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By

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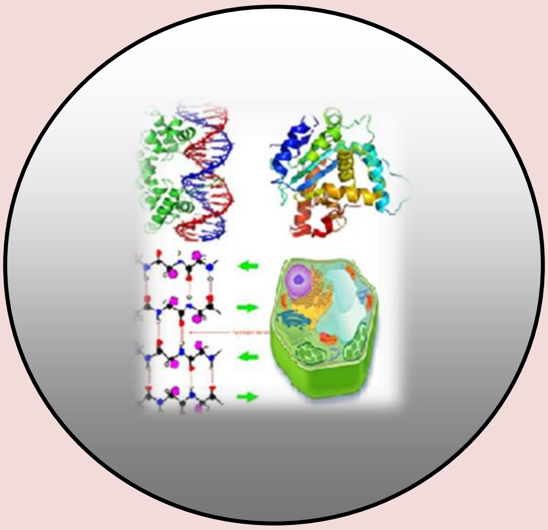

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Impact of Watershed Interventions on Soil Pysico Chemical Properties in Kechi Micro-Watersheds of Kechi District, Dawuro Zone, of Ethiopia

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ABSTRACT

A watershed or catchment or basin or drainage area refers to any topographically delineated area that can collect water and is drained by river system with an outlet. The objective of this study is to evaluate the Impact of watershed interventions on soil properties micro-watersheds of Kechi district, Dawuro Zone, SNNPR of Ethiopia. In this study the researcher adopted a combination of both quantitative and qualitative methodologies. The necessary information were collected from both from primary and secondary sources. Descriptive statistics like tables, percentage and frequency distribution were used to analyze quantitative data. Qualitative data that were generated from semi-structured interviews, key informant interview and focus group discussion was analyzed by narrative description. Soil sample were taken from representative area and analyzed by soil laboratory analysis. The result shows that Watershed interventions implemented in the kechi micro watershed have improved the soil condition as a result of reduction in runoff and sediment transport. This is indicated by the significant variations in soil physicochemical properties between tura and tuta watershed. The soil of the watershed was dominated by clay loam content indicating relatively higher mean value in tura watershed. As a result, regular community mobilization for conservation, assistance, maintenance, and reconstruction of demolished structures needs better attention from the concerned stakeholders, mainly the local government. Since conservation structures were constructed through community mass-mobilization in a campaign form, some individual farmers have been reluctant to retain and maintain structures for long.

Keywords: Watershed Interventions, Water Resources, Soil properties and Socio-Economic Status Micro-Watersheds.

INTRODUCTION

Unique to the concept of watershed management is recognition of the relationship between land use, soil loss and productivity, water quantity and quality, wildlife populations and habitat, social factors, and economic factors. Upstream and downstream land areas and entities are linked on a watershed through the hydrologic cycle (Ababa, 2014).

Watershed is not simply the hydrological unit but also socio-political-ecological entity which plays crucial role in determining food, social, and economical security and provides life support services to rural people. It is the people oriented supporting process designed to reach the objectives of watershed management. In this concept is the recognition of the ecological interrelationships among land use, soil and water, as well as the, social and economic linkages between upland and downstream areas. Watershed management balances the three dimensions of sustainable development: ecological, economic and social in a watershed context (Wani and Garg, 2016). Government of Ethiopia have initiated watershed development since 1970's and 1980's respectively and increasingly been managed and developed for poverty alleviation and environmental conservation (Chimdesa, 2016). In Ethiopia 85 percent of the population are directly dependent on the agricultural economy. Watershed resource degradation is a serious problem in the Ethiopian which threatening agricultural development and rural livelihood. Since the economy of the country is agrarian in nature, the decline in agricultural productivity adversely affects the economic growth of the country. However, the productivity of that economy is being seriously eroded by unsustainable land management practices, both in areas of food crops and in grazing lands (FAO, 2016). The present Governments have been recognized that protection of watersheds cannot be achieved without the improving the livelihood of local people and taking lessons from the past shortcomings and it has been initiated community based watershed management (Habtamu, 2011). At socio economic level a watershed includes people, their farming system and interactions with their land resources, coping strategies, social, economic and cultural aspects (Adane, 2010). Watershed Management is the management of land and other resources on a watershed to achieve well-defined environmental, social, and economic goals. Watershed degradation, in turn, leads to accelerated ecological degeneration, reduced economic opportunities and increased social problems (Berry, 2016).

Most watershed interventions are implemented with the twin objectives of soil and water conservation and enhancing the livelihoods of the rural poor. Different types of treatment activities carried out in a watershed include soil and moisture conservation measures in agricultural lands (contour/ field bunding and summer ploughing), drainage line treatment measures (loose boulder check dam, minor check dam, major check dam, and retaining walls), water resource development/management (percolation pond, farm pond, and drip and sprinkler irrigation), crop demonstration, horticulture plantation and afforestation The aim has been to ensure the availability of drinking water, fuel wood and fodder and raise income and employment for farmers and landless labourers through improvement in agricultural production and productivity (Rao, 2017).

Land and water, the most important natural resources on the earth, are under intensive use. The population of the Ethiopia is dependent on land resource-more than 85 % of the total food is derived from land, the remaining from the aquatic systems. Agriculture is an essential component of societal well-being and occupies 40 % of the land surface and consumes 70 % of global water resources. At every point of production, agriculture influences and is influenced by ecosystems, biodiversity and the economy (Mulugeta Demelash and Karl Stahr, 2010). Degradation of vegetation cover and loss of biodiversity, soil erosion, depletion of organic matter, reduced rainwater infiltration and water holding capacity of the soil and loss of productivity and effects on wider ecological functions and effects on social and economic wellbeing of the people.

Today watershed development has become the main intervention for natural resource management. The impact assessment of the watershed development initiatives on water resource generation, production systems, soil physic-chemical properties and socio-economic status is necessary to make the programme more successful by incorporating midterm corrections and to prepare the future road map for the implementation of watershed programmes. In light of these observations, the present study was undertaken to assess the impact of watershed interventions in some micro-watersheds of Integrated Watershed Development Programme (IWMP) implemented in Kechi District, Dawuro Zone, SNNPR of Ethiopia with the following objectives. Analysis and impact assessment of watershed development interventions require measurement of well-defined indicators such as crop production, cropping intensity, crop diversity, water resource generation, net returns as well as revenue generated from cultivation activities, input usage such as fertilizers, pesticides, water, machinery and labour and others measured in terms of costs of cultivation, etc. To assess the impacts properly, it is necessary to measure these indicators by collecting data from both the treated and untreated (control) micro-watersheds within the same macro-watershed. Though the literature on watershed impact assessment in Ethiopia is quite large, but most of them are qualitative in nature and also suffer from the drawbacks of lack of structure for study as well as data availability for both the treated as well as control villages and households. The objective of this research is to study the impact of watershed intervention on soil properties in kechi district of Dawuro Zone, Ethiopia.

MATERIAL AND METHODS

In an effort to address the stated objectives, the following research instruments, sampling techniques, and analysis methods will be employed in the research process.

Description of the Study Area

The study will be conducted in Southern Nations, Nationalities and Peoples Regional State (SNNPRS) of Ethiopia in the *Kechi District* of Dawuro zone, southwestern Ethiopia. The capital of *Kechi* is kechi. It is situated in the Omo basin located 323 km and 670 km far from Hawassa and Addis Ababa which are capital cities of the Southern Peoples Region and Ethiopia, respectively. The *woreda* shares boundary with *Gessa District* in the east, *Tocha* District in north, *Konta* special *woreda* in the west, *Loma District* south east and Essera district in the south. According to 2007 population and housing census population of the district had an estimated population of 82,218 of which 41,762 male and 40,456 female. The district has 29 rural kebeles. The area is topographically rugged. The Woreda covers total area of 110018 hectar and lies between 6º36`00-7º.34`00 degree north latitude and 36º.38`00 to 37º.13`00 degree east longitudes, with an elevation ranging 501-3000m. Regarding the Agro-Ecology, 47 % is *kolla*, 32 % is *Weinadega* and 21 % is *Dega*. The annual mean temperature ranges between 15.1 to 27.5^{o}c. The rainfall is a bimodal type: the short rainy season is between (February to March) and the long between (May to September). The average annual rainfall ranges from 1201 to 1800 mm. According to the land utilization data of the region, 38.4 % is cultivated land, 13.39 % grazing land, 16.81 % forest bushes and shrub land, 17.09 % cultivable and 14.31 is covered by others.

Data Analysis Technique

Descriptive statistics like tables, percentage and frequency distribution will be used to analyze quantitative data. Qualitative data that was generated from semi-structured interviews, key informant interview and focus group discussion was analyzed by narrative description. Soil sample were taken from representative area and analysed by soil laboratory analysis.

RESULT AND DISCUSSION

Analysis of Soil Physico Chemical Properties

Composite soil samples were air-dried, grinded, and sieved to pass through a 2 mm sieve to make it ready for lab analysis. The soil laboratory analysis was done at Jimma Agriculture research center. Selected soil fertility indicators such as soil texture, soil pH, bulk density, total nitrogen, organic carbon, available phosphorus, exchangeable bases, and caution exchange capacity were analyzed using standard laboratory procedures. For the analysis of total nitrogen and organic carbon content, the soil sample was further sieved by 0.5 mm sieve. The soil bulk density was determined by core sampler method described in Black 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 Osman (2013). Soil reaction (soil pH) was determined by a 1:2.5 soil: water ratio using a pH meter as described by Van Reeuwijk (2002). The soil organic carbon (SOC) concentration was determined by using Walkley and Black rapid titration method as described in Sakar and Haldar (2005). Soil organic matter (SOM) was determined by multiplying percent organic carbon by 1.724 (Jones 2001). Total nitrogen (TN) was determined by the modified Kjeldahl methods as modified by Sakar and Haldar (2005). The available phosphorus (av. P) content was determined using Olsen extraction method as described by Van Reeuwijk (2002). The exchangeable bases and CEC were determined by using ammonium acetate method (Sakar and Haldar 2005). Ca2 + and Mg2 + were determined by atomic absorption spectrophotometer, flame photometer method was used for determination of Na+ and K+. Statistical analysis Mean and mean differences were used as a descriptive statistical analysis method. One-way ANOVA was used to test whether there is a significant difference in soil physicochemical properties between conserved and non-conserved plots. Two-way ANOVA was applied to test whether soil properties are affected significantly due to the interaction effect of land uses and SWC treatment. In addition, bivariate correlation analysis was used to show the relationships between soil physicochemical properties. The statistical analysis was manipulated using Statistical Package for Social Scientists [SPSS] version 20. Results The Impact of watershed intervention initiatives practiced through free labor communities' mass-mobilization on selected soil physicochemical properties (bulk density, soil texture, soil pH, total nitrogen, organic carbon, available phosphorous, cation exchange capacity (CEC), and exchangeable basis) were evaluated using mean differences and ANOVA. Furthermore, the assumptions of ANOVA were tested using Levene's test of homogeneity and Shapiro-Wilk test of normality (Table 1).

The test of normality for SOC, av. P, clay, and silt content of the soil were found significant, which indicates non-normal distribution ($p< 0.05$, Table 1). In this regard, Blanca et al. (2017) and Stevens (2007) reported the robustness of F test for non-normally distributed data ($p < 0.05$). Therefore, the robust test of ANOVA result was used for dependent variables showing non-normally distributed data. The homogeneity of variance assumption of one-way ANOVA for TN was violated ($p < 0.05$) in the data collected from treated and untreated cultivated plots. In this case, the robust test (Welch) were used; as the Welch test is the best method for homogeneous but normal and balanced data to control type I error (Liu 2015 and Stevens 2007).

The impact of Watershed intervention on soil physical properties

Soil particle size proportions (distributions)

The textural classes were identified using soil equilateral triangle recommended by USDA and described by Osman (2013). Accordingly, the mean particle size proportion showed that the soil was fine textured in Tuta and Tura micro Watershed plots. The soil in the study area has been dominated by clay content experiencing a mean value of 67.8 % and 60.5 % in Tura and Tuta soil respectively (Table 2), which implies that the mean value of clay content was higher under conserved plots. The mean sand fraction is the lowest proportion of soil particle content in the area. It was also indicated that the mean sand fraction was relatively lower in conserved plots. This might be attributed to the relative effect of SWC on soil erosion, which reduces the removal of top fine soil particles. On the contrary, higher sand content of the soil in Tura plots may be resulted due to removal of fine particles via soil erosion. A land that receives a high amount of rainfall and continuously cultivated without any conservation measure could allow free and easy removal of fine particles via rainfall runoff. The silt content of the soil was higher in non-conserved plots against the conserved plots. However, the differences in the mean soil particle size distribution (sand, clay, and silt) among conserved and non-conserved plots were not statistically significant at $p < 0.05$ (Table 2).

Soil Bulk Density

The effect of SWC on the mean soil bulk density was found to be minimal and slightly lower values were observed in conserved plots. A relatively higher bulk density in non-conserved plots could be related with washing out of fine organic matter rich soils by erosion and thereby exposed slightly heavier soil particulates. The ANOVA result indicated that the variation in bulk density was not statistically significant following treatment ($p < 0.05$, Table 2).

Table 1. Test of normality and homogeneity of variance for soil physical and chemical properties in both land uses and per micro watershed.

Soil properties	Both land uses (n=24)		Cultivated land (n=12)		Grazing land (n=12)	
	Tura	Tuta	Tura	Tuta	Tura	Tuta
PH (H_2O)	0.35^{ns}	3.94^{ns}	0.627^{ns}	0.400^{ns}	0.318^{ns}	
SOC (%)	0.272^{ns}	0.002*	0.496^{ns}	0.629^{ns}	0.111^{ns}	0.152^{ns}
TN (%)	0.269^{ns}	0.102^{ns}	0.507^{ns}	0.487^{ns}	0.143^{ns}	0.941^{ns}
Bulck density (gcm^3)	0.446^{ns}	0.053^{ns}	0.285^{ns}	0.661^{ns}	0.645^{ns}	0.659^{ns}
Sand (%)	0.811^{ns}	0.021^{ns}	0.391^{ns}	0.084^{ns}	0.086^{ns}	0.139^{ns}
Clay (%)	0.571^{ns}	0.049^{ns}	0.467^{ns}	0.042*	0.331^{ns}	0.117^{ns}
Silt (%)	0.433^{ns}	0.014*	0.468^{ns}	0.605^{ns}	0.080^{ns}	0.036*
Av.P (ppm)	0.344^{ns}	0.021*	0.919^{ns}	0.391^{ns}	0.972^{ns}	0.517^{ns}
CEC and Each cations ($cmol^{(+)}kg$-1) CEC	0.608^{ns}	0.808^{ns}	0.475^{ns}	0.987^{ns}	0.425^{ns}	0.219^{ns}
Na^+	0.091^{ns}	0.223^{ns}	0.907^{ns}	0.071^{ns}	0.104^{ns}	0.770^{ns}
K^+	0.83^{ns}	0.143^{ns}	0.876^{ns}	0.200^{ns}	0.797^{ns}	0.910^{ns}
Ca^{2+}	0.972^{ns}	0.474^{ns}	0.898^{ns}	0.545^{ns}	0.934^{ns}	0.102^{ns}
Mg^{2+}	0.614^{ns}	0.385^{ns}	0.867^{ns}	0.476^{ns}	0.360^{ns}	0.425^{ns}

Av. P available phosphorus, CEC cation exchange capacity, ns not significant at $p<0.005$, p p value, SOC soil organic carbon, *Significant at $p<0.005$, TN total nitrogen.
Source, Author 2021

The Impact of watershed intervention on soil chemical properties

Soil reaction (soil pH)

The acidity level of the watershed in general was rated as medium acidic based on Osman (2013) acidity and alkalinity categories of soil pH. The mean pH of the soil in the study watershed was 5.77 and 5.66 in conserved and non-conserved land respectively (Table 3). The acidity of the soil could be related with its sub-humid nature of the area and high amount of rainfall. This is true that greater rainfall increases soil acidity and humid areas are more acidic than arid and semi-arid areas (Osman 2013).

Soil organic carbon (SOC) and soil organic matter (SOM)

The analysis of variance result for SOC and SOM showed a statistically significant mean difference following treatments ($p < 0.05$, Table 3). The mean organic carbon and organic matter content of the soil in conserved plots were higher (SOC = 2.49 %, SOM = 4.3 %) than non-conserved plots (SOC = 1.66 %, SOM = 2.83 %). Besides, the mean soil organic carbon (SOC) content was rated low in conserved and very low in non-conserved plots according to the rating standard developed for tropical soils (Landon 2013). It could be explained by soil erosion, continuous cultivation, harvesting crop residues, and animal dung. The use of animal dung for fuel instead of manure may reduce the effectiveness of SWC practices in SOC concentration (Mengistu et al. 2016).

Total nitrogen

The total nitrogen (TN) content of the soil was significantly affected by SWC practices (p $p < 0.01$, Table 3). TN content of the soil in Kechi watershed was rated medium and low in conserved and non-conserved plots respectively (Landon 2013). The mean total nitrogen of the soil was greater in conserved (0.27 %) than non-conserved plots (0.138 %).

Table 2. The mean and their significant variations (one-way ANOVA) of soil physical properties in kechi micro Watershed.

	Soil particle size proportions				Soil texture	Soil textural class	Bulck density (gcm3)
		Sand (%)	Clay (%)	Silt (%)			
Treatment	Tura	761	645	187	Fine	Clay	1.250
	Tuta	87	557	243	Fine	Clay	1.247
	F ratio	643	950	1178	Fine	Clay	.002
	P	.265	.18	.267	-	-	.963

Source Author, 2021

Table 3. The mean and their significant variations (one way ANOVA) of soil chemical properties in Tura and Tuta Micro watershed.

							CEC and Each cations ($cmol^{(+)}$kg-1)				
		PH (H_2O)	SOC (%)	SOM (%)	TN (%)	Av.P (ppm)	CEC	Na^+	K^+	Ca^{2+}	Mg^{2+}
Treatment	Tura	5.54	2.46	4.2	.270	6.96	33.4	31	.52	19.3	8.67
	Tuta	5.34	1.67	2.76	.136	7.9	31.9	.18	.46	21.4	5.45
	F ratio	0.67	4.367	4.357	8.503	.354	.186	12.35	361	.453	8.525
	P	0.381	0.046*	0.046*	.008**	.558*	.663	.002**	.553	.523	.005**

Source Author, 2021

Available phosphorous

Available phosphorous of the soil was not significantly affected by conservation measures ($p > 0.05$). Its mean value was lower in conserved plots (6.96 ppm) as compared to non-conserved plots (7.9 ppm) (Table 3). The variations in the use of artificial fertilizer (diammonium phosphate) may be the reason for the prevailed variations in the soil. As compared to the requirements of crops that have been dominantly practiced in the area, the phosphorous content of the soil was questionable (4.1– 8 ppm) and deficient (< 11 ppm) for low demand crops (such as cereals and maize) and high demand crops (such as potatoes, onions) respectively (Landon 2013).

Cation exchange capacity

According to the rating standards of Landon (2013), the cation exchange capacity (CEC) of the soil in kechi micro watershed was rated as high (25–40 cmol (+) kg−1) in both Tura and non-Tuta micro watershed. The study result revealed that watershed intervention had a positive effect on the CEC content of the soil. The mean difference was higher in Tura (33.6 cmol (+) kg−1) than Tuta (31.9 cmol (+) kg−1) (Table 3), but not statistically significant ($p > 0.05$). This is believed to be caused by the relative effect of conservation measures in the watershed.

Exchangeable cations (Na+, K+, Ca2+, and Mg2+)

The relative abundance of basic cations in the exchange complex was Na+ < K+ < Mg2+ < Ca2+ for both conserved and non-conserved soils. Exchangeable Ca2+ (19.3 cmol (+) kg−1, 21.4 cmol (+) kg−1) and Na+ (0.31 cmol (+) kg−1, 0.18 cmol (+) kg−1) constitutes the highest and lowest proportion in Tura and Tuta micro watershed respectively (Table 3). One-way analysis of variance result for exchangeable Na+ and Mg2+ showed a statistically significant difference ($p < 0.01$) between Tura and Tuta micro watershed. By contrast, the effect of conservation practices for exchangeable Ca2+ and K+ was not statistically significant ($p > 0.05$).

DISCUSSION

Watershed interventions implemented in the kechi micro watershed have improved the soil condition as a result of reduction in runoff and sediment transport. This is indicated by the significant variations in soil physicochemical properties between tura and tuta watershed. SWC structures decreased the slope length and steepness and consequently led to better infiltration, slow movement, and less accumulation of runoff. As a result, the removal of soil particles, crop residues, and other organic components can be limited, which improves the soil condition as compared to the non-conserved soils. The particle size proportion of the soil was fine textured in both conserved and non-conserved soils. The soil of the watershed was dominated by clay loam content indicating relatively higher mean value in conserved plots. Similarly, Mengistu et al. (2016) reported higher mean clay content in the Tura than in Tuta sub-watershed. Higher soil erosion, removal of fine materials, clay contents, and organic matter could be possible reasons for relatively lower clay content in Tuta Watershed. Clay contents are fine particulates and more vulnerable to be washed out by erosion unless treated with SWC measures (Hishe et al. 2017, Selassie et al. 2015). A clay soil has an inherent advantage of good water and nutrient holding capacity and low level of leaching (Osman 2013). This nature of the soil helps the area to be more productive, even though it has been influenced by high soil erosion, continuous cultivation, and other natural and manmade influences. However, significant variation was not observed between Tura and Tuta micro watershed. This might be related with the prevailing parent materials and its inherent properties; such nature of the soil determines the texture of a soil, even if erosion, deposition, and other human activities may modify (Osman 2013). Watershed intervention affected the bulk density of the soil in Kechi micro watershed. A relatively higher bulk density in tura watershed could be related with washing out of fine organic matter-rich soils by erosion and thereby exposing slightly heavier soil particles. On the other side, several potential causes may explain lower bulk density in conserved plots such as lesser effects of soil erosion (SWC structures as a barrier) and relatively higher SOM content resulted from accumulation of crop residues decay, plant leaves' decay, and less vulnerability for easy removal of this components. The study finding was consistent with the results reported by Hishe et al. (2017) and Hailu et al. (2012) for tura and tuta watershed respectively. On the other hand, Challa et al. (2016), Husen et al. (2017) and Selassie et al. (2015) reported a statistically significantly lower bulk density in Tura than in Tuta watershed. Soil pH showed slightly higher mean values in Tura micro watershed. Relatively higher soil acidity in Tuta micro watershed may be related with high rainfall, associated with leaching and removal of important soil nutrients. Amare et al. (2013) and Osman (2013) explained that high amount of rain water leaches soluble bases and consequently contributes to soil acidity. Similarly, long term cropping, high rainfall, topographic steepness, and the application of inorganic fertilizer could probably increase soil acidity (Selassie et al. 2015). The analysis of variance results show that soil pH was not statistically significantly affected by conservation practices (Table 3). Similar results were reported by Challa et al. (2016) and Husen et al. (2017) in the southern of Ethiopia. The effect of conservation measures on SOC, SOM, and TN has been significant in the watershed. This coincides with Challa et al. (2016), Hailu et al. (2012), Hishe et al. (2017), Selassie et al. (2015) and Sinore et al. (2018), who reported statistically significantly higher SOC in terraced landscapes. It could be mainly related with conservation structures and biomass accumulation (Selassie et al. 2015). Soils exposed for severe erosion has been more vulnerable to decomposition of SOC than slightly eroded soils (Abegaz et al. 2016).

This implies that non-conserved soils are more vulnerable to erosion and most likely to have low SOC concentration as compared to conserved soils. As a result, supporting SWC structures by agro-forestry practice has been suggested for better carbon sequestration in the soil (Abegaz et al. 2016, Degefu et al. 2011). Similarly, supporting terracing with susbania and elephant grasses could result in high SOC and SOM due to high biomass return, which contributes to symbiotic fixation and soil erosion reduction (Sinore et al. 2018). However, we identified during on-site observation that as an agro-forestry and gully rehabilitation system, and other related benefits in the study watershed. The variation is primarily explained by conservation effects on soil erosion, because soil bund reduces loss of fine soil particles and residues (Husen et al. 2017, Mengistu et al. 2016, Selassie et al. 2015, Sinore et al. 2018). This process further improves the concentration of SOM and SOC which consequently leads to increase TN in the soil. The result was consistent with Challa et al. (2016), Hailu et al. (2012), Husen et al. (2017), Selassie et al. (2015), and Sinore et al. (2018), who stated that conserved plots resulted in significantly higher TN content. On the other side, the result did not agree with the findings of Hishe et al. (2017) who reported statistically non-significant difference in plots following treatments. The available phosphorous content of the soil between conserved and non-conserved plots did not have consistent pattern with conservation measures. The application of diammonium phosphate (DAP) may be the reason for its indistinguishable availability in the soil. This result coincides with the result reported by Hishe et al. (2017) for Middle Silluh valley, Northern Ethiopia. Hailu et al. (2012) did not find a statistically significant difference between treated and non-treated fields. Our result was not in agreement with Mengistu et al. (2016) and Selassie et al. (2015) who observed insignificant but higher available phosphorous concentration in conserved soils. The concentration of av. P in the soil in kechi micro watershed was deficient. This could be explained by different factors; the medium acidity nature of the soil and soil erosion through runoff may contribute to its limited availability in the soil. The limited availability of phosphorous in the soil may limit the growth and productivity of plants in the area. Phosphorous in the soil is highly required by plants and may cause slow growth when its concentration is very low (Hishe et al. 2017). The CEC and exchangeable basis content of the soil in the watershed was rated as high. This might be due to the inherent characteristics of the soil because fine textured soils have more exchangeable basis (Osman 2013). Soils having high clay and SOM content have strong probability to hold positively charged ions and consequently hold high CEC concentration (Selassie et al. 2015, Sinore et al. 2018). Conservation measures caused a relatively higher CEC and cation exchange capacity in conserved soils than in non-conserved but the difference did not show statistical significance. Different researchers reported that the effect of SWC measures showed non-significant difference in the CEC content of the soil (such as Hailu et al. 2012, Hishe et al. 2017). On the other hand, the findings of Challa et al. (2016), Mengistu et al. (2016) and Selassie et al. (2015) reported significantly higher CEC contents in conserved soil. The variation among research reports may be attributed to the level of effectiveness of SWC measures due to variations in conservation types, proper construction, and maintenance. Sinore et al. (2018) reported a significantly higher CEC and exchangeable bases in a soil treated with susbania and elephant grasses than in controlled soil. Supporting terracing with such plants/ grasses strengthens the bund, generates high biomass, and increases OM and better control of erosion, consequently increases CEC in the soil.

CONCLUSION

Watershed intervention has been an important means to reverse the degraded land and limit further damages to the land resources. They have been a tool for the communities to care for their local environment. This study evaluated the impact of watershed intervention in improving soil physicochemical properties in kechi micro watershed. In this regard, the study revealed that SWC resulted in improvement in soil nutrient content in kechi micro watershed. Soil organic matter, soil organic carbon, total nitrogen, and exchangeable Na^+ and Mg^{2+} showed significantly higher mean values in Tura as compared to Tuta micro watershed. Furthermore, the mean values of soil pH, bulk density, clay content, caution exchange capacity, and exchangeable Ca^{2+} were better following Tura than Tuta watershed, even if the difference was not statistically significant. Our results also showed that the effectiveness of SWC measures was better in cultivated land than in grazing land. This could be mainly related with poor management and maintenance of conservation structures in grazing land, year-round open grazing with little attention for treatments. SWC practices are effective ways in minimizing soil erosion and improving soil fertility mainly in cultivated lands. However, in general, the issue of continuity (spatial and temporal), maintenance, and reconstruction of structures has been given little attention, which is among the main challenges for limited effect of SWC practices in the watershed.

As a result, regular community mobilization for conservation, assistance, maintenance, and reconstruction of demolished structures needs better attention from the concerned stakeholders, mainly the local government. Since conservation structures were constructed through community mass-mobilization in a campaign form, some individual farmers have been reluctant to retain and maintain structures for long. In addition, supporting SWC structures with grasses and trees is very important for strengthening their effectiveness in improving soil fertility and decrease soil erosion in the watershed.

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