

# Effects of Soil and Water Conservation Measures on Selected Physico-chemical Properties of Soil in Qenshiben Watershed, Central Ethiopian Regional State

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## Abstract

*One of the main causes of declining soil resources in Ethiopia has been identified as soil erosion, which in turn negatively affects the agricultural productivity of the country. In order to alleviate the problem of soil erosion, numerous soil and water conservation measures have been implemented over the past ten years in numerous parts of the country through community mass mobilization. In spite of the fact that conservation measures had been implemented in the country, no consensus was found among the studies conducted on the effects of physicochemical soil properties. The aim of this study was to examine the effect of soil and water conservation measures on the physicochemical properties of soil within the Qenshiben watershed. There were composite and core soil samples collected from conserved cultivated lands, which had gentle, medium, and steep slopes, as well as adjacent non-conserved cultivated lands. A standard soil laboratory procedure has been used in order to analyze the physicochemical properties of elite soils. According to the results of the study, almost all of the selected physicochemical soil properties were statistically significantly affected ( $p \leq 0.05$ ) by soil and water conservation measures. Significantly, better mean values of clay fraction (48.4%), total porosity (54%), soil reaction (5.5), soil organic carbon (2.64%), total nitrogen (0.22%), and cation exchange capacity (28.14 cmolc/kg) were found beneath conserved lands than non-conserved lands, having 42.3%, 47%, 5.1, 1.78%, 0.16%, and 21.5 cmolc/kg, respectively. Furthermore, the result indicated that basic exchangeable  $K^+$ ,  $Mg^{2+}$ , and  $Ca^{2+}$  cations were significantly better beneath conserved than non-conserved lands. Sand fraction, soil moisture content, available phosphorus, and exchangeable  $Na^+$  were not statistically significantly ( $p \leq 0.05$ ) affected by the treatment. As a result of the study, it was determined that soil and water conservation measures have great implications for improving the physicochemical soil properties within the Qenshiben watershed. However, soil and water conservation measures have affected soil properties, and there has been a lower improvement in the status of elite physicochemical soil*

*properties within the studied watershed. Therefore, integrated use of biological and physical soil and water conservation interventions and continuous follow-up of implemented structures would have paramount importance in raising physicochemical soil properties within the Qenshiben watershed.*

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## INTRODUCTION

Land degradation and the consequent reduction in the productivity potential of agricultural land threaten the economic and social well-being of

current and future generations of the earth (Haregweyn et al., 2012) [1]. Soil erosion is the main cause of land degradation and a major factor in poor agricultural development in developing countries (Gemechu, 2016) [2]. Marginal land management, agroforestry degradation, and overgrazing are the main reasons why agricultural lands in Ethiopia are increasingly vulnerable to soil erosion (Adimassu et al. 2014) [3]. Soil erosion is exacerbated by steep slopes, ancient farming techniques with outdated technology, and overgrazing (Nyssen et al. 2004) [4]. It is considered a major threat to national economies (Hurni, 1993) [5] and one of the greatest challenges to agricultural sustainability (Hurni et al., 2015 [6, 7]; Molla and Sisheber, 2017 [8]). As part of the Ethiopian highlands, the upper Blue Nile basin has high soil erosion rates (0–200 t ha<sup>-1</sup> year<sup>-1</sup>) (Haregweyn et al. 2017) [9], with an annual soil loss of 131 million tons due to poor land use management systems (Betrie et al., 2011) [10].

To address soil erosion, Ethiopia introduced soil and water conservation (SWC) measures in the 1970s and 1980s. The main objectives of these initiatives are to minimize erosion, restore soil fertility, rehabilitate degraded lands, and increase agricultural productivity (Adimassu et al. 2014). Since 2012, the country has formulated community-based watershed development policies, fully considering community participation in sustainable development and management of watersheds. Community-based participatory integrated watershed management activities are being vigorously implemented in most regions. As part of this effort, a 30-day watershed management public works campaign has been initiated across the state over the past decade (Haregeweyn et al., 2012). After the launch of the program, regional, zonal, and district agriculture offices were mobilized to support farmers in implementing SWC measures. Farmers massively and voluntarily implemented soil and water conservation measures on the farmlands at several watersheds.

However, SWC measures are capable of reducing soil erosion and restoring soil fertility, but they are not equally effective in several regions of the country, and there is no consensus on their effectiveness among various studies reported in Ethiopia (Tilahun, 2019) [11, 12]. Furthermore, in the study area, although observation and analysis reports on the area coverage of implemented SWC measures were presented, no more meaningful study on the impact of soil properties was conducted. As current watershed management approaches are community-based, assessing their impact on soil properties is critical to facilitating and improving SWC trials. Therefore, a study on the effect of SWC measures on the physical and chemical properties of soil in the Qenshiben watershed was carried out.

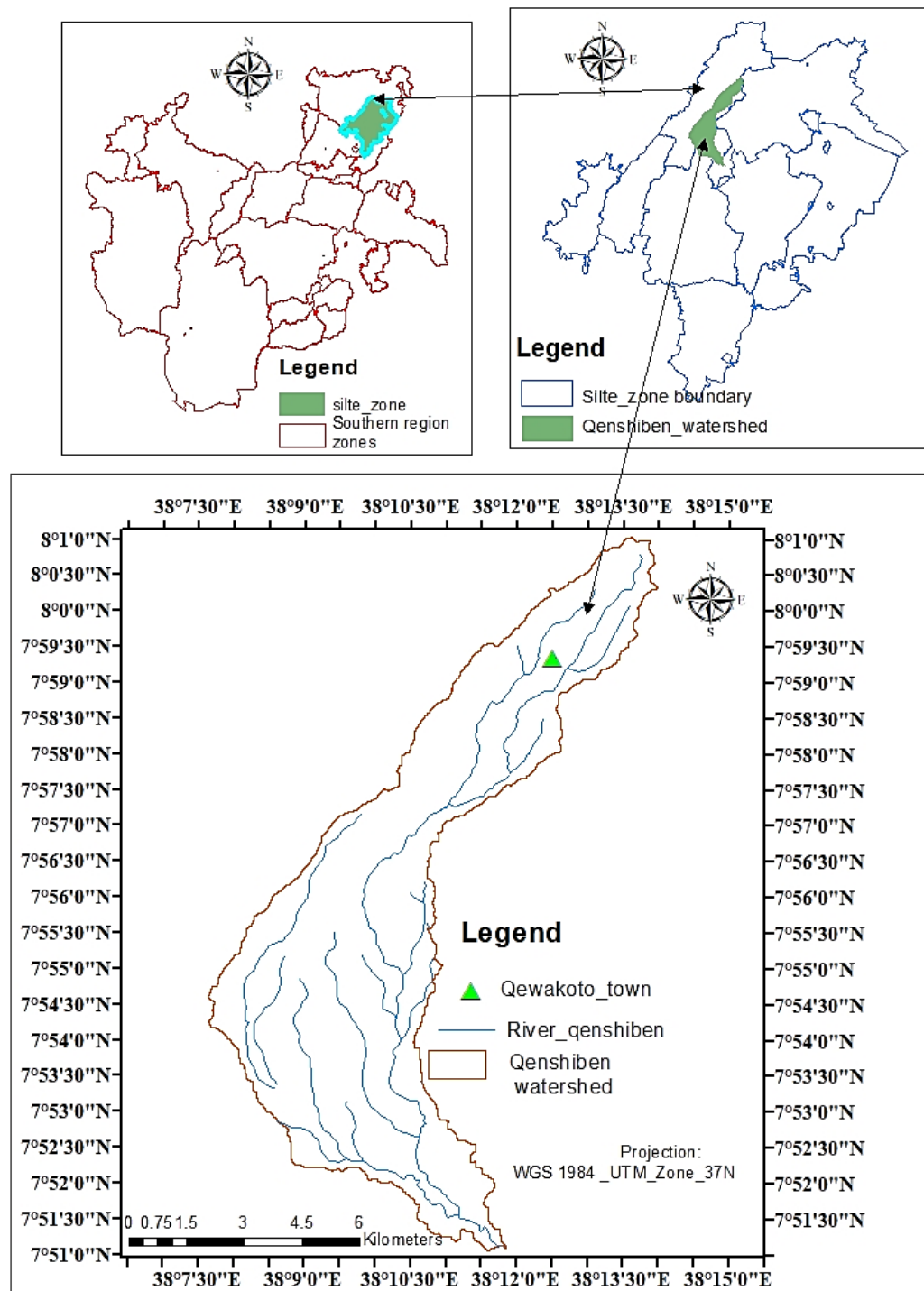
## MATERIALS AND METHOD

### Description of the Study Area

The study was conducted within the Qenshiben watershed (Figure 1), located within the Alichu Wuriro District of Silte Zone Administration in the Central Ethiopia regional state. Geographically, the watershed extends from 7°51'0"N to 8°1'0" N and 38°7'30" E to 38°15'0" E. It is located 210 km south of Addis Ababa, which is the capital town of Ethiopia.

It is estimated that the annual precipitation in the study area ranges from 900 to 1120 millimeters and that the average annual precipitation in the watershed is 1010 millimeters. The precipitation distribution of the Qenshiben watershed is uni-modal rainfall with one long rainy season (April, May, June, July, August, and September). The study area has an average minimum temperature of 9.6°C and a maximum temperature of 26.6°C on an annual basis. The watershed has tropical (Dega) and subtropical (Woina dega) agroecologies, in which 80% of the watershed is dominated by highland tropical agroecology (AWDANRMO, 2021) [13].

It is estimated that the study watershed has covered 4496 hectares as a whole. The study watershed is characterized by undulating, rugged, and craggy topography with an altitude ranging from 2400 to 3100 meters above sea level. In line with the Food and Agriculture Organization of the United Nations soil classification system, the soil of the study watershed is characterized by *Pellic Vertisols* and *Haplic Phaeozems* soil types. *Pellic Vertisols* is the dominant soil within the watershed, which covers 80% of the watershed, while *Haplic Phaeozems* soil type covers only 20% of the watershed (FAO, 2012) [14].



**Figure 1.** Location map of the watershed.

Mixed plantations cultivated and grasslands are the major land uses in the watershed. Mixed plantation is the dominant land use type, which covers 75%, while crop and grasslands cover solely 15 and 10% of the watershed, respectively. The primary source of resources in the watershed is subsistence agriculture, specifically in the form of a mixed crop and livestock system. Maize (*Zea mays*), sorghum (*Sorghum bicolor*), barley (*Hordeum vulgare*), and wheat (*Triticum aestivum*) are the four essential cereal crops of the watershed. Potato (*Solanum tuberosum L.*), cabbage (*B. oleracea var. capitata*), faba bean (*Vicia faba L.*), pea (*Arachis hypogea*), and haricot bean (*Phaseolus vulgaris*) are the main vegetables that grow in the study area (AWDANRMO, 2021).

## Methods of Data Collection

### Soil Sampling

To study the effects of SWC measures on the physicochemical properties of soil, soil samples were collected from the plot constructed with soil bunds six years ago and from the adjacent non-protected plot. Sites with protected and unprotected areas were identified through reconnaissance surveys. Soil samples were collected from 0 to 30 cm depth using a 15 cm depth drill and a 294.375 cm<sup>3</sup> core sampler. A total of 18 composite and core soil samples were collected from two treatments (conserved and non-conserved plots). Three slope categories (gentle (3–8%), medium (9–15%), and steep (16–25%) and three replicates. According to Margesin, the “X” sampling was designed to collect soil from four corners and centers of a 10 m × 10 m plot (Margesin, 2005). For protected areas with SWC structures, the sampling area is the area between two contiguous soil bund structures, whereas for non-protected areas, the sampling area is the area of cultivated land between contiguous farm boundaries.

### Soil Laboratory Analysis

To prepare composite soil samples for laboratory analysis, they were air-dried, ground, and sieved through a 2 mm sieve. Soil laboratory analysis was performed at the Areka Agricultural Research Center following standard procedures for soil laboratory analysis. The particle size distribution (PSD) of the soil was analyzed using the Bouyoucos hydrometer method (Bouyoucos, 1951) [15]. Soil bulk density was determined using the core sampling method described by Black (1965) [16]. Total porosity was estimated from bulk density and particle density (assuming a particle density of 2.65 g/cm<sup>3</sup>). Therefore, total porosity (%) = 1 – bulk density/particle density\*(100). Soil moisture content (SMC%) was determined using the method described by (Hazelton and Murphy, 2007) [17]. Soil response (soil pH) was determined by using a soil-to-water ratio of 1:2.5 as described by a pH meter (Van, 2002) [18]. Soil organic carbon (SOC) concentration was determined using the Walkley and Black rapid titration method as described in (Sakar and Haldar 2005) [19]. Total nitrogen (TN) was determined using a modified Kjeldahl method (Sakar and Haldar 2005) [20]. Available phosphorus content (avP) was determined using the Olsen extraction method, according to Van (2002) [21]. CEC was determined using the ammonium acetate method (Sakar and Haldar 2005) [19]. An atomic absorption spectrophotometer was used to measure the basic exchangeable cations Ca<sup>2+</sup> and Mg<sup>2+</sup>, and flame photometer was used to measure the exchangeable bases Na<sup>+</sup> and K<sup>+</sup>.

### Methods of Data Analysis

The analysis of variance (ANOVA) was done to take a look at the variations in physicochemical soil properties due to SWC practices following the general linear model (GLM) procedure at the ( $p \leq 0.05$ ) level of significance. A least significant difference (LSD) was used to separate significant differences between treatment means when the main effects had been found to be significant at ( $p \leq 0.05$ ). Pearson’s correlation coefficient was performed to look at all potential paired combinations between physicochemical soil properties to get a correlation coefficient matrix. SPSS version 26.0 was used to analyze the overall soil property parameters.

## RESULT AND DISCUSSION

### The Effect of Soil and Water Conservation Measures on Soil Physical Properties

#### Soil Particle Size Distribution (SPSD, %)

The evaluation made use of statistical strategies revealed that, besides the sand fraction, clay and silt fractions of the soil had been statistically significantly ( $p \leq 0.05$ ) affected by treatments. Considerably better clay fraction was found beneath conserved land (48.4%) than the adjacent non-conserved land (42.3%) with the SWC measure. The study also discovered that a higher silt fraction of soil was found beneath non-conserved lands (29.2%) than the land conserved (24.4%) with SWC measures (Table 1). Higher soil erosion, removal of fine materials, clay contents, and organic matter might be attainable reasons for comparatively lower clay and better silt content in non-conserved lands. According to USDA soil textural categorizations delineated by Osman (2013) [22], the soil textural class of the study watershed has been dominated by clay (Table 1). The result of this study is in line with Mengistu et al. (2016) [23] and Mengie et al. (2019), who determined a better clay fraction in croplands beneath terraces than adjacent non-terraced croplands.

**Table 1.** The mean values of soil physical properties in conserved and non-conserved land.

Treatments	Soil physical properties					
	Clay (%)	Silt (%)	Sand (%)	BD (g/cm <sup>3</sup> )	SMC (%)	TP (%)
CL	48.4±1.64 <sup>a</sup>	24.34±0.85 <sup>a</sup>	27.28 ±1.01 <sup>a</sup>	1.22±0.04 <sup>a</sup>	10.45±0.99 <sup>a</sup>	54±0.014 <sup>a</sup>
NCL	42.3±0.94 <sup>b</sup>	29.12±0.64 <sup>b</sup>	28.38 ±1.17 <sup>a</sup>	1.4±0.03 <sup>b</sup>	8.22±0.87 <sup>a</sup>	47±0.013 <sup>b</sup>
LSD (0.05)	4.87	3.7	1.12	0.18	2.25	1.17

*Note:* Means within columns followed by the same letters are not significantly different at  $p \leq 0.05$ ; CL, conserved land; NCL, non-conserved land; LSD, least significant difference.

### Soil Bulk Density (SBD, g/cm<sup>3</sup>)

The bulk density of the soil was statistically significantly ( $p \leq 0.05$ ) tormented by SWC measures. The decrease in BD of the soil was determined in conserved lands (1.2 g/cm<sup>3</sup>) compared to adjacent non-conserved lands (1.4 g/cm<sup>3</sup>) with SWC measures (Table 1). The lower BD of soil found within the preserved lands might be due to higher clay fractions and total porousness found within the conserved lands. According to Landon (2013) important degree score for tropical soils, the imply cost of soil bulk density in the examined watershed is dense. The end result of the present study is in line with Abay et al. (2016) [24] and Worku (2017), who reported a significantly higher value of BD in non-conserved than conserved watersheds with soil and water conservation measures.

### Total Porosity (TP, %)

The result of SWC measures on the total porosity of the studied soils was statistically significantly ( $p \leq 0.05$ ) varied following the treatment. Significantly better imply cost of soil TP was found within conserved (54%) than non-conserved land (47%) with SWC measures (Table 1). The better the TP found in conserved lands might be, the soils with conservation practices would have less erosion and a higher proportion of clay. The study is in accordance with Damte et al. (2020) [25], who confirmed considerably higher total porousness of the soil was found within conserved than non-conserved farm lands with soil and water conservation measures.

## The Effect of Soil Water and Conservation Measures on Soil Chemical Properties

### Soil Reaction (pH)

The soil's reaction (pH) value in the studied watershed was statistically significantly ( $p \leq 0.05$ ) affected by treatments. A significantly higher mean value of soil hydrogen ion concentration was found beneath conserved (5.5) than non-conserved lands (5.1) with SWC measures (Table 2). The better the soil pH found within the conserved land could be, the soils protected with conservation practices would retain the basic cations along with the phenol fraction, raising the soil pH. According to (Osman, 2013) acidity and alkalinity categories of soil pH, the acidity level of the study watershed in general was rated as strongly acidic. Correspondingly to this study, Ademe et al. (2017) [26] and Sirna and Leta (2020) [12] jointly reported significant variations in pH values for SWC practices and found higher pH values in areas with SWC practices than areas without SWC practice.

### Soil Organic Carbon (SOC, %)

The LSD check discovered that the SOC was statistically significantly ( $p \leq 0.05$ ) affected by treatments. Significantly better imply cost of SOC turned into determined in conserved lands (2.64%) than adjacent non-conserved (1.78%) lands with SWC measures (Table 2). The higher SOC found in conserved lands could be due to SWC measures that provide mechanical barriers to the runoff water, thus reducing the loss of fine soil fractions from the land and accumulating and maintaining organic matter and organic carbon within the lands. Likewise, Hishe et al. (2017) [27, 18] and Sirna and Leta (2020) reported significantly lower SOC content beneath the farmland while SWC was not conserved cultivated lands. In line with Landon (2013) important level rating for tropical soils, the mean SOC contents of the Qenshiben watershed are rated as low (2–4%).

### Total Nitrogen (TN, %)

The examined end result additionally confirmed that the total nitrogen of the soil was statistically significantly ( $p \leq 0.05$ ) affected by SWC measures. Significantly better imply cost of TN of the soil turned

**Table 2.** The mean values of soil chemical properties in conserved and non-conserved land.

Treatments	Chemical soil properties									
	pH	SOC (%)	TN (%)	C:N	AP (ppm)	CEC (cmolc/kg)	Basic cations (cmolc/kg)			
							Na <sup>+</sup>	K <sup>+</sup>	Mg <sup>2+</sup>	Ca <sup>2+</sup>
CL	5.5± 0.05 <sup>a</sup>	2.64± 0.14 <sup>a</sup>	0.22± 0.009 <sup>a</sup>	11.83± 0.3 <sup>a</sup>	11.74± 0.48 <sup>a</sup>	28.14± 1.3 <sup>a</sup>	0.05± 0.008 <sup>a</sup>	0.22± 0.015 <sup>a</sup>	9.36± 0.47 <sup>a</sup>	11.7± 1.14 <sup>a</sup>
NCL	5.1± 0.06 <sup>b</sup>	1.78± 0.10 <sup>b</sup>	0.16± 0.01 <sup>b</sup>	10.77± 0.44 <sup>b</sup>	11.45± 0.23 <sup>a</sup>	21.5± 0.37 <sup>b</sup>	0.06± 0.004 <sup>a</sup>	0.14± 0.0078 <sup>b</sup>	6.85± 0.3 <sup>b</sup>	6.5± 0.38 <sup>b</sup>
LSD (0.05)	0.36	0.85	0.05	1.12	0.3	6.65	0.012	0.07	2.51	2.2

*Note:* Means within columns followed by the same letters are not significantly different at  $p \leq 0.05$ ; CL, conserved land; NCL, non-conserved land; LSD, least significant difference.

into determined within conserved (0.22%) than adjacent non-conserved (0.16%) lands with SWC measures (Table 2). The higher TN levels on the conserved lands are probably due to the fact that SWC practices reduce runoff soil loss and enhance profile water storage, which would enhance crop growth as well as contribute to the organic matter and nitrogen inputs to the soil during the growing season. Harmoniously, Dagnachew et al. (2019) [28] and Damte et al. (2020), also reported significantly higher TN in farmlands conserved with SWC measures as compared to the non-conserved land. In line with Landon (2013) important level rating for tropical soils, the mean TN of the Qenshiben watershed is rated as medium (0.15–0.3%).

#### **Carbon to Nitrogen Ratio (C:N)**

In the examine watershed, the C:N ratio turned into statistically significantly ( $p \leq 0.05$ ) affected by treatments (Table 2). Significantly, a better C:N ratio turned into determined with inside the conserved lands (11.83) than non-conserved lands (10.77). The better C:N cost determined with inside the conserved lands, because of better imply cost of SOC and TN determined with inside the conserved lands as in comparison to non-conserved lands. In distinction to the current finding, Damte et al. (2020) [29], was reported the C:N ratio of the soil wasn't considerably affected by SWC measures. According to Landon critical level rating for tropical soils the calculated C:N ratio of Qenshiben watershed is rated as optimum (Landon, 2013).

#### **Cation Exchange Capacity (CEC, cmolc/kg)**

The CEC of the studied soil was statistically significantly ( $p \leq 0.05$ ) affected by SWC measures. Significantly better imply cost of CEC turned into determined in conserved lands (28.14 cmolc/kg) than adjacent non-conserved land (21.5 cmolc/kg) with SWC measures (Table 2). The better mean CEC of soils found within the conserved lands might be due to the presence of higher organic matter and clay contents in lands conserved with SWC measures. The study is in line with Mulugeta and Karl (2010) [30, 31], who reported that the mean distinction in CEC was higher in conserved plots than non-conserved plots. In line with Landon (2013) important level rating for tropical soils, the mean CEC of the soil in the Qenshiben watershed is rated as high (21–30 cmolc/kg).

#### **Exchangeable Basic Cations (Na<sup>+</sup>, K<sup>+</sup>, Mg<sup>2+</sup> and Ca<sup>2+</sup>, cmolc/kg)**

The end result indicated that, besides Na<sup>+</sup>, other basic exchangeable cations had been statistically significantly ( $p \leq 0.05$ ) affected by SWC measures. Considerably higher mean values of exchangeable K<sup>+</sup>, Mg<sup>2+</sup>, and Ca<sup>2+</sup> basic cations had been determined within the conserved lands than adjacent non-conserved lands with SWC structures (Table 2). The better mean values of basic cations found in the conserved land might be the result of conservation structures against the leaching of basic cations by erosion. As a result of using all SWC practices, the relative abundance of basic cations in the exchange advanced for both conserved and non-conserved soils was Na<sup>+</sup> < K<sup>+</sup> < Mg<sup>2+</sup> < Ca<sup>2+</sup>. Exchangeable Ca<sup>2+</sup> (11.7, 6.5 cmolc/kg); Mg<sup>2+</sup> (9.36, 6.85 cmolc/kg); and K<sup>+</sup> (0.22, 0.14 cmolc/kg) constitute the highest and lowest proportions in conserved and non-conserved plots, respectively. Correspondingly, Mengie et al. (2019) reported that higher basic exchangeable cations were found in conserved lands than non-conserved lands with SWC measures. They confirmed that the high-clay soils can hold more exchangeable cations than the low-clay soils.

### ***The Correlation Between Physicochemical Soil Properties***

The simple linear correlation results show the strength and magnitude of the relationship among the selected physical and chemical soil properties (Table 3). The hydrogen ion concentration of the studied soil showed a robust positive and important relationship with TN (0.76\*\*), TP (0.75\*\*), CEC (0.62\*\*), clay (0.61\*\*), and every other exchangeable base except sodium. The matrix revealed a really strong positive and significant relationship (0.93\*\*) between TN and SOC. Total nitrogen additionally confirmed a sturdy, high-quality enormous correlation (0.76\*\*, 0.55\*, 0.50\*, 0.55\*) with TP, CEC, exchangeable Ca<sup>2+</sup>, and K<sup>+</sup> content, respectively. The bulk density of soil showed a strong negative and important relationship with TP (-0.94\*\*), TN (-0.76\*\*), CEC (-0.75\*\*), and hydrogen ion concentration (-0.75\*\*) and had a positive and significant relationship with the silt fraction (0.70\*\*) of the soil.

**Table 3.** Correlation among soil properties.

	SMC	SBD	TP	Clay	Silt	Sand	pH	SOC	avP	TN	CN	CEC	Ca	Mg	K	Na
SMC	1															
SBD	<b>-.58*</b>	1														
TP	<b>.55*</b>	<b>-.94**</b>	1													
Clay	<b>.77**</b>	<b>-.62**</b>	<b>.64**</b>	1												
Silt	<b>-.73**</b>	<b>.70**</b>	<b>-.70**</b>	<b>-.80**</b>	1											
Sand	<b>-.57*</b>	.33	<b>-.34</b>	<b>-.66**</b>	.25	1										
pH	<b>.61**</b>	<b>-.75**</b>	<b>.75**</b>	<b>.61**</b>	<b>-.66**</b>	<b>-.38</b>	1									
SOC	<b>.53*</b>	<b>-.72**</b>	<b>.76**</b>	<b>.60**</b>	<b>-.77**</b>	<b>-.32</b>	<b>.63**</b>	1								
avP	.37	<b>-.43</b>	.28	.39	<b>-.28</b>	<b>-.34</b>	.24	.27	1							
TN	<b>.68**</b>	<b>-.76**</b>	<b>.76**</b>	<b>.67**</b>	<b>-.85**</b>	<b>-.29</b>	<b>.76**</b>	<b>.93**</b>	.34	1						
C:N	<b>-.07</b>	<b>-.28</b>	.36	.11	<b>-.13</b>	<b>-.25</b>	.04	<b>.58*</b>	<b>-.02</b>	.25	1					
CEC	.31	<b>-.41</b>	.43	.40	<b>-.55*</b>	<b>-.18</b>	<b>.61**</b>	<b>.54*</b>	.23	<b>.55*</b>	.26	1				
Ca	.35	<b>-.33</b>	.37	.41	<b>-.48*</b>	<b>-.28</b>	<b>.63**</b>	<b>.48*</b>	.19	<b>.50*</b>	.23	<b>.95**</b>	1			
Mg	.18	<b>-.38</b>	.41	.36	<b>-.43</b>	<b>-.16</b>	<b>.59*</b>	.38	.27	.40	.12	<b>.77**</b>	<b>.78**</b>	1		
K	.24	<b>-.38</b>	.34	.32	<b>-.46</b>	<b>-.29</b>	.42	<b>.70**</b>	.39	<b>.55**</b>	<b>.58*</b>	<b>.64**</b>	<b>.62**</b>	<b>.57*</b>	1	
Na	<b>-.42</b>	.36	<b>-.33</b>	<b>-.55*</b>	.35	.43	<b>-.30</b>	<b>-.31</b>	<b>-.29</b>	<b>-.39</b>	.08	<b>-.05</b>	.02	.06	<b>-.08</b>	1

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\*. Correlation is significant at the 0.01 level (2-tailed).

### **CONCLUSION AND RECOMMENDATION**

The study revealed almost all of the physicochemical soil properties had been undoubtedly tormented by soil and water conservation measures implemented within the study watershed. Bulk density, total porosity, silt and clay fractions, soil pH, total nitrogen, soil organic carbon, cation exchange capacity, and basic cations (K<sup>+</sup>, Mg<sup>2+</sup>, Ca<sup>2+</sup>) had been statistically significantly ( $p \leq 0.05$ ) affected by SWC measures. The sand fraction of soil, soil moisture content, and available phosphorous and exchangeable Na<sup>+</sup> ions had not been statistically significantly ( $p \leq 0.05$ ) affected by SWC measures. Generally, the SWC measures have shown a positive impact on the soil conditions, as measured by the elite physicochemical soil properties.

Though most physicochemical soil properties had been affected by soil and water conservation interventions, the improvement of soil fertility status was lower. Therefore, integral use of physical and biological soil and water conservation interventions and continuous follow-up of implemented structures would have paramount importance in raising the status of physicochemical soil properties.

#### **Declarations**

##### ***Consent to Participate***

Not applicable

##### ***Consent for Publication***

Not applicable

### ***Competing Interests***

I declare that the authors have no competing interests, as defined by Springer, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

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### ***Availability of Data and Materials***

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### ***Authors' Contributions***

DA has made significant contribution, starting with proposal writing, data collection, data analysis and interpretation, and the final manuscript preparation. AT has participated in advising, guiding, and editing proposal and manuscript preparation process.

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