Impacts Of Land Uses Changes on Soil Fertility, Carbon and Nitrogen Stock under Smallholder Farmers in Central Highlands of Ethiopia: Implication for Sustainable Agricultural Landscape Management Around Butajira Area

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Abstract: Landuses/land cover changes from natural forests to farmland, open grazing and eucalyptus woodlots, and subsequent changes in soil physical and chemical properties are widespread in Highlands of Ethiopia. Thus, assessing land use-induced changes in soil properties are essential for addressing the issues of agricultural landscape sustainability . The aim of this study was to examine the impacts of land use/land cover changes on soil properties, SOC and TN stock around Butajira area, Southern Ethiopia. The types of land uses considered on this study were: enset, cereal farms, grazing land, and *Eucalyptus camaldulensis* woodlots. Seven households having all the above mentioned land uses adjacent to each other were selected. For the purpose of this study, the selected household and land use types were considered as replication and treatments, respectively. 28 soil pits were dug i.e. one soil pit was dug at each land uses hence a total of eighty four soil samples were collected at three depths, namely 0-15cm, 15-30cm, and 30-45cm for chemical analysis. In addition, similar undisturbed soil samples were collected from same pits but opposite sides for soil bulk density and moisture content determination. Standard soil analytical procedures were followed in carrying out soil analysis. The results of the present study showed that land use changes induced significant differences on soil properties as reflected by the changes in bulk density, MC, pH, OC, TN , available P , OC and TN stocks. Soil bulk density was significantly higher in the cereal farms as compared to enset farms reflecting compaction of soil due to intensive tillage in cereal farms. Soil MC was significantly lowest under Eucalyptus woodlots compared to enset. Moreover, soil pH was lowest in woodlots and cereal lands as compared to other land uses. Soil under enset farms had higher OC, TN, available P, carbon and nitrogen stock as compared to other land uses. OC and total N stocks were shown a trend of enset farm > eucalyptus woodlots > grazing land > cereal land within 0-45 cm. Lowest OC and TN under cereal land showed the severity of land degradation under this land use utilization, where as the higher soil nutrients, OC and TN under enset soils suggesting the importance of this land use utilization for addressing soil nutrient and carbon depletion. Besides, woodlots and grazing land had higher OC, TN, SOC and TN stock as compared to cereal lands. Therefore, future restoration of soil should focus on strategies that improving the soil nutrient and carbon storage under cereal land for enhancing sustainable agricultural landscape management, thereby improving the livelihood of agrarian community. However, fast growing nature of *eucalyptus species* may negatively affects soil reaction and moisture . Planting eucalyptus also negatively affects the crop yield of adjacent farm lands due to root competition and shading effects. Thus, current strategies of planting fast growing eucalyptus woodlots in response to scarcity of forest products and economic benefits, should be considered the negative impacts on soil and crop yields of neighboring farmlands . Hence, there is a need to develop proper land use policy and sustainable soil management and cropping practices to combat the on ongoing soil degradation in the study area.

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1. Introduction

Soil degradation in the form of plant nutrient depletion is the major environmental problems in the highlands of Ethiopia. Among Sub-Saharan countries, Ethiopia is the most seriously affected country by land degradation [World Bank, 1998]. Previous studies have shown negative nutrient balance mainly C, N and P indicating that soil is already mined [Stoorvogel and Smaling, 1990]. The overwhelming land degradation in Ethiopia have been caused due to land use changes, including deforestation, over grazing, and improper cultivation of agricultural land which led to accelerated soil erosion and associate soil nutrient deterioration [FAO, 1986; Hurni, 1988]. Furthermore, widespread poor agriculture activities, including intensive tillage, complete removal of crop residues, low levels of fertilizer application, lack of appropriate soil conservation measures and cropping practice are also a contributing factors [Abebayehu and Eyassu,2011; Eyasu, 2002; Haileslassie et al., 2005]. Besides, land use changes and widespread poor agricultural practice the human factors of poverty, insecure land tenure and high population pressure have acted more indirectly as driving forces for land degradation [Eleni.,2013].

Obviously, land use can influence soil chemical and physical properties because of different anthropogenic activities, namely tillage, livestock trampling, harvesting, planting, application of fertilizer etc. Research have showed that linkage between land uses and soil properties, particularly in relation to soil nutrients and carbon sequestrations[Solomon, 2002; Nega and Heluf,2013;Agbede, 2010]. Land uses have evolved or vanished response to regional differences in soil properties, climate, population density, economic opportunities, cultural practices, and socio-economic factors. In Ethiopia, several studies[e.g. Yimer et al., 2007;Yimer and Abdelkadir, 2010; Awdenegest et al.,2013; Lemenih,2004; Alemayehu and Sheleme, 2013;Yihenew and Getachew,2013; Fikadu *et al*, 2013] have considered the effects of land use and their management on soil properties. For example, Yimer et al. [2007] compared croplands, forestlands and grazing lands and found that significant changes on selected physical and chemical in the Southeastern highlands of Ethiopia. Another study conducted by Lemenih, [2004] reported that land use changes significantly influences soil proprieties such as available P and K, exchangeable bases and CEC in Southern highlands of Ethiopia. Yimer and Abdelkadir, [2010] also reported that higher contents of SOC and total N under closed grazing land compared to farm land and open-grazing in Central Rift Valley area of Ethiopia. Another study by Alemayehu and Sheleme,[2013] also found comparable higher OC, TN under grassland as compared to cereal farms, whereas they found higher available P under enset farms than pasture land and cereal farms in Southern Ethiopia. Similar study by [Yihenew and Getachew, 2013; Mesfin, 2013] also reported that conversion of natural forest into human-managed land uses (i.e.crop land, grazing land and eucalyptus plantation) had more deleterious effects on soil moisture content, pH, soil organic carbon, total nitrogen, and exchangeable potassium in Northwestern Ethiopia. In contrast, Fikadu *et al* [2013] found no significant differences among land uses on soil chemical properties, but found significant difference in physical properties on Andosol in Southern Ethiopia.

Restoration efforts have been taking place to recuperate of degraded farmlands, particularly, through reconversion of former degraded farmlands into eucalyptus woodlots. Indeed, restoration of degraded lands is a subject that is receiving considerable attention today in many parts of the worlds. Various studies have been considered the effects of planting fast growing plantation on soil properties. Nevertheless, the evidence from these previous studies is mixed. For instance, several studies [e.g.Yeshanew et al,.2003; Abiyu et al., 2011, Lalisa et al., 2010; Lemma,2006; Lemenih et al. 2004; Zerfu,2002;] were reported a positive impacts of converting former degraded farmlands into fast growing exotic plantation on soil properties, whereas the results by [Solomon et al., 2002; Woldeamlak and Stroosnijder, 2003 Girmay and Singh, 2012] showed a negative impacts on soil properties.

Generally, land use changes and their associated management can influence soil properties in localized area, though the amount of changes could be varied depending upon the extent of human management. More importantly, the outcome the evaluation may be imperative in designing a sound land use for sustainable agricultural landscape management. Therefore, being Ethiopia is a large country with large biophysical and socio-economic setting, the evidence from these previous studies is less adequate to describe the extent of soil degradation associated with land use and management in the country.

Furthermore, many of these previous studies fail to consider the effects of land that are solely manage by smallholder individual farmers except one study by Lalisa et al., [2010] who reported remarkable difference on soil chemical properties among land uses that have been managed by small holder farmers. Nonetheless, this study still fail to take into account the effects of land use on soil physical properties. In addition, here different sampling strategies was used as the households and the compared land uses were considered as replication and treatment, respectively to minimize the possibility of material transfer among the different land use types.

In recent years, farmers have begun planting fast gowning exotic tree in the form of eucalyptus woodlots on former cropland in response to scarcity of forest products and economic opportunity. These tree planting have managed at a household level and cannot be compared with an enterprise or government plantations, which have cared for well and hence expected to have different effects on soil properties. Thus, there is a need to know the changes in soil properties when they are under farm household management and little have done in this area. The aim of the present study were, therefore (1) to assess the impact of land uses and their management on soil physical and chemical properties; (2) To assess the overall relationships of some selected soil physical and chemical properties (3) assess the soil carbon and total

N stock under different management. Therefore, such localized comparison of the possible linkage between land use changes and soil properties could be necessary to identify land uses that are favorable for improved nutrients and soil carbon storage and responsible for nutrient and soil carbon depletion. The out puts of this study could help for development of an appropriate land use planning and sustainable land resources management, and thereby for improvement of the livelihood of the agrarian community in the study area and other similar agro-ecological Zone.

2 Methods

2.1Description of the study area

This study was conducted at the Meskan District in the area called Mekicho in Gurage Zone, SNNP Regional State, Ethiopia. This area is 5 km NW away from the Woreda (the district capital) Butajira town, which is 133 km south of Addis Ababa (Fig. 1). Gurage Zone, which is part of the Southern Nation, Nationalities, and People Region, is located in the Western part of Central Ethiopia.

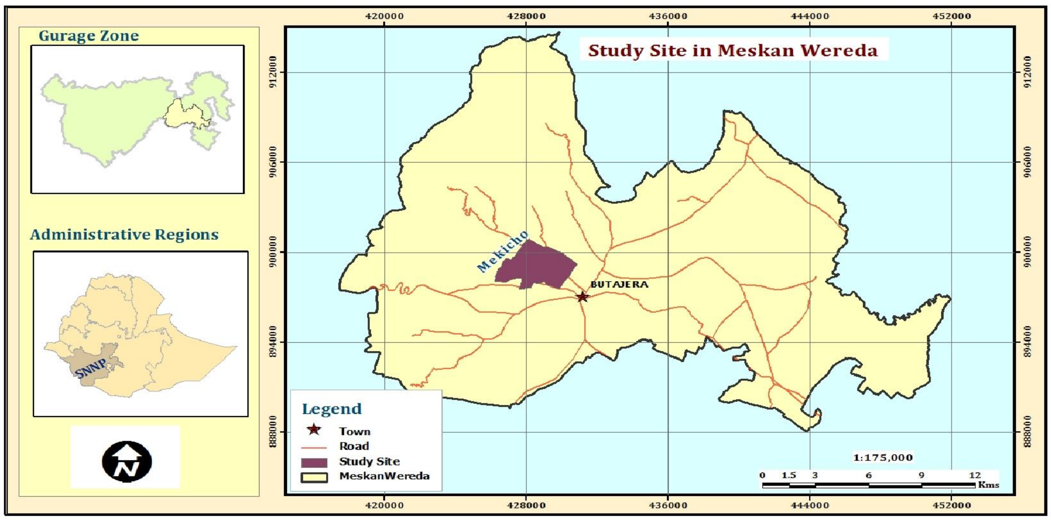


Figure1. Location Map of the Study Area

In terms of topography, Meskan Wereda has diverse topography that consists of plain (55%), sloppy (35%) and mountainous (10%).

2.2 Climate and soil resources

The position of ITCZ (Inter tropical Convergent Convergence Zone), that divides the humid tropical air mass to the south from the dry northeast, highly determines the climate of Ethiopia. As part of the land escapes of Ethiopia, ITCZ can influence climate of the study area. The study area receives the small rains in March to May and the big rains during June to September with higher concentrations of the rain observed in July and August. According to climatic record near the study area, the mean annual rainfall in the district is 1058 mm whereas the mean daily maximum and minimum temperatures are 27.7 °C and 6.5°C,respectively[National Meteorology Services Agency,2005]. The main crop-growing season begins towards the end of June and continues up to the end of October. The District has altitude ranging from 1800-3500 m asl. The altitude of the specific study site is 2100 m asl.

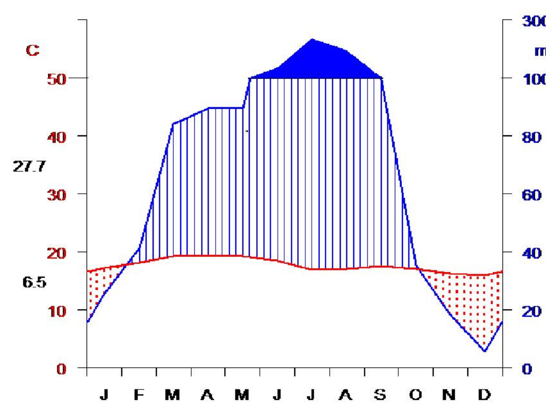


Figure 2. Mean monthly rainfall (mm) and temperature (oC) of Meskan District

The study areas, received highest temperature during February and March while coolest in November and December. The soils of the area may closely relate to their parent materials and their degree of weathering. The study area is geographically located in Central Rift Valley of Ethiopia. The main parent materials are basalt, ignimbrites, lava, gneiss, volcanic ash, and pumice [Zewdie, 2004; Itanna, 2005]. Though no detailed soil study has so far been conducted in the study area, the dominant soil types of Meskan district includes eutric Cambisols, chromic Luvisols, pellic Vertisols chromic Vertisols, eutric Fluvisols and Leptosols [FAO, 1996). The specific soil types of the study sites is eutric Cambisols that is the dominant soil of the study area.

2.3 Dominant land use /cover of the study area

The population density of Meskan District, which is approximately about 250 people's km^{-2}. The average land holding per household head is less than 0.5 ha, which is one of the main factors exerting a profound influence on land use/cover changes and land use intensification, resulted in severe land degradation in the area. Farmers own 2 or more fragmented plots of land and they practice diversified land use types to diversify their products and as risk aversion strategies . The major land uses land/ cover in the study area includes cultivated land, natural vegetation, grazing land and plantation forest of exotic species mainly eucalyptus are the dominant land use/cover in the area. Eucalyptus *camaldulensis* is dominantly growing in Weyna dega agro ecological Zone, whereas Eucalyptus globulus is most common in dega agro-ecological Zone. The common annual crops grown in the areas includes wheat (*Triticum spp*.), teff (*Eragrostis tef*) and barley (*Hordeum vulgare*) and maize (*Zea mays*), and perennial crops such as enset(*Ensete ventricosum*). Teff is a fine stemmed tufted endemic annual grass to Ethiopia. The grains of the crops used as main ingredient in the Ethiopian traditional flat bread called injera. Enset is a perennial, banana-like crop which native to Ethiopia that produces psuedostem and a starchy belly corm pulped for food, feed and fiber. Enset based land use is one of the dominant agricultural practices used for feeding about 13-15millions people in the Central and Southern Highlands of Ethiopia[Tilahun and Mulugeta,2005].

2.4 Description of studied land use and experimental design

Seven households were selected all having four types of adjacent land use(enset farms, cereal farms, open grazing land and Eucalyptus *camaldulensis*) on the same soil types, same landscape (slope) position and climate. Private owners own all the four land use types. The rationale behind selecting households each having four adjacent land uses is to minimize the possibility of material transfer, mainly through litter fall and erosion/deposition (i.e., potential nutrient translocation) between the different land uses. For the purpose of this study, the seven households were considered as replications, where as the four land use types and their management was considered as treatment. According to the information obtained from local elders enset land and cereal lands have been in place over 50 year after converted from natural vegetation. On the other hand , eucalyptus woodlots and grazing land are within the age range of 15-20 and 30-40 years, respectively. The description of each land use type presented as follows. Cereals farms are relatively large sized plots compared to other land uses. The dominant annual crops in cereal land use are teff, wheat and maize. Teff and wheat are the two small sized seed annual crops that need intensive land preparation. Farmers have been applying inorganic fertilizer like Urea and DAP either by mixing or independently for cereal crops . Enset are perennial crops often intercropped with maize. This land use is located closed to homestead, hence it received large amount of fresh manure and household wastes. Pastureland is former cropped land that was converted into open grazing land. In this study, small-scale woodlots refer to small-sized plantations of Eucalyptus camaldulensis established on degraded farmlands. Farmers have begun to convert unproductive cereal lands with trees(especially Eucalyptus) as trees demand less nutrients and due to economic reasons. It could also be because of the potential of trees to draw nutrients from the deeper soil layer that are not accessible to shallow rooted annual crops.

2.5. Soil sampling, sample preparation and analysis

Twenty-eight soil profile pits (four land use * seven replication) were dug and sampled in the enset farms, cereal farms, grazing land and eucalyptus woodlots. We collected soil samples from three soil depths: 0 to 15 cm, 15 to 30 cm, and 30 to 45cm. Eighty four soil samples (four land use * three soil depth classes * seven replication) were collected for chemical analysis: Soil sampling from different depths was done by inserting a core sampler into the wall of the pits; the lowest first and the top soil at last to avoid contamination between the two layers. Approximately, 1 kg of sample from each soil depth were collected and sent to laboratory then air-dried at room temperature, crushed, homogenized, and passed through a 2mm sieve and further sieved at 0.5mm for TN before laboratory analysis.Total nitrogen content was determined following the Kjeldahl method [Jackson, 1958]. The available phosphorus content of the soil was analyzed using 0.5M sodium bicarbonate extraction solution (pH=8.5) following the method of [Olsen et al., 1954].The organic carbon determinations was made following the wet oxidation method of [Walkley and Black, 1934].The soil pH was measured using pH meter in 1:2.5 soils to water solution ratio. For bulk density and moisture content determination undisturbed soil samples were collected with a manual core sampler of 5 cm ht * 3 cm diameter from three soil depth of 0-15 cm, 15-30cm and 30–45cm from same pits, but opposite sides. Soil-water content determined by standard procedures described for the gravimeter method after oven drying to a constant weight at 105°C [Anderson and Ingram, 1993] for 30 hrs. Bulk density was determined using core method after oven drying wet undisturbed soil samples at temperature of 105°C for 30 hours. Bulk density was calculated by dividing the weight of oven-dried soil with the volume of the core. All the chemical and physical analyses done at Holetta soil-testing laboratory, Ethiopia

Calculation of carbon stocks.

Soil carbon stock (Mg C ha^{-1}) for each sample depth was computed using the following equation.

Carbon stock [Mg ha-1] = [% C * BD * Depth in (m) * 10^4 m^2 ha^{-1}]/100 (equation 1)

BD=bulk density (g/cm3) of each sample depth, where percentage C was the Walkley-Black carbon (Walkley - Black 1934). A total N (Mg ha-1) stock also computed using a similar equation. Subsequently, C and TN stock in each soil layer thickness was summed up to determine total C stock contained up to 45 cm depth for each land-use type

2.6 Statistical analysis

The results on the physical, chemical properties and soil carbon and total N stock of the various land uses practices were subjected to one-way analysis[SPSS Inc, 2006]. When the analysis of variance (ANOVA) showed significant differences (at ≤ 0.05) among the various land uses and soil depths for each parameter, a mean separation for each parameter was made using Turkey's pair wise comparisons. Pearson correlation test was employed to examine the relationships between some soil properties. The soil properties analyzed and compared were bulk density, moisture content, pH, OC, total N, available P, soil organic carbon and total nitrogen stock in the soils of each land use category in 0-15 cm, 15-30 cm, and 30-45cm depth layer. In order to made normal distribution the field data for available P was log transformed and reported after back transformed.

3. Results and discussion

3.1. Soil Physical Properties in relation to land use and soil depth

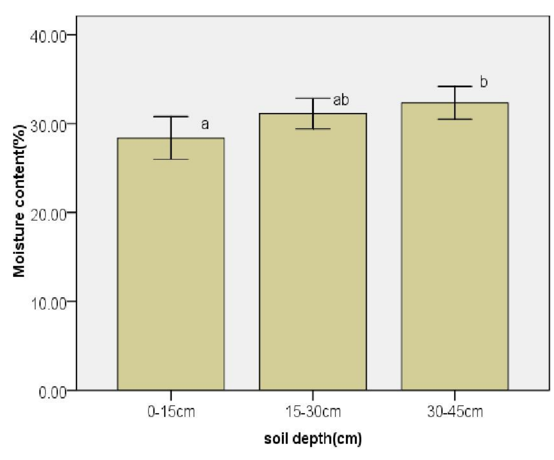
Results of soil moisture content and bulk density are presented in Tables 1 and Figure 3 for land use and soil depth, respectively. Soil bulk density was significantly differed (P < 0 .05) among land use at surface layer (0-15cm), while bulk density did not show any significant difference among land uses at 15-30cm and 30-45cm (Table 1). In contrary by [Fikadu et al 2013, Birru *et al*., 2013] found that no significant difference in bulk density among land uses in the high lands of Ethiopia.

Table 1. Mean ± SEM of soil MC (%) and BD (g cm-3) the soil of in relation to land use.

Property	D(cm)	Enset	Cereal	Grazing land	woodlots	ANOVA
MC(%)	0-15cm	31.42±1.96a	29.24±2.59ab	26.04±2.13ab	22.51±1.64b	*
	15-30cm	30.32±0.91b	33.41±2.52b	31.72±2.52b	27.72 ±1.51b	ns
	30-45cm	31.59±1.26b	34.57±2.08b	32.02±2.08ab	28.18±1.58b	ns
BD(g cm-3)	0-15cm	1.07±0.04a	1.23±0.05b	1.18±0.04ab	1.15 ±0.05ab	*
	15-30cm	1.15±0.06b	1.13±0.05b	1.13±0.02b	1.11±0.03b	ns
	30-45cm	1.23±0.06c	1.35±0.04c	1.22±0.04c	1.24±0.05c	ns

Values followed by the same letters in a row are not significantly different at P < 0.05; or 0.01* significantly different at p < 0.05; ** significantly different at p = 0.01 ns denotes not significantly different.

The bulk density was lowest under enset farms (1.07±0.04 g/cm3), while it was highest under cereal farms (1.23±0.05g cm-3) (Table 1). This result goes well with similar studies by [Haileslassie *et al*. 2005; Abebayehu and Eyasu,2011] who found that lowest bulk density under enset land as compared to cereal farms. Similar study by [Abiyu et al, 2011, Yechale, 2011] reported that significant higher bulk density under grazing land as compared to other land uses in Northern and Central highlands of Ethiopia, respectively. Similar study by [Lemenih et al.,2005] also reported that significant higher bulk density under farmlands as compared to other land uses in the high lands of Ethiopia. In contrary, study by Zerfu [2002] reported that conversion of farmland to eucalyptus plantation and vice- versa was not caused significant change on soil bulk density in the Amahara Regional State of Ethiopia.



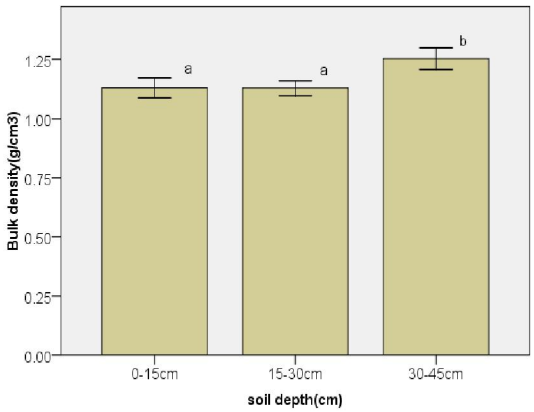


Figure 3. Distribution of soil moisture % and bulk density (gm/cm3) across soil depth. Error bars represent standard error. Different letters denote significant difference between (P <0.05) while same letters denote no significant difference between (P <0.05).

Soil bulk density was significantly (p<0.05) vary across soil depths (Figure 3). Higher bulk density (1.24±0.02g cm^{-3}) was observed at 30-45cm, while soil at 0-15cm and 15-30 cm had a similar lowest bulk density of (1.16±0.02 g/cm^3) and 1.13±0.02 g/cm^3, respectively (Figure 1). This result agrees with studies by [Awdenegest et al, 2013; Ahukaemere et al., 2012] who reported that increasing trend of bulk density across soil depth in Ethiopia and Nigeria, respectively.

Soil moisture was significantly differ (P=0 .05) among land use at surface layer (0-15cm), whereas, soil moisture content was not show any significant difference(p=0.05) among land uses both at 15-30cm and 30-45cm soil depths (Table 1).

Soil moisture content was lowest under eucalyptus woodlots (22.51±1.64 %), while it was highest under enset farm(31.42±1.96%) at 0-15cm (Table 1). This is in harmony with study by Fikadu *et al*.,[2013] who reported that significant lower moisture content under Eucalyptus saligna plantation as compared to other land uses around Wondo Genet area of Southern, Ethiopia. This results also agrees with similar study by [Mesfin, 2013] who reported that lowest soil moisture content under eucalyptus camaldulensies plantation as compared to other land uses in Mizewa Watershed of Lake Tana Basin of Northwestern, Ethiopia. Similar study by Tilashwork *et al*.,2013] were also reported lowest soil moisture under eucalyptus plantation compared to other land uses in Ethiopian.

Furthermore, soil moisture(%) was significantly (p=0.05) vary among soil depths (Table1). Surface soil had significantly lowest moisture content of (27.30± 1.19%) while. sub surface soil had a similar highest values of (30.79±0.94%) at 15-30cm and (31.56±0.87%) at 30-45cm depth, respectively(Figure 3).

3.2 Soil chemical properties in relation to land use and soil depth

Soil chemical properties of the soils under the different land uses and soil depths are present in Tables 2 and Figure 4, respectively.

The results reported showed that soil pH significantly (p<0.05) differed among land use types at surface layer (Table 2). However, soil pH did show any significant difference among land uses both at 15-30 cm and 30-45cm soil depth (Table 2). Woodlots and cereal lands had the lowest pH value of (5.63±0.01) and (5.78 ±0.01), respectively, while enset lands had highest pH values of (6.31±0.15) as compared to other land uses types(Table 2). This results agrees with studies by [Hailes-ilassie *et al*. 2005, Alemayehu and Sheleme, 2013] who reported that highest pH values under enset land than cereal land uses in Central and Southern Ethiopia, respectively. Similar results was also reported by [Amusan et al,2006] who reported significant low soil pH in soils under the continuous arable cropping land as compared to other land uses in Nigeria.

Another study by[Olowolafe and Alexander,2007] also reported that, low pH under eucalyptus plantation as compared to other land uses in Nigeria. Similar study by Lemenih et al, 2005) also reported that significantly lower pH under *Eucalyptus saligna* plantation compared to natural forest or cultivated lands or *Cupressus lusitanica* plantation in the highlands of Ethiopia. This results also goes well with several other studies [Lalisa et al. 2010; Yihenew and Getachew,2013; Yitaferu et al.,2013] who reported that lowest soil pH under eucalyptus plantation and small scale woodlots as compared to other land uses in the high lands of Ethiopia. Zerfu [2002] also showed that a high content of active acidity, while low pH soil under *eucalyptus globulus* plantation in Amhara Regional State of Ethiopia. Abbasi and Rasool,2005 also reported that a significant difference on soil pH among land use types in Rawalakot Azad of Jammu and Kashmir.

Table 2. Mean ± SEM of soil OC (%) TN (%) available P (ppm), pH (H2O) in relation to land use.

Property	Depth(cm)	Enset	Cereal	Grazing	Woodlots	ANOVA
pH	0-15	6.31± 0.15a	5.78± 0.11b	6.09± 0.04ab	5.63± 0.01b	*
	15-30	6.66± 0.64a	5.73± 0.19a	6.09± 0.01a	5.48± 0.01a	ns
	30-45	6.18± 0.11c	5.96± 0.2c	6.19± 0.01c	5.72± 0.21c	ns
OC(%)	0-15	3.09± 0.13a	1.50± 0.12b	2.31± 0.25c	2.14±0.19bc	**
	15-30	2.46± 0.16a	1.49± 0.14b	1.63±0.14b	1.75± 0.12b	**
	30-45	1.90± 0.23a	1.18± 0.10b	1.23± 0.10b	1.47± 0.04ab	*
TN(%)	0-15	0.26± 0.01a	0.13± 0.02b	0.20± 0.02a	0.19± 0.01ab	**
	15-30	0.20± 0.01a	0.12± 0.01b	0.13± 0.01b	0.15± 0.01b	**
	30-45	0.16±0.05a	0.11± 0.02b	0.11± 0.01b	0.13±0.01ab	*
P(ppm)	0-15	22.52±1.70a	17.63±1.69a	15.73±1.95a	15.80±2.00a	ns
	15-30	20..97±1.49a	11.72± 1.53b	15.13±1.94b	15.68±1.90b	*
	30-45	15.52±2.07b	13.01± 1.24b	14.22±1.21b	14.70± 0.92b	ns

Values followed by the same letters in a row are not significantly deferent at P <.05; or 0.001* significantly different at p < 0.05; ** significantly different at p = 0.001 ns denotes not significantly different.

Soil pH did not show any significant (p<0.05) differences across soil depth (Table2). However, soil pH was increased with increasing soil depth(Figure 4). Similar results were reported by [Malo *et al*.,2005] who indicated that an increasing trend of soil pH with increasing soil depth.

The soil organic C content was significantly affected by land use type (p = 0.001) in 0-15 cm and(p=0.05) in 15-30cm soil dpeth (Table 2). The organic C content was lowest for cereal farms (1.50±0.12), while pastureland(2.31±0.25) and woodlots (2.14± 0.19%) had relatively similar higher values of OC at 0-15cm(Table 2). Enset farms had the highest OC(3.09±0.13%) at 0-15cm. Likewise, the organic carbon content was higher for enset farms(2.46±0.16%) while OC was the lowest under cereal farm(1.49±0.14),grazing land (1.63±0.14%) and woodlots(1.75±0.12%)at15-30cm (Table2).

Furthermore, enset farms had the highest OC content(1.90±0.23%), whereas cereal farms(1.18± 0.10) and grazing land(1.23± 0.10) had a similar lowest values in the sub-surface layers of 15-30 and 30-45 cm depths, respectively(Table 2).

The total N content was significantly affected by land use type (p = 0.001) in 0-15 cm and 15-30cm and(p=0.05) in 30-45 cm (Table 2).Total N content was found to be the lowest under cereal farms (0.13±0.02%), while enset farms (0.26±0.01) and grazing land(0.20±0.02%) had a similar highest value at 0-15cm (Table 2). More importantly, total N content was found to be the lowest under cereal farm (0.12±0.01) and grazing land (0.13±0.01), while enset farms (0.26±0.01) and woodlot (0.15± 0.01) had a similar highest value at 15-30 cm. In addition, the TN content was lowest for cereal farms (0.11± 0.02) and grazing land(0.11± 0.01%) while enset farms had the highest TN (0.16±0.05) at 30-45cm(Table 2).

Similar results were reported by [Amusan et al,2006] who found a significant low organic matter content and available P in soils under the continuous arable cropping as compared to other land uses in Nigeria.

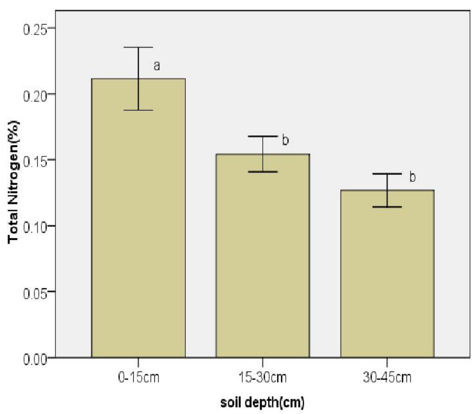
A significant difference (p = 0.001) was observed among the land uses in total N content at 0-15cm and 15-30cm and p=0.05) at 30-45cm(Table 2).

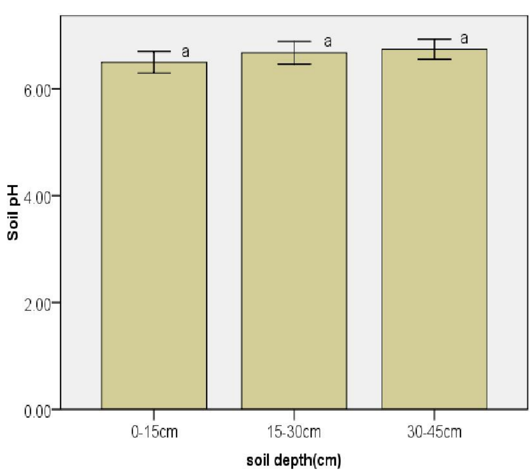
This result agrees with similar studies by [Emiru and Gebrekidan,2013; Lalisa *et al*. [2010]] who reported that a significant difference on OC and TN among land use in Western and Central Ethiopia. This result also goes well with similar results by [Tilahun and Mulugeta,2005; Hailes-ilassie *et al*., 2005] who reported that significantly higher total N under enset land use as compared to cereal farms in Ethiopia. Another study by Boke, 2004 cited in Alemayehu and Sheleme, 2013] also reported that higher content of organic carbon and total nitrogen under enset land use as compared to grassland in Southern Ethiopia. Similar studies conducted in Ethiopia by [Yimer et al., 2008] and in Nigeria by [Onweremadu,2007] also found highest total N content in pasturelands as compared to cultivated lands. However, this result disagree with studies by[Alemahehu and Sheleme,2013] who found that higher OC under grassland as compared to enset land Ethiopia

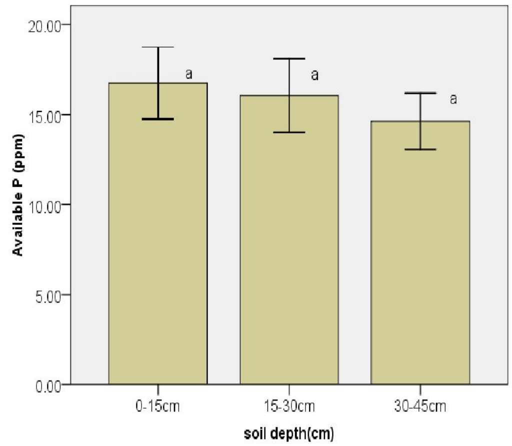
Enset farm had much higher available P (20.97±1.49ppm),while cereal farms (11.72±1.53ppm), grazing lands(15.13±1.94ppm) and woodlots (15.68±1.90) had a similar lowest value at 15-30cm, respectively(Table 2). Although, no statistically significant (p<0.05) differences in available P among land uses at surface layer , enset soils had also higher available P(22.52±1.70) followed by to cereal farm (17.63±1.69 ppm), woodlots (15.80±2.00 ppm) and grazing land (15.73±1.95ppm) Table 2).

Likewise, enset land had the highest available P of(15.52±2.07 ppm) followed by woodlots(14.70±0.92 ppm), grazing land (14.22±1.21ppm) and cereal fams(13.01±1.24ppm) (Table 2). It was observed that the available P was significantly affected by land use type (p= 0.001) at 15-30 cm, while it was not affected by land uses at 0-15cm and 30-45cm, respectively (Table 2).

This result agrees with similar studies by [Emiru and Gebrekidan,2013; Yechale and Solomon, 2011; Alemayehu and Sheleme, 2013] who found that land use changes significantly influence the available P in Ethiopia. However, the present finding is contrary with the finding of [Birru et al.2013; Mulugeta, 2004; Lemma, [2006] who reported no significant difference in available P among land uses in the high lands of Ethiopia. This results is goes well with other similar studies by [Aticho and Elias, 2011; Alemayehu and Sheleme, 2013; Boke, 2004 cited in Alemayehu and Sheleme, 2013] who found higher available P under enset land use as compared to other land in Ethiopia.







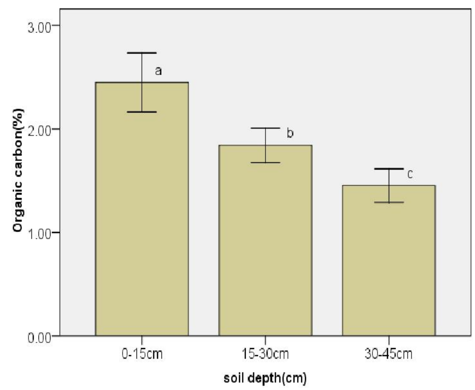


Figure 4. Distribution of soil OC%, TN%, pH and available P(ppm) across soil depth .Error bars represent standard error. Different letters denote significant difference between (P <0.05). Same letters denote no significant difference between (P <0.05).

As showed in (Figure 4) OC and TN were significantly different across different soil depths at (P=0.001). However, available phosphorus and pH did not show any significant difference (p<0.05) across soil depths (Figure 4).

Higher OC of (2.61± 0.21%) was found at 0-15cm followed by 1.83±0.10 % at 15-30cm and 1.49±0.13%) at 30-45cm (Figure 4). TN content was higher (0.20± 0.01%) at 0-15cm, while similar low values of TN (0.15± 0.01%, 0.13±0.01%) was found at 15-30cm and 30-45cm, respectively (Figure 4). This result agrees with studies by [Yifru and Taye, 2011; Lalisa *et al.* 2010; Yimer and Abdelkadir, 2011] who found a decreasing trend of organic carbon and total N content with increasing soil depths in Central Highlands of Ethiopia.

Available P did not show any significant difference across soil depth. However, surface layer had relatively higher available P of (17.50±1.09 ppm) followed by (16.40 ±1.14ppm) and (14.90±0.83ppm) at 15-30cm 30-45cm, respectively.

3.3 Relationships between selected soil physical and chemical properties

The correlation matrix for physical properties and chemical properties were presented in (Table 3). Positive correlation was observed between OC and TN at correlation coefficient(r)=0.973**). TN and available P showed a positive correlation at correlation coefficient of r(0.406*). This results agrees various studies in Ethiopia[Fikadu, et al, 2003; Lalisa et al., 2010; Mulgeta,2004; Yimer and Abdelkadir,.2011] who reported linear relationship between OC, and TN and available P. Available P also showed a positive relationship with pH (r = 0.483**) (Table 3). Negative correlation was observed between BD and MC (%) at correlation coefficient (r) of (-0.398**) in surface layer(Table3). This results is in line with similar study by (Fikadu et al.,2013) who reported that negative correlation between bulk density and moisture contents.

Table 3. The correlation matrix for soil properties in surface layer(0-30cm) soil depth

	pH	OC (%)	TN (%)	P(ppm)	MC (%)	BD (g/cm3)
pH	1					
OC(%)	.272	1				
TN(%)	.295	.973**	1			
P(ppm)	.483**	.340	.406*	1		
MC(%)	-.162	.222	.171	-.142	1	
BD(g/cm3)	.082	-.300	-.228	.191	-.398*	1

Notes: * significant at 5%, ** significant at 1%.

3.3 Soil organic carbon and total N stock in relation land uses

Results of soil carbon stock are presented in Tables 4 and Figure 5 for land uses and soil depths, respectively.

The organic carbon stock was lowest for cereal farms (27.58±2.2 Mg ha-1) and highest for enset farms (49.41±2.0 Mg ha-1) with relatively higher values in pastureland(41.03±5.19 Mg ha-1) and woodlots (37.17±4.03 Mg ha-1) at 0-15cm. Furthermore, enset farms had the highest carbon stock (43.09±4.91 Mg ha-1), while cereal farms (25.34±2.58 Mg ha-1), grazing land (27.33±2.36 Mg ha-1) and eucalyptus woodlots) 29.15±2.17 Mg ha-1) had a similar lowest values at 15-30cm, respectively(Table 5). Likewise, higher soil organic carbon was observed under enset farms (34.86±4.17 Mg ha-1), while cereal farm (23.72±1.89 Mg ha-1) and grazing land (21.74±1.79 Mg ha-1) had the lowest values at 30-45cm(Table 5). A significant (p=0.05) difference was observed between land uses in soil carbon stock in all considered soil depths (Table 5).

Total nitrogen stock was found least under cereal farms (2.49±0.26 Mg ha-1), while woodlots (3.23±0.32 Mg ha-1) and grazing land (3.63±0.45 Mg ha-1) had a similar relatively higher total nitrogen stock at 0-15cm (Table 6). Enset land had the highest total nitrogen stock of (4.11±0.15Mg ha-1) at 0-15cm (Table 6). Furthermore, total nitrogen stock was higher under enset farm(3.55±0.41 Mg ha-1), while cereal farm (2.12±0.18 Mg ha-1), grazing land(2.27±0.2 Mg ha-1) and woodlots(2.47±0.20 Mg ha-1) had a similar low total nitrogen stock at 15-30cm (Table 5). In addition, cereal farms(2.13±0.18 Mg ha-1) and grazing land(1.92±0.15 Mg ha-1) had a similar lowest values, while enset farm had the highest values(2.94±0.36 Mg ha-1) at 30-45cm (Table 6). A significant difference(p= 0.001) was observed among the land uses in total N carbon stock at 0-15cm and (P<0.05) at 15-30cm and 30-45cm.Total carbon stock within 0-45cm was higher for enset (127.36±11.09 Mg ha-1) followed by woodlots (92.55±7.66 Mg ha-1) and grazing land (90.30±9.34 Mg ha-1) and cereal land(76.64±6.71 Mg ha-1). This estimate is within the range of earlier finding by [Mulugeta and Itanna, 2004] who reported that SOC stock ranging (42.9 -234.6 Mg ha-1) for Andosols, Nitosols and Solanchak for 0-60cm depth in Southern Ethiopia.

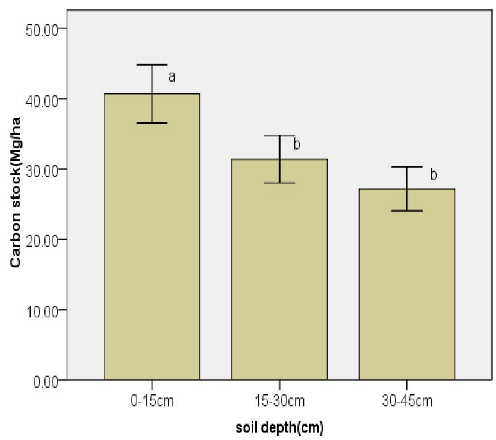
This results also agreed with similar study by [Girmay and Singh,2012] who found highest soil organic carbon of (43 Mg ha-1) under ex-closure followed by plantation (36 Mg ha-1), grazing land (33Mg ha-1) and cereal land 26Mg ha-1) at 0-20 cm in Northern Ethiopia

Likewise enset land had higher total nitrogen stock of (10.66±0.62 Mg ha-1) followed by woodlots (8.04±0.66Mg ha-1) and grazing land(7.82±1.05Mg ha-1) and cereal farm(6.74±0.62Mg ha-1).Similar study by Sing et al.,[2010] found significantly higher SOC and TN stock of (221±13.7 Mg ha-1, 18±2.2 Mg ha-1) in forest lands followed by traditional agro-forestry(166.8±13.7 Mg ha-1, 16.4±1.26 Mg ha-1) and agricultural lands(149.5±9..46Mg ha-1, 15±1.2 Mg ha-1) in the Central Rift Valley of Ethiopia

Table 4. Mean ± SEM of soil carbon stock (Mg C ha-1) in relation to land use types

Property	depth(cm)	Enset	Cereal	Grazing	Woodlots	ANOVA
OC(Mg/ha)	0-15cm	49.41±2.01a	27.58±2.24b	41.03±5.19ab	37.17±4.03ab	*
	15-30cm	43.09±4.91a	25.34±2.58b	27.53±2.36b	29.15±2.17b	*
	30-45cm	34.86±4.17a	23.72±1.89b	21.74±1.79b	26.23±1.46ab	*
Total	0-45 cm	127.36±11.09	76.64±6.71	90.30±9.34	92.55±7.66	
TN(Mg/ha)	0-15cm	4.11±0.15a	2.49±0.26b	3.63±0.45ab	3.23±0.32ab	**
	15-30 cm	3.55±0.41a	2.12±0.18b	2.27±0.45ab	2.47±0.20 b	*
	30-45cm	2.94±0.36a	2.13±0.18ab	1.92±0.15b	2.34±0.14ab	*
Total	0-45cm	10.66±0.62	6.74±0.62	7.82±1.05	8.04±0.66	

Values followed by the same letters in a row are not significantly deferent at P <.05 or p=0.001 values followed by different letter are Significantly different at p < 0.05; * Significantly different at p = 0.001 ns denotes not significantly different.



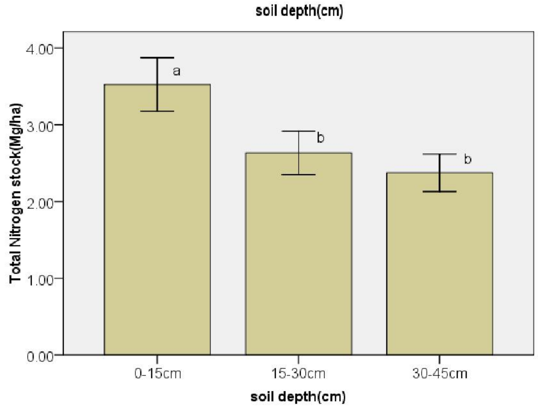


Figure 5.Total Soil carbon and Total Nitrogen stock (Mg ha-1) across soil depth.
Error bars represent standard error. Different letters denote significant difference between (P <0.05). Same letters denote no significant difference between (P <0.05).

Surface soil had highest soil organic carbon stock (56.10±3.56 Mg C ha^{-1}) and TN stock (4.86±0.31 Mg ha-1), while subsurface soil had similar low of soil organic carbon (45.17±3.31Mg C ha^{-1}, 38.26±3.08 Mg ha-1) and total nitrogen stocks of (3.77±0.27 Mg ha^{-1}, 3.35±0.24Mg ha-1), at 15-30cm and 30-45cm, respectively (Figure5).

A significant (p=0.001) difference was observed across soil depths in soil carbon stock and total nitrogen stock. The surface layer (0–15cm) contributed 39% to the total (0-45cm) SOC stock for the Enset, 36% for the cereal farms, 45.44 % for the grazing and 40.16 % for eucalyptus woodlots.

The surface layer (0–15cm) contributed 38.56 % to the total (0-45cm) total nitrogen stock for the Enset, 36.94 % for the cereal farms, 46 % for the grazing and 40.17 % for eucalyptus woodlots. Thus, OC total N stock were shown a trend of enset farm > eucalyptus woodlots > grazing land > cereal at 0-45 cm. More OC and TN stock were concentrated in grazing land and eucalyptus woodlots.

4 Discussions

4.1 Soil physical properties

The results of this study showed that bulk density varied greatly in response to land uses and their managements. Cereal farms had a greater soil bulk density as compared to enset farm at surface layer. Increased bulk density under cultivated lands was also reported by several authors[Yechale and A. J. Solomon,2011; Khormali et al.,2009; Lemenih et al. 2005; Yihenew and Getachew,2013]. Frequent tillage for growing for small sized annual crops, particularly teff (*Eragrostis tef*) may be a contributing factors.

The highest bulk density in the cereal land use may also be a reflection of low organic carbon under cereal lands . Tillage could be the main factors that could reduced organic carbon by destroying soil aggregate, thereby exposing organic carbon for decomposing agent[Solomon,2002].Several studies could noticed the influences of tillage on bulk density and organic carbon[Akamigbo,1999; Onweremadu et al.2009 cited in Ahukaemere et al.,2011]. A linear relationship between OC and bulk density was reported by [Mulugeta 2004; Fikadu et al 2013] from the high lands of Ethiopia.

Soil compaction in cereal land may eventually affect infiltration rate if such kind of intensive tillage will be continued in the future which in turn may aggravates erosion hazard, which finally have led to high soil erosion and land degradation, which are the main soil degradation agent in the high lands of Ethiopia [Hurni, 1993; Hawando, 1997]. This was reflected by the inverse relationship between bulk density and moisture content (r=-0.398**).

Furthermore, a similar bulk density under grazing land and woodlots as compared to other land uses can be explained by the equal exposure of these land to free grazing. Normally, shortage of grazing land is very acute in the study area and farmers often use to graze their animals on farmlands after crop harvesting and inside woodlots and in boundary of farm lands . However, the lowest bulk density under enset farmlands may be due to limited tillage practiced which could reduce the trampling effects of livestock .

A significantly higher bulk density was measured in soil subsurface layer of 30-45cm as compared to soil in 0-15cm and 15-30cm. The increasing trend of soil bulk density with increasing soil depth may be due to the weight of the overlying soil. Decreasing soil organic carbon content with increasing soil depth may also be contributing factor. This result agrees with similar results reported by [Birru et al 2013] who found that higher bulk density of (1.24 g cm^{-3}) in subsurface soil at (20-40cm) as compared to (1.11 g cm^{-3}) in surface soil at (0-20cm) in highlands of Ethiopia. Similar increasing trend of bulk density with increasing soil depth were also reported by [Awdenegest et al, 2013 and Ahukaemere et al., 2012] in Ethiopia and Nigeria, respectively.

Soil bulk density is one the important soil quality indicator since it affects aeration and infiltration rate and restrict root penetration when it exceed the critical limit. Miller and Donahue, [1997] reported that for good plant growth, bulk densities should be below 1.4 g cm^{-3} for clays soils. Therefore, the value obtained here showed that the current utilization of cereal farms slightly less than this ranges .

The observed lowest moisture content under eucalyptus woodlots may be attributed due to the nature of the species. Eucalyptus is a fast growing and various species with high moisture and nutrient uptake. Sanginga and Swift[1992] confirmed that mono-crop of eucalyptus species has a general trend of high uptake for soil moisture as well as nutrients. Lower moisture content under eucalypts was also found by similar study from Ethiopia [Fikadu et al,.2013; Tilashwork et al.,2013; Mesfin,2013]

On the other hands, the highest moisture content under enset farm may be attributed due to its funnel like leaves and spongy nature of the root systems which can form mate-like structure in the root zone that may minimizes soil erosion and run-off, which ultimately improve the water and nutrient storage [Tsgaye,2002; Amede and Diro, 2005]

4.2 Soil chemical properties

The results of this study showed that the chemical properties (OC, TN, available P and pH) significantly changed in response to land use and management.

The results reported in current study showed that soil pH significantly varied among land uses. Soil pH under enset farm was significantly higher as compared to woodlots and cereal farms. The higher soil pH under enset soil could be attributed due to higher values of exchangeable bases in the enset soil. The content of exchangeable base namely, Ca2+, Mg2+ may be changed due to the application of large amount of household refuses and wood and /or biomass ash. In addition, by-products from enset processing may also be contributing factors as it temporarily burned inside enset farms. Pitman, [2006] and Misra *et al*., [1993] found that wood ash provides considerable amount of Ca^{2+}, Mg^{2+} and K^{+}. Similar study by [Alemayehu and Sheleme, 2013] also reported higher values of exchangeable Ca^{2+}, Mg^{2+}, and K^{+} under enset field in Ethiopia.

However, woodlots and cereal land had similar lower soil pH. Lower content of exchangeable base may be a contributing factors for the observed changes due to high uptake of exchangeable base by eucalyptus species . On the other hand low pH under cereal lands may be caused due to complete removal of crop biomass. Continuous total biomass removal may also be attributed to observed changes in pH[Saikh *et al*.,1998b]. The lower level of pH under cereal land may be also attributed due to the long-term application of chemical fertilizer mainly urea which may rise the carbonate level of the soil.

This results agrees with similar studies by [Muluneh, 2011, Zewdie, 2008] who found a decreasing trend of Ca^{2+} and Mg^{2+} with increasing age of eucalypts globulus plantation in the high lands of Ethiopia. Similar study by Olowolafe and Alexander, 2007 was also reported a lower Ca^{2+} and Mg^{2+} under eucalyptus camaldulenisis plantation in Nigeria. Thus, fast growing nature of eucalyptus species and its voracious nutrient uptake may causes the changes.

On the other hand, the relatively higher pH under grazing land may be caused due to temporal burning of grass . In the study area grazing land have been served as threshing ground during crop harvesting hence before threshing the above ground cover of the grass often burned to clean the ground . Thus biomass ash may be temporarily increased the concentration of the base cations as reported by (Islam, Weil, 2000).

The increasing concentration the exchangeable Na^+ due to livestock urine, which have added daily to open grazing land by cattle may also be a contributing factors[Lalisa et al., 2010].

Though not significant difference was measured on soil pH across soil depth , an increasing trend of pH with increasing soil depth was observed indicating the increasing content of exchangeable bases ($Ca^{2+,}$ Mg^{2+} and K^+) with increasing soil depth owing to leaching of exchangeable base along soil profile [Mohammed *et al*., 2005].

The results reported in this study showed that OC and TN greatly varied among land uses. Enset farm had significantly higher OC and TN, carbon and total nitrogen stocks as compared to other land uses. Similar results was reported by [Abebayehu and Eyassu,2011].

The high organic C, total N under enset soil could be attributed to their management and location. Large amount of household wastes, livestock manure, wood and/or dung ash and other decomposable materials are often thrown to the enset, which in aggregate changes nutrient and carbon storage over long time. Proximity of enset for homestead also make easy the manual transportation of household refusal, stall manure and enset by-products on daily basis [Bekunda, 1999; Elias, 2000]. Cultural favarism towards enset have also a contributing factors as enset become one of food security crop in Gurage culture .Bouajila and Sanaa, [2011] indicated that application of manure and household wastes caused a significant changes on the content of soil organic carbon and total nitrogen. Thus, these external inputs may promotes the concentration of total N and organic. The association of different types of plants (fruits trees, vegetables, herbs, grass and shrubs and tree species) within and around enset farm, may also be a contributing factors as their leaf and other plant remains all add up to the high C content.

The observed strong positive correlation between organic carbon and total nitrogen suggested that that the contribution of OC for total N was high. Richards and Wolton,[1976] suggested that livestock urine and dung as the good potential sources for N.

Similar study by [Brandt et al., 1997; Tsegaye, 2002; Tilahun. and Mulugeta[2005]suggested application of large amount of organic manure and crop residue, including the nutrients coming from outfield in terms of feed and mulch for improving the enset soil. Besides this, the funnel like leaf and spongy root nature can protect under enset farm from water soil erosion hence indirectly enhance soil nutrient and moisture storage [Tsgaye,2002; Amede and Diro,2005].

Higher OC and TN under grazing land, particularly in surface layer may be due to the growing habit of the grasses i.e. the grasses frequently develop juvenile leaves, which add to the N and C content of the soil. Although the majority of the above ground biomass have removed by intensive free grazing, the below ground biomass mainly root may add higher organic carbon and nitrogen into the soils of grazing lands. It is known that grass roots decompose faster than tree roots i.e. it have faster fine root turnover and decay. and hence contribute as higher organic matter inputs of surface soil [Guo and Gifford, 2002; Rhodes *et al*., 2000].

Livestock waste may also be another possible nutrient sources in grazing land as the animals stay the whole day in the grazing land and their waste remains out there especially in the rainy season when they totally confined on grazing land and no collection of dung by land users, then it becomes solubilized by rain water and mixes with the soil. In addition, grazing land served as heaping sites and threshing ground at the time of crop harvesting which could be contributing factors for observed higher OC and TN. In addition, the land use /cover types of grazing land also a contributing factor for the observed as the grazing land cover by grass through out the year as compared to cereal land often bare hence it reduced soil erosion and thereby minimize nutrient depletion .

This study findings confirmed effectiveness of grazing land as restoration measure for soil of degraded farmlands as reflected by better OC and TN compared to continuously cropping lands. Previous studies have shown higher OC and TN under grazing land as compared to cereal farms when grazing land established on former cropping lands that were abandoned by farmers because their poor crop yield [Lalisa et al.,2010] signaling the great need for soil amelioration activities

Likewise, eucalyptus woodlots had higher OC and TN, carbon and nitrogen stock than cereal land.

Previous studies have reported the positive impacts of trees on soil of degraded lands particularly OC and N [Young, 1989]. Similar study by [Bekele et al, 2006; Lemenhi et al., 2005] were reported the positive impacts of fast growing exotic trees including eucalypts species on organic carbon and total nitrogen. Similarly Birru et al 2013; Yitaferu *et al*., 2013 also found no significant negative impacts on soil of eucalypts plantation following re-conversion former eucalyptus plantation to crop land in Ethiopia. This results is also in harmony with studies by[Zerfu,2002; Mulugeta,2004a] who reported that planting degraded farmlands with eucalyptus species increased the OC, while planting eucalyptus on newly cleared forestland decreased the OC and total N. On contrary studies by [Chen et al., 2004; Tilashwork et al.,2013, Zewdie, 2008] indicated that reforestation with eucalyptus decreased soil chemical properties, notably organic carbon, total nitrogen, phosphorus and potassium decreased as a result of reforestation with Eucalyptus.

The observed higher OC and TN content under woodlots compared to cereal land could be due to the absence of leaf litter raking by land users which ultimately improve nutrient cycling of the soil through litter decomposition . Absence of litter raking also can reduce soil erosion. Similar study by[Zewdie,2008] reported the negative impacts of litter removal on soil properties under eucalyptus globulus plantation in the high lands of Ethiopia .

Furthermore, the frequency of nutrient removal through the wood harvest is low compared to annual crops as trees has a long gestation period compared to annual crops [Zewdie,2008]. Above all trees are very efficient biomass generators, which can adding more nutrient to the soil, through nutrient cycling and minimize soil erosion as compared to annual crops [Haigh *et at*., 1994].

The high nutrient content OC and TN under eucalyptus woodlots may also be due to proximity of woodlots to living quarter, hence they may serve as a toilet. For instance , Lalis et al, 2010 reported that more than 95% of the community in the Central high lands of Ethiopia had not toilet. Besides, the addition of cattle and bird excrement may also be contributing factors. In addition, the indigenous trees, shrub and herbaceous undergrowths that frequently die and decomposed may also changes the nutrient contents.

The results of this study showed that cereal land had significantly lower organic carbon and nitrogen stock. This goes well with the finding of various studies [Mulugeta and Itanna,,2004, Yimer et al.,2007; Sombroek et al.,1993 and Teissen et al.,1994 cited Lemenih et al, 2005].

The OC total N stock were shown a trend of enset farm > eucalyptus woodlots > grazing land > cereal at 0-45 cm.

This result is in agreement with the finding of [Lemenih et al, 2005] who reported that significant difference among land use on SOC and TN stock in the order of: natural forest > Cupressus lusitanica> Eucalyptus saligna> farmlands. Similar study by Lal et al., 1999 and Smith et al., 2000 cited in Haiqing et al., 2007) suggested the conversion of former farmlands into grassland for enhancing soil carbon sequestration.

The lower OC and TN stock under cereal farms indicates the severity of degradation under cereal lands, whereas the higher OC and TN stock under enset followed by woodlots and grazing land may indicates that the importance of these land uses as restoration measures for addressing soil nutrient and carbon depletion in the study area. Importantly, grazing land may be an effective means of soil carbon sequestration in the upper layer, while eucalyptus woodlots could be better in addressing both below and above soil carbon sequestration.

Thus, farmers should scale up planting enset crops for enhancing soil nutrients and C sequestration. Besides, converting degraded agricultural land into pasture land may enhance soil nutrient storage. Planting fast growing exotic trees(including eucalyptus species) in the form of woodlots could also be alternative options for restoration of degraded soil. In the present study, eucalyptus woodlots showed positive effects on soil carbon stock within the age 15-20 year though, they were established on degraded formers farmlands. The finding of the present study agrees well with several studies from the high lands of Ethiopia [Mulugeta, 2004; Lemma, 2006; Zerfu, 2002 Lalisa et al.,2010] who reported that the conversion of abandoned farm land to plantation increase soil carbon. This results disagree with [Solomon *et al*., 2002; Woldeamlak and Stroosnijder, 2003] who reported that the negative impacts of converting of former farmlands into fast growing plantation.

Furthermore, Enset land had higher available P as compared to other land uses. This may be attributed due to the application household waste in the form of wood and crop biomass ash, which is daily cleaned from the kitchen and thrown out to the enset soil over several decades. Crop biomass and ashes could have adequate P source comparable to that of highly soluble commercial P fertilizer [Pitman, 2006]. In addition, bone remains from slaughtered animals can also be a possible sources of P in the enset. Slaughtering animal have been common in Gurage culture during celebration of Meskele festivity every year.

On other hand, the relatively higher available P under cereal land as compared to grazing land and woodlots in surface layer may be attributed due to the continuous application of phosphorus fertilizer(DAP) for more than three decades. In the study area famers use 100kg per ha of DAP for maize while they use 50kg per ha of DAP for wheat and teff. Similar results were reported by [Wakene and Elufe,2004; Alemayehu and Sheleme, 2013; Woldeamlak and Stroosnijder, 2003] who found higher available P in surface layers in cereal land owing to annual leftover of P from fertilizer application.

On the other hand , the observed high available P in the surface layer as compared to subsurface layer indicates that large amount of external inorganic fertilizers temporarily remain in the top surface soil as compared to the deeper soil layer.

Thus, it is clear from the finding reported in this study that enset land use is the best land use in improving soil nutrients and carbon storage as it was reflected by the good state of OC, TN , P and pH . The results of this study also showed that OC could be an important sources in contributing to the pool of TN and available P as reflected by the observed strong positive correlation between TN, OC and P. Thus, organic amendment like addition of animal manure and household waste may be used as mechanism for improving the nutrients contents of degraded tropical soils.

Nevertheless, the lower contents of OC and TN, organic and total nitrogen stock under cereal land may be attributed due to the frequent and intensive traditional tillage practice (often oxen plowed Maresha). It is obvious that intensive tillage enhance oxidation of organic carbon thereby lead into depletion of nutrient and carbon . This results is in agreement with other studies by [Mulugeta, 2004; Yimer and Abdelkadir, 2010; Yifru A and Taye B.2011; Wakene and Heluf. 2004; Eshetu et al, 2004; Ahukaemere et al.,2011; Nega and Heluf.2013] who found significant negative impacts of tillage on organic carbon and nutrients .

Accordingly, the lower OC, TN, pH , carbon and total nitrogen under cereal farms reflect the severity of land degradation under this land utilization types. This can also be associated with inappropriate land use practice such as total removal of crop biomass and frequent cropping of small sized annual crops without adequate external inputs. For example, small sized crop like wheat and teff plots plowed 7 to 8 times before actual sowing of these crops. Such an intensive plowing exposes the available organic matter to moisture, aeration and other decomposing agents, which could be facilitating the fast degradation and mineralization of the available organic matter thereby reducing the soil C and N[Solomon et al.,2002].Complete or total removal crop biomass could also aggravate depletion of SOM and soil nutrients as reported by[Haileslassie et al., 2005]. Farmer have often completely remove biomass of crop from fields during harvesting through mowing close to surface. Then livestock freely grazed on crop residue remains after harvest until the next growing time. Coupled to this, over cultivation of farm lands due to land shortage is another factor for the diminishing quality of the farmlands(cereal farm have a cultivation history of more than 50 years) [Murage *et al*., 2000; Mulugeta et al., 2005b, Solomon, 2002] with minimal return rate every year. Further, low fertilizer application due to economic reasons and risk aversion could also be another factor for the observed low nutrient and carbon storage [Mulugeta, 2004].

Finally, the results reported in this study showed that OC, TN, carbon and nitrogen stock were higher in surface layer as compared to subsurface layers. Obviously, OC and TN accumulated in surface soil where large amount of root biomass, eternal inputs like human and animal wastes and other plant debris and inorganic fertilizers temporarily remain in the top surface soil as compared to deeper soil horizon.

As illustrated in Table 3 there were significant and positive correlation observed among soil nutrients such as OC, TN and available P, indicating OC is important in contributing to the pool of TN and available P. Thus, organic amendment may be used as mechanism for improving the nutrients contents of degraded soil in the study area and other similar agro-ecological area . Subsequently, enset farms are found in good soil state in term of both soil physical and chemical properties, while cereal land is the least.

Therefore, reducing intensive cultivation, and integrated use of inorganic and organic fertilizers should be recommended to replenish the degraded soil quality of cereal land and for sustainable agro-ecosystem management. Nevertheless, soil under eucalyptus woodlots had lower pH and moisture content as compared to enset land and grazing land, respectively. Thus, farmers are advised to plant eucalyptus on marginal land, which are not suitable for agriculture. As this land use provide an important alternative to generate income and provide wood products, planting of eucalyptus in the form of wood lots may be continued in the future .

Our results provide strong evidence that in appropriate cereal farming system can caused soil degradation, including soil nutrients and carbon depletion. Besides inappropriate cropping and tillage of cereal land could also led towards soil compaction and soil acidification.

Furthermore, in comparison to other lands uses, eucalyptus land use could caused dry up of soil moisture and soil acidification

Therefore, development of sustainable land use practices is imperative to minimize the extent of the ongoing soil quality degradation and sustainable soil resources management in the future. Above all, as most of the smallholder farmers are dependent on natural fertility of soil, steps should be taken to improve soil nutrients and carbon sequestration through existing and introducing new cropping system and nutrient saving technology. One of the strategies may be scaling up the coverage of enset plantation far from homestead . Enset planting is win-win strategies for improving agricultural productivity and soil carbon sequestration as this land use provide high food production while maintain soil nutrient and carbon storages. In addition, converting degraded farmlands into grazing land and/ or eucalyptus woodlots can also be an alternative options for restoration of plant nutrients and carbon sequestration. Nevertheless, eucalyptus land use may cause some ecological disadvantage such as soil moisture depletion and soil acidification. Therefore, farmers should be advised to plant eucalyptus on unproductive /marginal lands .

Based on the present finding We can conclude that depending on the intensity of land use activities exercised land use owned and managed by individual smallholders farmers are likely to improve and/ or degrade soil nutrients and carbon storage. Based on the present finding enset land use types is the best land use practices as reflected by improved soil nutrients, carbon storage while feeding over 13 million people in South and Southwest Ethiopia. Its high soil carbon sequestration potential of the this land use could also open the way to claim for the benefit obtained from carbon-trading in the future .

4 Conclusions and Recommendation

The results of this study showed that land use changes and their associated management can causes a significant changes in bulk density, soil moisture, pH, OC, TN, available P, carbon and total nitrogen stock. Bulk density of cereal farms was higher as compared to enset land which may be resulted due to soil compaction due to frequent tillage. Enset land had significant higher soil pH, OC, TN, available P, carbon and nitrogen stock than other land uses. OC total N stock were shown a trend of enset farm > eucalyptus woodlots > grazing land > cereal at 0-45 cm.

Eucalyptus woodlots had low moisture content and soil pH as compared to other land uses owing to the high moisture and nutrient uptake nature of fast growing eucalyptus species. In view of this evidence, due regard should be given for appropriate site selection during planting . Eucalyptus woodlot may be an alternative option for restoration of soil nutrient and carbon storage of degraded farmlands. However, its negative consequences of soil reaction and moisture should be re-cognized . Further as the evidence of the current study is based on woodlots ranging between 15-20 ages. Thus, the long term effects of Eucalyptus on soil degradation should be investigated in the future. Based on this findings, there is a need to develop proper land use policy and sustainable soil management and cropping practices to combat the on ongoing soil degradation and to improve soil fertility in the study area.

Therefore, it is clear from the results found in this study, enset land is an appropriate land use for improving soil properties as reflected by higher contents of OC, TN , soil carbon and total nitrogen stock. This study finding also confirms that grazing and woodlots are an alternative land use for increasing OC TN contents and improve carbon sequestration. However, soil under cereal land showed less OC, TN , carbon and nitrogen stock. Hence, there is a deficit of the very essential nutrient elements. Therefore, the following agronomic measures are recommend: minimizing frequent plowing, incorporation of crop residues, use of integrated soil nutrients management such as use of organic and inorganic organic fertilizers, planting legume as rotation crops and incorporation of nitrogen fixings fodder species(both herbaceous and grass). In addition, intensifying widely adopt agro-forestry systems such as enset based around homestead which could be an option for improving soil nutrient and C storage. To replenish the degraded soil quality and enchasing sustainable agricultural production and land management there is an urgent need of appropriate land use policy and land use planning.

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