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By

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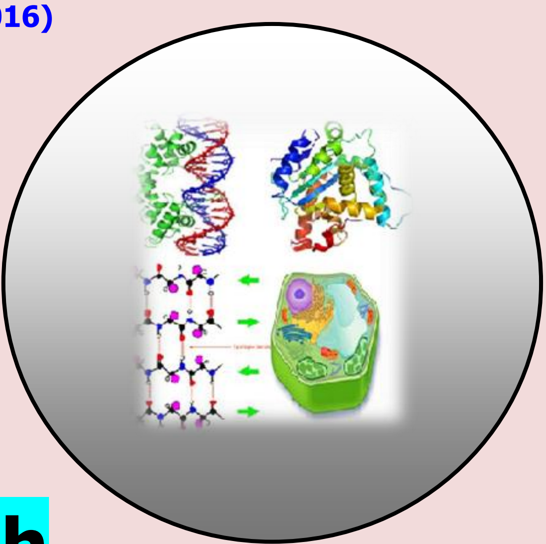

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RESEARCH PAPER

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Evaluating the Contribution of Agroforestry on Soil Physico-Chemical Properties in the Case of Lemmo District, Southwestern, Ethiopia

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ABSTRACT

This research was designed to analyze contribution of agroforestry on selected soil physico-chemical properties of Lemmo district, southwestern, Ethiopia. For this study the land was stratified in to three land use systems namely: Agroforesty, area enclosure and cultivated land with two soil depths which have similar soil types, slope classes and altitude range. A total of 24 undisturbed and disturbed soil samples were taken from each land use and soil depths (0-15 to 15-30cm) by replicating four times to analysis selected physico-chemical soil fertility indicators. The experimental results indicated that there were no significant differences at (p<0.05) in sand, silt and clay fraction on the three land use types except for sand on the soil depth. On the contrary, soil moisture content and bulk density were shown significant change under each land use type at (p<0.05). For soil chemical analysis, the main effect of soil pH , organic carbon, organic matter, total nitrogen, cation exchange capacity and exchangeable bases revealed a significant variation at (p<0.05) on land under agroforestry practices and area closure at soil depth of (0-15cm). The mean combine effect of land use with soil depth for (clay, soil moisture content, soil pH, soil organic carbon, organic matter, available phosphors, exchangeable bases (Ca^{+2}, Mg^{+2} and K^{+}) were significantly higher under agroforestry except sand and soil bulk density at (p<0.05).Thus, using agroforestry as soil and water conservation measures are not only considered as an alternative but also should have to practice as compulsory in study site.
Key words: Agroforestry, Soil Physico-Chemical Property, Soil and Land Management.

INTRODUCTION

Land degradation was a significant global issue during the 20th century and as it affects the environment, food security and quality of life (Eswaran *et al.*, 2001). In most developing nations, in particular, agricultural productivity showed a dramatic decline and reached the level of beyond the subsistence requirement of a household's due to land degradation as results of erosion, nutrient depletion and deforestation. The dominant immediate consequence of land degradation were reduced crop yield, water depletion, disturbed hydrological behavior in the river basins and food insecurity followed by economic decline and social stress (Daniel, 2001). Several factors contribute to unsustainable land management in Ethiopia with steady growth in population, clearing of woodland for agriculture has been a continuous process at a estimated rate of 62 000 ha per year; methods of cereal production are conducive to soil loss and cattle dung and crop residues are needed for fuel, reducing their availability for use on the land to maintain fertility (Taffa, 2002).

Now days, the rates of soil erosion in Ethiopia are terrifyingly high, which is estimated to have affected 25% of the highland area, near to 4% of the highlands are now so seriously eroded that they will not be economically productive again in the foreseeable future (Fekadu *et al*., 2013). In Southwestern, Ethiopia particularly, Hadiya Zone, which is the focus of the current study, has many natural resource management problems that combined to cause soil erosion leads to agricultural stagnation. According to Barry and Ejigu (2005) reported shown, the main causes of fertility decline in Southwestern Ethiopia together with the study area; deforestation, removal of crop residues from fields, land fragmentation, reduction of fallowing periods, overgrazing and cropping of marginal lands are the major one.

To reverse those problems, in recent year, agroforestry has emerged as a sustainable land management practices by addressing land degradation and loss of soil fertility. Predominantly, agroforestry as a land use system is receiving greater attention since agroforestry practices offer considerable benefits for the long term agricultural sustainability, via improving overall physico-chemical and biological properties of the soil (ICRAF, 2004). Similarly, Fikadu (2006), report indicated that agroforestry systems enriches the soil fertility by providing organic matter which helps water to infiltrate, increasing soil fauna and flora, lower bulk density when compared to the bare soil.

Another important feature of agroforestry systems is contribution towards nitrogen economy through atmospheric nitrogen fixation. Nitrogen, a commonly limiting nutrient in tropical soils, to which growth response is immediately obtained on previously unfertilized soils. Thus, besides their role in above-ground carbon sequestration, agroforestry systems also have a great potential to increase carbon stocks in the soil and certainly merit consideration in mechanisms that propose payments for mitigation of greenhouse gas emissions to reduce climate change **(**Rachel C.et *al*., 2012). Therefore, based on the above mentioned problems together with decisive role of agroforestry practices, this research was designed to analysis the contribution of agroforesty practices on selected physico-chemical properties of the soil of Lemmo district, southwestern Ethiopia. The outcome of this research is essential and plays a significant role for policy maker, academic purpose, research institutions particularly, putting a base line for Lemmo district development on contribution of agroforestry and overall land management system.

MATERIALS AND METHODS

Description of the study area

The Lemmo district is situated in Hadiya zone southwestern part of Ethiopia as indicated by (Figure 1). Geographically, the area is located between $7^0 22'$-$7^0 45$ E' latitude and $37^0 40'$-38^0 00 N' longitude respectively, whereas the altitudinal range of the area is between 1900 and 2700 m.a.s.l. The mean annual precipitation of the site is varying from 1200 mm to 2500 mm. The estimated mean annual temperature ranges from 13^oc to 23^oc respectively. The most dominant soil type of the study area is nitisols which derives from highly weathered rocks, mainly basalts.

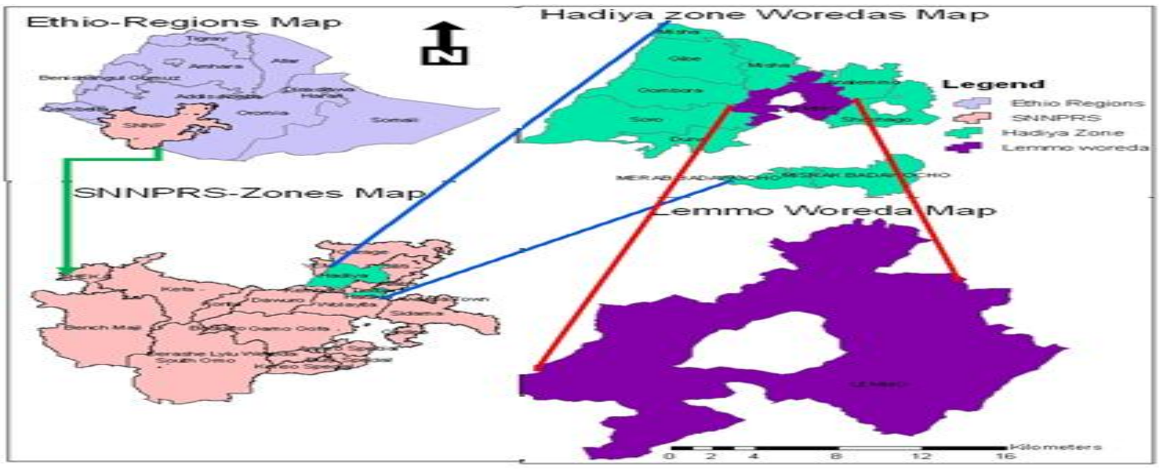

Figure 1. Map of study area.

Soil sampling and laboratory analysis

For this study, the area was stratified in to three land use types namely: cultivated land, area enclosure and agroforestry with two soil depth (0-15cm and 15-30cm) for taking the soil samples. The section of three land uses were based on similarity in soil types, slope class and altitude range. Taking this under consideration, from each land uses and soil depth undisturbed and undisturbed soil sample were collected in order to investigate soil physical and chemical properties accordingly. For both physical and chemical soil properties analysis, a total of 24 undisturbed and disturbed soil samples were collected from 3 land use types x 2 soil depths (0-15cm and15cm-30cm) x 4 replications respectively. The samples were taken by using five points in an 'X' design (from the middle and four corners of the plot) and from two successive depths (0-15cm and 15-30cm). Fifteen (15) soil samples were sampled from each land use and two soil depths to make one composite sample for each replication. The disturbed soil samples collected were air dried, mixed well and pass through a 2 mm sieve for chemical analysis. Finally; the analysis was carried out following standard laboratory procedures. Soil particle size distribution was determined by Boycouos hydrometric method (Bouyoucos, 1962; Van Reeuwijk, 1992) after destroying organic matter using hydrogen peroxide (H_2O_2) and then sodium hexameta phosphate $(NaPO_3)_6$was used to disperse the soil. The soil textural classes were determined using the international society of soil science system (Rowell, 1994), triangular guideline. Moisture content was determined by Gravimetric method. Initially, weight the field samples and dry it at 105°C for 24 hours, then weighing them again. The percentage of water held in the soil was calculated as the weight difference of field and oven dried soils divided by weight of oven dried soil multiplied by 100:-

$$Percent\ of\ moisture(wt\,\%) = \frac{(A-B)x100}{B-C}$$

Where A=fresh weight (g) + weight of empty core (g), B=weight of oven dry soil (g) + weight of empty core (g) and C=weight of the empty core (g), B-C= weight of oven dry soil (g).

Soil bulk density also determined by the undisturbed core sampling method after drying the soil samples in an oven at $105^{o}{}_{C}$ to constant weight and calculated by the following formula indicated by (FAO, 2007). Soil pH was measured by using a pH meter in a 1:2.5 soil: water ratios (Reeuwijk, 1992) whereas electrical conductivity (EC) was measured in soil to water ratio of 1:2.5(Reeuwijk, 1992). The soil organic carbon was determined by the Walkley-Black oxidation method with potassium dichromate (K_2Cr2O_7) in a sulfuric acid medium then converted to soil organic matter by multiplying it by the factor of 1.724 following the assumptions that OM is composed of 58% carbon (Walkley and Black, 1934).The Total Nitrogen was determined by micro-Kjeldahl digestion method (Bremmer and Mulvancy, 1982) by oxidizing the OM in concentrated sulfuric acid solution (0.1N H_2SO_4) and the digest was distilled and about 50 ml of the distillate was collected which was then titrated with 0.05N H_2SO_4 to pink end point. Available phosphorus was determined using Bray II extraction method as described by Reeuwijk, (1992). Cation exchange capacity (CEC) was determined by the saturated ammonium acetate (1 Normal NH4OAc at pH 7.0) method (Chapman, 1965).Exchangeable calcium ($Ca^{2+)}$ and magnesium (Mg^{2+}) by ammonium acetate extraction and measured by the atomic absorption spectrometry (AAS) method. Exchangeable potassium (K^+) and sodium (Na^+) extracted by sodium acetate method and measured by flame photometer. Percentbase saturation(PBS)was calculated by dividing the sum of the base forming cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+) by the CEC of the soil and multiplying by 100 (Fageria, 2009):-

$$\mathrm{Pbs} = \frac{(\mathrm{Ca^{2+} + Mg^{2+} + K^{+} + Na^{+}})}{\mathrm{CEC}} \mathrm{x100}$$

Where the values of CEC, $Ca^{2+,}$ $Mg^{2+,}$ K^+, and Na^+ are expressed in cmol (+)/kg

Statistical analysis

Prior to data analysis the data was checked for the assumption of ANOVA following standard procedure of the statistical analysis software SAS version 9.2. The mean separation in soil parameters among land uses was carried out using least significant difference (LSD) at the ($p \le 0.05$).

RESULTS AND DISCUSSION

Effect of agroforestry on selected soil physical properties

Soil texture

The soil textural analysis results revealed that there was no significant difference in percentage of sand, silt and clay particles statically at (*p<0.05*) under the three land use systems and two soil depth except sand on the soil depth (Table 1).

Based on USDA soil textural classification, soils under area enclosure and agroforestry practices were grouped as clay texture while cultivated land categorized as clay loam textural class. In line with this, finding, Mulugeta (2004) and Belayneh (2009) reported that farming practices change soil texture by aggravating soil erosion. The interaction effect of land use by the soil depth also showed a significant variation at (*P < 0.05*) for mean value of sand and clay particles under area enclosure and cultivated land at the depth of 0-15cm (Table 1). The highest mean value (27%) of sand was obtained under area cultivated land while the lowest value (22.3%) was recorded on the area closure as indicated by (Table1). This may be due to more susceptibility of cultivated land to erosion that leads for removal of fine particles and gave chance for accumulation of coarse particles on the site. The results was harmonized with (Gebeyhu, 2007), report that sand fractions were significantly (*p< 0.05*) affected by land use and soil depth.

Table 1. Main effect of land use types with soil depth on selected physical properties of the soil.

Parameters	Sand (%)	Silt (%)	Clay (%)	SMC (%)	BD(g/cm^3)	Textural classes
Land use						
AE	22.34^{b*}	29.66	43.67^{ab}	28.7^{b*}	1.24^{b*}	clay
AF	24.66^{ab}	31.67	48^{a*}	32.6^{a*}	1.02^{c*}	clay
CL	27^{a*}	30.66	42.34^{b*}	23.2^{c*}	1.57^{a*}	Clay loam
P-value	*0.003*	*0.57*	*0.11*	*0.0001*	*0.002*	
Lsd(0.05)	*2.41*	*3.97*	*5.61*	*1.84*	*0.13*	
Soil depth(cm)						
0-15	26.11^{a*}	30.00	43.88	28.31	1.22	clay
15-30	23.22^{b*}	31.33	45.44	28.08	1.20	clay
P-value	*0.007*	*0.39*	*0.47*	*0.74*	*0.82*	
Lsd(0.05)	1.96	3.24	4.58	1.50	0.10	
CV (%)	7.89	10.45	10.15	5.28	8.67	

≠The means within a column followed by the same letter are not significantly different from each other at P ≤ 0.05; ns = not significant.

Soil moisture content

The analysis results revealed that there was significant variation in soil moisture content at (*p< 0.05*) for the three land use types. The highest soil moisture content was recorded under agroforestry (32.6%) followed by area enclosure (28.7%) and cultivated land (23.2%) respectively (Table 1). The probability reason for this can be agroforestry has ability to improve the water holding capacity of the soil by adding organic matter to the soil. Similar with this result Ajayi *et al.* (2008) reported that organic matter in tree based systems leads to increases in soil water retention capacity. However, difference was no observed on mean value soil moisture content for the two soil depths (0-15 and 15-30cm). The interaction effects of land use by the soil depth indicated that there was significant difference (*p <0.05*) for mean value of soil moisture contents under agroforestry and area enclosure at soil depth 0-15cm (Table 2). The highest mean soil moisture content (33.79 %) was recorded under agroforestry at the soil depth (0-15cm) whereas the lowest value (23 %) was obtained on cultivated land on the same soil depth *(p<0.05).* The reason for this was due to high clay and high organic matter which come from leaf and other biomass accumulation under land with agroforestry practices that leads to high soil moisture retention. The lowest value indicated that there was high soil disturbance in physical, chemical and biological properties of the soils due unscientific types of cultivation practices that exposed the soil to loss moisture holding capacity. In line with this finding Dai *et al.* (2006) and Wang, (2009) stated that land use was one of the main factors that controlling soil water variability.

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Soil bulk density

The bulk density at ($P \leq 0.05$) beneath the three land use systems was shown significantly differences. The highest value bulk density value (1.57g/cm^3) was recorded under cultivated land and the lowest value (1.02 g/cm^3) was underneath the agroforestry practices as presented in (Table 1).The highest mean values of bulk density in cultivated land might be due to livestock trampling, low OM input and high soil disturbances on cultivated land. On the other hand, the lowest bulk density under agroforestry systems indicated that, there was addition of high OM from plant residues and litters. Similar with this study Mulugeta (2004) reported that bulk density of cultivated soils was higher than forest soil.

The combined effects of land use by soil depth designated significant variation in soil bulk density at the soil depth of 0-15cm beneath agroforestry and cultivated land at 0.05 levels of significances (Table 2). The reason for this can be the highest accumulation of humus on the top layer of the soil of the study area due to AF practices. This study harmonized with the findings which indicated bulk density decreases as OM increases (Heuscher, 2005).

Table 2. The interaction effect of land use by soil depth on selected physical properties of the soil.

Parameters	Sand (%)		Silt (%)		Clay (%)		SMC (%)		Bd(g/cm^3)	
Land use	Soil depth(cm)									
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
AE	22.3^{c*}	22.3	28.7	30.7	49^{a*}	47	28.15^{c}	29.3^{bc}	1.13^{bc}	1.2
AF	27^{ab}	22.3	30.7	32.7	42^{ab}	45	33.79^{a*}	31.4^{ab*}	1.1^{c*}	1.2
CL	29^{a*}	25	30.7	30.7	40^{b*}	44.3	23^{c}	25.97^{bc}	1.4^{a*}	1.32
P-value	*0.0001*		*0.84*		0.30		*0.0001*		*0.02*	
Lsd(0.05)	2.98		NS		8.32		2.47		0.19	
CV (%)	6.66		11.34		10.23		4.8		8.8	

††Interaction mean within a column followed by the same letter are not significantly different from each other at (*p<0.05*),SMC: Soil moisture content ,Bd: soil bulck density

Table 3. Main effect of land use and soil depth on selected chemical properties of the soil.

Parameters	pH	OC (%)	OM (%)	TN (%)	AvP (ppm)
			Land use		
AE	7.01^{b*}	1.98^{b*}	3.43^{b*}	0.12b*	11.69
AF	7.28^{a*}	2.84^{a*}	4.90^{a*}	0.37a*	12.51
CL	6.98^{b}	1.56^{b}	2.87^{b}	0.15b*	12.20
P-value	*0.02*	*0.01*	*0.03*	*0.22*	*0.05*
Lsd(0.05)	0.22	0.78	1.46	0.05	0.65
Soil depth(cm)					
0-15	7.13	2.40	4.25	0.17	12.33
15-30	7.05	1.86	3.36	0.13	11.93
P-value	*0.32*	*0.09*	*0.13*	*0.07*	*0.13*
Lsd(0.05)	0.18	0.63	1.19	0.04	0.53
CV (%)	2.55	19.63	18 .02	21.01	4.37

≠The means within a column followed by the same letter are not significantly different from each other at *p < 0.05*; ns = not significant. OC: Organic carbone, OM: Organic matter, TN: Total nitrogen and Avp : Available phosphorus

Effect of agroforestry practices on selected soil chemical properties

Soil pH

The analysis result revealed that highest mean value of soil pH (7.28) was recorded beneath agroforestry while the lowest value of soil pH (6.98) on cultivated land. The result was shown satirically significant difference at (*p<0.05*) level of significances (Table 3).

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The reason for this can be the accumulation of relatively high amount of basic cation (Ca^{+2}, $Mg^{+2}$and K^{+}) due to low leaching effect under agroforestry as result of trapping nutrients and trees add organic matter to the soil system in the form of roots or litter fall or as root exudates in the rhizosphere that can release those basic cation during mineralization of OM .Some studies have demonstrated that tree species diversity can lead to higher mineral soil carbon stocks and pH (Guckland *et al*., 2009). The lowest value of soil pH was due continuous cultivation practices and application of inorganic fertilizer could have attributed for the reduction of soil pH. Based on the classification by Pandey *et al.* (2000), soil pH among sites of the study area grouped in neutral pH scale. The soil depth has no shown significant effect on soil pH at ($p<0.05$) (Table 3).Taking the mean interaction effect under consideration, there was significant variation in the value of soil pH at ($p<0.05$) for the both soil depth under agroforestry practice and area excuse.

Table 4. The mean interaction effect of land use by soil depth on selected chemical properties of the soil

Parameters	pH		OC (%)		OM (%)		TN (%)		AVP(ppm)	
Land use	Soil depth(cm)									
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
AE	7.012^{c*}	7.02^{bc*}	2.15^{b*}	1.8	$3.7.8^{b*}$	3.6	0.15	0.10	11.55^{b*}	11.8
AF	7.26^{ab*}	7.03^{a*}	3.68^{a*}	2.01	6.34^{a*}	3.46	0.2	0.14	13.17^{a*}	11.8
CL	6.88^{c}	7.09^{abc}	1.37^{c*}	1.76	2.71^{b}	3.03	0.16	0.15	12.29^{b}	12
Lsd(0.05)	0.24		0.63		1.57		0.08		0.79	
P- value	*4.15*		*0.0002*		*0.005*		*0.26*		*0.014*	
CV (%)	1.93		16.35		22.72		22.00		3.59	

††Interaction means within a specific soil parameter followed by the same letter (s) are not significantly different from each other at ($p< 0.05$).

Table 5. The main effect of land use and soil depth on selected chemical properties of the soil.

Parameters	CEC(cmol(+)/kg)	Ca^{+2}(cmol(+)/kg)	Mg^{+2}(cmol(+)/kg)	K^{+}(cmol(+)/kg)	PBS (%)
Land use					
AE	29.07^{b*}	22.02^{b*}	5.41^{b*}	$0..43^{c*}$	97.20
AF	33.84^{a*}	25.13^{a*}	7.56^{a*}	1.15^{a*}	97.54
CL	24.77^{c*}	19.19^{c*}	2.93^{c*}	0.8^{b*}	96.9
P-value	*0.013*	*0.026*	*0.0003*	*0.0003*	*0.45*
Lsd(0.05)	3.12	2.73	2.03	0.277	1.04
Soil depth(cm)					
0-15	30.64^{a*}	22.91	9	2.12	97.54
15-30	27.81^{b*}	21.32	7.01	1.35	96.89
p- value	*0.03*	*0.15*	*0.12*	*0.04*	*0.12*
Lsd(0.05)	2.54	2.23	2.5	0.75	0.85
CV (%)	8.62	9.97	10.3	9.98	0.89

*The means within a column followed by the same letter are not significantly different from each other at $P \leq 0.05$; ns = not significant

Organic matter and organic carbon

The analysis result of soil OM and soil organic carbon were shown significantly difference at ($p < 0.05$) between agroforestry practices and area enclosure (Table 3) .The highest mean values of soil OM and soil organic carbon (4.9%, 2.84%) were recorded under agroforestry practices and the lowest value (2.87% 1.56%) were observed in cultivated land followed by enclosure. The for reason may be due to higher contribution of agroforestry for soil OM and soil organic carbon accumulation by hindering the loss of soil OM and soil carbon while reducing velocity of runoff which leads to minimum the chance of soil erosion to be occurred. As Alemayewet *et al*., (2010) stated that soil under agroforestry showed that high accumulation of OM created in the surface soil where large amount of root biomass and other plant remains found. Similarity, Young (1991), emphasized that agroforestry systems have the potential to control both water and wind erosion, which ultimately reduces the loss of soil OM and nutrients. The effect of soil depth on both soil OM and soil organic carbon at (*p<0.05*) were statically non significant as indicated in (Table 3).The combined effect of land use with soil depth (0-15cm) revealed that there was significant variation in soil organic carbon at (*p<0.05*) p-value but non significant for soil organic matter at this depth (Table 4).

Total nitrogen and available phosphors

The total mean value nitrogen for the three land use systems except for soil depths (0-15 to 15-30cm) showed significant variation but available phosphors was not revealed the significant different for three land use and soil depths(0-15 to 15-30cm) at (*p<0.05*) as indicated under (Table 3). The increment in mean value of total nitrogen not only due to the existence of varies tree species in agroforestry practices which has responsibly for nitrogen fixations but also be able to create favorable situation for mineralization activities to take place. This resulted in maximizing the amount of available nitrogen in the soil. Even though, the result was statically non significant, there was numerical variation for the mean value of available phosphors for each land use types and sampled soil depths (0-15 to15-30cm). In line with this finding Anthony (1990) report indicated that increases of 50-100% in soil nitrogen and OM beneath trees, as compared with surrounding soils. The combined effects of land use types with that of soil depth illustrated that there was no significant differences on the mean value of total nitrogen and available phosphors at the (*p<0.05*) except available phosphors at the soil depth (0-15cm) as indicated here after in (Table 4).

Cation exchange capacities, (exchangeable bases (ca^{2+},$mg^{2+}$and k^{+}) and pbs

The study result revealed that there were significant change in the mean value of CEC and exchangeable bases (Ca^{2+}, $Mg2^{+}$ and K^{+}) under the three land use types at (p*<0.05*) as shown in (Table 5). The highest and the lowest CEC, $Ca^{2+,}Mg^{2+}$ and K^{+} (33.84 and 24.13, 25.19 and 19.19, 7.56 and 2.93, 1.15 and 0.43) value were respectively recorded under agroforestry practices. The reasons for this can the addition of OM from biomass and litters of agroforestry that able to realize those exchangeable cations beside of reducing the chance of those nutrients to be leached by rainfall. The finding of this study revealed that there is no impact of soil depth no exchangeable bases ($Ca^{2+,}Mg^{2+}$ and K^{+}) excluding CEC as shown in (Table 5) . Taking, the interaction effect of land use by the soil depth under consideration, the analysis results signified that there were difference in mean value of CEC,Ca^{+2} Mg^{+2} K^{+} and PBS except the mean value of Ca^{+2} and Mg^{+2} at (15-30cm) and K^{+} and Pbs at (0-15cm) soil depth respectively(Table 5). The three land use (AE, AF and CL) but no any statically change was recorded for Pbs at the (*p<0.05*) p-value (Table 5). The highest value of CEC, Ca^{+2}, $K^{+}$and Pbs (35.9, 26.61and 2.63) on the soil depth of (0-15cm) were obtained under whereas e as agroforestry practices respectively whereas the highest value Mg^{+2} was recorded on the area closure.

Table 6. The mean interaction effect of land use by soil depth on selected chemical properties of the soil.

Land use types	CEC(cmol (+)/kg		Ca^{+2}(cmol(+)/kg		Mg^{+2}(cmol (+)/kg		K^{+}(cmol(+)/kg		Pbs(%)	
	Soil depth									
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
AE	29.28^{b*}	28.9^{b*}	21.64^{b*}	22.41	2.85	3.27^{a*}	2.31^{b*}	2.37	2.31^{b*}	2.37
AF	35.9^{a*}	27.78^{bc}	26.61^{a*}	21.66	2.96	2.88^{b*}	2.63^{a*}	2.37	2.61^{a*}	2.37
CL	26.76^{c*}	26.8^{c*}	20.48^{b}	19.91	2.88	2.84^{b}	2.45^{b}	2.42	2.45^{b}	2.42
Lsd (0.05)	1.87		3.41		0.25		0.15		0.73	
P-value	*0.0001*		*0.016*		*0.02*		*0.026*		*0.011*	
CV (%)	3.52		8.49		4.68		3.54		0.41	

**Interaction means within a specific soil parameter followed by the same letter (s) are not significantly different from each other at (*p < 0.05*).

CONCLUSION

In this case study, it was clearly understood that the agroforestry practices have ability to play a significant role in reducing soil erosion and improving overall soil physico-chemical properties as well as the fertility status of the soil. The soil physical properties such as sand, clay, soil moisture content and soil bulk density and soil chemical properties i.e. soil pH, soil organic carbon, soil organic matter, available phosphorus, CEC and exchangeable bases (Ca^{+2}, Mg^{+2} and K^{+}) revealed statically significance variation at p-value of (*p<0.05*) under the three land use system(AE, AF and CL).

Among the three lands use systems the highest improvement in soil physico-chemical properties was observed under agroforestry practices The mean combine effect of land use with soil depth for (clay, SMC, soil ph, SOC, SOM ,available p, exchangeable bases (Ca^{+2}, Mg^{+2} and K^{+}) were significantly higher under agroforestry except sand and soil bulk density at ($p< 0.05$). Based on obtained results of this investigation agroforestry based land use systems make a valuable contribution to improve nutrient cycling within the systems that come up with the improvement entire physical and chemical properties of the soil in study area. Therefore, using agroforestry as soil and water conservation measures are not only considered as an alternative but also should have to practices as compulsory work in study site. As if we need to bring sustainable land management for foreseen able future.

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