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Evaluating the Impact of Indigenous Structural Soil and Water Conservation Practices, on Selected Soil Chemical Properties at Konso District, SNNPR, South west-Ethiopia

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ABSTRACT

Indigenous Structural technologies are common practices to conserve soil and water, thereby, maintaining soil quality parameters. The purpose of this study was to analyze impact of the application of biological and physical soil and water conservation practices in maintaining soil fertility and evaluated variability in its performance within different terrain position, at Konso District where land degradation is a critical problem. Quantitative method of research design was employed. For soil analysis two samples were taken from adjacent farm fields for best conservation practices and weak or no conservation practices. Samples were taken at different terrace position as lower, middle, and upper terrace. A total of 36 soil samples were collected from 12 farmer's fields. Soil samples from each sampling point were collected by using auger at 15cm depth with record in a zigzag manner and mixed into one composite soil sample. The samples were analyzed for total nitrogen, phosphorous, total organic carbon, potassium, cation exchange capacity, bulk density, and pH. The findings of this study revealed that except for bulk density and potassium there is significant varation in nutrient content between land with and without structure, and at different terrace positions. The result revealed that concentration of nutrient ranged from comparable to beyond optimum studared for cultivable land (1.82%, 0.39g/kg, 0.28%, 1.49g/kg, 31.93g/kg, 5.58 and 31.31Cmol/kg) for TOC, P, N, Bd, K, pH(H_2O) and CEC, respectivelly. And there is positive correlation between total organic carbon and total nitrogen (r=0.56), and strong negative correlation between bulk density and total organic carbon (r=-0.64). Therefore, Indigenous biological and physical soil and water conservation practices improved cropland productivity through addition and maintaining of organic matter to the soil, adding nitrogen, plant nutrients, and improving soil structures and reducing run off. Hence, development of road maps that encourage such community wealth would contribute for sustainable conservation of the landscape resource.

Keywords: *Soil and Water Conservation, Chemical Properties, Konso Districts*

INTRODUCTION

Soil erosion is a destructive process altering and changing the topsoil layer and soil carbon stocks through selective removal of fertile top soil along the slope (Olson et al. 2016). In Ethiopia, soil erosion is one of a serious problem challenging the agricultural sector and economic development. The problem became worst in areas where there is undulating hilly landscape with harsh environmental condition. (Mezgebe, 2011).

The Konso people are among those who live in inhospitable harsh environment on steep slope landscape and high susceptibility of soil erosion. This has provoked the people to develop efficient coping up strategies. Because of this fact, the inhospitable Konso terrain was transformed by people into remarkable traditionally engineered physical structures capable of conserving soil and water. The people are known for their stone-based terracing, unique mixed agriculture and well-integrated agro-forestry (Beshah, 2003). They are known for indigenous and intensive agricultural landscape that has been maintained for hundreds of years despite the social changes (Tadesse, 2010). The indigenous agricultural system in Konso zone is characterized by stone-based terraces and well-integrated Agroforestry practices. It has existed for at least four hundred years. The strength of the system is expressing culture and its institutions that contribute to this kind of agriculture (Beshah 2003). Thousands of kilometers long interweave water systems across the landscape to conserve available moisture and protected soil were unique indigenous talents. Terraces are built with stone walls (Forch, 2003). The Konso are unique in their investment in their environment with terrace and other soil and water conservation structures (Watson, 2009). The practice has got recognition and was inscribed as the World Heritage Site by UNESCO on June 27, 2011. In addition, the quality of traditionally engineered soil and water conservation structures of Konso were found to be fit and even well beyond the recommended standards set for quality of soil and water conservation structures which is quite uncommon in modern structures (Barako & Alemayehu, 2019). Soil erosion lowers base saturation and soil organic carbon (SOC) contents; as a result, it decreases the soil pH. The pH of the soil influences the availability of phosphorus, which is low for non-conserved agricultural land (Bekele *et al*. 2016). Similarly, Ademe et al. (2017), indicated that soil and water conservation improve the soil properties on conserved cropland (pH, K^+, available P, SOC, TN, CEC and clay content) than in the adjacent crop land that is without soil and water conservation measures. This indicates the positive impacts of soil and water conservation practices in improving the nutrient status of the cropland. Hence, the impact of this indigenous Structural Soil and Water Conservation (SWC) practices on soil chemical properties of the study area were not evaluated so far, this study was designed to evaluate the effect of application of indigenous structural technologies in improving soil quality parameters like total nitrogen, phosphorous, total organic carbon, potassium, CEC, bulk density, and pH, and Propose ways for maintaining this useful knowledge for sustainable environmental resilience. Research hypothesis was: Indigenous SWC practices will promote positive impacts on soil property dynamics in highly impacted environments.

METHODOLOGY

Description of The Study Area

Konso is located in the Southern Nations, Nationalities and Peoples Region in South-Western Ethiopia, 600km South of the capital Addis Ababa (Figure1). The people occupy a rugged area formed as a result of early Miocene volcanism which created the basaltic hills. The Konso area is generally dry with mean annual rainfall of 551 mm. The average maximum temperature is 32.7ºC (February and March); and lowest minimum temperature is 12.2ºC (June to August). Based on the traditional Agro-climatic classification, 70% of the land is in the Kola agro-climatic zone (warm semi dry with an altitudinal range between 500- 1500masl) while 30% is in the Woina Dega Zone (cool sub humid on the mid altitudes of 1500-2300masl) (Beshah, 2003). As described by Beshah (2003), soil of study area was classified as Bolbolta: brown soil from alluvial deposits with good depth; Borbora: black vertic nature that sticks between the fingers when wet and cracks when dry, it is difficult for farming tools to penetrate though when the depth is adequate; Kelkelita: reddish, slightly sticky, resembling Borbora, but cracks less, it has a good depth; Ateta : grayish (ashy) with fine texture; Tahita: a mixture of sand, rough texture; Amata : soil with a mixture of stone.

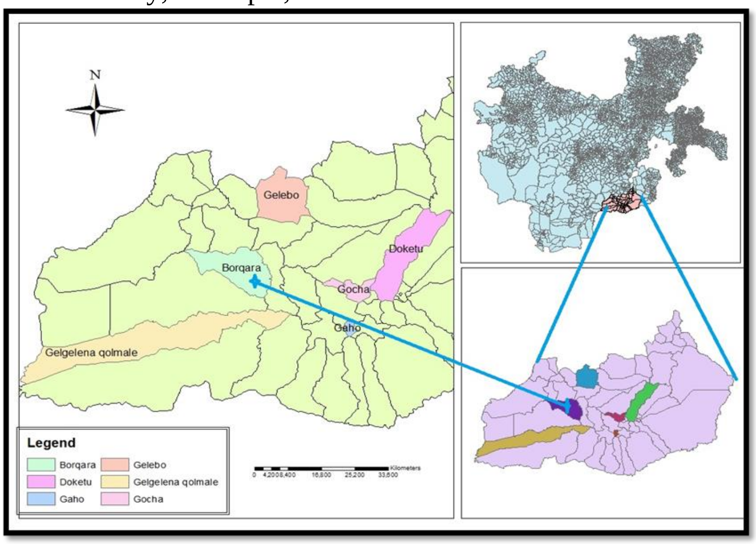

Figure1. *Location map of the study area, Konso.*

Design of the Study

Before sampling and site identification, a reconnaissance was undertaken. During the survey, physical land management practices were observed. Quantitative method of research design was employed to evaluate the effect of application of indigenous structural technologies in improving soil quality parameters. Multi stage sampling technique was used to select peasants' associations (PAs) and draw sample watersheds for the study.

The criteria for the selection of PAs was based on agroecological zone (1400-2000masl), that the local administrations were usually using as four different clustered agroecological zones, where the traditional soil and water conservation practices are prominent, and are randomly selected (Table 1). For that matter 6 PAs were selected, and in each PA specific watersheds are identified through reconnaissance survey among the existing watersheds and randomly sampled.

In the selected watersheds specific farmer's field was selected randomly and a maximum possible rectangular plot was drowned and random selection among four corners and middle of the point diagonal were selected and randomly sampled to take soil samples (Figure 2).

Soil samples were taken from selected 6 farmer's fields with best SWC practices, those who practiced at minimum four SWC practices which are managed properly on their farmland. Another 6(control) soil samples from 6 farmers' fields with weak or no biological and physical land management practices with none of the practices is managed properly or not exercised on their field in the past 10 years were randomly sampled and collected. The distance between the two samples (for treated and untreated plot) will be from adjacent to near adjacent plot land from each PA.

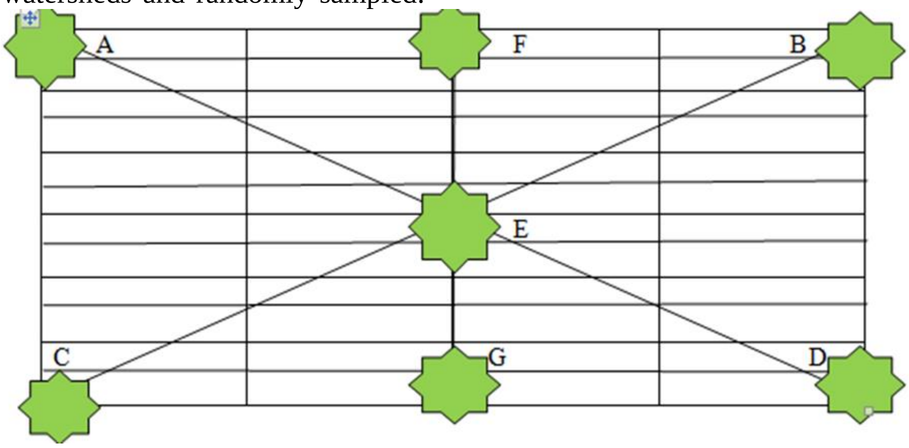

Figure2. *pictorial representation of sampling plot*

Sampling Procedures

Soil samples from each farmland were collected by using auger at 15cm depth and if no such a depth were taken at available depth with record in a zigzag manner and mixed into one composite soil sample and taken to laboratory for soil chemical properties analysis. A total of 36 soil samples (6*3 from treated and 6*3 untreated) were collected from 12 farmer's fields. That's, for each sample point, three category samples at different terrace positions, as at lower terrace, middle terraces, and at upper terraces were collected (Figure 3; Figure 4), and were analyzed as three replicates for total nitrogen, phosphorous, total organic carbon, potassium, CEC, bulk density, and pH.

Table 1: *Sample site identifications.*

Sites	Specification (clustering)	Agro-climatic zone*	Soil type*	Slope measured	Specific watershed sampled (kebele)
1	Karat one	kola	Amata	Strongly sloping (36%)	Dokatu-kuttele
2	Kolme one	Woina dega	Amata	Steep sloping (54%)	Gelgelena-kolmale-Qolmale area
3	Turo	Woina dega	Tahayta	Moderately sloping 17%)	Gelabo-kashalle
4	Fasha	Woin adega	kalkalayta	Moderately sloping 12%)	Gaho-laka
5	Karat two	Woina dega	Borbora	Gently sloping (3%)	Gocha-Pishelle
6	Kolme two	kola	Tahayta	Strongly sloping (30%)	Borkora-Amaritta

Agro-ecologic zone and soil type were as described by (Beshah, 2003)

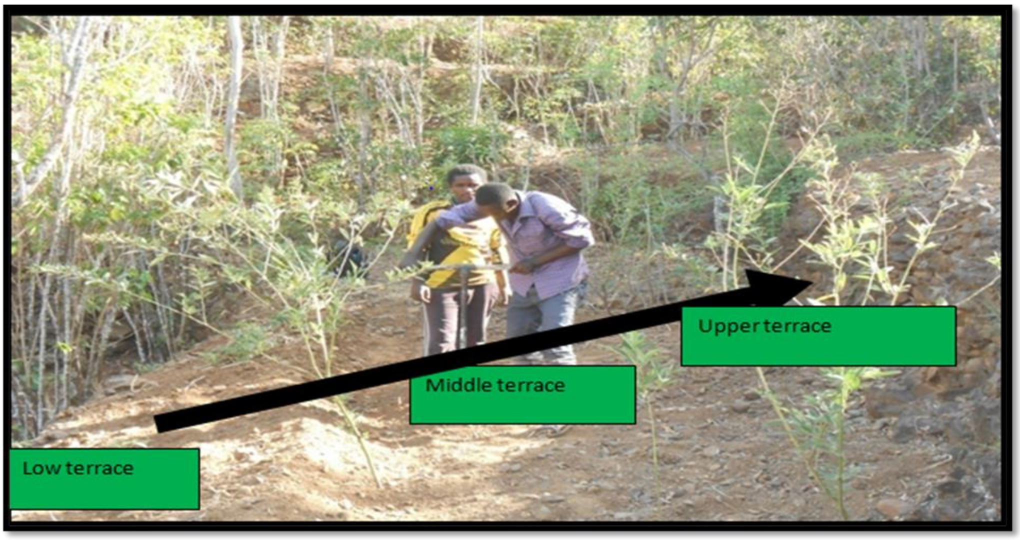

Figure3. *Sampling points at different terrace positions at Steep sloping (54%)*

Figure4. *Sampling point at Gently sloping (3%).*

Methods of Data Analysis

The soil samples were air dried, crushed with mortar and pestle, mixed well and passed through 2mm sieve for the following physicochemical analysis; organic carbon content, total nitrogen, phosphorus, Potassium, soil pH, Soil Cation exchange capacity (CEC) and bulk density. Organic carbon content was determined by wet oxidation method (Walkly, 1947). This method involves a wet oxidation of the organic carbon with mixture of potassium dichromate, sulfuric acid and titrated by ferrous sulphate solution. Conversion of carbon to organic matter was done with the empirical factor of 1.724. Total nitrogen was determined following the Kjeldehal procedures as described in Black (1965). Total phosphorus of soil samples was determined by measure absorbance on spectrophotometer following the Olsen method of (VanReeuwijk, 1992) at pH 7.0. Total potassium was analyzed by Flame atomic absorption measurement (soil and plant analysis Inc., 1992). pH of soil samples was measured from a soil suspension solution prepared with 1:2.5 soil water ratios using conventional glass electrode meter (Van Reeuwijk, 2002). CEC was determined by direct method NH_4CHCOO (Ammonium Acetate) at pH 7.0 (Houba *et al.*, 1998). Bulk density of the soil samples was estimated by taking undisturbed soil core from the surface of the soil by driving a metal cylinder /core sampler as described by Blake (1965).

Data Analysis

Statistical differences were subjected to analysis of variances (ANOVA) using the General Linear Model (GLM) procedure of Statistical Analysis System (SAS) software (Version, 9.1). The significant differences among the means were declared at $P \leq 0.05$ and means were separated using Duncan's least significant difference (LSD) test with model of Yijk = μ + Vi + Yj + Vi* Yj + eijk, where; yijk = all dependent variables; μ = overall mean; Vi = the effect of treatment; Yj = the effect of position; Vi* Yj = the interaction effects of treatment and position and eijk = random error.

RESULT AND DISCUSSION

Table2. *Mean comparison for soil with and without physical SWC structures (N=36)*

Variables	Parameters						
	P (g/kg)	K (g/kg)	N (%)	Db (g/cm^3)	CEC (Cmol/kg)	pH (H2O)	TOC (%)
For soil with SWC structures	0.39^a	31.93^a	0.28^a	1.49^b	37.31^a	5.58^a	1.82^a
For soil without SWC structures	0.22^b	31.14^a	0.16^b	1.75^a	33.55^b	4.56^b	1.01^b
F value	17.14	0.37	17.16	6.18	20.18	45.36	24.40
P value	0.0003	0.5487	0.0003	0.0187	0.0001	0.0000	0.0000

(Means with the same letter (a, b) in across column for soil with and without SWC structure are not significantly different (p>0.05)

Table3. *Mean comparison for soil properties at different terrace positions (N=36)*

Variables	Parameters						
	P (g/kg)	K (g/kg)	N (%)	Db (g/cm^3)	CEC (Cmol/kg)	pH (H2O)	TOC (%)
L	0.26^b	31.66^a	0.19^b	1.59^a	33.97^b	4.95^b	1.39^a
M	0.40^a	32.14^a	0.31^a	1.58^a	38.75^a	5.53^a	1.59^a
U	0.25^b	30.81^a	0.17^b	1.69^a	33.56^b	4.73^b	1.25^a
F value	5.72	0.36	9.04	0.46	15.88	9.86	1.4
P value	0.0078	0.7010	0.008	0.6334	0.0000	0.0005	0.2633

(Means with the same letter (a, b) in across column for average soil at different terrace positions are not significantly different (p>0.05). where L=low terrace position; M= middle terrace position; U= upper terrace position.

Table4. *Correlations (Pearson)*

Soil properties	P		K		N		Db		CEC		pH		TOC	
	r	p	r	P	r	P	r	p	r	p	r	p	r	p
P			-0.21	0.22	0.55	0.001	-0.54	0.001	0.48	0.003	0.57	0.000	0.50	0.002
K					-0.04	0.821	0.21	0.209	0.31	0.064	0.46	0.005	0.07	0.688
N							-0.35	0.037	0.62	0.000	0.54	0.001	0.56	0.001
Db									-0.10	0.548	-0.17	0.339	-0.64	0.000
CEC											0.72	0.000	0.42	0.010
pH													0.47	0.003

Correlation is significant at 0.05 level

Table5. *Summary of mean soil chemical properties as compered per site per treatment*

Sites	Treatment	P (g/kg)	K (g/kg)	N (%)	Db (g/cm^3)	CEC (Cmol/kg)	pH (H2O)	TOC (%)
1	W	0.511667	31.6694	0.220333	1.4	35.65	5.966667	1.854667
1	Wo	0.177333	31.23633	0.164333	1.7	32.403	4.666667	1.430333
2	W	0.394667	36.79235	0.319	1.566667	38.24	6	1.752
2	Wo	0.126	36.547	0.115333	1.87	35.58333	4.8	1.443
3	W	0.289333	34.53825	0.285333	1.966667	40.00667	5.666667	1.868
3	Wo	0.165333	28.82513	0.165333	2.233333	34.81733	4.666667	0.126
4	W	0.303333	29.76138	0.341	1.3	37.29667	5.033333	1.888667
4	Wo	0.291667	29.48633	0.21	1.333333	31.85833	4.133333	1.491333
5	W	0.331333	32.4071	0.235667	1.3	35.68333	5.7	1.867333
5	Wo	0.198	34.57933	0.121333	1.866667	33.64667	4.933333	0.177333
6	W	0.491667	26.39617	0.276	1.433333	36.95333	5.1	1.674
6	Wo	0.387333	26.18967	0.201	1.5	32.99333	4.136667	1.36

Where sites 1-6 are (as explained in Table 1), and W= soil treated with physical SWC structures and Wo= soil not treated with physical SWC structures.

Among chemical properties analyzed, except for potassium all has shown statistically significant difference for soil with and without SWC Structure ($p < 0.05$) (Table 2). If we compare significance at different terrace position total P, N, CEC and pH showed statistically significant difference at different terrace position where middle terrace position is significant to both upper and lower terrace positions ($p < 0.05$) and whereas, K, Db and TOC showed no significant differences between the three terrace positions (Table 3)

The mean soil phosphorus ranges from 0.39 to 0.22g/kg (p=0.0003) for soil treated and not treated with biological and physical soil and water conservation (BPSWC) structure, and also ranges from 0.26, 0.40 and 0.25g/kg (p=0.008) for soil at low, middle and upper terrace positions, respectively (Table 2; Table 3). Soil phosphorous for soil with BPSWC structure is highly significant than soil without BPSWC structure implies that mean soil P of the structure are greater than the absolute minimum. This may be because of the continuous supply of nutrient from fallen leaves of intercropping and agroforestry practices, or also from the supply of animal manure on the field or from decomposed crop residues. Watson and Mullen (2007) suggested that 15 ppm (15 g/ton) is a critical soil P concentration for categorizing the soil as P sufficient or deficient. While the differences between different terrace positions could be related to organic matter (OM) input differences. As observed from Table 4, phosphorous is positively correlated with pH (r=0.57), N (r=0.55) and TOC (r=0.50). This positive correlation indicates that the pH of the soil influences the availability of phosphorus, which is low for non-conserved agricultural land (Bekele *et al*. 2016). The finding of this study is also in agreement with study conducted by Yadav (2011) which indicates positive and strong correlation among nitrogen, phosphorus and SOM.

The mean soil Nitrogen ranges from 0.28 to 0.16% (p=0.0003) for soil treated and not treated with biological and physical soil and water conservation (BPSWC) structure, and also ranges with 0.19, 0.31 and 0.17% (p=0.008) for soil at low, middle and upper terrace positions, respectively (Table 2; Table 3). Soil Nitrogen for soil with BPSWC structure is highly significant than soil without BPSWC structure. While the significant differences between different terrace positions could be related to organic matter (OM) input distribution differences between different terrace positions. The results of the total nitrogen content of soil analysis revealed that, traditional land management practices have a significant role in adding and maintain the total nitrogen contents of soil. Those fields with biological and physical land management practices showed significant different in the amount of total nitrogen than the untreated one. The higher total nitrogen values on the soil with BPSWC fields could be a result of conservational tillage, crop rotation, intercropping, grass strip, agroforestry, continuous supply of animal manure and other physical structures common to the area which added SOC (mean 1.82%). Thereby, prevent soil erosion, and such condition creates favorable condition for the activities of micro-organism in decomposing SOC. Incorporating legume crop in the sequences of crop rotation enables to add Organic nitrogen to the soil through fixation. Nitrogen content of soil is directly related to the presence of SOC. SOC content of cropland without BPSWC practice is low as relative to cropland with BPSWC practices. According to (Alexander, 1991; Bergmann, 1992; Sys *et al*., 1993) topsoil on average had 1.9 kg t-1 (0.19%) total nitrogen. And if we compare this with our results mean total nitrogen for cultivable land with BPSWC practices and land not managed at least for ten years are 0.28 and 0.16%, respectively. Implying that our results are highly significant than the absolute minimum. The significant difference in soil TN between terraces positions is in line with Gebermichael *et al*. (2005) which reports that, there is statistically significant nutrient gradient across a terrace. The Pearson correlation from Table 4, revealed the significant correlation of Nitrogen with CEC (r=0.62), pH (r=0.54) and TOC (r=0.56) indicates their interdependency. The higher the CEC in surface soils, the more capable the soil can retain mineral elements (Landon, 1991) and it is also the major nutrient reservoirs of K^+, Ca^{2+} and is important in holding nitrogen in ammonium ($NH4^+$) form.

The mean soil total organic carbon ranges from 1.82 to 1.01% (p=0.000) for soil treated and not treated with biological and physical soil and water conservation (BPSWC) structure, and also ranges with 1.39, 1.59 and 1.25% (p=0.263) for soil at low, middle and upper terrace positions, respectively (Table 2; Table 3). Soil organic matter (OM) determines soil quality, physical properties, crop nutrition and the link between these. The soil physical properties affected by soil OM include aggregate stability, infiltration, water-holding capacity, soil workability, bulk density, aeration and water movement (Bergmann, 1992; Loveland & Webb, 2003). The analysis revealed a relatively low SOC (mean SOC =1.82%) content and slight increase with slope of the terrace position from lower to upper terrace reaching 1.59% in the middle terrace (Table 3). Loveland and Webb (2003) reported that, 2% soil OC is a critical level for crop production and soil aggregate stability. The Pearson correlation from Table 5, revealed the significant correlation of total organic carbon with CEC (r=0.42) and pH (r=0.47) indicates their interdependency, which is generally accepted that SOM is responsible for 25 to 90 % of the total CEC of surface mineral soils (Oades *et al*., 1989). For our soil samples even though the result is below the required minimum standard, the Konso agriculture could have to be appreciated for its being intensive, mixed and hundreds of years of continuous cropping without nutrient depletion. As seen on field, addition of inorganic fertilizer is not yet well practiced and there has been a continuous supply of organic nutrients at in-situ level at farm. The results of the soil organic matter content analysis showed that traditional land management practices have a significant impact in maintaining and improving the soil organic matter content. Those fields without biological and physical land management practices showed significantly lower amount of organic matter than those of the treated fields (Table 2). The finding was in agreement with Bauer and Black (1994) who reported that increased infiltration also improves groundwater recharge, thus increasing well supplies and also organic matter builds and improves soil structure, thereby, improving soil drainage, infiltration of water in to the soil, aeration and water holding capacity.

The mean soil total Potassium ranges from 31.93 to 31.14g/kg (p=0.5487) for soil treated and not treated with BPSWC structure, and also ranges with 31.66, 32.14 and 30.81g/kg (p=0.7010) for soil at low, middle and upper terrace positions, respectively (Table 2; Table 3).The results of soil analysis for total Potassium content showed that, traditional land management practices have no significant impact on the Potassium availability in the soil. Those fields with biological and physical land management practices, and untreated field was not significantly (P = 0.5487) different in Potassium contents (Table 2). The result is in agreement with the report of EPA (2001) which states that, Potassium tends to be fixed in soil and is not that easily leached out. There are no implications of toxicity for potassium that toxicity standard is not set forth yet.

The mean soil CEC ranges from 37.31 to 33.55 (p=0.0001) for soil treated and not treated with BPSWC structure, and also ranges with 33.97, 38.75 and 33.56Cmol/kg (p=0.000) for soil at low, middle and upper terrace positions, respectively (Table 2; Table 3). According to FAO (2006) scaling nutrient balance report, our soil result for CEC was rated high at average for both soil with and without structure, 37.30 and 33.46Cmol/kg, respectively (Table 2). And, for terrace position at the middle terrace CEC was rated very high (38.75Cmol/kg). The high CEC values have been implicated with high yield in most agricultural soils and CEC values in excess of 10 cmolkg-1 are also considered satisfactory for most crops (FAO/IIASA/ISRIC/ISSCAS/JRC, 2012). The result of cation exchange capacity level of soil revealed that traditional land management practices have a significant role in improving soil quality by providing necessary soil cover, organic matter and reduces run off, as the result CEC of the soil was improved. Those fields with biological and physical land management practices were significantly higher in CEC than untreated fields. The reasons for relatively low CEC of soil without BPSWC practice is due to low organic matter content of the soil implying significantly positive correlation with TOC (r= 0.42) as indicate in Table 4. Therefore, traditional land management practices are important in improving cropland productivity by adding organic matter to the soil; as a result, CEC of soil is also increased.

The mean soil pH (H_2O) ranges from 5.58 to 4.56 (p=0.000) for soil treated and not treated with BPSWC structure, and also ranges with 4.95, 5.53 and 4.73 (p=0.0005) for soil at low, middle and upper terrace positions, respectively (Table 2; Table 3). The possible reasons for lower pH value for soil without BPSWC practice is due to low organic matter content. This has resulted from inadequate traditional land management practices, as a result water soluble nutrient are removed by soil erosion and leaching, and what is remaining in the soil is water insoluble acid forming elements like; Fe and Al. According to Batije (1995) report, when

5.5≤ pH <7.3 the soil is moderately acidic, slightly acidic and neutral, and it is a preferred pH range for most crops, where lower end of range is too acidic for some. In the range 6.0-7.0 range, phosphorus fixation is at a minimum. Neutral pH favors the fixations of molecular N by free living micro-organisms and symbiotic microorganisms. Above pH 7.0, the availability of Fe, Mn, Zn, Cu, and Co declines. The results are in agreements with this that, for conserved soil pH ranges from 5.01 - 6.0 with mean value of 5.58, and for non-conserved soil pH ranges from 4.13- 4.93 with mean value of 4.56 (Table 5). This implies that traditional BPSWC practices will reverse the condition by providing necessary soil cover, organic matter and reduces run off, as the result plant nutrient is easily accessible to the crop.

The mean soil Bulk Density (Db) ranges from 1.49 to 1.75 g/cm^3(p=0.0187) for soil treated and not treated with BPSWC structure, and also ranges with 1.59, 1.58 and 1.69 (p=0.6334) for soil at low, middle and upper terrace positions, respectively (Table 2; Table 3). A report from other scholars, high bulk density usually inhibits the emergence of seedlings (Tsidale *et al*., 1985). Average soil bulk density of cultivated loam is approximately 1.1 – 1.4g/cm^3. For good plant growth, bulk densities should be below about 1.4gm/cm^3 for clay soil and 1.6gm/cm3 for sand soil (Danahue, 1990). If we compare our results even though the mean difference between group were not significant, soil with conservation structure has shown smaller Db (1.49g/cm^3) and soil without structure has shown larger Db (1.75g/cm^3) these indicates that, traditional land management practices have an impact in maintain soil fertility (Table 2). The possible reason for the reduction of bulk density in soil with BPSWC practice is due to the addition of soil organic matter to the soil through the application of traditional land management practices. The result of organic matter content and bulky density is inversely proportional to each other. The negative correlation between Db and TOC indicates that the higher the OM the lesser bulk density (r= -0.64) (Table 4). Therefore, traditional land management practices have a role in improving cropland productivity by providing necessary organic matter to the soil. There was also a variation in mean Db difference at different site for soil with BPSWC practices ranging from 1.97 to 1.3g/cm^3 and for soil without BPSWC practices Db ranges from 2.23 to 1.33 g/cm^3 (Table 5). The mean is comparable to the standard that, for the case of Konso intensive farming system, most of faming system is restricted to hoe plough and there is no free grazing and problems of compaction.

Conclusion

The purpose of this study was to analyze impact of the application of BPSWC in maintaining soil fertility and evaluated variability in its performance within different terrain position. The findings of the study revealed that indigenous BPSWC practices have a significant role in improving crop land productivity. Because, it infulence soil quality parameters like; soil organic carbon contents, total nitrogen, total phospherous, potassium, cation exchange capacity, pH, and soil bulk density. Except for bulk density and potassium there is significant varation in nutrient content between land with and without structure, and at different terrace positions. The higher nutrient values on the soil with BPSWC fields could be a result of conservational tillage, crop rotation, intercropping, grass strip, agroforestry, continuous supply of animal manure and other physical structures common to the area which added SOC, thereby, prevent soil erosion, and such condition creates favorable condition for the activities of micro-organism in decomposing SOC. As seen from Figure 2 and 3, where soil samples were taken at slope range from gentle sloping (3%) to steep sloping (54%) (Table 1), all the conservation structure are beyond optimum against the slope gradient resulting in the soil quality parameters being comparable with the sampling sites and with the standards. As to Konso terracing system, the top of stone terrace is raised by banded soil that, the slope is tilted towards the middle terrace, so that most sediments are accumulated there. As the result the soil nutrient content has been higher in the middle and lower in the low and upper terrace. This soil accumulation gradient develops until the slope difference between the two edge of the terrace are minimized and this process caused higher sediment accumulation in front of terrace, which results in nutrient gradient with in a terrace. When the sediment fills farmers dig out the sediment and redistribute within the terrace. The sediments are re-banded that it will further accumulate in order to maintain nutrient loss and increase infiltration and further reduce run off within terraces. Based on the results of soil quality analysis above, the role of traditional BPSWC practices in this regard is providing vegetation cover, adds organic matter to the soil, and reduces the removal of available water-soluble cation by erosion and increase buffering capacity of the soil. It can be concluded that even though Konso agriculture is intensive in nature and the same land had been cultivated about more than 400 years, the land management practices were designed perfect that value of the nutrient is yet been with in comparable to optimum standard range. Even though, this is quite uncommon in modern structures, the skill and work culture that pass-through generation has paved the way for continuous monitoring and sense of ownership in Konso. Thus, development of road maps that encourage such community wealth would contribute for sustainable conservation of the landscape resource.

REFERENCES

[1] Ademe, Y., Kebede, T., Mullatu, A. & Shafi, T. (2017). Evaluation of the effectiveness of soil and water conservation practices on improving selected soil properties in Wonago district, Southern Ethiopia. *Journal of Soil Science and Environmental Management*, 8, 70-79.

[2] Alexander, M. (1991). Introduction to soil microbiology. Wiley, New York. pp 467

[3] Barako, B & Alemayehu, M. (2019). Evaluating Indigenous Structural Technologies of Konso People, Ethiopia. *International research journal of engineering and technology*, 6(2).

[4] Batije, N.H. (1995). A global data set for soil pH properties. Technical Paper 27, International Soil Reference and Information Center (ISRIC). Wageningne.

[5] Bauer, A., & Black, A. L. (1994). Quantification of the effect of soil organic matter content on soil productivity. *Am. J. Soil Sci. Soc*., 5: 185-193.

[6] Bekele, M., Lemenih, M., & Regassa, A. (2016). The Effects of Integrated Soil Conservation Practices on Soil Physico-Chemical Properties: The Case of Menesibu District, West Ethiopia. *Journal of Natural Sciences Research*.

[7] Bergmann, W. (1992). Nutritional disorders of plant: Development, visual and analytical diagnosis, New York.

[8] Beshah, T. (2003). Understanding Farmers: Explaining soil and water conservation in Konso Walaita and Wello, Ethiopia. PhD. Dissertation Wegeningen University. The Netherlands.

[9] Black, C., A. (1965). Methods of soil analysis Part I, American Society of Agronomy. Madison, Wisconsin, USA

[10] Danhue, R., Miller, R., & Shikluna, J. (1990). *Soils. An introduction to soils and plant growth* (5th ed.). Prentice-Hall of India. New Deli, India

[11] EPA (Environmental Protection Agency) (2001). Parameters for Water Quality Interpretation and Standards 2001, Johnstown castle, co. wexford, Ireland. ISBM 1-84096-0015-3

[12] FAO (Food and agricultural organization) (2006). Scaling soil nutrient balances. Fertilizer and plant nutrition bulletin. 15. Rome.

[13] FAO/IIASA/ISRIC/ISS-CAS/JRC (2012). Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria.

[14] Forch, W. (2003). The agricultural system of the Konso in South-Western Ethiopia. *FWU Water Resource Publications*: University of Siegen.

[15] Gebermichael, D., Nyssen, J., Poesen, J., Deckers, J., Haile, M., Govers, G., & Moeyersons, J. (2005). Effectiveness of stone bunds in controlling soil erosion on cropland in the Tigray highlands, northern Ethiopia. *Soil Use and Management*, 21(3).

[16] Houba, V. J., Vander Novozamski & Walinga, I. (1998). Soil and Plant analysis part 5. Soil analysis procedures. Dept. of soil science and plant nutrition. Agricultural University. Wageningen, The Netherlands.

[17] Landon, J., R. (1991). Booker tropical soil manual. A handbook for soil survey and agricultural land evaluation in the tropics and sub tropics. John Wiley and Sons, New York, pp. 94-95.

[18] Loveland, P., & Webb, J. (2003). Is there a critical level of organic matter in the agricultural?

[19] Mezgebe A. H. (2011). Indigenous talents of Konso people to cope with climate change susceptibility, Ethiopia. A paper presented in International workshop on Indigenous Peoples, Marginalized Populations and Climate Change, United Nation University, From 19 - 21 Jul 2011 Mexico City, Mexico

[20] Oades, J.M., Gillman, G.P., Uehara, G., Hue, N.V., van Noordwijk, M., Robertson, G.P., Wada, K. (1989). Interactions of soil organic matter and variable-charge clays. University of Hawaii Press, Honolulu, HI, pp. 69-95.

[21] Olson, K. R., Al-Kaisi, M., Lal, R. & Cihacek, L. (2016). Impact of soil erosion on soil organic carbon stocks. *Journal of Soil and Water Conservation*.

[22] Soil and Plant analysis Council, Inc. (1992). Hand Book on reference methods for soil analysis, Council on soil testing and plant analysis, Gorgia University Station, Athens GA30612-0007 USA.

[23] Sys, C., Ransi, V., Debaveye, J., & Beernaert, F. (1993). Land valuation, Part III, Crop Requirements. *Agriculture Publication* No. 7, ITC, Ghent, pp 7-178

[24] Tadesse, M. (2010). Living with adversity and vulnerability. Adaptive strategy and the role of

trees in Konso, southern Ethiopia. Faculty of natural science and agricultural science department of urban and rural development, Uppsala. Doctorial thesis Swedish university of agricultural science.

[25] Tsidale, S., Warner, L., & James, D. (1985). *Soil fertility and fertilizers* (4th ed.). Macmillan Publishing Company. New York, USA

[26] Van Reeuwijk, L., P. (1992). *Procedures for soil analysis*. 3rd ed. International Soil reference and Information center, Wageningen (ISRIC). The Netherlands.

[27] Van Reeuwijk, L., P. (2002). *Procedures for soil analysis*, 6th edition. ISRIC, Wageningen, The Netherlands. Technical paper 9.

[28] Walkly, A. (1947). Critical examination of rapid method for determining organic carbon in soils, effect of variation in digestion conditions and an inorganic soil constituent. Soil Science.

[29] Watson, E. E. (2009). Living Terraces in Ethiopia: Konso Landscape, Culture and Development. Woodbridge and New York: James Currey (an imprint of Boydell and Brewer) East Africa Series.

[30] Watson, M., & Mullen, R. (2007). Understanding Soil Tests for Plant-Available Phosphorus.

[31] Yadav, B., K. (2011). Micronutrient Status of Soils under Legume Crops in Arid Region of Western Rajasthan, India. *Academic J. Plant Sci.*, 4 (3).

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