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Original Research

Impacts of Land Use Types on Selected Soil Physico-Chemical Properties of Loma *Woreda*, Dawuro Zone, Southern Ethiopia

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Abstract

A study was conducted in Loma Woreda, Dawuro Zone, Southern Ethiopia, to investigate the impacts of land use types (forest, grazing and cultivated) on the selected soil physico-chemical properties of the study area. Composite surface (0-20 cm) soil samples were collected randomly from three sites of each land use which were adjacent to each other and subjected to laboratory analysis. The results of the study revealed that there was relative variation in proportion of sand and clay content among the land use types though they have the same textural class. The bulk density of the soils decreased from grazing to cultivated and then to forest land, while total porosity decreased from forest to cultivated and then to grazing lands. The average soil pH-H_2O value of the area varied from very strongly acidic to strongly acidic. Exchangeable acidity and Percent Acid Saturation were significantly lower by about 60.02 and 61.54% in the forest soils than the soils of cultivated lands, and 29.70 and 38.32% than that of grazing lands, respectively. As compared to the soils of forest land, the amount of soil OM, TN and CEC in cultivated land have declined by about 76.53, 60.83 and 38.97%, respectively. The available P, exchangeable bases and PBS have shown decreasing trends in the soils of forest to grazing and then to cultivated land uses. From this study, it can be concluded that the soil fertility and quality were well maintained relatively under the forest land, while the impact on most parameters were negative on the soils of the cultivated land. Applications of lime, organic and inorganic fertilizers and crop rotation especially in the cultivated lands may enhance the productivity of the soils, implying the need for undertaking integrated soil fertility management in sustainable way to improve and maintain the favorable soil properties.

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INTRODUCTION

Land use changes are regarded as important components and a primary cause of global environmental changes (Turner *et al*., 1995). These changes are driven by the interaction in space and time between biophysical and human dimensions (Turner, 1995). The rate of soil quality degradation depends on land use systems, soil types, topography, and climatic conditions. Several works showed that inappropriate land use aggravates the degradation of soil physico-chemical and biological properties (Saikh *et al*., 1998b; He *et al*., 1999). Changes in land use and management practices often modify most soil morphological, physical, chemical and biological properties to the extent reflected in agricultural productivity (Heluf and Wakene, 2006).

The conversion of native forest and native range land into cultivated land is known to deteriorate soil properties (Mulugeta *et al*., 2005; Eyayu *et al*., 2009; Nega and Heluf, 2009). The authors reported increment of bulk density, organic matter deterioration and reduction in cation exchange capacity (CEC), which in turn reduce the fertility status of the given soils, as main impacts. In addition, change in land use, long term cultivation, deforestation, overgrazing and mineral fertilization can cause significant variations in soil properties and reduction of output (Conant *et al.,* 2003).

Earlier studies by Agoume and Birang (2009) showed that land use systems significantly affected the clay, the silt and the sand fractions. Sand and silt decreased with the soil depth, whereas clay increased with it. Soil pH, total N, organic carbon, available P, exchangeable Ca, exchangeable Al, sum of bases, effective cation exchange capacity (ECEC) and Al saturation significantly differed with the land use systems. Al saturation increased with soil depth, and the top soils presented acidity problems while the sub soils exhibited Al toxicity.

The soils of the study area have been continuously cultivated and depleted. Although knowledge of soil physical and chemical properties plays a vital role in enhancing production and productivity on sustainable basis, there is limitation of knowledge and detail information on the characteristic features of soils around study area of Loma *Woreda*, Southern Ethiopia. Thus, this study was to investigate the impacts of different land use types (forest, grazing and cultivated) on the selected soil physico-chemical propertiesof the study area. The findings of the study are expected to contribute to the improvement of the productivity of the acidic soils and to fill-in the knowledge gap in soil acidity management problems in the study area.

MATERIALS AND METHODS

Description of the Study Area

Location, Climate and Soil

The study was conducted in Loma *Woreda*, Dawuro Zone of Southern Nations, Nationalities and People's Regional State (SNNPRS), Ethiopia. Geographically, the study area lies between 6°54′29.96'' to 6°55′16.78″ N and 37°13'49.10'' to 37°14'18.05'' E. It is at about 500 km south west of Addis Ababa, the capital of Ethiopia (Figure 1). The study area lies between 2286 and 2516 masl receiving a total annual rainfall range from 1355.4 to 2565.6 mm with mean monthly temperature varying from 11.7 to 23.5°C. The rainfall is a bimodal type: the short rainy season is between March and May, and the long between June and September (Figure 2). According to Tefera *et al.* (1999), the geology of the study area is abundant with rhyolites and trachy basalts mainly overlying in the Precambrian basement and tertiary volcanism. Most of the area is mountainous, having well drained and moderately weathered brown soil (Nitisols) and Orthic Acrisols (BoPED, 1998).

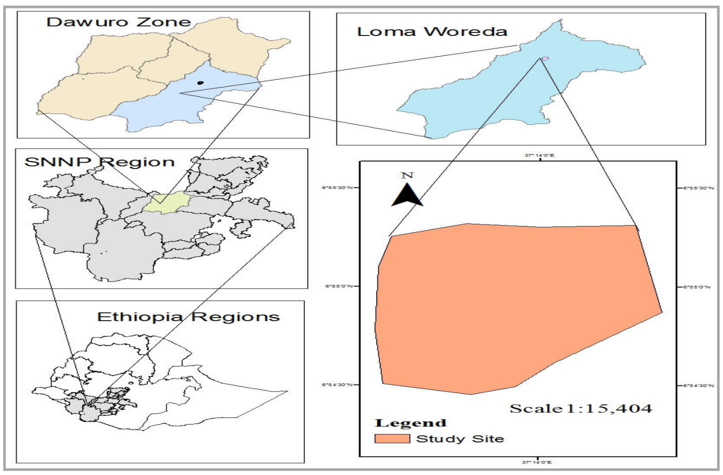

Figure 1: Location map of the study area

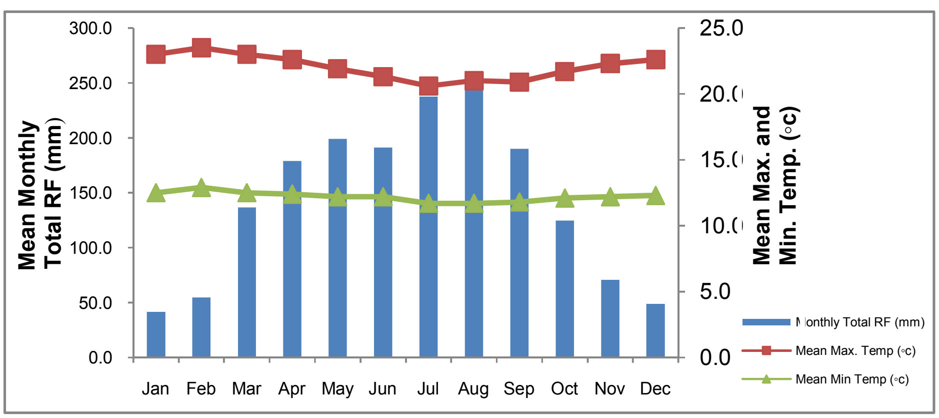

Figure 2: Mean monthly minimum and maximum temperatures (^{0}C) and mean monthly total rainfall (mm) of the study area recorded for the year from 1999-2010 (**Source:** National Meteorological Agency; Gessachare station)

(A) (B) (C)

Figure 3: Photos of land use types in the study area; A = Cultivated land, B = Grazing Land, and C = Forest land

Land Use and Farming Systems

Cultivated land uses are areas cultivated for annual crops production. These areas contain very few scattered trees deliberately left as traditional agro-forestry trees. The problem of cultivated lands on the study areas are being on steeper slopes and losing their depth and fertility due mismanagement. The grazing land uses include areas comprising of private lands with little or no vegetations which are used for livestock grazing and brewing purpose. Forest land use considered in the study are areas covered with long and dense trees with dense indigenous natural forest. It is under constant pressure due to the expansion of agricultural lands. The natural vegetation is shrunk near the bottom of high mountains, course of rivers and around the churches.

The dominant vegetations grown in the study areas include *Arundinaria alpina, Erythrina brucei, Eucalyptus spp., Juniper procera, Maesa lanceolata, Vernonia theophrasti folia, Cordia africana, Croton macrostachyus* and others. The farming system of the area is predominantly subsistence farming based on mixed crop-livestock production.

The dominant crops grown in the study area include legume crops (faba bean, lentil and field peas), cereal crops (wheat, rye, barley, maize), perennial crops such as Enset (*Ensete ventricosum* L.), coffee, different agro-forestry tree species and eucalyptus plantations and root crops (potatoes and taro) and others. Enset is the source of the staple food in the area which provides vegetation cover and creates green scenery. The scattered trees in the cultivated lands are preserved from the original forest during clearance, which are indicator of previously existing forest in that area (LWADO, 2013; Mathewos *et al.,* 2013).

Site Selection and Soil Sampling for Laboratory Analysis

A preliminary survey and field observation was carried out to generate key information regarding the land forms, land uses, topography and vegetation cover of the study sites. Accordingly, three major representative land use types (forest, grazing and cultivated lands) of the study area, which are adjacent to each other, were identified. Undisturbed core and disturbed composite surface (0-20 cm) soil samples were collected randomly from each land uses, replicated three times and subjected to laboratory analysis. Eighteen to twenty three sub-samples were augured following the 'zigzag' pattern and mixed thoroughly to make composite samples according to variations on their drainage, slope gradient, vegetation cover, management practices, soil color, history and occurrence at different landscape positions. Analysis of soil samples was carried out at the Haramaya University Soil Chemistry Laboratory.

Laboratory Analysis of Soil Samples

Soil pH was measured potentiometrically with a digital pH meter in the supernatant suspension of 1:2.5 soils to water ratio (Barauah and Barthakulh, 1997). Particle size and bulk density were determined following Bouyoucos hydrometer (Day, 1965) and core sampling (Jamison *et al*., 1950) methods, respectively. Average particle density (PD) of mineral soil (2.65 g cm^{-3}) and bulk density were used to estimate total porosity as described as follows: Total porosity (%) = $(1-\left(\frac{\mathrm{BD}}{\mathrm{PD}}\right))*100$; Where BD = bulk density in (g cm^{-3}) and PD = particle density (g cm^{-3})

Soil organic carbon was determined by dichromate oxidation method (Walkely and Black, 1934) and organic matter content was computed from organic carbon content by multiplying the latter by 1.724. Total Nitrogen was determined using the micro-Kjeldahl digestion, distillation and titration procedure as described by Bremner and Mulvaney (1982). Available phosphorus was extracted by the Bray-II method (Bray and Kurtz, 1945) and quantified using spectrophotometer (wave length of 880 nm) colorimetrically using vanado molybdate as an indicator.

Exchangeable basic ions (Ca, Mg, K and Na) were extracted using 1 M ammonium acetate (NH_4OAc) solution at pH 7. The extracts of Ca and Mg ions were determined using AAS while K and Na were determined by flame photometer. To determine the cation exchange capacity (CEC), the soil samples was first leached with 1 M NH_4OAc, washed with ethanol and the adsorbed ammonium was replaced by sodium (Chapman, 1965). The CEC was then measured titrimetrically by distillation of ammonia that was displaced by Na following the micro-Kjeldahl procedure. Total exchangeable acidity was determined by saturating the soil samples with 1 M KCl solution and titrating with 0.02 MHCl as described by Rowell (1994). From the same extract, exchangeable Al in the soil was determined by titrating with a standard solution of 0.02 M HCl. The soil percent base saturation (PBS) was calculated from sum of the basic exchangeable cations (Ca, Mg, K and Na) as the percentage of CEC.

Data Analysis

Data recorded were subjected to analysis of variance (General Linear Model (GLM) procedure) using SAS software version 9.1 (SAS Institute, 2004) to test differences in selected soil physical and chemical properties among the different land use. Least Significant Difference (LSD) ($p\leq0.05$) test was used to separate statistically significant means of soil parameters. Correlation analyses were also carried out to detect the magnitude and degree of relationships among key soil variables.

RESULTS AND DISCUSSION

Selected Soil Physical Properties under Different Land Use Types

Particle Size Distribution

The Analysis of variance indicated that silt content was not significantly *($P\leq0.01$)* affected by land uses (Table 2). However, the least significant difference (LSD) *($p\leq0.05$)* test showed that the mean values of sand and clay contents were statistically significantly affected by land use types. Generally, the overall textural class of the soils under the different land use types is found to be clay loam, which may indicate the similarity in parent material (Table 1).

A relative variation in proportion of clay and sand content in the cultivated land could be due to soil erosion, because most of the cultivated fields in the study area lacks soil and water conservation measures as well as management practices, which might have resulted in removal of a smallest soil separates of clay that are easily transported by either water or wind erosion. In agreement with this Teshome *et al.* (2013) indicated the reason for low clay in surface layers of cultivated lands might be due to selective removal of clay from the surface by erosion. Similarly, Achalu *et al.* (2012) reported that soils of different land use systems, but of same area with same soil type and textural class, differed in some other soil physical conditions mainly due to the fact that soil physical properties change with the change in land use systems and its management practices.

Table 1: Effects of land use types on selected physical properties of surface soil (0-20 cm) of the study area

Land Use Types	Soil Physical Properties					
	Sand	Silt	Clay	Soil Class	Bulk Density (gcm^{-3})	Total Porosity (%)
Forest	24.33^b	33.78	41.89^a	Clay Loam	1.07^c	59.63^a
Grazing	25.67^b	35.00	39.33^a	Clay Loam	1.36^a	48.69^c
Cultivated	31.67^a	34.56	33.77^b	Clay Loam	1.15^b	56.61^b
LSD(0.05)	**1.99**	**3.83**	**3.16**	**-**	**0.03**	**1.15**
CV (%)	**3.67**	**5.57**	**4.12**	**-**	**1.28**	**1.05**

*Means within a column followed by the same letter are not significantly different at *$p \le 0.05$;*
LSD = Least Significant Difference, CV = Coefficient of Variation

Table 2: Analysis of variance (ANOVA) results of soils of study area under three land use types (forest, grazing and cultivated land)

Soil property	DF	SS	MS	EMS	F-value	P >F
Sand (%)	2	91.55	45.77	1.00	45.78	0.0002
Silt (%)	2	2.30	1.15	3.68	0.31	0.743
Clay (%)	2	103.23	51.61	2.50	20.62	0.0002
Bulk Density (gcm^{-3})	2	0.134	0.06	NS	288.43	≤0.0001
Total Porosity (%)	2	191.53	95.76	0.33	289.64	≤0.0001
pH-H_2O	2	0.44	0.22	0.008	30.49	0.0001
Exchangeable Aluminum($cmol_{(+)}kg^{-1}$)	2	47.39	23.69	0.14	159.14	≤0.0001
Exchangeable Acidity($cmol_{(+)}kg^{-1}$)	2	53.28	26.64	0.13	198.57	≤0.0001
Available Phosphorous(ppm)	2	38.02	19.01	0.92	20.48	0.0002
Organic Matter (%)	2	47.42	23.71	0.008	2819.91	≤0.0001
Total Nitrogen (%)	2	0.04	0.02	NS	151.9	≤0.0001
Carbon to Nitrogen Ratio	2	77.63	38.81	0.66	58.97	0.0001
ExchangeableCalcium ($cmol_{(+)}kg^{-1}$)	2	16.96	8.48	0.08	103.82	≤0.0001
Exchangeable Magnesium($cmol_{(+)}kg^{-1}$)	2	12.50	6.25	0.09	66.35	≤0.0001
Exchangeable Potassium($cmol_{(+)}kg^{-1}$)	2	0.13	0.06	0.002	31.89	0.0001
Exchangeable Sodium($cmol_{(+)}kg^{-1}$)	2	0.105	0.05	0.001	27.38	0.0001
Cation Exchange Capacity ($cmol_{(+)}kg^{-1}$)	2	213.68	106.84	0.93	114.20	≤0.0001
Percent Acid Saturation (%)	2	2742.75	1371.37	6.83	200.55	≤0.0001
Percent Base Saturation (%)	2	273.26	136.63	8.99	15.19	0.0005

*DF = Degree of Freedom, SS = Sum Square, MS = Mean Square = EMS = Error Mean Square, F Value = F calculated Value, P r= Probability

Bulk Density

As compared to the usual bulk density of mineral soils suggested by Pam (2007),the mean value of surface (0-20 cm) soil bulk density of the area was low for soils of forest and cultivated land while moderate for soils of grazing land. The LSD *($p \le 0.05$)* test also revealed that the mean value of soil bulk density was statistically significantly influenced by land use types. The mean value of bulk density of the soils of grazing and cultivated land increased by 27.1% and 19.62%, respectively from the soils of adjacent forest land (Table 1).

The observed lowest bulk density value in forest land soils is largely due to its relatively highest soil OM content, as it holds high proportion of pore space to solids, which as a result lowered bulk density. In line with this, the overall bulk density showed negative but not significant correlation (r = -0.32) with soil OM (Table 6). The practice of ploughing in cultivated soil also tends to lower the quantity of its OM. The continuous exposure of the soil surface to the direct impact of rain drops under fields with long period of continuous cultivation might have also contributed to the increment of bulk density as raindrop impacts cause soil compaction through disintegration of the soil structure.

The observed relatively high bulk density value of the grazing land soil could also be due to compaction resulting from animal trafficking and large sand proportions. The findings of the present study are in line with the findings of Nega (2006) and Solomon *et al.* (2002). Similarly, Eyayu *et al*. (2009) stated that the bulk density in grazing and cultivated lands increased by 15.5 and 10.7%, respectively, in relative to the natural forest.

Total Porosity

The mean total porosities recorded for all the considered land use types were classified as very high for the study area in general according to the rating of FAO (2006). The least significant difference (LSD; p≤0.05) test has shown significant differences in total porosity among the land use types (Table 1).

Highest soil mean total porosity under the soils of forest land use type may be attributed to the relatively lower animal trampling while lowest porosity is the result of higher animal tracking in the soils of grazing land use.A decline in total porosity in the soils of grazing and cultivated land as compared to soils of forest land were attributed to a reduction in pore size distribution and it is also closely related to the magnitude of SOM loss which depending on the intensity of soil management practices (Ogunkunle and Eghaghara, 1992; Achalu *et al.,* 2012).

Selected Soil Chemical Properties under Different Land Use Types

Soil pH

The average surface soil (0-20 cm) pH-H_2O value of the area was low and classified as strongly acidic as per the pH rating category suggested by Tekalign (1991). As indicated in Table 3, the acidic nature with low soil pH obtained from all land use types may be attributed to the leaching of basic cations (Ca Mg, K and Na) from the surface soil since the area receives high rainfall. It was observed that soil pH was significantly affected by land use types *(P*≤0.01) (Table 2).

Table 3: Effects of land use types on pH-H_2O, Exchangeable Acidity, Exchangeable Al and PAS of the surface soil (0-20 cm) in the study area

Land Use Types	pH-H_2O (1:2.5)	Exch. Ac ($cmol_{(+)}kg^{-1}$)	Exch. Al ($cmol_{(+)}kg^{-1}$)	PAS (%)
Forest	5.11^a	3.97c	3.41^c	26.51^c
Grazing	4.86^b	6.98^b	6.31^b	42.98^b
Cultivated	4.60^c	9.93^a	9.03^a	68.92^a
LSD(0.05)	**0.11**	**0.73**	**0.77**	**5.22**
CV (%)	**1.14**	**5.26**	**6.17**	**5.66**

*Means within a column followed by the same letter are not significantly different at *p≤0.05;* Exch. Ac = Exchangeable Acidity, Exch. Al = Exchangeable Aluminum, PAS = Percent Acid Saturation

The observed relatively higher pH in forest land soils could be associated with higher OM content as it can bind tightly Al ions and reduce their activity in the soil solution and thereby increase pH and reduce acidity. Pearson's simple correlation analysis has also showed strong positive correlation (r = 0.97^{**}) between soil pH and soil OM (Table 6). In connection with this, Abreha *et al*. (2012) reported that the significantly high pH of soils from the forest land might be attributed to the ameliorating effect of the high accumulation of OM at surface. The same authors indicated that the ameliorating effect of soil OM could be due to the combined effect of the continuous releasing of basic cations from the slow decomposition rate of the accumulated OM in that cool humid area, deposition of basic cations at the surface by the relatively deep root forest trees from the subsoil and the specific adsorption of organic anions on hydrous Fe and Al surfaces and the corresponding release of hydroxyl ions.

The lower pH in soils of the cultivated land could be attributed to the removal of basic cations by harvested crops, more removal of basic cations by surface runoff and deep percolation in cultivated land because of less plant cover in cultivated land as compared to other land uses. Likewise, it is reported that although acidity is naturally occurring, agricultural practices such as the removal of plant residues carrying organic anions and excess cations from the farm or paddock are likely to accelerate soil acidification (Schumann and Glover, 1999; Nanthi and Mike, 2003).

Exchangeable Acidity and Aluminum, and Percent Acid Saturation

The LSD (*P≤0.05)* test has revealed that there was highly significant difference in exchangeable acidity and exchangeable Al among the soils of all the considered land uses. Exchangeable acidity was significantly lower by about 60.02 and 29.70% in the forest land soils as compared to the soils of adjacent cultivated and grazing lands, respectively (Table 3).

The high soil exchangeable acidity in the cultivated and grazing lands might be associated with the occurrence of lower soil pH in both land use types. The observed high exchangeable acidity and Al^{3+} in the soils of cultivated land uses were due in part to plant uptake of Ca^{2+} and in part to mixing up with soil to lower depth through tillage, ploughing and losses through leaching. In connection with this, correlation analysis has showed strong negative correlation (r = -0.98^{**}) between exchangeable acidity and soil pH (Table 6). Reports also indicated that exchangeable acidity is a function of soil pH composed of compounds such as $Al(OH)^{2+}$ or $Al(OH)_2^{+}$, and weak organic acid ions held at the colloidal surfaces of the soil (Matzher *et al.,* 1998; Hinrich *et al.,* 2001).

The decrease in exchangeable Al and Al saturation in the soils of forest land caused by increased pH and/or complexation of Al by solid-phase OM that will favor a reduction in Al concentrations in soil solution. Pearson's simple correlation analysis has showed strong positive correlation of exchangeable acidity with PAS (r = 0.98^{**}) while strong negative correlation with PBS(r = -0.87^{**}) (Table 6). The inverse relationship of exchangeable acidity and PAS with PBS could be due to deforestation and intensive cultivation, which leads to the higher exchangeable acidity content in soils of cultivated lands than the other two adjacent land uses (Baligar *et al*., 1997; Achalu *et al.,* 2012).

Organic Matter Content

The OM contents of the soils in forest, grazing and cultivated land use types were rated as very high, high and low as per the rating of Murphy (1968). As compared to the soil of forest land, the amount of soil OM in grazing and cultivated land has depleted by 42.56 and 76.53%, respectively (Table 4).Similarly, ANOVA revealed that soil OM contents under the various land use types were significantly *(P≤0.01)* (Table 2).Significantly higher quantity of OM in forest land soilis mainly due to the addition of more plant residues on its surfaces and their reduced rate of disturbance as compared to the other land use types.

Table 4: Effects of land use types on soil OM, TN, C: N, and Available P of the surface soil (0-20 cm) in the study area

Land Use Types	OM (%)	TN (%)	C:N	Av. P (ppm)
Forest	7.33^{a}	0.263^{a}	16.14^{a}	10.18^{a}
Grazing	4.21^{b}	0.154^{b}	15.94^{a}	6.95^{b}
Cultivated	1.72^{c}	0.103^{c}	9.81^{b}	5.22^{b}
LSD(0.05)	0.18	0.02	1.62	1.92
CV (%)	2.07	6.64	5.81	12.92

*Means within a column followed by the same letter are not significantly different at $p \le 0.05$; OC = Organic Carbon, OM = Organic Matter, C:N = Carbon to Nitrogen Ratio, Av. P = Available Phosphorous

Table 5: Effects of land use types on exchangeable bases (Ca, Mg, K, and Na), CEC and PBS of the surface soil (0-20 cm) in the study area

Land Use Types	Exch. Ca	Exch. Mg	Exch. K	Exch. Na	CEC	PBS
	----------------------$(cmol_{(+)}kg^{-1})$				----------------------------	----(%)----
Forest	5.82^{a}	4.26^{a}	0.51^{a}	0.45^{a}	29.76^{a}	37.26^{a}
Grazing	5.22^{b}	3.30^{b}	0.38^{b}	0.34^{b}	26.40^{b}	35.07^{a}
Cultivated	2.66^{c}	1.42^{c}	0.20^{c}	0.19^{c}	18.16^{c}	24.63^{b}
LSD(0.05)	**0.57**	**0.61**	**0.09**	**0.08**	**1.93**	**5.99**
CV (%)	**6.25**	**10.24**	**12.72**	**13.28**	**3.90**	**9.27**

*Means within a column followed by the same letter are not significantly different at $p \le 0.05$; Exch. Ca = Exchangeable Calcium, Exch. Mg = Exchangeable Magnesium, Exch. K = Exchangeable Potassium, Exch. Na = Exchangeable Sodium, CEC = Cation Exchange Capacity, PAS = Percent Acid Saturation, PBS = Percent Base Saturation, LSD = Least Significant Difference, CV = Coefficient of Variation.

Table 6: Pearson`s Correlation coefficient (r) among selected soil physicochemical properties

	Sand	Silt	Clay	BD	pH	EAl	EA	AvP	OM	TN	C:N	Ca	Mg	K	Na	CEC	PAS
Sand	1.00																
Silt	-0.03	1.00															
Clay	-0.89*	-0.41	1.00														
BD	-0.07	0.24	-0.04	1.00													
pH	-0.94*	-0.06	0.88*	-0.23	1.00												
EAl	0.90*	0.19	-0.91*	0.27	-0.98**	1.00											
EA	0.91*	0.19	-0.92*	0.26	-0.98**	0.99**	1.00										
AvP	-0.76*	-0.29	0.82*	-0.38	0.86*	-0.89*	-0.90*	1.00									
OM	-0.89*	-0.19	0.89*	-0.32	0.97**	-0.99**	-0.99**	0.93*	1.00								
TN	-0.82*	-0.17	0.83*	-0.45	0.94**	-0.96**	-0.96**	0.95**	0.98**	1.00							
C:N	-0.91*	-0.16	0.90*	0.22	0.84*	-0.84*	-0.85*	0.68*	0.82*	0.70*	1.00						
Ca	-0.98**	0.02	0.88*	0.06	0.94**	-0.92*	-0.92*	0.76*	0.90*	0.83*	0.93*	1.00					
Mg	-0.96**	-0.03	0.89*	-0.08	0.97**	-0.96**	-0.96**	0.79*	0.94**	0.89*	0.91*	0.98**	1.00				
K	-0.94**	0.05	0.83*	-0.17	0.96**	-0.94**	-0.94**	0.78*	0.94**	0.90*	0.83*	0.95**	0.98**	1.00			
Na	-0.94**	0.04	0.83*	-0.16	0.96**	-0.94**	-0.94**	0.75*	0.93*	0.89*	0.85*	0.95**	0.98**	0.99**	1.00		
CEC	-0.95**	-0.12	0.92**	-0.03	0.93*	-0.93**	-0.94**	0.88*	0.94**	0.90*	0.90*	0.96**	0.94**	0.92*	0.90*	1.00	
PAS	0.95**	0.11	-0.92*	0.14	-0.98**	0.98**	0.98**	-0.86*	-0.97**	-0.92*	-0.90*	-0.97**	-0.99**	-0.96**	-0.96**	-0.96**	1.00
PBS	-0.94*	0.13	0.78*	0.07	0.90*	-0.87*	-0.87*	0.61	0.83*	0.75*	0.89*	0.95**	0.96**	0.93*	0.95**	0.85*	-0.92*

* = significant at $p \le 0.05$ and ** = significant at $p \le 0.001$; BD = Bulk Density, Av. P = Available Phosphorous, CEC = Cation Exchange Capacity, EA = Exchangeable Acidity, EAl = Exchangeable Aluminum, TN = Total Nitrogen, OM = Organic Matter, PAS = Percent Acid Saturation, PBS = Percent Base Saturation

The lower OM content in cultivated and grazing land soil is attributed to anthropogenic factors like reduced biomass return and livestock grazing. Coupled with this, the well-drained conditions of the soils of the study area enhanced the rate of OM decomposition. In line with this, the findings of other works at different areas revealed that the low OM content in soils of cultivated land could be attributed to increased rates of mineralization of OM mainly caused by tillage activities; the decline in total OM inputs such as litter, crop residues and manures; increased soil temperatures due to exposure of the soil surface and increased wetting and drying cycles and the loss by soil erosion (Chroth *et al.,* 2003; Abreha *et al.,* 2012).

Reduced soil disturbance in the grazing land soils has apparently led to an increase in OM content as compared to soils in cultivated land use. Though absence of such soil disturbance minimized rapid loss of soil OM, removal of nutrients and low biomass return after grazing have led to its decrease compared to the OM content observed in forest land soils. This is may be partly due to the continuous accumulation of un-decayed and partially decomposed plant residues in the surface soils of forest land use. Generally, forest clearing followed by conversion into grazing and agricultural land uses in tropical ecosystems brought about remarkable decline of the soil OM stock (Nega, 2006; Achalu *et al.,* 2012).

Total N and Carbon to Nitrogen Ratios

Total N has showed significant variation among the different land use types (Table 4) and rated as low, medium and high for cultivated, grazing and forest land soils, respectively, as per the rating of Berhanu (1980) and Tekalign (1991). The depletion of total N in grazing and cultivated land was 41.44 and 60.83%, respectively, as compared to that of the soils of adjacent forest land use. Analysis of variance also indicated that there is significant *($P \leq 0.01$)* difference in total N among the considered land use types (Table 2). An addition of a relatively higher plant residue and minimal rate of decomposition might have contributed to higher amount of total N in forest land soil. In agreement with this correlation analysis has showed strong positive correlation of total N ($r=0.98^{**}$) with soil OM (Table 6).

The considerably large losses of total N in the cultivated land could be attributed to rapid mineralization of soil OM following cultivation, which disrupts soil aggregates, and thereby increases aeration and microbial accessibility to OM. Reduced input into the soils of plant residues in such cereal based farming also has contributed to the depletion of soil OM thereby soil N in these cultivated soils. As the area receives high rainfall, the N leaching problem can be another reason for the decline of total N in soils of cultivated land. Nitrate ions which are not adsorbed by the negatively charged colloids that dominate most soils, therefore move downward with drainage water and are thus readily leached from the soil (Solomon *et al.*, 2002; Yihenew and Getachew*,* 2013).

The mean comparison test revealed that the soils in the cultivated land varied significantly in terms of C: N from the soils of forest and grazing land use types ($p \leq 0.05$) (Table 4).The lower C: N ratio in cultivated land use compared to grazing and forest land uses could be attributed to lower level of OM content. In line with this, correlation analysis has also shown strong positive correlation ($r = 82^{*}$) of C: N with OM (Table 6). Relative to forest land, soils of the cultivated land recorded narrow C: N ratio could be probably due to aeration during tillage and increased temperature that enhance higher microbial activity and more CO_2 evolution and its loss to the atmosphere from the top (0-20 cm) soil layer resulted to the narrow C: N ratio (Abbasi *et al*., 2007; Achalu *et al*., 2012).

Available Phosphorus

The mean available soil P contents were very low for grazing and cultivated lands and low for forest land soil as per the rating suggested by Jones (2003).In soils of the forest land available soil P was significantly higher by about 46.47 and 95.01% as compared to that of grazing and cultivated land soils, respectively(Table 4).

The very low available P status in the cultivated and grazing land soils could be associated with the low pH and high exchangeable acidity. Hence, these soils with relatively high exchangeable acidity can have the acidic cations such as exchangeable Al, H, and oxides of Al and Fe that could fix the soluble P in the soil solution. In connection with this correlation analysis has showed strong positive correlation ($r = 0.86^{*}$) of available P with soil pH but strong negative correlation ($r = -0.90^{*}$) with soil exchangeable acidity (Table 6). In line with this, Tekalign and Haque (1987) and Dawit *et al*. (2002) reported SOM as the main source of available P and the availability of P in most soils of Ethiopia decline by the impacts of fixation, abundant crop harvest and erosion.

Exchangeable Bases, CEC and PBS

As per the ratings of FAO (2006), the exchangeable Ca, K and Na contents were medium in the soils of forest and grazing land uses and low in the soil of cultivated land use, whereas exchangeable Mg is high in soils of forest and grazing land use types and medium in the soils of cultivated land use (Table 5).

Compared to cultivated land the relatively higher concentrations of exchangeable Ca, Mg, K and Na contents recorded in soils of forest land could be due to their continuous losses in the harvested parts of plants (both grain and straw) and leaching of basic cations from top soils of cultivated land. As one move from forest to agricultural soils, the exchangeable bases readily decreased showing the declining dominance of basic cations in the exchange complex of the soil colloids and this result is in agreement with the findings of Saikh (1998a) and Jaiyeoba (2003). Similarly, He *et al*. (1999) reported that domination of soil by extractable Al^{3+} and Fe^{2+} ions as well as adsorption of the cations by higher content of clay in the top soils of cultivated land resulted in relatively lower contents of Ca and Mg ions in the soil.

The relatively lower concentration of exchangeable K and Na contents in the cultivated and grazing lands than in the forest land might be due to the same reason explained for Ca and Mg ions. Variations in the distribution of exchangeable bases depends on the mineral present, particle size distribution, degree of weathering, soil management practices, climatic conditions, degree of soil development, the intensity of cultivation and the parent material from which the soil is formed (Heluf and Wakene, 2006). Generally, the exchangeable base contents were well maintained in the forest ecosystem due to nutrient recycling when compared to grazing and cultivated lands, where basic nutrients loss upon grazing and harvesting prevailed. The exchange complex was dominated by Ca followed by Mg, K and Na, indicating productive agricultural soils (Bohn *et al*., 2001).

The observed reductions in the mean soil CEC values of the considered land use types due to conversion of forest lands into grazing and cultivated lands accounts 11.29 and 38.97%, respectively, in surface soils of the study area (Table 5). The mean CEC values are rated as high for forest and grazing land soils and medium for cultivated land soils as suggested by Landon (1991).

The soil CEC values in the cultivated land uses decreased mainly due to the reduction in OM content. In agreement with this correlation analysis has showed strong positive correlation ($r = 0.88^{*}$) of CEC with soil OM (Table 6).The findings of the present study concur with the work of Woldeamlak and Stroosnijder (2003) who reported highest CEC value in soils of forest land and lowest under cultivated land. Basically, CEC of soil is determined by the relative amounts and/or type of the two main colloidal substances; humus and clay. Organic matter particularly plays important role in exchange process because it provides more negatively charged surfaces than clay particles do. On the other hand, the decrease in CEC with pH can be attributed to a decline in CEC values as pH-dependent charge (Johnson, 2002).

The PBS of the top soils (0-20 cm) was classified as low status as per the ratings recommended by Pam (2007). According to the same authors based on PBS as a criterion of leaching, cultivated lands of the study area are strongly leached while those of forest and grazing lands are moderately leached. The trends of the distribution of PBS showed similarity with the distribution of CEC, exchangeable Ca and Mg, since factors that affect these soil attributes also affect the PBS (Achalu*et al.*, 2012). The findings of this work indicated that exchangeable bases, especially Ca and Mg ions dominate the exchange sites of most soils and contributed higher to the PBS which is also in agreement with Eyelachew (1999).

CONCLUSIONS

It was obvious that conversion of land use systems from natural forest to other land use systems would have detrimental effect on soil physical and chemical properties. Coupled with high population pressure, practices like deforestation, overgrazing and intensive cultivation of soils with low inputs in the present study area may have resulted in disturbances, differences and even deteriorations of soil properties among the considered land use types.

The study has revealed that most of the soil physical and chemical properties showed significant changes associated with forest clearing. There are high risks to the sustainable crop production and soil fertility in cultivated lands of the study area which is highly nutrient depleted. This might be due to continuous intensive cultivation, overgrazing, erosion and removal of crops and crop residues with poor soil management practices. Therefore, best integrated land management practices, like liming, returning crop residues to the fields and integrated use of organic and inorganic fertilizers are very crucial and should be given special attention to increase the essential soil basic nutrients and increase soil pH of these acidic soils to the desired level for sustainable natural vegetation management, crop production and to recover intensively cultivated degraded lands.

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Conflict of Interest

Conflict of interest none declared.

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