Effects of Soil and Water Conservation Measures on Selected Soil Physicochemical Properties: The Case of Ejersa Lafo District, Central Highlands of Ethiopia.

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Abstract

Background

Land degradation in the form of soil erosion and fertility depletion is the major environmental problem in Ethiopia. However to curb this problem, Soil and Water conservation (SWC) measures are commonly practiced in many rural parts of Ethiopia. This study was conducted to assess the effects of SWC measures on selected soil quality indicators in Ejersa Lafo District. For this study two peasant associations (kebeles) were selected from the district based on the severity of soil erosion and information on SWC practices. A total of 12 composite soil samples from soil 0 to 20cm depth from two sub watersheds with SWC and without SWC practices at Jamjam laga batu and Koriso Odo guba from three landscape positions (upper slope, middle slope, and bottom) were collected. All the soil samples were analyzed following the standard and recommended procedures in Ambo University chemistry laboratory and subjected to ANOVA using the SPSS computer program.

Result

Most of the selected soil physicochemical properties were affected by watershed management intervention. Comparing the two farmlands, the highest bulky density of $1.37 gcm^{-3}$ was observed from unconserved farmland. The results of the study also showed higher values of Soil electrical conductivity (EC), Total nitrogen (TN), Cation exchange capacity (CEC), Soil Organic matter (SOM), Organic Carbon, Available Phosphorus (Av. P) and Available Potassium (Av. K) in conserved land and those all significantly varied between farm plots. On the other hand, Sandy, pH, SOM, TN, Av. P and Av. K values were significantly affected ($p<0.05$) by slope and all increased from upper (>30%), middle (15-30%) and lower (8-15%).

Conclusion

The contribution of watershed management intervention to improve soil physicochemical properties is significant in the study area as it improved some of the selected soil physicochemical properties of soil. Furthermore, efforts are required to enhance community adoption towards soil and water conservation. Additionally, further research has to be carried out on socio-economic aspects and impacts of the intervention on crop productivity for better understanding of the sustainable use of the land and to make a comprehensive conclusion.

Background

Ethiopia is one of the oldest agrarian nations in sub-Saharan Africa (SSA) with large agricultural potential. It is one of the largest sectors in the economy both in terms of its contribution to the GDP and generating employment (Wolka, 2014). The majority of the people in Ethiopia are dependent on agriculture for livelihood which resulted in fast and vast land degradation. Hence, most Ethiopian farmers perceive land degradation as the major cause of soil nutrient depletion from the top zone of soil as well

as one of the most important environmental problems (Tullu, 2002). Expansion of cultivated area, reduction of natural forests and grasslands, intensifying grazing in smaller areas to accommodate a growing population has been underway in Ethiopia highlands for centuries (Merrey & Gebreselassie, 2011).

In Ethiopia, particularly in the highlands of the country land degradation is a major environmental problem causing severe impacts on natural resource conservation, crop productivity and food security (Erkossa *et al.* 2018; Adimassu *et al.* 2017; Laekemariam *et al.* 2016). Soil erosion affects the physical and chemical properties of soils. The physical parameters are primarily organic matter content, structure, texture, bulk density, infiltration rate, rooting depth, and water-holding capacity. Changes in chemical parameters are largely a function of changes in physical composition.. According to Dessalegn *et al.* , (2015), soil erosion is the major environmental problem which affects half of Ethiopia's agricultural land ha^{-1} year^{-1} and results in a soil loss rate of 35 to 42 t year^{-1} and a monetary value of US\$1 to 2 billion. Loss of soil implies a loss of productive capacity of the land; as a consequence, it reduces the productivity of agricultural land and crop yield which is actually essential to sustain human life on earth

The consequences of soil erosion can be seen on both where the soil is eroded and deposited; the earth's surface can either being degraded or increase land elevation due to deposition. The problem of soil erosion is threatening ecosystems and human wellbeing throughout the world because it results in a significant reduction in economic, social and ecological benefits of land for crop and other environmental service (Fu *et al*, 2011). It generates strong environmental impacts and major economic losses from decreased agricultural production and off-site effects on infrastructure and water quality by sedimentation processes (Haregeweyn *et al.,* 2005; Amsalu & De Graaff, 2007).

The major causes of land degradation in Ethiopia are the rapid population increase, deforestation, low vegetative cover and unbalanced crop and livestock production, inappropriate land-use systems and land-tenure policies that further enhance desertification and loss of agrobiodiversity, utilization of dung and crop residues for fuel and other uses there by altering the sustainability of land resources (Taddesse, 2001).

Sustainable use and management of land resources could only be achieved by adopting a system of improved land, water and vegetation use. The SWC treatment methods are aimed at promoting better management of soil as a natural resource and mitigate the negative impacts of soil fertility decline and degradation problems that lead to low yield on farmlands. SWC activities can change the physical conditions of the soil like soil structure, water holding capacity, bulk density, soil porosity and its workability (Erkossa, 2005).

The implemented SWC measures (terracing, gully stabilizations, check dams and plantation of multipurpose fruit and fodder trees) enhanced in-situ moisture conservation, storage of water and recharge groundwater that are creating opportunities for supplementary irrigation, thereby encourage farmers to go on for cultivation of high value commercial crops (Wolka, 2014).

Efforts towards SWC goal started since the mid-1970s and 80s to alleviate soil erosion and low crop productivity (Ademe *et al.,* 2017). Conserving and improving soil quality is about sustaining the long-term function of the earth- plant-soil relation as well as improving productivity (Siraj *et al.,* 2019). Ministry of Agriculture (*MoA*) and the NGOs such as GTZ, FAO and SOS Sahel have adopted participatory land use planning in different parts of Ethiopia during the last two decades.

Currently, campaign for construction and maintenance of SWC structures has offered a great contribution to watershed development and management for the country. However, in spite of having the aforementioned efforts on watershed management development, the effectiveness of watershed intervention practices in improving soil properties remains under studied. In order to fill this information gap and support the country's effort in combating land degradation, a study that assesses the effectiveness of SWC measures is of paramount importance.

Comparing changes with selected soil quality parameters between two watersheds (treated with soil conservation measures and untreated) could contribute for further improvement of the integrated SWC practices currently underway and to draw some recommendations. Therefore, this study was designed with the objective to investigate effects of SWC intervention on selected physicochemical properties so as to draw conclusions that contribute in future improvement of SWC measures implementation in improving soil for a better land productivity, erosion control and sustainable use of resources available in the country, as well as at Ejersa Lafo District.

Materials And Methods

Description of the Study area

The study was conducted in Jamjam laga batu and Koriso Odo guba Peasant association micro watersheds, Ejersa Lafo District, West Shewa zone, Oromia National Regional State (Fig 1). Ejersa Lafo district is located 70 km west of Addis Ababa and 47km away from the Ambo Zonal town. According to the current administrative structure, the district is separated from Dendi district and has 17 rural and three urban kebeles. Geographically, the district is located between $9^0 0'$ 0" to $9^0 50'$ 0" N latitude and 38^0 12' 30" to 38^0 17' 30"E longitude. The district is bordered with Dawo district in the southwestern Shewa zone from the south, Ejere district from the East, Jeldu from the North, Ilu District from the South East and Dandi district from the west.

Figure 1: Map of the study Area

The two watersheds have about 10.105 km. Agro- ecologically, Ejersa Lafo district is divided in to highland (74%) and midland (26%) agro-ecologies. The district has a total area of 32,365 hectare (Ejersa Lafo Agricultural and Natural Resources office, 2019). The altitude ranges between 2,000 to 3,288 meters above sea level (CSA, 2007). The mean average temperature of the area is 19.67^0c and the minimum and maximum temperature is 5.4^0c and 26.41^0c respectively (Holeta Research center, Dendi station, 2019).

The annual rainfall is 750-1170 mm (Shime, 2014). The warmest month of the area is March (26.41^{0}c). The coldest month of the study area is July and September. The soil of the study area is mainly dominated by Vertisols. The soil contains percentage of 30% sand, 18% silt and 52%   clay

The vegetation of the micro watersheds is characterized by the presence of tree species such as *Podocarpus falcatus*, *Juniperus procera*, *Olea africana subspecies cupsidata*, *Grevillea robusta*, Accacia Spp, and forage species such as *Sesbania sesbian*, tree Lucerne (*Chamaecytisus palmensis*), , and Desho grasses. (*Pennisetum pedicellatum*). The natural vegetation in the study area is under heavy pressure due to rapid population growth. The indigenous trees are removed mainly to expand agricultural farm lands, fuel woods and construction of houses, fences around farmers' settlement, charcoal production for market (Shime, 2014). The presence of natural vegetation is hardly rare but the remnants of tree species scattered here and there) is observed in the district.

Data Collection Method and Analysis

Experimental design and sampling

To locate representative sampling sites for both treated and control micro watersheds, landscape positions, we followed the judgment sampling method (USEPA (United State Environmental Protection Agency) (2002). Two representative Peasant associations (kebeles) were selected purposively for each site at three different landscape positions based on recommendation by District agricultural Expert and Development agent (DA) for soil sample collection. Stratified random sampling techniques were used for soil samples collection..

A reconnaissance survey was carried out before the actual samplings, to identify the representative watersheds and assign sample plots. Then judgment sampling was used to take representative soil samples from farmlands with and without SWC measures. Plots were selected from with and without SWC measures at various slopes. The soil samples were also collected by taking the slope into consideration. Accordingly, we categorized the farm land of the study area into three slope classes (3-8 %) is considered as lower slope (8-15%), middle slope (15-30%) and upper slope (30%).

Source of data were field survey, soil laboratory analysis and secondary data from relevant offices. The soil samples were collected from the top surface soil samples 20cm both with and without soil bund following (Laekemariam *et al. 2016*). The soil samples were collected from February 10-18/2019 through composite sampling techniques to obtain a representative sample of the plots determined by setting pre-defined sampling points. In all cases, the history of land management particularly of fertilizer application and the crop types were recorded for the site from where the samples were taken. Three sub-sampling plots were set up keeping a 10m distance from the central point and composite sampling was done.

The research design used in this study was systematic random design with split plot arrangement, taking frequency of controlling(C=controlling farm, R= farm with bund) as main plot and the interaction of frequency of bunding (b1= with bund, b2= without bund).

Soil and Data Analysis

Laboratory Analysis

The collected soil samples were taken to laboratory and air-dried in the laboratory, crushed, and sieved by a 2-mm mesh sieve (Descheemaeker *et al.* 2006). The soil samples were analyzed at Ambo University Chemistry laboratory following the standard and recommended laboratory procedures. The composited soil samples were analyzed for pH, available P, total N, and Soil Organic Carbon (SOC).The pH of the soil was measured in water suspension in a 1:2.5 (soil: liquid ratio) potentiometrically using a glass-calomel combined

electrode (Van Reeuwijk, 2002),Soil bulk density was determined by the core method (Blake & Hartge, 1986), Total nitrogen was determined by the modified Kjeldahl digestion and distillation procedure (Bremner&Mulvancy,1982); Organic carbon content by the wet combustion or dichromate oxidation methods (Walkley& Black, 1934). Soil organic matter (SOM) was determined titrimetrically; available phosphorus with modified version of Olsen's method (Olsen & Sommer, 1982), and available potassium by the ammonia acetate method (Thomas, 1982).

Data Analysis

All the selected soil quality parameters measured were subjected to a one-way analysis of variance using the statistical package for social sciences (SPSS) and where significant difference exists means were separated using the least significant difference method. Analysis of variance (ANOVA) was used to evaluate treatment effects on selected soil physical and chemical properties.

Results And Discussion

Effects of Sustainable Land management (SLM) interventions on Soil Physical Properties (texture, bulk density and moisture content)

Soil Texture

Soil textural fractions such as Sand, silt and clay; soil bulk density and moisture content showed no significant difference with SWC treatments. The non- significant difference in texture may be due to the age of the implementation of watershed practice which was Eight years that can't make significant change on weathering. The higher mean value of the sand content of the soil was 36.6% and 34.5% that recorded from Koriso and Jamjam respectively in untreated farm plots while the lower mean value was 26.4% and 26% respectively from Koriso and Jamjam in areas with SWC measures. The overall mean value of sand recorded from conserved farm plots was 29.65 ± 3.44 while that of unconserved farm plots was 31.76 ± 4.2. The mean value of sand contents were relatively greater in unconserved farms than conserved cultivation lands this, might due to soil aggregation greater in untreated for less contents of organic matter that minimize the sandy aggregates to contain moisture (Table 1).

Similar results were reported elsewhere, for example Terefe et al., (2020), Husen *et al.,* (2017), Mulugeta and Karl (2010), Anshebo (2009), who reported higher mean value of BD in non-conserved plots than in the plot treated with SWC measures.

Table 1: Mean values of selected soil physical properties

Land use type	Variables				
	Sand	Silt	Clay	SMC	BD
Conserved land	29.65 ± 3.44	18.54 ± 0.88	51.79 ± 3.36	10.64 ± 1.73	1.23
Non-conserved land	31.76 ± 4.2	19.88 ± 1.74	47.6 ± 1.36	5.529±1.435	1.37
Overall mean	30.0 ± 3.66	18.2 ± 1.67	51.8 ± 3.26	8.096±3.14	1.3
LSD (0.05)	0.641	0.642	0.175	0.22	
SEM	1.49	0.685	1.326	1.284	
Slope Gradient					
Upper (>30%)	34.27 ± 1.889	18.2 ± 1.621	47.525 ± 1.51	5.25 ± 0.884	
Middle (15-30%)	31.125 ± 2.09	19.5 ± 2.415	49.875 ± 2.26	5.679±0.862	
Lower (8-15%)	26.725 ± 1.56	19.95 ± 1.865	51.725 ±4.38	6.047±0.732	
LSD (0.05)	0.001	0.467	0.189	0.371	
SEM	1.053	0.567	0.932	0.871	

The result of ANOVA revealed highly significant differences (P = 0.001) for sand at landscape positions. The recorded mean value of sand for upper (>30 %), for the middle (15-30%) and lower is (8-15%) which were 34.27 ± 1.889, 31.125 ± 2.09 and 26.725 ± 1.56 respectively. This result is in agreement with (Tiki, *et al.,* 2015, Ademe *et al.*, 2017). Soils of the conserved farm land with SWC measures had the highest percent clay compared to the soils of the untreated/unconserved with SWC measures. However, sand and silt percent were lower in land treated with SWC measures. The sand contents of the soil of cultivated farm plots decreased from upper to lower landscape positions. This might be due to the top fertile soil is removed and deposited on the lower slope mixed with the former sand present on gentle slope change parts of sandy to clay loam and silt. High moisture content is rather present in the lower 6.047±0.73 landscape position compared to the upper and middle one, this enhance better condition for decomposition.

The Silt contents of the recorded results from the two micro-watersheds was not significantly varied (p>0.05) among conserved and unconserved with SWC measures farm plots as well as across landscape position. The mean value of silt contents of soil recorded from conserved farms of both micro watersheds was 18.54 ± 0.88, while that of untreated cultivation field was of 19.88 ± 1.74. The silt

contents of cultivated field untreated with SWC practices relatively smaller than that of untreated farmlands which might be due to farm plots treated with conservation structures contain greater organic matter contents there by decomposer breakdown residue (litters) then sandy and silt contents changed to clay loam and also bulk density reduction indicated soil compaction reduced thereby micro-organisms freely moves in soil horizon to decompose immobilized nutrients and improve soil structures and texture.

There was no significant difference of soil texture in slope position except sandy soil. The mean value of silt contents of both micro watersheds along upper, middle and lower was 18.2 ± 1.621, 19.5 ± 2.415 and 19.95 ± 1.865 respectively (Table 1). The recorded results indicated that the mean value of the silt contents from both micro watersheds of similar slope position from upper streams to lower streams relatively decreased, because the silt is very fine particle size that formed from sediments deposited in the lower sides and large mass of grass cover and residue present on the lower side that increase fine particles so that silt contents increased.

The result depicted that the farm plots mainly dominated by clay contents (Table 1). The mean value of clay contents of the farm plots was relatively lower in farm plots with SWC measures than that of without SWC measures. The mean value of clay contents of soil in conserved cultivation farm plots from both watersheds was 51.79 ± 3.36 while that of non-conserved cultivation field was 47.6 ± 1.36. The farms mainly dominated by clay contents in conserved plots than that of non-conserved due to large mass of sand and silt mixed with organic matter and became finer soil particles and also change normal clay to larger clay loam textural class by disintegrate clay colloids to finer soil available to plant growths.

The clay contents of the soil from both micro watersheds relatively increase through slope gradients (from upper to lower). The mean value of clay contents across slope position from upper (>25%), Middle (20-25%) and lower side (15-20%) was 47.525 ± 1.51, 49.875 ± 2.26 and 51.725 ± 4.38 respectively (Table 1). The presence of higher clay fraction in the lower slope might be due to larger deposition of silt and sand mixed with organic matter then large mass of clay and clay loam that mainly used for crops growth.

Soil Bulk Density

The soil bulk density of the study areas were significant ($p < 0.05$) between conserved and unconserved farm plots with SWC measures (Table 1). Similarly, Aşkin and Özdemir (2010); Chaudhari et al. (2013), indicated that soil bulk density is significantly influenced by sand content more than other soil properties. The overall mean of soil bulk density of the study areas covered with SWC practices at effective soil depth (0-20cm) was lower than that of the areas not treated (non-conserved) with structures. The untreated plots were found to exhibit significantly higher mean value of BD than treated plots at both sites. Lower soil bulk density of 1.23 gcm^{-3} was observed in treated farm plots as compared to untreated farms plot which was 1.37 gcm^{-3} (Table 1), which might be due to soil bulk density increase with subsurface compaction and also due to the presence of significantly higher organic matter and moisture availability differences in conserved farms.

The finding is in agreement with Husen *et al.,* (2017), Challa *et al.*(2016); Bezabin *et al. (*2016); Demelash & Karl (2010), who reported that the mean value of bulk density in conserved areas with SWC practice was lower than that of unconserved areas mainly due to the decomposition of plant biomasses on the conserved field increase organic matter contents which reduces soil bulk density. Alemayehu and Fisseha (2018), also, found higher bulk density in untreated farm land than the conserved farm land in Ethiopia. Heuscher *et al.* (2005) described soil bulk density, has inversely proportional relationship with soil organic matter. Land management practices like SWC can accumulate soil organic matter and modify soil properties such as bulk density and this innovation have agreement with present study (Amare *et al.,* 2013). Low bulk density was observed for conserved crop lands than non-conserved one (Haweni, 2015).

Soil Moisture Content (SMC)

Soil moisture contents of the study areas has shown significant ($p < 0.05$) variation between Conserved and unconseved land with SWC measures (Table 1). The highest SMC recorded from conserved farm plots with SWC was (**10.94)** and with non-conserved farm plots (5.87%) both from Jamjam micro watershed. which may be a result of water conservation structures which reduces runoff and evaporation and increases infiltration and soil moisture content (Tiki, *et al.,* 2015, Stroosnijder and Hoogmoed, 2004).

The overall mean of SMC recorded on conserved areas was 10.64 ± 1.73 while 5.53 ± 1.43 from non-conserved farm plots might due to slope length shorten by structures that makes barrier to run off and enhance soil water holding capacity thereby fill soil pores with moisture within the conserved areas (Table 1).The finding is in line with Challa *et al. (*2016) who stated moisture contents of farms land with SWC practices was higher than that of cultivation farms without any conservation structures. The area covered with improved soil bunds have higher infiltration capacity than cultivation fields without bunds due to runoff reduction for decreased slope length and allow longer time for infiltration on conserved areas with bunds in Melka watershed (Anania, 2015). Therefore, improving infiltration to make rain-water available for plant uptake, erosion control and fertility management practices are necessary (Vancampenhout *et al.,* 2006).

The variation of SMC was not significantly different ($p > 0.05$) in relation to slope. The result showed that SMC is higher in the lower slope (8-15%), 6.047± 0.732 followed by middle slope (15-30% and upper slope position (>30%) with value of 5.679 ± 0.862 and 5.25 ± 0.884 respectively (Table 2) because of organic matter contents of the study areas increase from upper steep slopes to lower parts of the watersheds. The area having larger organic matter contents has ability to capture moisture. Similar to Haweni, (2015) moisture availability in lower slope indicated greater in the upper and middle slopes of untreated farms land that might be related to accumulation of moisture in the lower which eroded from upper slope position. Soil moisture is necessary for the absorption of nutrients and increase yield (Abdzad *et al.,* 2014).

Soil chemical Properties

There were significant differences for selected soil chemical properties at micro watersheds for conserved and unconserved and landscape positions at $p \leq 0.05$.

Soil pH

The mean value of soil pH recorded was significantly different ($p \leq 0.05$) among conserved and non-conserved. The maximum and minimum pH value recorded in the study area was 6.735 and 4.265. The mean pH value recorded in conserved areas were 6.33 ± 0.36 while that non-conserved were 4.97 ± 0.45 (Table 2) which might due to more cation ion (Hydrogen ions (H^+) release from non-conserved areas as a result of leaching than that of conserved farm plots. It might also be due to more residue and grass left on conserved areas that used to maintain organic matter. In general, the mean value of soil pH recorded in the cultivation fields was 5.65 ± 0.84 which is followed by soil pH rating by Hazelton, and Murphy, (2007) and (Tekalign and Haque, 1991) that the pH value fallen in moderately acidic which is favorable for growth of crops.

Similar to Worku, (2017), the mean value of soil pH were lower in non-conserved farm land as compared to conserved farms due to leaching of cations in controlled farm plots for the absence of SWC practiced used to trap soil as well as lower ground cover in the farms as compared to the conserved farm plots.

The relatively higher mean pH on soil bunds than the control (non-conserved plot) may be explained by the difference in the extent of soil loss between cropland treated with conservation measures and those merely cultivated without any means of protection at least to keep the soil in place (Bezabih, 2015). Similar finding was reported by Bezabih *et al.*, (2016), in which the lowest value of soil pH in cultivated land in untreated with conservation structures, which can be due to result of high microbial oxidation which produce organic acid, soil erosion processes as well as basic cations depletion.

The statistical analyses revealed that there is no significant difference in pH levels between slope positions at $p \leq 0.05$. The mean pH value was lower in the upper slope (<30%) which was pH 5.25 ± 0.88, in middle (15-30%), pH 5.67 ± 0.86 and higher in the lower slope (8-15%) which was pH 6.05 ± 0.73 (Table 2) that might be attributed to some organic matter removal from steep slope and deposited on the lower side. Similar to such as Bekele *et al.* (2016) found pH value was lower in steep slopes and higher in gentle slopes due to the fact that the high rainfall coupled with steeper slope might have increased leaching, soil erosion and a reduction of soluble base cations leading to higher H+ activity.

Total Nitrogen (TN)

The result has shown that TN contents of the soil in both (Jamjam laga batu and Koriso odo guba) selected areas were significantly different ($p \leq 0.01$) with conserved and non- conserved watershed as well as along slope gradients. The overall mean contents of TN under the conserved land 0.228 ± 0.091% and non- conserved land 0.154 ± 0.012 %. This is because the area covered with structures treated with biological measures that are used to conserve soil such as Acacia spices and *Sasbania sesban* that is

used as fodder and have nodule on their roots that are used in fixation of nitrogen. The higher TN recorded on conserved area was 0.247% and the lower content of soil nitrogen identified was 0.137% mainly in the upper parts of the watershed areas (Table 2).

This study is in line with other finding (Mulugeta & Karl, 2010; Anania, 2015; Keberku, 2017), who reported that farmland with physical SWC measures have high TN as compared to the non conserved land. In general, TN content of a soil is directly associated with its Organic Carbon (OC) content and become lower in continuously and intensively cultivated and highly weathered soils of the humid and sub humid tropics due to leaching and then low OM content (Tisdale *et al.,* 1995; Haweni, 2015). The result of this study is also in line with the report of Haweni, (2015) who stated total nitrogen in conserved lands of Dimma watershed was higher than the total nitrogen content in the corresponding sites without conservation measures and Shafi et al., (2019) who reported an increment of total nitrogen in conserved soil of Ezha District.

There was also significant difference in TN ($p \leq 0.01$) in relation of slope. The mean value of TN higher in the lower slope (8-15%) was 0.205 ± 0.044 % followed by middle slope (15-30%) and upper slope position (>30%) with value of 0.192 ± 0.046 % and 0.177 ± 0.039 % respectively (Table 2) which might be because of the removal of top fertile soil which contain organic matter from upper stream and deposited at lower parts of the watersheds. Following Landon, (2014) the overall mean contents of the study areas was low (0.191 ± 0.043%) which need nitrogen recommendation for the areas.

Soil Organic Matter (SOM) and Soil Organic Carbon (SOC)

Results of the study indicated that there was significant difference in SOM contents between conserved and non-conserved areas in the watersheds. The higher OM contents recorded from conserved areas were 5.983% and 4.584% while the lower were 2.930% and 3.204% in Jamjam and Koriso micro watersheds respectively. The overall mean recorded in conserved areas was 4.915 ± .47 % and 3.404 ±.473 % in non-conserved areas might be due to loss larger mass of effective soil depth by erosion from non-conserved farm plots (Table 2).

The mean value of SOM was not significantly different across slope position. The recorded SOM in the upper (>30%) was 3.8 ± 0.86 % , in the middle (15-30%) was 4.06 ± 0.99% and at the lower part (8-15%) was 4.16 ± 0.97% that indicated SOM increased from upper to lower might due to greater available soil condition to convert litter and other cover crops to soil. This study is in agreement with Kediro, (2015), who stated organic matter content of the soil increased down the slope both conserved and no-conserved suggesting the accumulation of humus-rich fine particles eroded from upper slopes and levels of increasing in OM contents down the slope were higher in the treated fields suggesting the accumulating of sediments behind the conservation structures.

The depletion of SOC as a result of soil degradation within intensified agricultural systems can lead to loss of nutrients and soil structure, loss of soil resilience, a loss of soil biodiversity, and disruption of key

biotic and abiotic processes necessary for productivity (Lal, 2015). The mean value of organic carbon (OC) obtained was significantly affected (p<0.05) between conserved and non-conserved cultivation plots. The overall mean of SOC recorded in conserved farms was 2.789 ± 0.2263 while that of non-conserved areas was 1.974 ± 0.275 % (Table 2). The mean value of carbon contents of soil in conserved areas relatively greater than that of non-conserved might due to greater land cover by residues as mulching thereby greater carbon sequestration (carbon stock) than that of non-conserved where severity of erosion case land left bare and soil carbon contaminate with air and react and released to environment. . The study agree with that of Gebreselassie *et al.* (2009), Wolka *et al.* (2011) and Shafi *et al.,* (2019) who reported the presence of higher SOC in the field with different conservation measures

The mean value of SOC was not significantly different among upper, middle and lower parts of selected watersheds. The mean value of SOC recorded from upper (>30%), middle (15-30%), and lower (8-15%) were 2.272 ±.579 %, 2.356 ±.574 % and 2.675± 0.564 % respectively (Table 2). The value recorded relatively decreased down slope might be due to degree of residue and grass cover of soil surface is higher on the lower parts.

Soil Electric Conductivity (EC)

Fertile soil with high amount of mineral compounds will have high conductivity while depleted soil with less minerals will have lower conductivity and soil conductivity also depends on types of mineral salts present. The result of the study showed that there was no significant variation (p<0.05) between mean value EC of soil in the conserved and non-conserved as well as across slope position on the farmers' farm plots. The mean value of soil electric conductivity recorded on conserved cultivation plots was 0.0485 ± 0.015 dS/m and 0.0402 ± 0.005dS/m in non-conserved (Table 2). The mean value of EC recorded from conserved farm is relatively greater than the mean recorded on non-conserved areas might due to soil acidity minimized for the leaching of cations (H^+) in the conserved farm plots.

The finding is similar to the finding of Anania, (2015) who reported that the higher electrical conductivity in soil obtained from control farm plot might be due to higher clay content than that of a farm with soil conservation. Gankiso, (2017) also reported the mean value of EC recorded from treated with SWC measures was greater than that of the EC recorded from non-conserved farm plots. The electric conductivity measurement detects the amount of ions in the solution; the greater the amount of cations, the greater conductivity reading.

The overall mean value of EC recorded from the upper stream, Middle and lower of both watersheds were 0.0384 ± 0.0055dS/m, 0.0449 ± 0.006 dS/m and 0.0499 ± 0.006 dS/m respectively (Table 2). The mean value of EC increased from upper to lower slope position since soil pH has positive correlation with soil EC.The increases were due to erosion and leaching of soluble salts from the upper slope and accumulation at the down-slope land positions (Olarieta *et al.,* 2008). The overall mean value of EC recorded in the study areas was 0.045 ± 0.0073dS/m so that soil of the selected farm plots salt free following Scherer (1996) of rated electric conductivity.

Available Phosphorous (Av.P)

The results indicated that Av.P was significantly different (p<0.05) with the conserved and no-conserved farm plots. The relative higher value of Av.P that recorded from conserved farms (Table 2) was 7.481 mg/Kg and the lowest value from non-conserved cultivation plots was 4.358 mg/Kg. The mean value of Av. P in soil under plots with conservation structures (from both Jamjam and Koriso) was 6.627 ± .77 mg/Kg while the mean value of Av. P in non-conserved farm plots was 4.13 ±0.3 mg/Kg might due to soil organic matter contents of conserved farms with SWC structures have greater than that of non-conserved plots. The overall mean value of available phosphorous recorded from the farm plots was 5.37 ±1.47 mg/Kg in that the available phosphorous in soil of the study areas was low following Barber, (1984) available phosphorous.

The finding is similar to the finding of Worku, 2017, that the mean Av. P in soil under conserved plots was relatively better than in the no-conserved plots might be due to higher organic matter contents of the conserved plots than the non-conserved ones. The level of Av.PinSebata central Ethiopia is significantly higher on treated field (11.87 ppm) compared to the untreated fields (6.84 ppm) and its level decreased down the slope (Kediro, 2015).

There was no significant variation shown in soil Av.Pacross slope position. The recorded result indicated that the mean value of Av. P increased down the slope from steep slope (>30%), Middle (15-30%) and Lower slope 8-15%) in both watersheds that were 4.798 ± 1.13 mg/Kg, 5.49 ± 1.61 mg/Kg and 5.84 ± 1.63 mg/Kg respectively (Table 2) might due to limited organic matter that make better condition for soil micro microorganism used to breakdown other fresh organic matter so that phosphorous present in the form of immobility rather than changes to plants available forms. It might be also due to fertilizers and animal manure added to the cultivation field removed by rainfall and run off and laid on the lower side so that the Av. P increased gentle slope.

Available Potassium (Av. K)

The result of soil Av. K of the study areas were significantly affected (p<0.05) by land use type (conserved with SWCstructures and no-conserved farm plots). The mean value of the available potassium was relatively higher in both conserved farm plots 0.874 ± 0.009 Cmol (+)/Kg (341.756 mg/Kg) than the mean value of soil Av. K of non-conserved of both areas of the cultivation farms was 0.835 ± 0.013 Cmol (+)/Kg (326.828 mg/Kg) (Table 2) might due to excessive rainfall can cause potassium to leach out soils in no-conserved areas with the structures and less surface cover (barriers) that hinders the run-off velocity of rainfall.

The finding is similar to the finding of Bekele*et al.* (2016), who reported that the mean value of the Av. P in soil of conserved areas with structures was relatively greater than that of non-conserved farm plots due to the fact that soil conservation practices which were applied on the land have created conducive environment for the progress of the nutrients available in the soil.

The result obtained from laboratory indicated the mean value of Av. K was not significantly affected (p>0.05) by slope position. The mean value of Av. K recorded with in both watershed of similar slope position from upper (>30%), middle (15-30%) and lower (8-15%) was 0.84 ± 0.025Cmol (+)/Kg, 0.858 ± 0.23Cmol (+)/Kg, and 0.864 ± 0.21Cmol (+)/Kg respectively (Table 2).

Table 2: Mean values of selected soil chemical properties

Land use type	Variables						
	pH	OM	TN	Av. P	Av. K	EC	OC
Conserved land	6.33 ± .36	4.915 ± .47	0.228 ± .091	6.627± .77	0.874±.009	0.0485 ± .015	2.789 ±.2263
Non-conserved land	4.97± .45	3.404 ±.473	0.154 ± .012	4.13 ±0.3	0.835±.013	0.0402 ± .005	1.974 ±.275
Overall mean	5.65 ± .84	4.159 ± .94	0.191± .043	5.37 ±1.47	0.85 ± .023	0.045 ± .003	2.435 ±.5566
LSD (0.05)	0.0205	0.0205	0.003	0.0085	0.0195	0.175	0.014
SEM	0.343	0.384	0.087	0.601	0.0095	0.003	0.227
Slope Gradient							
Upper (>30%)	5.25 ± .88	3.8 ± 0.86	0.177 ± .039	4.798 ± 1.13	0.84 ±.025	0.0384 ± .0055	2.272 ±.579
Middle (15-30%)	5.67 ± .86	4.06 ± 0.99	0.192 ±.046	5.49 ±1.61	0.858 ±.23	0.0449±.006	2.356 ±.574
Lower (8-15%)	6.05 ± .73	4.61 ± 0.97	0.205 ±.044	5.84±1.63	0.864 ±.21	0.0499±.006	2.675 ±0.564
Overall mean	5.66 ± .23	4.16 ±0.92	0.1913 ±.04	5.37±1.41	0.855 ±.23	0.045±.007	2.435 ±.548
LSD (0.05)	0.431	0.494	0.675	0.611	0.424	0.068	0.595
SEM	0.238	0.266	0.0118	0.407	0.0066	0.00212	0.158

The mean value of Av. K relatively increase from upper to lower in the watersheds might be due to larger biomass of grass cover preset on the lower parts so that less leaching of potassium and better soil conditions of soil for micro-organisms to decompose organic nutrients to available nutrients used plant growth.

In general, the overall mean value of available potassium (Av. K) recorded in Jamjam and Koriso micro watersheds was 0.85 ± 0 .023 Cmol (+)/Kg (334.292 mg/Kg). Following FAO, (2006) that the available potassium rating in Cmol (+)/Kg as very high (>1.2), High (0.6-1.2), Medium (0.3-0.6), Low (0.2-0.3) and

very low (<0.2). Therefore, that the available potassium present in the soil of the study area was fallen in high. There was no potassium deficiency in the cultivation field of the farmer's farm plots.

Conclusion And Recommendation

The objective of this study was to assess the effects of conservation measures implemented through a watershed management practices approach on selected physicochemical properties of soils by comparing conserved and non-conserved sites in the Ejersa Lafo District, West Shewa of Ethiopia. Assessing the effectiveness of SWC practices on physicochemical properties of soil very important for promoting soil fertility and achieves food security. Generally, watershed management is very essential to reduce soil erosion especially in developing countries and is considered as the main source of income and improving communities' livelihood.

The findings showed that the implementation of sustainable land management interventions had brought about significant improvement in some of the soil physicochemical properties considered such as BD, soil moisture, pH, TN, SOC.SOM, Av.P and Av.K than in the adjacent farm land without watershed management in the same micro watershed. This indicates the positive impacts of watershed management practices in improving the nutrient status which, in turn plays a great role in benefiting the local households and farmers, the local community, and the society at large.

The watershed management practices have positive effects in improving fertility of the degraded lands. The major effects of watershed management intervention were effects such as erosion control by shorten the length of steep slopes and make barriers to run off, enhance soil fertility by making feasible condition for micro-organisms to decompose and breakdowns organic immobile macronutrients, water retention by covering surface as mulching and increase infiltration and water holding capacity of soil. The mean value of soil pH fallen in moderately acidic and salt free that was favorable for major crops grown in the study areas. The total nitrogen and available phosphorous contents of the soil low thereby the productivity is decreasing through time.

Based on the finding of this study, the following recommendation are suggested for further consideration and improvement of physical and chemical properties of the soil in the study areas in particular and in Ethiopia as general. Most of the cultivation field of the farmers fall in steep slope 30% to 50% and above in the study area especially in Jamjam., Hence, government need to amend new land use policy concerning cultivation in slope position. Furthermore, there is a need to conduct further research on analyzing the cost effectiveness of recommended SWC techniques on soil fertility and crop productivity. There should be a continuous awareness creation method for technically efficient implementation and a follow up process on the proper maintenance for optimum soil properties improvement.

Abbreviations

Av.K =Available Potassium, Av.P =Available Phosphorus, CEC=Cation exchange capacity, EC= electrical conductivity, FDG=Focus group discussion, SOC=Soil organic carbon, SOM=Soil organic matter, SWC=Soil and water conservation, TN=total nitrogen, USEPA=United State Environmental Protection Agency.

Declarations

Availability of data and materials

I declare that the data and materials presented in this manuscript can be made available as per the editorial policy of the journal.

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Authors' contributions and consent for publication

All authors made a valuable and unreserved contribution as well as read and approved the final manuscript.

Conflict of Interests

The authors declare that they have no conflict interests.

Ethics approval and consent to participate

Prior oral informed consent was obtained from the local communities as well as from all individual participants.

Consent for publication

Authors agreed to submit the manuscript for publication in Environmental Systems Research and approved the manuscript for submission

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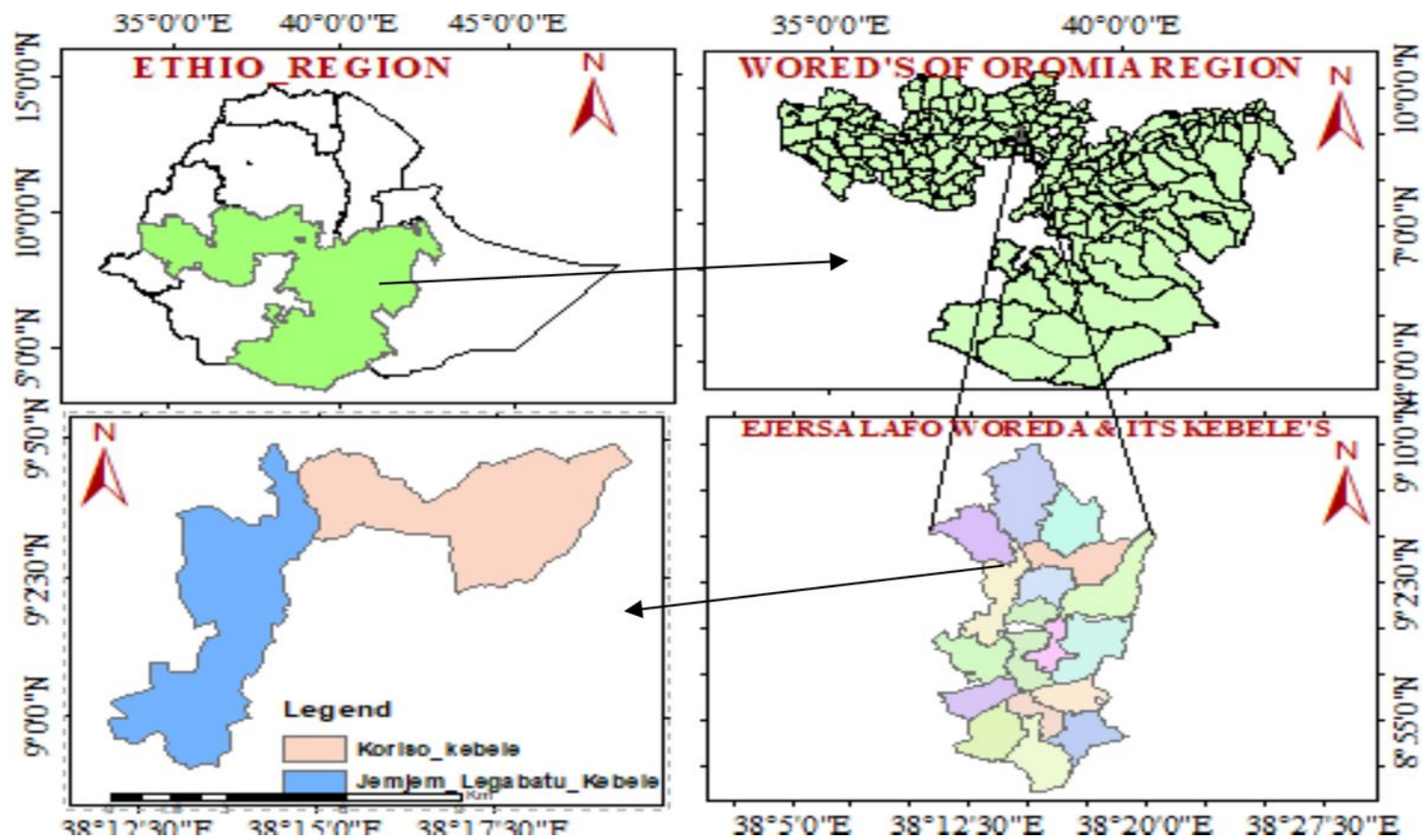
Figures

Figure 1

Map of the study Area