Effects of land use changes on the dynamics of selected soil properties in the Northeast Wollega, Ethiopia

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Abstract

Land use change can have negative or positive effects on soil quality. Our objective was to assess the effects of land uses changes on the dynamics of selected soil physical and chemical properties. Soil samples were collected from three adjacent soil plots under different land uses, namely forestland, grazing land and cultivated land at 0–15 cm depth. Changes of soil properties on cultivated and grazing land was computed and compared to forestland, and ANOVA were used to test the significance of the changes. Sand and silt proportions, soil organic content, total nitrogen content, acidity, cation exchange capacity, and exchangeable Ca^{2+} content were higher in forestlands. Exchangeable Mg^{2+} was highest in grazing land while clay, available phosphorous and exchangeable K^+ was highest in cultivated land. The percentage changes in sand, clay, soil organic matter, cation exchange capacity, exchangeable Ca^{2+} and Mg^{2+} were higher in cultivated land than the change in grazing land compared to forestland. In terms of relation between soil properties; soil organic matter, total nitrogen, cation exchange capacity and exchangeable Ca^{2+} were strongly positively correlated with most of soil properties while available phosphorous and silt have no significant relationship with any of other considered soil properties. Clay has negative correlation with all of soil properties. Generally, cultivated land has the least concentration of soil physical and chemical properties except clay and available phosphorous which suggest increasing degradation rate in soils of cultivated land. So as to increase soil organic matter and other nutrients in the soil of cultivated land, integrated implementation of land management through compost, cover crops, manures, minimum tillage and crop rotation; and liming to decrease soil acidity are suggested.

Keywords: cation exchange capacity, land degradation, organic matter, soil acidity, soil texture

1 Introduction

Land use changes have remarkable effects on the dynamics of soil properties (Biro et al., 2013). Land use changes from forest cover to cultivated land may reduce the input or organic residues that lead to a decline in soil fertility (Muñoz-Rojas et al., 2015), increase rates of erosion (Biro et al., 2013), loss of soil organic matter and nutrient (Saha and Kukal, 2015), and accelerate rate of soil degradation (Barua and Haque, 2013). Vegetation cover is, therefore, a key indicator of soil degradation as plants play a role in the control of soil erosion (Kropfl et al., 2013; Keesstra et al., 2009; Cerdà, 1998). Biro et al. (2013) observed expansion of cultivated areas can substantially affect soil nutrient content by reducing composition of plant species, net primary productivity, above and belowground allocation in plants, and nutrient cycling. Soil organic matter is lesser in extremely degraded areas where overgrazing manifested. Saha and Kukal (2015) found higher bulk density and lower macro-porosity and water retention in cultivated soils than soils of grassland and forests. These indicated a degradation of soil properties due to the conversion of natural ecosystem to agricultural system.

In Ethiopia, rapid population growth and environmental factors lead to the conversion of natural forest and grassland into cultivated farmland (Tesfahunegn, 2013). Such land use changes have contributed to soil degradation and soil loss by deteriorating the soil physical and chemical properties (Karltun et al., 2013). Soil compaction, loss of soil structure, SOM degradation, undulating terrain, highly erosive rainfall and inappropriate farming practices make soil highly vulnerable to soil erosion. Soil erosion is highest in cropland (42 Mtha^{-1} average annual rate) compared with 5 Mtha^{-1} from grassland. Soil degradation causes loss of fertile topsoil and reduces the productive capacity of the land. The country lost an estimated USD 1 billion per year from both on-site and off-site changes (Bewket and Teferi, 2009). This has been confirmed by empirical studies carried out in different parts of Ethiopia (for example, Angassa, 2014; de Mulenaere et al., 2014; Tesfaye et al., 2014; Tesfahunegn, 2013; Asmamaw and Mohamed, 2013; Fantaw and Abdu, 2011; Eyayu et al., 2009). Soil degradation in the area makes necessary to apply restoration strategies (Mekonnen et al., 2015; Bizoza, 2014; Zhang et al., 2013). Soil protection is fundamental so as to keep sustainable services of the soils and avoid land degradation (Berendse et al., 2015; Keesstra et al., 2012).

In a study conducted in the rift valley area of Ethiopia, Fantaw and Abdu (2011) recounted an increase in bulk density and decrease in soil organic matter (SOM), total nitrogen (TN), exchangeable cations and cation exchange capacity (CEC) contents following the conversion of native woodlands into farmland and grazing land. In Gerado catchment, northeastern Ethiopia, Asmamaw and Mohammed (2013) observed changes in the amount of clay, SOM and total N following changes in land use and land cover. Eyayu et al. (2009) reported declining pH value and the content of SOM in leached and degraded cultivated land than forestland in the Tara Gedam catchment and the adjacent agro-ecosystems of north western Ethiopia. Emiru and Gebrekidan (2013) indicated deforestation has resulted in deterioration of SOM in the soil. Similarly, Tesfahunegn (2013) showed that soil quality indicators varied across the land use and soil management systems, among which natural forestland and afforestation protected areas are the most important systems in maintaining soil quality, where as cultivated and marginal lands seriously deteriorated the physical soil system. The same author revealed that soil organic carbon (SOC), pH, total N, available phosphorous (AP) and clay are significantly higher in natural forest and afforestation protected areas. On the other hand, Yeshanew et al. (2005) found SOC and total N at 0–20 cm depth remained the same after natural forest conversion into eucalyptus plantation in Munesa, Ethiopia. Fantaw et al. (2007) in their study in Bale Mountains of Ethiopia found no variation in soil organic carbon content after natural forest converted into grazing land. These conflicting findings suggest that conversion of forestland into cultivated or grazing land leads to changes of soil physical and chemical properties and degradation of the land is not at all times and in all places applicable. This further suggests the need for empirical inquiry into effects of land use changes on the dynamics of selected soil properties and subsequent degradation of farm household land. To this end, little work was established on the effects of land use on soil properties which have implications for land degradation and land management strategies in eastern Africa. Natural forest, comprising trees species such as *Podocarptus falcatus (*Zigba*), Olea europaea (*Woyera*)* and *Rosa abyssinica (*Kega), was selected as the control field against which different soil properties of cultivated and grazing lands were compared to assess the level of land degradation in the Northeast Wollega, Ethiopia. The interpretation of our results is limited to the current status of some soil parameters such as soil texture, soil pH, TN, CEC, exchangeable cations ($Ca^{2+,}$ Mg^{2+}, K^{+} and Na^{+}), AP, and SOC, due to the fact that there was no documented data on the former land uses.

2 Materials and methods

2.1 Study area

The study area is located in Northeast Wollega (Horo-Guduru Wollega zone, Oromia Region, Ethiopia), approximately on the coordinates of $9^{o}45^{'}$ -$10^{o}00$'N and $37^{o}00$'- $37^{o}15^{'}$E (Fig. 1). The area belongs to the trap series of tertiary volcanic eruptions (ORLEPB, 2013). Its topography is typical of volcanic landscapes, which were later deeply incised by streams, resulting in the current diversity of landforms. The soils have developed from volcanic ashes and reworked materials resulting from tertiary volcanic eruptions and sedimentation processes (ORLEPB, 2013). Nitosols are the dominant soil type, mainly on undulating to steep slopes. Relatively flat areas and especially those closer to river valleys, are largely covered by well develop Vertisols. Dominant soils on steep slopes are Leptosols, Regosols and Cambisols. Its elevation ranges between 1800 and 2657m. Mean annual temperature of the area is 25^0C. Annual rainfall, which is heavy during the summer months (June–August) ranges between 1750 and 2000mm (EMS, 2013). For 2013, the population of the study area was projected to 58,339 of which only 10% was urban population (CSA, 2013). The same document reported that the population of the district has increased by 39% from 1980 to 2013. Except for a small percentage of the population living in the urban area, the inhabitants are farmers engaged in mixed crop-livestock farming system.

2.2 Current land use types

We identified and classified the present land use types through surveys in 2012 and 2013 supported by the elderly households who are assumed knowledgeable about the local land use types by the local community and aged 60 and above. Accordingly, three major land use categories, namely forestland, grazing land, and cultivated land were identified for the purpose of this study (Table 1). Based on the information obtained from the elders, these sites were under the same land cover at least during the last 40 years. Since then, some portions were converted into cultivated and grazing lands while some portions remained as forestland.

Table 1: A brief descriptions of the three land use types in the northeastern Wollega, Ethiopia

Land use type	Description
Forest land	Areas covered with long and dense trees forming closed canopy or nearly closed canopy (70-100%), and without apparent and reported human impacts. This unit also includes undercanopy trees mixed with short bushes and open areas. Dominant tree species in this group include *Celtisaafricana*, *Calpurinasubdecandra* and *Croton mycrostachyus*. In addition, leaves from plants fall, macrofauna (worms, large insects, etc.); soil microflora (bacteria, fungi, algae, etc.) and microbial activities are common in this land use. No sign of rill or sheet erosion.
Grazing land	Formerly this land use was under forest cover. Since 40 years back, this land use evolved with permanent grass cover, with continuous grazing systems (information from local elders). Cattle dung is continuously collected as a source of household energy from this land use. Short grass species dominate this land unit. In some places rill erosions are observed.
Cultivated land	Formerly this land use was under forest cover and this land use evolved since 40 years back with continuous plowing, clearing and removal of above ground biomass (yield and crop residue), disposing and leveling of farming fields (information from local elders). Weathered fragmented rock materials are common in the plowing soil layer. Structural soil conservation (rock and earth terracing) practices are common. For the last 30 years Urea And DAP (up to 100 kg/ha each) and cattle manure have been applied.

	This unit includes areas used for rain-fed agriculture. Major crops grown include cereals (maize, *teff*, and barley), legumes (beans, pea) and oil crops (*neug*).

2.3 Soil sampling

The cluster sampling design by Thompson (1991), which later has been applied by Vågen et al. (2013), Vågen and Winowiecki (2013), and Assefa et al. (2016) was modified and used for this study. The studies by Vågen et al. (2013) was on mapping of land degradation prevalence and soil functional properties in Ethiopia; Vågen and Winowiecki (2013) was on mapping of soil organic carbon stocks for spatially explicit assessments of climate change mitigation potential along the Ethio-Kenya highlands; and Assefa et al. (2016) was on spatial and temporal dynamics of soil organic carbon in landscapes of the upper Blue Nile Basin of the Ethiopian Highlands. In each of these studies three different areas each with 10 km × 10 km and 16 clusters or tiles have been used. Since our study is on a small catchment so as to assess the impact of land use differences on selected soil properties, we modified and applied this sampling design to suit to our study area.

Accordingly, three adjacent sites under different land use types (forestland, cultivated land and grazing land) were selected for this study, with similar slope, elevation and aspect in each land use. We established a 1 km × 1 km cluster (sampling area), and 5 cluster centroids (sampling plots) were stratified into 200 m × 200m tiles and their locations within the sampling area were placed systematically (Fig. 2). The first tile (sampling plot) established first by fixing its central point at the center of 1 km × 1 km area. Then, the area of this sampling plot was established using 100 m radius from the cluster center (sampling area) point. The centers of the other four sampling plots were established at 300 m distance from the center of this sampling plot (the central plot) to north, east, south, and west. The area of each of these sampling plots was established using 100 m radius from their center point. Thus, a 100 m buffered area exists from the boarder of the sampling area and between the neighboring sampling plots. Within each tile four subplots were randomly established, each with an area of 100m^2, one in the center and three on a radial arm with 120^o angles between them (Vågen and Winowiecki, 2013; Vågen et al., 2013; Assefa et al., 2016). This form of sampling allows the assessment of variability of soil properties at different spatial scales (Vågen et al., 2013) (in our case among land uses at site level). For each tile, soil samples (0-15 cm depth, the average plough layer in the area) were collected from the center of each sub-plot and composite samples were prepared by hand mixing. Totally, we prepared 15 composite soils.

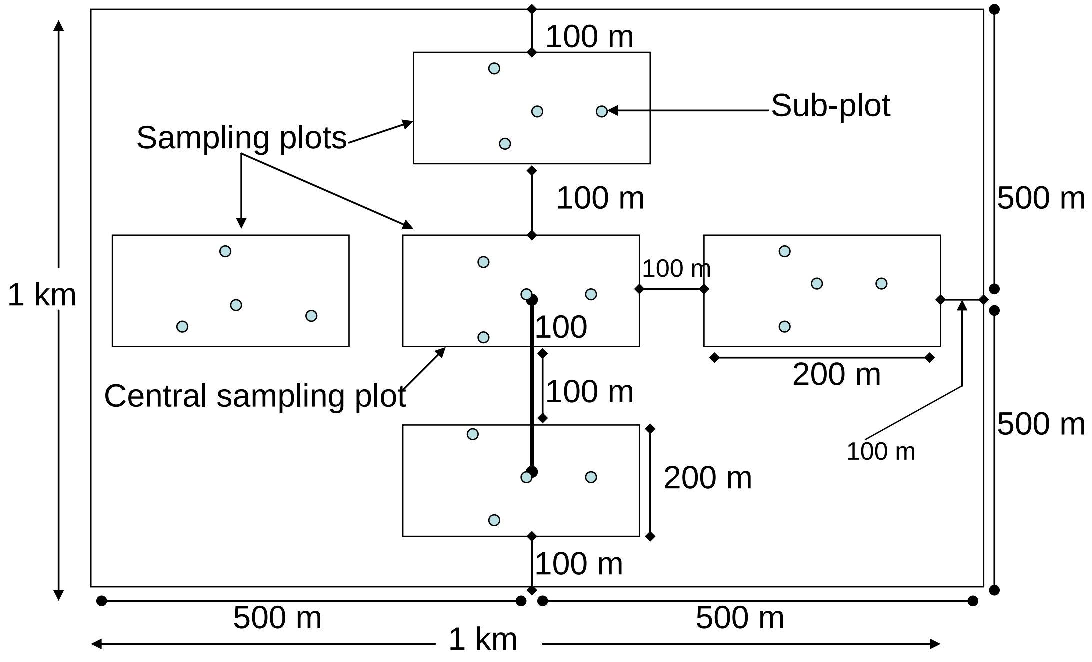

Figure 1. Adapted sampling design of soil samples in the Northeast Wollega, Ethiopia (after Vågen and Winowiecki (2013), Vågen et al. (2013) and Assefa et al. (2016).

2.4 Soil analysis

Composite soil samples were air-dried and grounded to pass through a 2mm sieve prior to laboratory analysis. Soil analysis included soil texture (determined by Bouyoucos Hydrometer Method; Black et al.,1965), soil pH (determined in a 1:2.5 soil: water ratio), total N content, cation exchange capacity (CEC) and exchangeable cations ($Ca^{2+,}$ Mg^{2+}, K^+ and Na^+) by atomic absorption spectrophotometery, AP (Olsen et al., 1954) and organic carbon (OC) content (Walkley and Black, 1934). Soil organic matter (SOM) content (%) was determined by multiplying OC% by 2.0 factors.

2.5 Statistical analysis

One-way ANOVA was used to analyze the differences in soil texture, pH, available P, SOM, N-Kjeldahl, CEC and exchangeable cations of the three land use types by collecting 15 composite soil samples (five each from each land use) at the 0.05 level.

Percentage changes in the soil properties of cultivated land or grazing land compared to forestland ($Ch_{Cl,\ Gl}$) were computed by:

$$Ch_{Cl,Gr} = \frac{Lu_{Cl,orGl} - Lu_{Fl}}{Lu_{F1}} X100 \text{--} (1)$$

Where $Ch_{CI,GI}$ is the percentage changes in soil property of cultivated or grazing lands compared to forestland and Lu_{CI}, Lu_{GI} and Lu_{FI} are mean values of soil property under consideration of cultivated, grazing and forestland respectively. Bivariate correlation analysis was conducted to assess the relationships between the studied soil properties.

3 Results and discussion

3.1 Particle size distribution

Sand content of soils of forestland is the highest and the lowest on soils of cultivated land (Table 2). These differences are statistically significant ($P < 0.05$, Table 4). The percentage change in sand particle size distribution is higher in cultivated land than the change in grazing land compared to forestland (Table 6). Clay content of soils is the highest on cultivated land and the lowest on soils of forestland (Table 2). Clay fraction on cultivated land and grazing land increased compared to forestland; but the change is higher in cultivated land than grazing land (Table 6). Lower content of sand and higher content of clay fractions in the cultivated land may be attributed to the process of plowing, clearing, disposing and leveling of farming fields. Because the clay particles are very small in size, silt and sand fractions could be removed by runoff from the cultivated land. These are deposited on topsoil of forestland and grazing land (Biro et al., 2013). Differences in clay content of soil influence the levels of microbial biomass. These assumed to hold much more water and plant nutrients than forest and grazing lands (Kartul et al., 2013). Soils with high clay content have sufficient particle-to-particle contact points to form strong bonds when the soil dries (Eyayu et al., 2009). Cultivated land with highest clay fraction has the most compact soils.

3.2 Soil organic matter, total nitrogen and available phosphorous

The content of SOM was the highest in forest lands and the lowest in cultivated land (Table 2), and the differences are statistically significant (Table 4). SOM decreases as forestland land changes into cultivated and grazing land (Table 6). The percentage change is higher in cultivated land than the change in grazing land (Table 6). The more rapid decrease of SOM contents in cultivated land may be attributed to accelerated rates of erosion and decomposition, because these processes were most active on cultivated lands than forest and grazing lands (Assefa et al., 2016). On the other hand, the reduction is lesser on grazing land because grass roots were fibrous near the soil surface and easily decompose and increasing organic matter. Land management such as poorly designed terracing and cut-off drainage that practiced over cultivated land facilitated the drainage of water and soil from cultivated land and deposited over forestland. Farming system in the area, which is heavily dependent on traditional practices, also facilitates removal of top soil on the cultivated land. This suggests that SOM shows strong response to land use, land use change and land degradation (Vågen and Winowiecki, 2013). Thus, the highest SOM in forestland is potentially the highest reservoir for plant essential nutrients of nitrogen, phosphorus, and sulfur (Zeng et al., 2015). It also increases soil water holding and CEC and enhances soil aggregation and structure of soils of forestland.

Expectedly, the mean value of total N was highest on soils of forestland and lowest on cultivated land (Table 2). The change in total N is higher in cultivated land than the change in grazing land compared to forestland (Table 6). The C: N ratio was the highest on soils of forestland while it is the lowest on grazing land (Table 2). Due to the close relationship between SOM and total N, soil C:N ratio indicates the status of soil fertility. C:N ratio is often influenced by climate, soil condition, vegetation type and agricultural management practices (Oedraogo et al., 2006; Zhang et al., 2009). The content of available P was the highest in cultivated land and lowest in grazing land (Table 2). The mean differences between soil available P of forest and grazing lands, and cultivated and grazing lands are statistically significant ($P < 0.05$,Table 4), while the mean difference between forest and cultivated lands is not statistically significant. Compared to the available P contents of forestland, available P of cultivated and grazing lands is increased (Table 6).

Secondary minerals, organic and inorganic fertilizer are important pools of soil phosphorous (P) (Assefa and van Keulen, 2009). Thus, the fact that soils in the forest land has higher available P than the grazing land may be attributed to two reasons. Firstly, even though, in forestland, a pool of available P could be removed by trees, there is a probability of P return through litter fall to soil surface (Asmamaw and Mohammed, 2013). Secondly, microbes which are abundant in the litter layers of the forest may quickly add high proportion of P pool under forest cover. On the other hand, a higher AP in cultivated land than grazing land may be attributed to three reasons.

Table 2: Mean variation and standard deviation (SD) of soil fraction, organic matter, total nitrogen, C:N ratio and available phosphorous at 0-15cm depth at different land use types in the northeastern Wollega, Ethiopia

Land use type	Soil fraction (%)						Organic matter (%)		Total nitrogen (%)		C:N ratio		Available phosphorus (PPM)	
	Sand		Silt		Clay									
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Forestland	51.6^{a}	3.6	32.8^{c}	1.1	15.6^{a}	2.6	$9.0^{a,c}$	1.3	$0.4^{a,c}$	0.1	12.1^{c}	0.4	$3.6^{b,c}$	1.0
Grazing land	38.4^{a}	1.7	26.8^{c}	10.8	34.8^{c}	10.6	$7.3^{a,b,c}$	1.5	$0.4^{a,b,c}$	0.1	11.9^{c}	3.8	2.1^{b}	0.4
Cultivated land	29.6^{a}	5.4	28.4^{c}	4.56	$42.0^{a,c}$	6.6	$4.6^{a,b}$	0.7	$0.3^{a,b}$	0.1	10.8^{c}	1.9	$3.7^{b,c}$	1.5

Note: $^{a,\ b}$ the mean differences of soil properties along each column is significant at P<0.01 and 0.05 levels respectively; ^{c} the mean difference is not significant.

Table 3: Mean variation and standard deviation (SD) of soil acidity (pH), cation exchange capacity (CEC), exchangeable bases (K^{+}, Ca^{2+} and Mg^{2+}) at 0-15cm depth at different land use types in the northeastern Wollega, Ethiopia

Land use type	pH (1:2.5 H_2O)		CEC Cmol(+)/kg		Exchangeable bases Cmol(+)/kg					
					K^{+}		Ca^{2+}		Mg^{2+}	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Forestland	$6.1^{a,b}$	0.36	32.85^{a}	4.04	0.13^{c}	0.04	12.81^{a}	4.01	$3.96^{a,c}$	1.21
Grazing land	$5.7^{c,b}$	0.22	$25.65^{a,b}$	3.32	0.12^{c}	0.07	$5.98^{a,c}$	1.34	$4.80^{a,c}$	1.10
Cultivated land	$5.4^{a,c}$	0.13	$20.19^{a,b}$	3.66	0.14^{c}	0.08	4.08^{c}	1.79	1.71^{a}	0.27

Note: $^{a,\ b}$ the mean differences of soil properties along each column is significant at P<0.01 and 0.05 levels respectively; ^{c} the mean difference is not significant.

Firstly, applied cattle dung on cultivated field may increase level of P concentration in this land use, while cattle dung has been collected from grazing land (Table 1). Secondly, frequent application of inorganic P-fertilizer on the cultivated fields (Table 1) may provide a considerable amount of inorganic P pool to the soil of cultivated filed. Thirdly, a higher P release as a result of higher weathering process on cultivated land than on grazing land may provide higher amount of available P to the soil of cultivated land. This is because of repetitive plowing to prepare the plot for cereal crop production. The finding in this study appeared in agreement with the observation made in Ethiopia by Fantaw and Abdu (2011).

Table 4: Percentage changes in selected soil properties on cultivated and grazing land uses compared to forestland in northeastern Wollega, Ethiopia.

LU Type	Sand	Silt	Clay	pH	AP	OM	TN	CEC	EK^+	ECa^{2+}	EMg^{2+}
Cropland	-43	-13	+169	-11.5	+2.8	-49	-43	-38.5	+7.7	-68	-56.8
Grassland	-26	-18	+123	-6.6	-42	-19	-16	-22	-7.7	-54	+21.2

Notes: LU= land use, EK^+= exchangeable K^+, Eca^{2+} =exchangeable Ca^{2+}, EMg^{2+}= exchangeable Mg^{2+}, - indicates loss and + indicates gains

3.3 pH, cation exchange capacity and Exchangeable basic cations

The soils in the study land uses have a mean pH between 5.4 and 6.1 (Table 3). Mean pH from forest soils was statistically different from the cultivated and grazing land ($P<0.05$, Table 5). Compared to the pH of soils of forestland, pH of soils of cultivated and grazing lands were lower (Table 6). Thus, soils in the cultivated land appeared more acidic than those of the forest and grazing lands. This is expected where 13.2% of Ethiopian soils are strongly to moderately acidic ($pH<5.5$) (Ermias et al., 2013). This is because of intensive farming over a number of years with nitrogen fertilizers on cultivated land. Soil acidity is also a consequence of leaching of basic cations in soils due to high rainfall that have rapid erosion. Cultivated land is characterized by acidifying effects of acid forming nitrogen fertilizer, poor nutrient cycling and mining of basic cations through harvested crops, soil erosion and acid rain which contribute for development of soil acidity. Soil acidity affects the process of other nutrient transformations, solubility, or plant availability of many plant essential nutrients (Barua and Haque, 2013). In acid soils ($pH< 6$), nitrification will be slow, and plants with the ability to take up NH^{+4} may have an advantage (Parra-Alcantra et al., 2013). Thus, in the study area, nitrification will be slow in cultivated land pertaining to the acidity of soil. Acid soils affect the quantity, activity, and types of microorganisms in soils which in turn influence decomposition of organic materials (de Mulenaere et al., 2014; Emiru and Gebrekidan, 2013). Acid soil prone areas are characterized by aluminum and manganese toxic to crops growth, constrained productivity through stunted growth, poor response to applied fertilizer and vulnerability to drought. In Ethiopia, soil management strategies such as application of mineral fertilizers, lime, compost and manure are used to ameliorate soil acidity. Soil liming can increase soil pH, supply essential plant nutrients (exchangeable Ca^{2+} and Mg^{2+}), make other essential nutrients more available and prevent Mn and Al from being toxic to plant growth (Yao et al., 2010).

The mean CEC was highest on forestland and the lowest on cultivated land (Table 3); and the differences among the land uses are statistically significant ($P < 0.05$, Table 5). Compared to the CEC of soils of forestland, CEC of soils of cultivated and grazing lands were decreased (Table 6). Mean exchangeable Ca^{2+} content was highest on forest land and lowest on cultivated land (Table 3). The mean differences between forest and cultivated lands, and forest and grazing lands are statistically significant ($P < 0.05$, Table 5). The mean exchangeable Mg^{2+} was highest on grazing land and the lowest on cultivated land (Table 3). Exchangeable Ca^{2+} was highest in forestland and lowest in cultivated land (Table 3). Compared to soils of forest land, the overall pattern of CEC, exchangeable Ca^{2+} and Mg^{2+} concentrations on cultivated land showed declining trends, however with varying rates (Table 6). Exchangeable Ca^{2+} showed the highest decline, followed by exchangeable Mg^{2+} and CEC (Table 6).

3.4 Relationships between selected soil properties

Each of SOM, TN, CEC, exchangeable Ca^{2+} and Mg^{2+}, and pH are positively and significantly ($P < 0.05$, Table 7) associated with each of soil properties except with available P, silt and clay. In contrast, clay fraction is negatively and significantly ($P < 0.05$) associated with OM, total N, CEC, exchangeable Ca^{2+}, pH, and silt. SOM significantly and strongly associated with pH. This finding was in agreement with other studies made in different places of the country (e.g. Amare et al., 2013; Asmamaw and Mohammed, 2013; Lelisa et al., 2010). Thus, conversion of forestland into cultivated lands implies degradation of SOM. Since SOM is the major influences N in the soil, soil available P and CEC, it provides micronutrients through an effective soil food web. However, SOM in soils of cultivated land can be increased through compost, cover crops, manures, minimum tillage and crop rotation (Mikha et al., 2005; Martins et al., 2009). These can improve the concentration of physical, chemical and biological soil parameters in the cultivated land.

Table 5: The correlation matrix for selected soil properties at 0-15 cm depth in northeastern Wollega, Ethiopia

	OM	TN	CEC	Ca^{2+}	Mg^{2+}	pH	Silt
TN	0.80**						
CEC	0.80**	0.81**					
Ca	0.82**	0.76**	0.89**				
Mg	0.71**	0.67**	0.65**	0.52*			
pH	0.83**	0.76**	0.89**	0.88**	0.71**		
Clay	-0.74**	-0.54*	-0.77**	-0.74**	-0.32	-0.71**	-0.69**

**, * Correlations are significant at the 0.01 level and at the 0.05 level respectively, (2-tailed).

There is no significant correlation between available P and any of the other chemical properties most probably due to the generally low available potassium content and limited range of pH in the soil sampled. This finding contradicts the fact that phosphorus availability is related to soil pH. CEC significantly and strongly associated with exchangeable Ca^{2+}, pH and clay; exchangeable Ca^{2+} significantly and strongly associated with pH and clay. This shows the ability of CEC to retain cations and the dependency of CEC upon the pH of the soil, soil nutrient retention capacity and the capacity to protect ground water from cation contamination. Exchangeable Mg^{2+} is significantly and strongly associated with pH. On the other hand, clay is negatively correlated with all soil properties. The correlation was strong and statistically significant except for exchangeable Mg^{2+} and AP. Thus, clay in the soil has negative influence on most of soil properties. This suggests that both chemical and physical properties of soils are regulated by clay properties of soil. Fantaw and Abdu (2011) and Lelissa et al. (2010) observed similar relationship.

4 Conclusion

The purpose of our study was to explore the effects of land use changes on the dynamics of soil properties and its implications for land degradation. The result indicate that cultivated land has the lowest organic matter, total nitrogen, cation exchange capacity, pH, exchangeable Ca^{2+} and

Mg^{2+} contents compared to forestland and grazing land. Soil organic matter is lowest as caused by land use changes, cropping pattern and frequency, removal of crop residues, faster decomposition and oxidation process as well as soil erosion on cultivated lands. The losses of these essential elements may contribute to increasing degradation prevalence on cultivated land. Land degradation, in turn, is impairing the capacity of land to contribute to food security. So as to increase soil organic matter and consequently enhancing the concentration of other nutrients in the soil of cultivated land, we suggest integrated implementation of land management through compost, cover crops, manures, minimum tillage and crop rotation. Soils in the cultivated land appeared more acidic (pH<5.5) than those of the forest and grazing lands. This may lead to aluminum and manganese toxicity, microbial conversion of NH_4^+ to nitrate will be slow and crops with the ability to take up nitrate (NO_3^-) will be negatively affected. Thus, we suggest liming of cultivated land so as to increase soil pH, supply essential plant nutrients (Ca^{2+} and Mg^{2+}), make other essential nutrients more available and prevent Mn and Al^{-3} from being toxic to crop growth.

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