NSWC=Non-soil and water conservation**.***Means within a columns followed by the same letter (s) are not significantly different at P<0.05;% OC=Organic Carbon percent; %TN=Total Nitrogen percent**.**

The result of soil total nitrogen showed a significant variation with respect to treatments and slope position. The overall total nitrogen content of soils under non conserved site was not significant and lower than that of soils under integrated soil and water conservation (Table 12). Similarly Demelash M and Stahr K., (2010), also reported that farmland with physical SWC measures had higher total nitrogen compared to non-conserved land.

The relatively difference (p ≤ 0.005) in total nitrogen was observed along physical soil and water conservation and non conserved site, but higher mean value is 0.24 was observed in the integrated soil and water conservation site. The average total nitrogen content for both conserved and non-conserved treatment sites could probably rated to the rapid mineralization of existing low organic matter content. The other reason might be associated with the contribution fodder plant species and leguminous plants species which have the capacity to fix nitrogen through the stabilizing conservation structures within the integrated soil and water conservation practices.

The soil cation exchange capacity (CEC) value in the watershed

The ANOVA table shows that, CEC was significantly affected (p=0.0001) at 95%CI by all the study variables and some of the interaction effects of variables. The independent factors such Slope (p=0.0001) and treatment (TRM) p=0.0001 have significantly independently influenced at 95% CI while, the other interaction factors such as, treatment-slope interaction (p=0.0019) and trees species-sampling location (p=0.0606) were not significantly affected the model on soil CEC value at 95% CI in the following Table 13.

Table 13. The analysis of variance result for soil CEC.

Source	DF	MS	F- Value	Pr > F	CV	Mean
(CEC)					11.88	30.78
Model	8	115.83	8.66	<0.001		
Slope	2	131.14	9.80	<0.001		
Trm	2	258.68	19.33	<0.001		
Slope*Trm	4	36.76	2.75	0.0606		

DF=degree of freedom, Pr=Probability; F=F calculated, MS=Mean Squares, CV=coefficient of variance, Trm=treatment.

Soil PH value in the watershed

The ANOVA table shows that, PH was significantly (p=0.000) affected by the study variables at 95% CI (Table 11). Whereas, this value does not indicate that all variables have significantly Influenced this value, so that, independent and interaction effects were computed to understand the specific influence of variables. Consequently, the Treatment sites (p=0.0001), and slope gradient (p=0.0001) have brought significant impact on the model at 95% CI, where as the interaction effects of variables have not brought significant effect on the model (Table 14).

Table 14. Analysis of Variance results for soil PH value.

Source	DF	MS	F- Value	Pr>F	CV	Mean
(PH)					3.84	6.63
Model	8	3.84	6.63	<0.001		
Slope	2	1.61	24.82	<0.001		
Trm	2	6.32	97.33	<0.001		
Slope*Trm	4	0.17	2.64	0.0676		

DF=degree of freedom, Pr=Probability; F=F calculated, MS=Mean Squares, CV=coefficient of variance, Trm=Treatment.

The soil Available phosphorus (Av-P) value in the watershed

The ANOVA shows that, Av-P was significantly affected (p=0.0001) at 95% CI by the overall variables (Table 15).

Table 15. Analysis of Variance results for soil Av-P value.

Source	DF	MS	F- Value	Pr > F	CV	Mean
(Av-P)					34.24	15.72
Model	8	665.98	22.96	<0.001		
Slope	2	94.04	3.24	0.0627		
Trm	2	2174.19	94.95	<0.001		
Slope*Trm	4	197.85	6.82	<0.0016		

DF=degree of freedom, Pr=Probability; F=F calculated, MS=Mean Squares, CV=coefficient of variance, Trm=treatment.

Whereas, this value does not indicate that all variable have influenced this value significantly, so that, independent and interaction effects were computed to understand the specific influence of variables. Consequently, slope gradient (p=0.0001), and different treatment site (p=0.0098) have brought significant impact on the model at 95% CI. The interaction effects of variables of slope and different treatment site under the current study have not significantly affect the TN. Similarity, the soil Av-P, was not significantly varying at different slope ranges (Table 15).

Soil pH, Available Phosphorus (Av-P) and CEC

The study were conducted in different parts of the country points out that cropland with soil and water conservation practice showed significant variation in soil physicochemical properties and indicates that integrated soil and water conservation practice improves the soil properties on conserved cropland (pH, available P, OC, CEC) than in the adjacent crop land that is without soil and water conservation measures. This indicates the positive impacts of soil and water conservation practices in improving the nutrient status of the cropland, (Bekele, M., et al., 2016; Fisseha, G., and Alemayehu, T., 2018). This finding similar with, Kebede Wolka, et al., (2011) reported that the constructed bench terrace had been significantly affected most of the tested soil properties in cropland with soil and water conservation as compared to the non-conserved one. This might be due to past erosion and land use practice of the site. The significant difference is ($p \leq 0.0005$) observed in soil pH with treatments site integrated soil and water conservation practice, physical soil water conservation well as non-conserved. The mean values of soil pH were lower in non-conserved site and as compared to integrated soil and water conservation practice and physical soil and water conservation practice, and this finding supported with the work of Worku, H., (2017). The variation might be due to leaching of cation in controlled soil (Non-conserved) due to absence of ISWC structure that trap soil as well as low ground cover in the soils as compared to the integrated conserved farm plot. Soil pH was lower in non-conserved sites recorded the pH value is 5.9 and higher in integrated soil and water conservation practiced soil. This could be due to the fact that the soil is affected by erosion removing top-soil but, integrated soil and water conservation practice positively influences or increases soil pH value or soil fertility and the result show with Integrated soil and water conservation site pH is 7.3 Yimer, S Ledin, and A. Abdelkadir, (2011) similarly findings like lower values of pH were observed in the NSWC than in the SWC alone. Generally the soil in the study area can be classified as moderately fertile soil.

Table 16. Tukey Mean difference of soil chemical properties.

Soil Properties	Slope gradient	SWCP(Conservation stractures)			Over all	P-Value
		NSWC	SWC alone	ISWC		
P^{H}	Upper>15%	4.26 ± 0.10^{c}	6.2 ± 0.11^{b}	7.27 ± 0.06^{b}	11.82 ± 0.54^{b}	0.005
	Middle<15%	4.50 ± 0.09^{a}	6.68 ± 0.32^{b}	7.47 ± 0.75^{b}	6.21 ± 0.2^{B}	
	Lower<8%	6.23 ± 0.07^{b}	7.16 ± 0.72^{a}	8.65 ± 0.76^{a}	7.34 ± 0.29^{A}	
	Over all	22.86 ± 5.28^{c}	30.06 ± 10.0^{b}	36.51 ± 4.98^{a}		
CEC (meq)	Upper >15%	21.64 ± 2.00^{c}	30.55 ± 1.27^{c}	30.91 ± 0.87^{b}	27.03 ± 1.38^{c}	0.005
	Middle <15%	22.57 ± 3.92^{d}	23.65 ± 4.95^{b}	37.66 ± 1.39^{a}	28.62 ± 8.1^{B}	
	Lower<8%)	32.99 ± 4.69^{b}	34.83 ± 8.94^{a}	39.27 ± 3.07^{a}	35.69 ± 8.14^{A}	
	Over all	22.86 ± 5.28^{c}	30.06 ± 10.0^{b}	36.51 ± 4.98^{a}		
Av-P	15-34%	1.86 ± 1.409	8.29 ± 1.97	12.00 ± 3.64 d	7.29 ± 0.94 ^{C}	0.0002
	8-15%	2.33 ± 0.30 b	10.17 ± 1.09a	15.25 ± 1.40 b	9.25 ± 3.76 ^{B} 11.96 ± 3.94^{A}	
	3-8%)	3.87 ± 2.90 a	13.71 ± 0.74b	18.306 ± 3.691		
	Over all					

(Source: Soil laboratory, 2021).

ISWC=Integrated soil and water conservation, SWC=Soil and water conservation alone, NSWC=Non-soil and water conservation. *Means within a columns followed by the same letter (s) are not significantly different at P<0.05; %, Av-P=Available phosphorus. The overall average CEC values were statistically highly significant with respect to treatments of ISWC, SWC alone and NSWC, though the differences among different treatments (Table 16). The overall mean CEC (cmolc/kg) in the study area recorded, 35.51, 30.06 and 22.86, among the treatment of ISW, SWC alone and NSWC practice site respectively. The mean CEC value was lower (21.64) recorded in upper slope with NSWC and higher (39.27) recorded in lower slope with ISWC practice.

The results also indicated that available phosphorous highly significantly varied ($P \leq 0.005$) in the treatments of ISWC, SWC alone and NSWC sites and upper, middle and lower slope position. The mean value of Av-P highest (18.306) in ISWC with lower slope position showed a significantly difference and the value of Av-P lower value recorded (1.86) in the site treated with NSWC and upper slope position. The mean Av-P in soil under integrally conserved treatment sites was significantly best than the non-conserved site. This could be due to higher organic matter content of the integrally conserved plots than the physical soil and water conservation alone and non-conserved ones. According to Barber, R., (1984) ratings, available P in soil of the study area can be described as medium to high.

Conclusion

There was significant difference between integrated soil and water conserved and non-conserved farm lands. The integrated soil and water conserved farm land had the highest soil pH, SOC, TN, Ava-P and CEC but a lower BD; suggesting that integrated soil and water conservation accompanied by plant species (Sesbania sesban and pigeon pea) and physical structure conservation practices (Bench terrace and Deep trench) and Sesbania sesban and pigeon pea fodder species are effective in improving soil Physico-chemical properties in the study area, and also slope position affects soil Physico-chemical properties, which could be indicate that, slope increase soil nutrient decreases in non-conserved site and slightly decreases in integrated conserved site, but where the slope position decrease integrated soil and water conservation practice positively and significantly affects soil Physico-chemical properties than non-conserved farm lands. Generally, the soil physical and chemical properties were better in integrality conserved farm lands than the non-conserved. Therefore, ISWCPs play an essential role improving soil physic-chemical and for erosion control and for sustainable watershed management. Farmers' perception on integrated conserved farm land in relation to productivity is better than that of non-conserved.

Author Contribution

TT collected, analyzed data, interpreted and drafting the manuscript.

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