Impacts of physical soil and water conservation measures on selected soil physico-chemal properties

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ABSTRACT
Soil erosion is the foremost cause of reducing soil fertility in Ethiopia negatively affecting agricultural productivity. To reduce soil erosion by water, physical soil and water conservation measures have been widely introduced. However, the study on the performance of those measures against its target is limited. Objective of this study was to assess the effects of physical soil and water conservation measures (e.g., *Fanya juu*) on selected soil physico-chemal properties. A total of 36 composite soil samples from 0–20 cm depth were collected from Uddo Wotate watershed. That is, 27 samples from field treated with *Fanya juu* (3 farm field*3plot*3samples per plot) and 9 from non-treated adjacent field (3 fields *3 samples per field) were collected and analyzed following standard laboratory procedures. Paired sample t-test and one-way ANOVA were used to analyze data. The result of the analysis revealed that soil pH, soil organic carbon (SOC), total nitrogen (TN), available phosphorous (Av.P, ppm), and available potassium(Av.K ppm) differed significantly ($p<0.05$) between conserved and non-conserved land, but textural composition did not differ significantly ($p>0.05$). This could be due to the positive effect of conservation measures in reducing erosion. In addition, in the intra- *Fanya juu* zones clay, sand, Av. K, TN, and SOC were significantly varied ($p<0.05$). The highest SOC and nutrients were observed at the deposition zone due to the downward movement of organic matter and surface soil and the protection ability of *Fanya juu*. The physical SWC measures could retain soil properties as compared to non-treated land. Therefore, the deteriorated soil physiochemical properties should be amended by integrating additional soil fertility management practices for better effect.
Keywords: *Fanya juu*; Nutrients; Physical soil and water conservation; Soil erosion; Soil physicochemical properties
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1. INTRODUCTION

Soil quality is critically important for growing crop (Bünemann et al., 2018). Soil erosion is among the major degrading processes that negatively affect the global soil quality for crop production (Klik et al., 2015; Pimentel & Burgess, 2013). Many human and natural processes could contribute to soil erosion, but agricultural activities account for over 80% of global soil erosion (Pimentel, 2006). Soil quality decline due to erosion and subsequent impact on crop production is a common challenge in many regions of the world including Sub-Saharan Africa (Tamene and Le, 2015; Bindraban et al., 2012). Soil erosion is a serious environmental problem in Ethiopia, resulting in a decrease in arable land productivity due to the removal of the fertile and biochemically active fractions from the top layer (Wolka et al., 2018; Alemu et al., 2013; Amdemariam et al., 2011; Wolka et al., 2011). Even though soil erosion in Ethiopia varies widely following topography, land use, climate, soil properties and conservation activities, the national average loss of about 30-ton ha^{-1} $year^{-1}$ (Haregeweyn et al., 2015), is three times greater than the suggested tolerable level.

To reduce the impacts of severe soil erosion primarily on crop production and ecosystem services of the soil, soil and water conservation practices were initiated in Ethiopia during the 1970s and 1980s as part of efforts to repair degraded areas and enhance agricultural production (Haregeweyn et al., 2015; Adimassu et al., 2014). The principal goal of the initiatives was to reduce erosion, restore soil fertility, rehabilitate degraded land, and boost agricultural productivity (Abera et al., 2019). Following that, the Ethiopian government has widely adopted and promoted soil and water conservation measures including soil and stone bunds, *Fanya juu*, cut-off drains, hillside and bench terraces, and tree and grass species planting on privately owned and communal areas via community mobilization and incentive-based schemes (Abera et al., 2019), which are designed using a national technical guideline (Hurni et al., 2016).

Among physical SWC measures, *Fanya juu, which means* "throw it upwards" in Kiswahili widely used in east Africa. This physical SWC is constructed along contour by digging soil to the depth of about 0.5 m and 0.5 m wide and forming embankment at upslope side of the trench. The embankment will be the first defense line against surface runoff and soil loss. In 1970s/80s it was introduced to Ethiopia and practiced through projects, programs, and public campaign for SWC (Hurni, 1986).

Studies assessed the performance of soil and water conservation (SWC) measures mainly in the semi-arid northern regions of the country (Haregeweyn et al. 2016; Nyssen et al. 2010). The efficiency and effectiveness of SWC measures are determined by both the prevailing agro-ecology and the type of conservation measures used (Haregeweyn et al., 2015). However, there is little consensus on the effectiveness of SWC intervention among the research findings presented so far. Some argue that physical SWC measures did not change soil properties significantly (Wolka et al., 2011; Bewket and Sterk 2002). On the other hand, some studies have reported the positive impact of SWC measures on soil properties. Example, Guadie et al. (2020), Teressa (2017), and Hailu et al. (2012) reported greater organic C, and nutrients on conserved farmland with Fanya juu and related structures than on non-conserved farmland. In the neighboring Kenya, long managed *Fanya juu* improved soil organic carbon (Saiz et al., 2016). The introduced soil and water conservation structures such as *Fanya juu* and soil bunds have been widely acknowledged as effective measures in preventing soil erosion and having the potential to improve land productivity (Eleni, 2008).

The Lake Hawassa watershed, where this study was conducted, has been affected by severe soil erosion and land productivity losses as a result of rugged topography and anthropogenic influences. To combat the problem of soil erosion in the study area, the government, non-governmental organizations, and public campaigns have invested resources and efforts in promoting physical SWC measures including *Fanya juu* (Tiki et al., 2015). However, little information is documented on the impact of such practices in improving soil properties. Knowing the effects of physical SWC measures on the soil is crucial for considering choices for proper management planning and implementation. Therefore, this study aimed to assess the effects of physical SWC measures such as *Fanya juu* on selected soil physico-chemal properties.

2. METHODS AND MATERIALS

2.1. Description of the Study Area

This study was carried out at Uddo Wotate Watershed in Hawassa Zuria district, Sidama region of Ethiopia. As represented in Figure 1, Uddo Wotate is located in (7° 1.42'N to 7° 5.90'N, 38° 21.37' E to 38° 25.10' E). The area has a semiarid climate with a long-term average annual rainfall of 958 mm, 81% of which falls during the crop growth season (April to October) and mean annual temperatures ranging from 23 to 27°C (EOSA, 2007). There is no perennial river that runs through the area. Lake Hawassa, one of the lakes in the rift valley area, is the major water source for livestock and irrigation of areas surrounding the lake. The soil is clay loam (EthioSIS, 2016). The major crops grown in the study area include maize (Zea *mays* L.) as the most extensively cultivated grain crop, sorghum (*Sorghum bicolor*), haricot bean (*Phaseolus vulgaris*), enset (*Ensete ventricosum*), and sugarcane (*Saccharum officinarum*). Farmers in the study areas usually use blanketly recommended chemical fertilizer to grow crops such as maize with conventional tillage and mono-cropping practices. The dominance of maize in the Hawassa Zuria woreda can be attributed to a combination of agro-ecological conditions, market demand, and cultural practices.

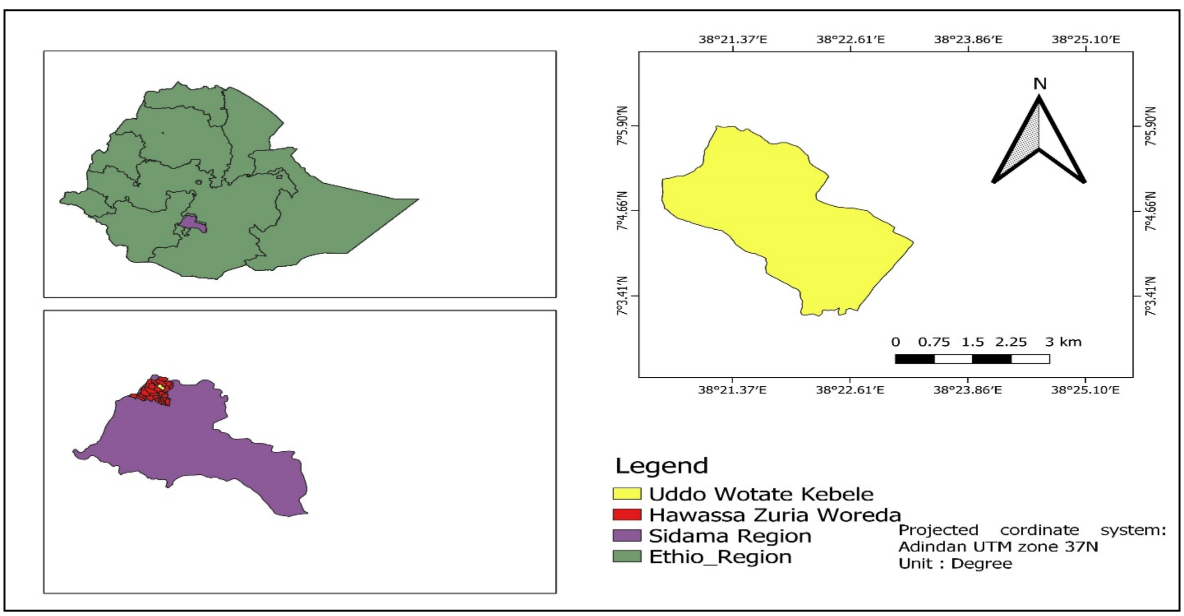

Figure 1: Location map of Uddo Wotate Kebele, southern Ethiopia.

2.2. Soil Sampling and Analysis

A reconnaissance survey was carried out to identify representative soil sampling plots. Soil sampling sites were selected both from the farm plots where different physical SWC measures have been practiced and non-conserved adjacent plots having similar land use histories. *Fanya juu* is constructed by digging soil to depth of 50-70cm, top width 50cm, on land with slope less than 15% (Hurni, 1986). It is constructed by digging a trench and throwing the soil uphill to form an embankment. Three farm fields, each with three consecutive *Fanya juu* and adjacent no-treated farmland were selected. In the fields with physical SWC measures, three inter- *Fanya juu* plots were selected per field. In each plot, a soil sample was collected from three sub-plots, i.e., near *Fanya juu* (at upslope and bottom sides), and sections. That is, soil samples were collected from the bottom spot (1.5 meters from the lower side of *Fanya juu*, above the *Fanya juu* at about 1.5 m, and at a center spot (midpoints between the two successive *Fanya juu*).

A total of 27 samples (three farm fields*3 inter-*Fanya juu* area*3 samples per plot) were collected from fields with physical SWC. In the fields considered for the study, Fanya juu was eight years old and managed traditionally. Adjacent to fields with physical SWC, from fields without physical SWC, 9 soil samples (three fields *3 samples per field) were collected. In all cases, the soil sample was collected from 0-20 cm depth using auger. These soil -samples were packed with plastic bags, coded and transported to lab analysis.

In the lab, soil samples were air dried for seven days, crushed with mortar and pestle and passed through a 2-mm sieve. Soil texture, pH, soil organic carbon (SOC), total nitrogen (TN), available phosphorous (Av.P), and available potassium (Av.K) were determined in lab. Soil texture was determined by the Boycouos hydrometric method (Bouyoucos, 1962; Van Reeuwijk, 1992). The pH of the soil was measured by a digital pH meter (1:2.5 soil to water ratio) using potentiometrically a glass-calomel combination electrode (Van Reeuwijk, 1992). The Walkley and Black (1934) wet digestion method was used to determine soil organic carbon content. Total N was analyzed using the Kjeldahl digestion, distillation and titration method as described by Bremmer (1965). Available soil P was analyzed P-Bray 2 method designated by Bray and Kurtz (1945). Available K was analyzed by flame photometer (Rowell, 1994).

2.3. Data Analysis

The soil results were analyzed with paired t-test and one-way ANOVA using SPSS software. A paired sample t-test was employed to detect whether there is a significant effect (at $P<0.05$) on soil attributes between treated and non-treated lands, while one-way ANOVA was used to investigate spatial variation of soil properties within consecutive structures of *Fanya juu*.

3. RESULTS AND DISCUSSION

3.1. Impacts of physical soil and water conservation on soil physical properties

Soil texture

The results showed that physical soil and water conservation structures had significant effects on the concentration of sand, clay, and silt content compared to the non-conserved land at $p<0.05$. However, there were no textural class changes, and the soil textural class of both conserved and non-conserved land falls under sandy loam. Table 1 shows that the concentration of sand is higher in non-treated land (61.22%) than in treated farm plots (55.07%). The higher sand content in non-conserved plots might be fine particles such as clay and silt have been easily removed due to soil erosion from non-treated fields, leaving the coarser fraction behind (sand, gravel, stones). A continually farmed land with no conservation measures may enable for the free and easy removal of fine particles by rainwater runoff. As a result, the concentration of sand content is relatively higher in non-treated land-use types. This is consistent with Belayneh et al. (2019) and Hishe et al. (2017) results that treated farmland contains less sand than untreated farmland.

The mean value for clay content was found to be greater in conserved land (17.62%) than in non-conserved land (16.11%) (Table 1). Higher soil erosion, removal of fine materials, clay contents, and organic matter could be possible reasons for relatively lower clay content in non-conserved plots. This finding is consistent with findings reported by Adimassu et al. (2012), Dagnachew et al. (2020) and Mengistu et al. (2016), who found that soil clay proportion is higher on conserved land than no-conserved land.

The silt concentration of treated farmland (27.31%) was higher than that of non-treated farmland (22.67%) (Table 1). This finding is consistent with the findings of Belayneh et al. (2019) and Bezabih et al. (2016). Nonetheless, the results contradict the findings of Demelash and Stahr (2010) and Mengistu et al. (2015), who found that silt concentrations were higher in non-conserved land than in conserved land, which is characterized by basaltic trap series of volcanic eruptions parent material.

Table 1: Effect of physical SWC measures on soil texture in Uddo Wotate watershed, Hawassa Zuria, Ethiopia.

Parameters	*Fanya juu*	Non-conserved	Std. Error Mean	t-value	P-value
Soil particle size distribution	Mean	Mean			
Sand (%)	55.07	61.22	1.47779	4.163	.003
Clay (%)	17.62	16.11	.4839	-3.127	.014
Silt t (%)	27.31	22.67	1.29681	-3.578	.007
Textural class	Sandy loam	Sandy loam			

3.2. Impacts of physical soil and water conservation on soil chemical properties

Soil pH

Table 2 shows that treated land with *Fanya juu* had a significantly higher mean value of soil pH than non-treated land, with a statistically significant difference between the two [t =-2.476; p=.038]. This could be related to the existence of more exchangeable cations that are needed for the growth of plants in treated plots due to reduced erosion and high cation nutrients that resulted from the presence of SWC structures. Other studies in the northern Ethiopia also reported related findings (Alemayehu and Fisseha, 2019;, Hailu, 2017; Hishe et al., 2017; Birhane et al., 2016). The treated land loses less surface soil, implying better fertility level that could balance the soil pH). However, this finding contradicts with Wolka et al. (2011), who found lower pH in the treated land as compared to the non-treated one. Perhaps, site specific management practice influence soil properties.

Soil Organic Carbon

Soil organic carbon is important for soil health and fertility, as it plays a key role in nutrient cycling, water retention, and soil structure. It also helps to sequester carbon from the atmosphere, which can help to mitigate climate change. In the study area, soil organic carbon (OC) was also influenced by SWC measures. A statistical paired samples t-test revealed that the organic carbon content of treated plots with *Fanya juu* and non-treated plots differed significantly [t =-3.39; p =0.0095]. The mean value of organic carbon content for treated plots with *Fanya juu* is 1.18% and non-treated plots is 0.99%) (Table 2). This coincides with other studies that reported significantly greater SOC in lands with physical structure compared to land without any structures (Challa et al., 2016;, Hailu et al.,2012;, Million,2003;, Selassie et al., 2015;, and Sinore et al., 2018). The variations in SOC could have been attributed to the effect of *Fanya juu* implemented on farmland and reduced loss of fertile topsoil (Abay et al., 2016; Tadele et al., 2013). Soils subjected to severe erosion are more sensitive to SOC decomposition than lightly degraded soils (Abegaz et al., 2016). that the erosion prone non-conserved soils could have lower SOC concentrations than conserved soils.

According to Landon (1991), the SOC concentration of both conserved and non-conserved farm plots is found very low in the study area. This could be attributed to previous land degradation and farming practices such as continuous cropping, intensive tillage, crop residue removal and low organic carbon input as well as fast mineralization of existing low organic matter content. Yihenew (2002) reported that most cultivated soils in Ethiopia have low organic matter contents due to the low amount of organic materials supplied to the soil and the total removal of biomass from the field. Crop residue removal for livestock and other purposes is a common practice in different parts of the country including the study area (Duncan et al., 2016).

Available Phosphorus

Table 2 shows that Av.P is greater on farmland with *Fanya juu* (5.3626 ppm) than non-treated (3.4267 ppm) and statistical paired samples t-test revealed a significant difference [t =-14.407; p =.001]. The variation could be due to the soil OM content difference and in situ deposition of the sediment in the treated site. This implies that the removal of P from topsoil when conservation measure is not sufficient to control it. The Av.P has a direct association with soil organic carbon. Other studies also report greater Av. P for croplands treated with conservation measures compared to the non-treated annual cropland (Mulugeta and Stahr,2010; Wadera Lemma, 2013). The low levels of available P in non-conserved land could be due to removal of soluble phosphorus by surface transport through erosion and eluviation (Smeek, 2003). However, it disagrees with Bezabih et al. (2016), who found that available phosphorus is higher on non-treated than treated farmland by physical measures in southwest Ethiopia.

According to Tisdale et al. (1997), the rating of available phosphorous in the soil in Uddo Wotate watershed was found to be low. This could be explained by several factors to its limited availability in the soil; including the acidity nature of the soil and strongly bonded to soil particles and easily washed away by soil erosion. Availability of P is usually optimum in the pH range of 6.5 and 7.0 and at low or acidic pH (5.5), phosphorus is combined with Al, Fe, and Mn as their polyphosphates (Osman, 2013).

Total Nitrogen

The TN content of the soil was significantly affected by SWC practices [t =-3.543; p=.008; Table 2). The plots treated with *Fanya juu* had higher (0.118%) of total nitrogen content than non-treated (0.085%). The reason is that the presence of SWC measures improved total nitrogen by increasing the amount of organic matter in the soil, which is a key source of nitrogen. Other researchers reported concurring findings. For instance, Alemayehu et al. (2020), Bezabih et al. (2016), Guadie et al. (2020), who reported that TN is higher on treated farmland than non-treated farmland based on physical measures. It could also be mainly related to conservation structures and biomass accumulation (Selassie et al., 2015). However, this contradicts with Wolka et al. (2011), who reported that total nitrogen did not differ significantly in cropland treated with related physical soil and water conservation structures such as soil bunds compared to non-treated cropland.

As rating standard outlined by Landon (1991), TN content of the soil in Uddo Wotate watershed was found to be low and very low in conserved and non-conserved plots in respectively. This indicates that the soil in the study area was generally poor in total nitrogen content. This could be due to TN content of the soil being directly associated with its SOC content and becoming lower due to previous land degradation. This also might be a lack of incorporation of leguminous plants, which can fix nitrogen through nodules, lack of integrating physical and biological conservation measures.

Available Potassium

In the study area, soil and water conservation measure has influenced available potassium positively as compared to adjacent non-conserved plots. According to Table 2, the available potassium under the treated field with *Fanya juu* (130.31ppm) is greater compared to the non-conserved farm plot (124.22ppm), which had a significant difference [t =-2.847; p=.022]. This could be because erosion removes soluble salts from non-treated land resulting in low available potassium. So that, physical soil and water conservation measures could have a positive impact on the availability of potassium in agricultural soils than adjacent non-conserved cropland. Wadera Lemma (2013) also reported that the adoption of SWC practices enhances the available soil potassium. Our result also agrees with the results Worku et al. (2012), who revealed that available K concentrations in farm plots with physical soil and water conservation structures were considerably higher than its concentration in the surrounding non-treated farm plots.

Table 2: Effect of physical SWC on soil chemical properties in Uddo Wotate watershed

Site and soil parameter	Mean	Std. Error Mean	Std. Deviation	t-value	P-value
PH					
Treated	5.57	0.125	.37777	-2.476	0.038
Untreated	5.26				
Soil organic carbon (%)					
Treated	1.18	0.055	0.1672	-3.39	0.0095
Untreated	0.99				
Total nitrogen (%)					
Treated	0.11849	0.0092	0.0278	-3.543	0.008
Untreated	.085607				
Available phosphorus (ppm)					
Treated	5.36	0.134	0.40	-14.407	0.001
Untreated	3.4267				
Available potassium(ppm)					
Treated	130.32	2.14	6.42255	-2.847	0.022
Untreated	124.22				

3.3. Spatial variation of soil properties in Intra- *Fanya juu* positions

Based on the one-way ANOVA analysis (Table 3), the mean value of the clay and sand fractions showed a significant difference within the structure's zones of *Fanya juu* at ($p<0.05$). The highest mean value of clay content (19.9%) was recorded at the deposition zone of *Fanya juu*, while the highest mean value of silt content (27.85%) was measured in the middle zone of *Fayna juu* (Table 3). The variation could be attributed to fine soil particle movement by erosion from the upper zone of structure and accumulation at deposition zones. This result is consistent with the finding of Gebremichael et al. (2005), who reported that selective removal of soil particles to steeper slopes leaves coarser materials (sand, gravel, and stones) behind; whereas the transported material is deposited as the slope steepness diminishes.

The loss zone of the *Fanya juu* had the highest percentage of sand content (57.73%) (Table 3). This could be caused by the movement of eroded fine soil particles to the deposition zone of the *Fanya Juu* and gravel and sand materials left in the upper zone of the *Fanya Juu* can increase the sand content of the loss zone of the structures, which can affect the soil structure and water-holding capacity. A similar pattern was reported by Hailu (2017), the mean sand content was higher at the top landscape position than at the lower landscape position.

Table 13 Mean value estimates for particle size distribution of intra-*Fanya juu* zones

Soil properties	*Fanya juu* position			
	Loss	Middle	Deposition zone	F-value
Clay (%)	15.2^{a}	17.74^{b}	19.916^{b}	9.929^{*}
Silt (%)	27.078^{b}	27.85^{b}	27.02^{b}	3.151^{Ns}
Sand (%)	57.73^{b}	54.42^{a}	53.07^{a}	6.297^{*}

Ns=not significant at $p>0.05$; (*) =Significant at $p<0.05$; Rows having the same letters are not statistically significant at 0.05 significance level.

In the study site, the soil pH was not significantly affected by the *intra-Fanya juu* position. The findings were consistent with those of Amare et al. (2013), who discovered no significant variation ($p<0.05$) in the mean pH value for the loss and deposition zones of terraced farmland. A similar pattern reported by Million (2003), Vancampenhout et al. (2006), and Worku (2017) reported that soil pH was not significantly affected by stone bunds and consecutive stone terraces.

However, the greatest pH (5.7061) value was observed at the deposition zone and the lowest (5.4767) at the loss zone of *Fanya juu* (Table 4). This could be due to changes in organic matter, as pH is changed by organic material contents (Wilke, 2005). The movement of organic matter from the top to the bottom in the Intra-structure area of *Fanya juu,* which can lead to a fall in soil pH in the upper section of the structure.

The SOC analysis was significantly varied ($p<0.05$) with zones of *Fanya juu*. The maximum (1.205%) SOC was found in the deposition zone, while the lowest (1.15%) was found in the loss zone of *Fanya juu* (Table 4). The variation of organic carbon could be due to the downward movement of fertile topsoil and biomass from the upslope through runoff and accumulation at the deposition zone as a result of *Fanya juu* delayed velocity of runoff. This result supports Amare *et al*. (2013), who observed that soil organic matter concentrations differed significantly across accumulation and loss zones. According to Bot and Benites (2005) and Mitiku et al. (2006), organic matter accumulation is often favored at the bottom of hills due to the downward movement of runoff and sediment in the landscape to the lowest point. According to Kirkels *et al*. (2014), the lightweight nature of organic materials makes them easy to transport to the depositional zones and leads to creating less stock in soil organic carbon matter content in the loss zone.

Total nitrogen analyses showed a significant ($p<0.05$) difference between *Fanya juu* positions. The highest mean values of total nitrogen value were recorded at the bottom sampling spot position (0.13%) and the loss zone had the lowest (0.11%) (Table 4). The finding is consistent with the findings of Amdemariam et al. (2011), who studied terraced terrain where soils are actively eroded and soil nutrients deposited in the soil accumulation zone. The cause could be runoff transports of soil nutrients and other plant components (organic materials) deposited near *Fanya juu*. In the bottom area of *Fanya juu*, soil erosion is expected to be negligible as compared to the upper area, leading to more accumulation of organic matter in the field. The result is inconsistent with finding reported by Dagnachew et al. (2020), found that total nitrogen was not significantly different with terrace position but was statistically different with slope and the effects of the interaction.

The available phosphorus of the sampled soils did not differ significantly ($p>0.05$) *intra- Fany ina juu* zones. However, the highest mean value of available phosphorus (5.6922ppm) was observed at the deposition zone of *Fanya juu* (Table 4). Tadele et al. (2011) also reported similar results. This might be related to phosphorus' natural ability to attach to other soil materials and be easily transported by erosion impact and accumulate due to structural obstacles of conservation practice. It is obvious that higher P concentrations in the depositions zone result in significantly higher biomass production, which in turn results in larger soil organic matter, which is a P store. The finding agrees with Vancampenhout et al. (2006), who found higher amounts of available phosphorus in the accumulation zone.

The available potassium was significantly ($p<0.05$) affected by the position of *Fanya juu.* Significantly ($p<0.05$) higher mean value (137.106 ppm) of available potassium at the bottom spot position and lower values at the upper sampling spot (124.28 ppm) were measured (Table 4). This could be in loss zones where potassium is tightly retained by soil particles and is thus lost from fields by erosion. As a result, the higher available potassium in the lower zone of *Fanya juu* might be attributable to the enhanced clay content of the soil and higher organic carbon. This is familiar with finding reported by Zhang *et al*. 2009, who reported that potassium availability is significantly connected with clay content and OC of the soils. The findings are also consistent with Khan *et al.* (2004), who discovered the maximum quantity of P and K at the bottom slope, followed by the mid-slope, and the lowest amount at the top slope. The high concentration of nutrients in the deposition shows the effect of *Fanya juu* in trapping eroded soil, which otherwise lost from the farming system.

Table 14: Mean value estimates for pH, SOC, TN, Av.P and Av.K of intra-*Fanya juu* zones

Soil properties	*Fanya juu* position			
	Loss	Middle	Deposition zone	F-value
PH (H_2O)	5.4767[a]	5.5456[a]	5.7061[a]	.942[Ns]
SOC (%)	1.1533[a]	1.1844[b]	1.2057[b]	4.689[*]
TN (%)	.1106[a]	.1133[a]	.1316[b]	6.935[*]
Av.P (ppm)	5.0678[a]	5.3278[a]	5.6922[a]	2.11[Ns]
Av.K(ppm)	124.28[a]	129.5633[a]	137.1067[b]	12.425[*]

Ns=not significant at p>0.05; (*) =significant at p<0.05; Rows with identical letters in Superscripts are not statistically significant at the 0.05 significant level.

4. CONCLUSION

Land degradation is one of the most serious environmental issues limiting farmland productivity in Ethiopia. In the last two decades, the government has widely introduced physical SWC such as *Fanya juu* to reverse degraded land and limit further damage to land resources. The physico-chemical properties of soil in croplands treated with *Fanya juu* were better than fields without any physical SWC measures. In terms of the *intra-Fanya juu*, greater nutrients were observed at deposition areas due to the downward movement of organic matter and nutrients by runoff from the upper zone. This showed positive impacts of *Fanya juu* in controlling erosion. The *Fanya juu* can contribute to retaining soil fertility at least by reducing surface soil loss by erosion. In the study area, in general, the nutrients concentration is less than threshold for optimium agricultural production which could be due to intensive tillage, continuous cropping, removal of crop residues, and low organic matter input. To improve the overall low soil fertility in the study area, additional soil fertility management techniques should be integrated with the *Fanya juu*.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

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

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