Earth Sciences
2016; 5(6): 96-103
http://www.sciencepublishinggroup.com/j/earth
doi: 10.11648/j.earth.20160506.12
ISSN: 2328-5974 (Print); ISSN: 2328-5982 (Online)

Soil Organic Carbon and Total Nitrogen Stock Dynamics in the Enset Dominated Farming System of Southwestern Ethiopia

Bahilu Bezabih[1, *], Biniam Tesfaye[2], Asrat Fikre[3]

[1]Department of Natural Resources Management, College of Agriculture and Veterinary Medicine, Jimma University, Jimma, Ethiopia
[2]Department of General Forestry, College of Agriculture and Natural Resource, Mizan Tepi University, Mizan Tepi, Ethiopia
[3]Water Resource Research Center, Arbaminch University, Arbaminch, Ethiopia

Email address:
behailubeza@gmail.com (B. Bezabih)
[*]Corresponding author

To cite this article:
Bahilu Bezabih, Biniam Tesfaye, Asrat Fikre. Soil Organic Carbon and Total Nitrogen Stock Dynamics in the Enset Dominated Farming System of Southwestern Ethiopia. *Earth Sciences*. Vol. 5, No. 6, 2016, pp. 96-103. doi: 10.11648/j.earth.20160506.12

Received: September 3, 2016; **Accepted**: September 21, 2016; **Published**: November 9, 2016

Abstract: The study was aimed to investigate soil organic carbon (SOC) and total nitrogen (TN) dynamics among different land use systems in the Essera district of Dawuro zone, southwestern Ethiopia. Landscape of the district was dominantly covered with enset (Ensete ventricosum) farming system. For this study, three representative land use types namely, Enset farm, woody and cultivated lands were considered. For each land uses, a plot of 25x25m size was marked as a sample plot to collect soil samples in an'X' design (from the middle and four corners of the plot). Accordingly, both composite and core sampled soils were gathered from the five subsequent soil depths (i.e.0-5, 5-10, 10-15, 15-20 and 20-25cm). Consequently, analysis of variance was conducted by using SAS version 9.2. Moreover, a mean separation for each parameter was made using LSD (Least Significant Difference) test. The result confirmed that soil organic carbon (SOC) and total nitrogen (TN) stocks were significantly influenced by topographic variation, land use types and soil depths. The highest SOC and TN stocks were observed in the lower slope position, enset farm land and upper soil depths. Regarding to land use difference, 18.65 and 13.50 t/ha SOC stock were observed in the enset and cultivated farm land respectively. TN was also highest in the enset farm land as compared with cultivated and woody land. In contrast, the lowest soil organic carbon stocks were recorded in the upper slope position of cultivated land and lower soil depths. Both SOC and TN stocks were significantly decreased from the upper soil layers to lower soil depths. Soil physical properties were also significantly influenced by topographic position, land use difference and soil depths. Soil clay contents were highest in the enset and woody land while lowest in the cultivated land. However, soil bulk density, soil silt and sand fractions were highest in the cultivated land. Moreover, soil clay content was significantly increased from upper to lower slope position and vice versa for soil bulk density, soil silt and sand fraction. In conclusion, based on the confirmed result, it deserves to improve soil fertility management under different land use types and slope categories, so that soil organic carbon, total nitrogen and soil clay contents could be improved accordingly.

Keywords: Soil Organic Carbon, Total Nitrogen, Farming System, Land Uses, Soil Depth

1. Introduction

Soil has three important and inter related physical, chemical and biological properties, which makes it functionally complete resources. The inherent characteristics of soil which are mainly the resultant of parent material and climate undergo subtle change due to different land management practices. Some inherent soil properties such as soil pH and texture as well as climatic conditions have substantial influences on soil properties transformation [1]. Types of land use, intensity of cultivation and fertilizer sources are major factors responsible for soil properties transformation. Among this factors, soil management has a marked influence on soil organic matter (SOM) dynamics in agricultural system [22]. Land-use practices affect the distribution and supply of soil nutrients by directly altering soil properties and by influencing biological transformations in the rooting zone. Although its consequences vary, land conversion frequently leads to nutrient losses when it disrupts surface and mineral horizons (e.g., by mechanical disturbance) and reduces inputs of organic matter [24].

In agricultural ecosystem soil organic matter (SOM) and total nitrogen (TN) are an essential ecosystem component which are major determinants of soil fertility whose dynamics are affected by soil management practices, and are closely related to soil productivity [22], [13]. Primary plant production and soil biological activity are the two main biological processes governing inputs and outputs of SOM in the system, and the equilibrium between both determines the SOM cycling dynamics [20]. Soil organic carbon also associated with other major nutrients especially phosphorus and nitrogen, and hence influences recycling and availability of nutrients for agricultural production system sustainability [2].

Declining soil fertility and land degradation in the forms of soil erosion is threatening agricultural productivity, which is the main stay of the economy, in Ethiopia [16]. However, despite the general recognition of the problem of soil degradation and its impact on agricultural productivity, there are few efforts to quantify the extent, rate and process of soil fertility depletions under various land use systems and management practices [8]. It is estimated that there is a 1-2% reduction of soil productivity annually from the crop lands in the Ethiopian highlands due to land degradation [14]. One aspect of land degradation leading to such decline of soil productivity is loss in organic carbon and total nitrogen due to erosion, intensive decomposition, or leaching. In countries like Ethiopia where there is serious food insecurity due to impoverished soils, the importance of soil organic matter maintenance need not be overemphasized [15]. Therefore, the major objective of this study was to investigate current status of soil organic carbon and total nitrogen dynamics under different land use types and topographic positions in the Enset dominated farming system of Southwestern Ethiopia

2. Methodology

2.1. Description of the Study Area

The study area is situated in the Essera district of Dawuro zone in Southern Nations, Nationalities and Peoples Regional State (SNNPRS) (Figure 1). It is situated in the Omo basin at about 507km South west of Addis Ababa, the capital of Ethiopia. The area is topographically undulating and rugged. The Dawuro Zone covers total area of 4436.7km^2 and lies between 6.59-7.34°N latitude and 36.68 to 37.52°E longitudes, with an elevation ranging 501-3000m [17]. The zone has 5 districts with a total population of 398, 796. It has also three agro-Ecological zones identified as: kola, *Weynadega and Dega* occupying 55.6%, 41.4% and 3% respectively. The annual mean temperature ranges between 15.1 and 27.5°C. The rain fall is a bimodal type: the short rainy season is between (February and March) and the long season between (May and September). The average annual rainfall ranges from 1201 to 1800mm. The regional data on land utilization shows that, 38.4% is cultivated land, 13.39% grazing land, 16.81% forest, bushes and shrub land, 17.09% cultivable and 14.31% is covered by others. The live stock resource of the zone was estimated to be 313,094 cattle, 113,554 sheep, 45,703 goats, 7,081 horses, 1,934 mules, 5,064 donkey, 157,996 chicken, and 28, 557 traditional hives [5]. According to [9] soil classification, the dominant soil of the region is Humic Nitisols with a clay and clay loam texture with dark redish brown color.

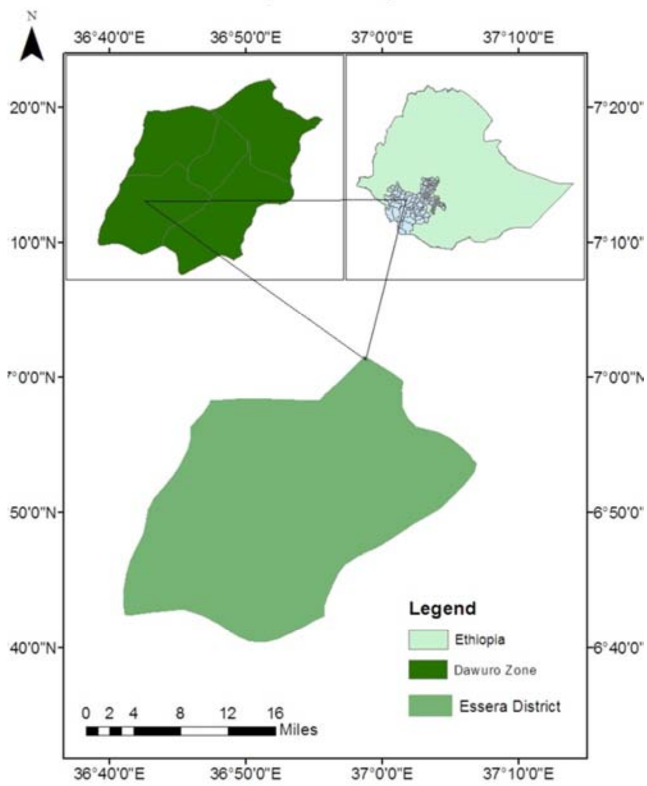

Figure 1. *Map of the study area.*

2.2. Farming System

Farming systems of the region (area) is broadly classified in to cereal based farming system and Enset- Root crops complex in combination with different agro- forestry systems. Enset is a plant native to Ethiopia that is often referred to as the false banana because, not surprisingly, of its resemblance to the banana plant. It is grown in the less arid highlands of the south western region of Ethiopia. The major annual food crops grown in the area, includes cereals (maize, sorghum, barley, wheat, and teff), pulses (beans, peas). Maize and wheat followed by beans and peas were grown in the highest proportion in the area. The most common agro-forestry tree species, in the grazing and enset farm in the study area includes, *Cordia africana, Millettia ferruginea, Ficus spp., Grevillea robusta, Acacia spp, Coffee (C.arabica) and some* fruit trees like *Mangifera indica L., and Persea*

Americana. *Musa acuminate* and root crop (potatoes and taro) are also grown in a considerably especially in enset farm land.

2.3. Methods of Data Collection and Analysis

2.3.1. Soil Sampling and Soil Laboratory Analysis

Three representative land use types namely, cultivated land, Enset farm and woody lands were selected from three slope positions, lower (3-8%), middle (8-15%), and upper (15-25%). From each slope positions and land use types a plot with 25x25m size was marked as a sample plot following a method applied by [7]. The soil samples were then taken from five points in an 'X' design (from the middle and four corners of the plot) and from five subsequent soil depths (i.e.0-5, 5-10, 10-15, 15-20 and 20-25cm). Accordingly, from each land use types both composite and core sampled soils were collected for soil chemical and physical analysis. For soil chemical analysis the samples were air dried and grounded to pass through a 2-mm sieve. Total SOC was quantified by wet digestion with a mixture of potassium dichromate and H_2SO_4, under external heating [25]. Soil TN was measured after sulfuric digestion followed by Kjeldahl distillation [23]. Soil bulk density was determined by the soil core method which is the ratio of oven dried mass of soil to core volume, and soil texture (sand, silt, and clay contents) was obtained by sieving and decantation procedures according to [21]. Soil texture was estimated using Hydrometer method [10] after destroying organic matter by adding hydrogen peroxide (H_2O_2) and dispersing the soil through adding sodium hexameta phosphate($(NaPo_3)_6$.

Total organic C and TN stocks were calculated by the formula:

Organic C or N stockt/ha (toneperhectare)=organic C or N content (dagkg^{-1})*ds*th

Where,ds is the soil bulk density

(tm^{-3}) and th is the thickness of the soil layer (m)[11]

2.3.2. Data Analysis

The comparisons among land use types, topographic positions and soil depths were conducted by using SAS version 9.2 software packages for analysis of variance (ANOVA). When the analysis of variance (ANOVA) showed significant differences ($P<0.05$) among the various land use types, soil depths and slope position for each parameter, a mean separation for each parameter was made by using LSD (Least Significant Difference) test.

3. Result and Discussion

3.1. Soil Physical Properties

The over all mean of several soil properties significantly influenced by land use types, slope position and soil depths. Soil physical properties includes soil bulk density, sand, silt and clay fraction were significantly affected by slope position (Table 1&2). The highest soil bulk density was recorded in the upper slope position which could be due to less addition of crop residue and trampling effect of livestock. Because of small land holding size grazing intensity was very high in the upper slope position. Similarly, sand, silt and clay proportion were also significantly influenced by land uses. Enset and woody lands have highest clay content and lowest silt and sand fraction. In opposite to this, cultivation land has lowest clay and highest silt and sand fraction (Figure 4). In the study area enset farm land receives more attention because it is considered as a food security crop. As a result, there is frequent addition of organic matter, crop residue, cow dung and house hold residue in the enset farm land. As soil organic matter improved, soil clay content might be increased and silt and sand content decreased (Figure 3). However, soil bulk density was not significantly different due to land use difference.

Table 1. *The influence of topographic positions,land use types and soil depth on selected soil physical and chemical properties.*

	Slope							
	oc(%)	**soc(t/ha)**	**TN(%)**	**TNS(t/ha)**	**BD(gm/cm^3)**	**Sand(%)**	**silt(%)**	**clay(%)**
lower	2.76a	17.05a	1.66a	10.31a	1.25b	24.44a	35.28b	40.28a
middle	2.84a	18.97b	1.89b	7.54b	1.38a	27.50b	33.78b	38.72a
upper	1.93b	13.15c	0.63c	4.23c	1.41a	30.00c	39.61a	30.39b
	Land use							
cultivation	1.99b	13.5a	13.5a	1.67a	1.39a	34.00a	37.89a	28.61c
enset	2.86a	18.65b	18.65b	12.19c	1.35a	22.56b	34.67b	42.78a
woody	2.68a	17.03c	17.03c	8.22c	1.29a	25.39c	36.61a	38.00b
	Depth							
0-5cm	3.3a	18.8a	1.69a	9.78a	1.15a	23.78a	35.78a	40.44a
5-10cm	3.01a	18.57a	1.61a	9.45a	1.24a	25.22ab	36.11a	38.67a
10-15cm	2.66b	17.22a	1.24a	7.87a	1.31abcd	26.22bc	36.00a	37.78ab
15-20cm	2.35bc	16.3ab	1.06ab	7.20ac	1.41bcd	28.11c	36.33a	35.56bc
20-25cm	2.02cd	14.88bc	0.78ab	5.69ab	1.49c	29.56d	36.33a	34.11c
25-30cm	1.72d	12.58d	0.56abc	4.15c	1.78d	31.00de	36.78a	32.22cd

Values followed by different letters are statistically different *($P\leq0.05$)*.

Table 2. *The interaction effect of topographic positions and land use types on SOC, TN stock and selected soil physical properties.*

LowerSlopePosition								
landuse	**Oc(%)**	**Soc(t/ha)**	**TN(%)**	**TNS(t/ha)**	**BD(gm/cm^3)**	**Sand(%)**	**silt(%)**	**clay(%)**
cultivation	2.31b	13.31b	0.51a	2.90a	1.16a	30.17a	36.83a	33.00b
Enset	2.93a	19.46a	2.59b	16.99b	1.37a	18.83b	35.50a	45.67a
woody	3.05a	18.38a	1.87c	11.02c	1.24a	24.33a	33.50a	42.17a
MiddleSlopeposition								
cultivation	2.14b	15.94b	0.19a	1.39a	1.51a	35.67a	33.50a	30.83b
Enset	3.49a	21.22a	1.99b	11.96b	1.23b	22.67b	32.33a	45.00a
woody	2.89a	19.75a	1.38c	9.27b	1.39ab	24.17b	35.50a	40.33a
UpperSlopeposition								
cultivation	1.53a	11.24b	0.10a	0.71a	1.51a	36.17a	41.83a	22.00b
Enset	2.15f	15.25a	1.10b	7.60b	1.46ab	26.17b	36.17b	37.67a
woody	2.1f	12.96b	0.72c	4.37c	1.26b	27.67ab	40.83a	31.50a

Values followed by different letters are statistically different*($P\leq0.05$).*

With respect soil depths soil bulk density and sand fraction were significantly increased from upper soil depth of 0-5 cm to lower soil depth of 25-30 cm. In contrast soil clay fraction was significantly decreased from upper soil depth to lower soil depth. However, soil silt fraction was not significantly different due to soil depth variation. The highest sand and silt proportion (36.67 and 38.67%) were observed on the sub layers of cultivated land (25-30cm) which might be due to high leaching of silt and sand particles down the profile in the cultivated land. In generally for all land uses, clay content decreased while sand and silt contents increased with increasing soil depths (Table 3).

Table 3. *The interaction effect of land use types and soil depths on SOC, TN and selected soil physical properties.*

	Depth(cm)	**Oc(%)**	**Soc(t/ha)**	**TN(%)**	**TNS(t/ha)**	**BD(gm/cm^3)**	**Sand(%)**	**silt(%)**	**clay(%)**
cultivation	0-5	2.58a	15.21a	0.41a	2.19a	1.14a	30.33a	37.67a	32.00a
	5-10	2.38a	15.1a	0.37a	2.21a	1.23a	31.33a	38.33a	30.33a
	10-15	2.12a	14.68a	0.3a	1.94a	1.35ab	32.33a	38.00a	29.67a
	15-20	1.88a	14.26a	0.23b	1.66b	1.49b	34.67a	36.67a	28.67a
	20-25	1.62b	12.61b	0.17bc	1.29b	1.55bc	36.67ab	36.33a	27.00ab
	25-30	1.37b	9.14b	0.12c	0.71c	1.61c	38.67b	37.33a	24.00b
Enset	0-5	3.93a	22.59a	2.67a	15.1a	1.16a	19.67a	33.33a	47.00a
	5-10	3.45a	21.31a	2.64a	16.29a	1.25a	20.67a	35.00a	44.33c
	10-15	2.97a	18.86a	1.97bc	12.46b	1.29a	22.33a	34.00a	43.67c
	15-20	2.62b	17.81b	1.8c	12.41b	1.41a	23.33a	34.67a	42.00c
	20-25	2.27bc	16.77bc	1.31de	9.78c	1.5b	24ab	35.67a	44.33c
	25-30	1.92c	14.53c	0.93e	7.08c	1.51b	25.33a	35.33a	39.33d
woody	0-5	3.4a	18.6a	2.03a	11.07a	1.09a	21.33a	36.33a	42.33a
	5-10	3.22a	19.29a	1.83a	10.85a	1.20a	23.67a	35.00a	41.33a
	10-15	2.88a	18.14a	1.47b	9.20a	1.26ab	24.00a	36.00a	40.00a
	15-20	2.54b	16.82b	1.43bc	7.54bc	1.32b	26.33ab	37.67a	36.00b
	20-25	2.17bc	15.25bc	0.86cd	5.99cd	1.39cd	28.00b	37.00a	35.00bc
	25-30	1.86c	14.06c	0.61d	4.66d	1.5d	29.00b	37.67a	33.33c

Values followed by different letters are statistically different *($P\leq0.05$).*

3.2. Soil Organic Carbon and Total Nitrogen Stock

Soil organic carbon and total nitrogen stocks were significantly influenced by slope position, land use types and soil depth (Table 1 & Figure 2). The average mean value of soil organic carbon stocks were 17.05, 18.97 and 13.15t/ha for lower, middle and upper slope positions respectively. Similarly, the average mean value of total nitrogen stocks were 10.31, 7.54 and 4.23t/ha for lower, middle and upper slope position respectively (Table 1). The result revealed that soil organic carbon and total nitrogen stocks were significantly decreased from lower to upper slope positions. The decreased soil organic carbon and total nitrogen stock in the upper slope position could be attributed to poor soil fertility management and the steepness of the topography which accelerates soil erosion.

Regarding to land use types, the average SOC stocks were 13.50, 18.65, 17.03t/ha and total nitrogen stock 1.67, 12.19, 8.22t/ha for cultivated, enset woody land respectively (Table 1). The result confirmed that the highest mean value of soil organic carbon and total nitrogen stock were recorded in the enset farm land and the second highest value were in the woody land while the lowest mean value were in the cultivated land. The declining soil organic carbon and total nitrogen stocks in the cultivated land might have been aggravated by the insufficient inputs of organic substrate from the farming system due to residue removal and zero crop rotation. Moreover, leaching problem that can be attributed to high sand content (Table 1&2) and the resultant light texture of soils also might be the cause of soil organic carbon reduction. The highest mean in the enset land could be due to frequent soil organic matter addition and mulching while the lowest value in the cultivated land is due to continuous cultivation, removal of crop residue, soil erosion and rapid oxidation and/or mineralization. The result agreed with [22], [26], [8], [3] who stated the organic management, topography, grazing activity and rapid oxidation and farm yard manure (FYM) application influenced the total SOC and TN stocks, mainly in the upper soil layers, as a response to the utilization of organic residues as fertilizer and mulch. [19], [18] also reported that lower levels of soil OM content was observed in cultivated land. With regard to the interaction effect of land use and soil depth, the both organic carbon and total nitrogen were significantly decreased from the upper soil layer of 0-5cm to lower soil depth of 25-30cm (Table 3). Among all land uses and soil depths the lowest mean soil organic carbon (1.37% or 9.14t/ha) in the sub layer of cultivated land and the highest (3.93% or 22.59t/ha) in the upper soil layer of enset farm land (Table 3). Soil organic carbon stock and total nitrogen stocks content (t/ha) for 0–5, 5–10, 10-15, 15-20, 20-25 and 25-30cm soil layers under the Enset farm, woody and cultivation land showed significant variationat (*P<0.001*). It was significantly highest in the upper soil layer (0-5 and 5-10cm) and declined with soil depth (Table 3). The soils of the Enset farm and woody land have the highest soil carbon and nitrogen stock while cultivated land has lowest mean value. An analysis of variation showed that both soil organic carbon and total nitrogen stocks were decreased from upper soil layer to lower soil depths.

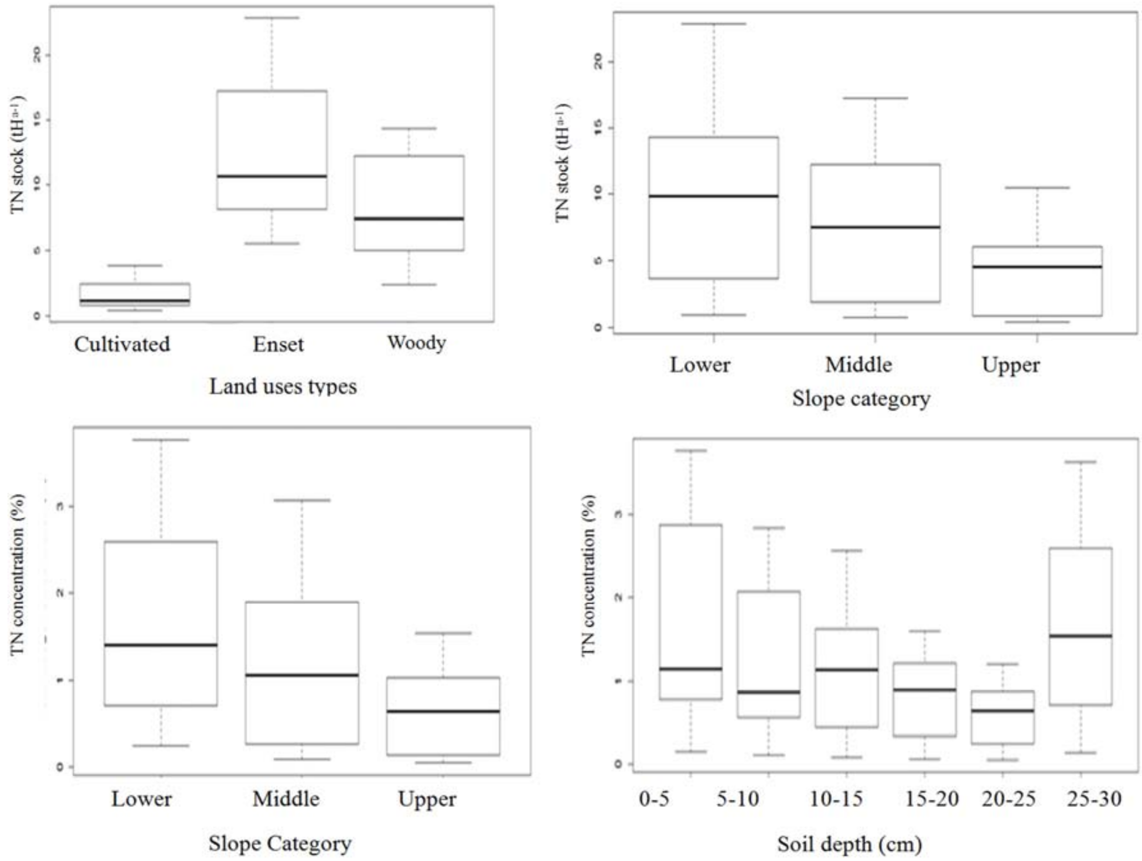

Figure 2. *TN concentration /stock comparisons in differentl and use types, slope categories and soil depth.*

The above figure 2 shows that the average SOC and TN concentration /stocks for all land use types, slope categories and soil depths. Both SOC and TN concentrations follow the order enset farm> woody land> cultivated land. Regarding to slope categories the concentration of SOC and TN of lower slope> middle slope> upper slope position.

3.3. The Relation Between SOC, TN and Soil Texture

Soil organic carbon (SOC), total nitrogen (TN) and soil texture analysis showed a strong relationship (Figure 3). As shown in the figure below, positive relationships were found between SOC & clay fraction, SOC & TN, SOC stock and TN stock (t/ha). However, soil clay and sand fraction showed a negative relationship (Figure 3). Numerous studies also confirmed the relationship between clay content, total nitrogen and SOM in soils from different sites in the tropics (Feller and Beare, 1997, Burke *et al.*1999, Plante *et al*. 2006, E. Sakin, 2012).

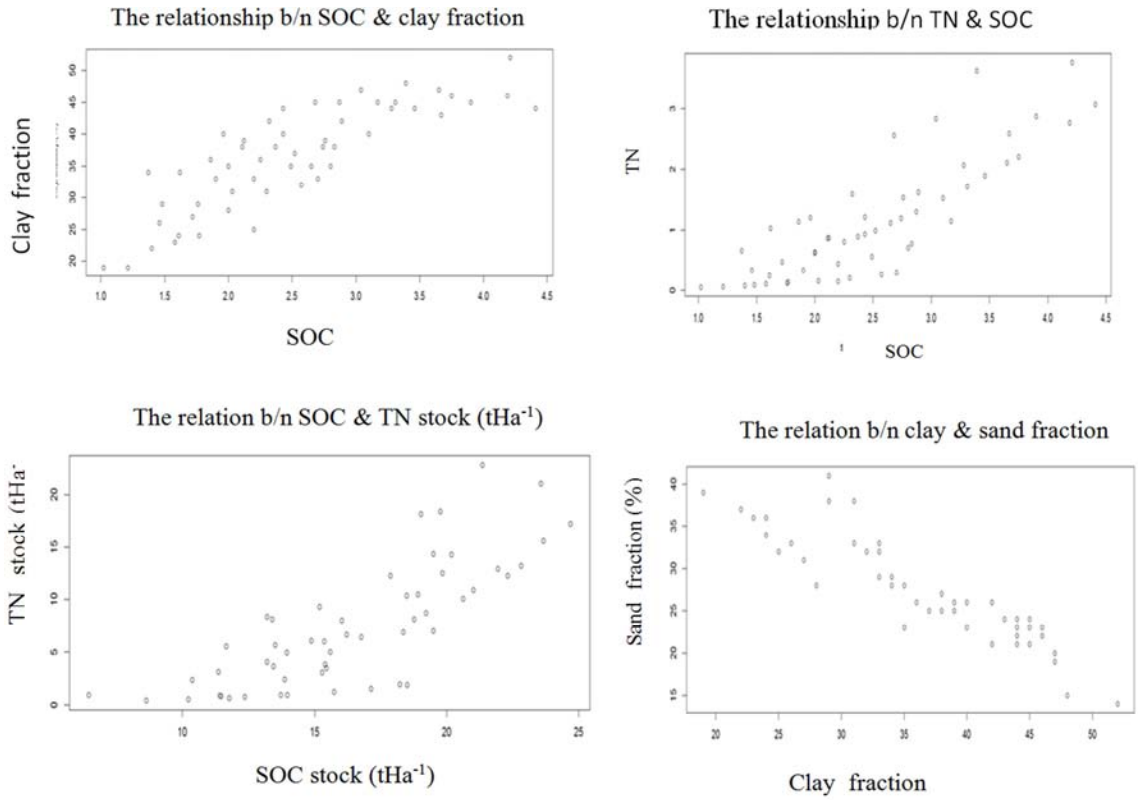

Figure 3. *The relationship between SOC, TN stock and soil texture.*

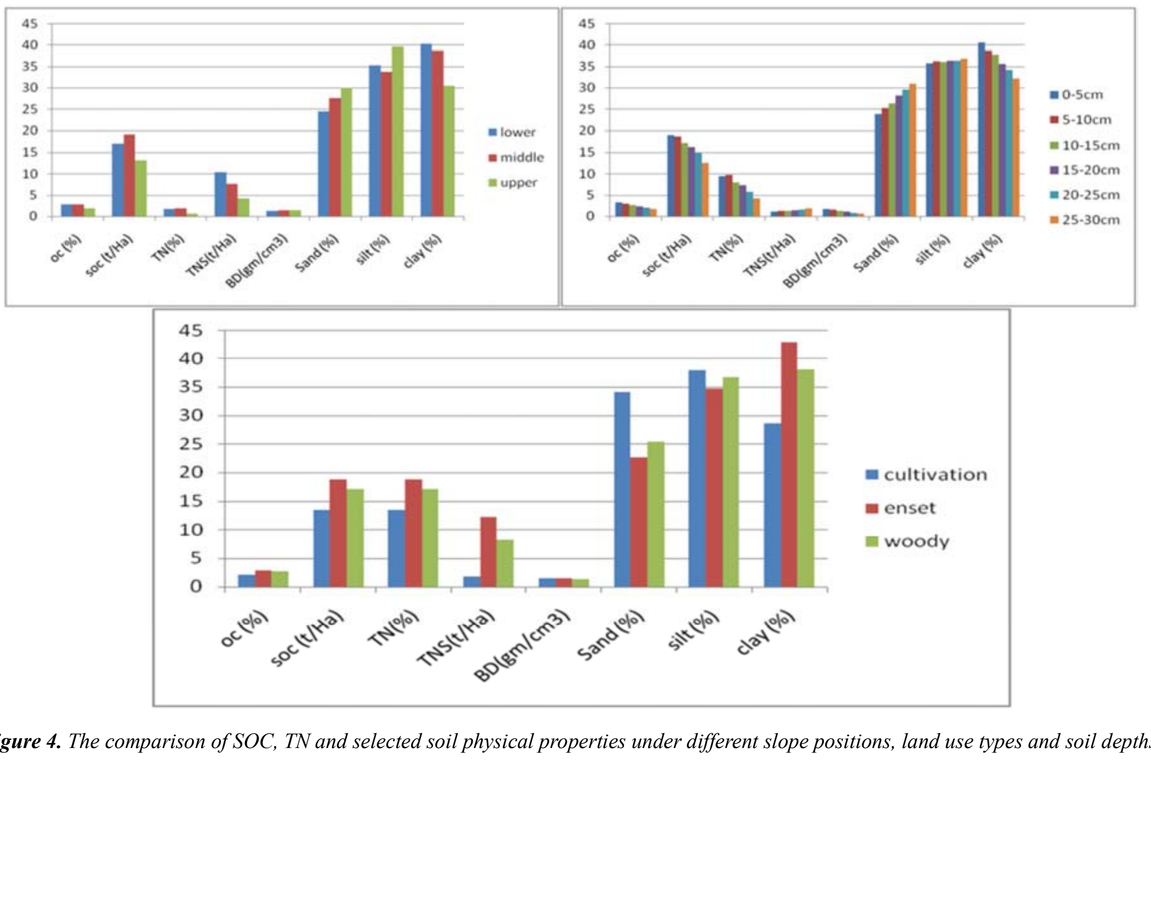

Figure 4. *The comparison of SOC, TN and selected soil physical properties under different slope positions, land use types and soil depths.*

4. Conclusions

Topographic position, land use types and soil depth interaction were significantly influences soil physical and chemical properties in the study area. Lower slope position has improved soil organic carbon and total nitrogen stock. Similarly, enset and wood land has highest clay content, organic carbon and total nitrogen. However, soil bulk density, soil silt and sand contents were lowest in the enset and woody land. This signals the great need for soil nutrient management measures such as integrated nutrient management (application of organic and inorganic fertilizers), growing of N_2 fixing crops and application of agro-forestry in to the farming systems. so that, soil organic carbon total nitrogen and soil clay contents will be improved and enabled production of sufficient food for the farm households by minimizing nutrient depletion.

References

[1] Abera, G. & Wolde meskel, E., 2013. Soil Properties, and Soil Organic Carbon Stocks of Tropical Andosol under Different Land Uses., 2013 (July), pp.153–162.

[2] Bell, L. W. et al., 2012. Agriculture, Ecosystems and Environmen Soil profile carbon and nutrient stocks under long-term conventional and organic crop and alfalfa-crop rotations and re-established grassland. *"Agriculture, Ecosystems and Environment"*, 158, pp. 156–163. Available at:http://dx.doi.org/10.1016/j.agee. 2012.06.006.

[3] Burke, I. C., 1999. Spatial variability of soil properties in the short grass steppe: the relative importance of topography, grazing, microsite, and plant species in controlling spatial patterns. Ecosystems., 2: 422–438.

[4] Chapman HD, 1965. Cation Exchange Capacity by ammonium saturation. In: C. A. Black(ed.). Methods of Soil Analysis. Agron. Part II, No. 9, Am. Soc. Agron. Madison, Wisconsin, USA. pp.891-901.

[5] CSA (Central Statistical Agency), 2006. Agricultural sample survey of livestock and livestock characteristics. Addis Ababa, Ethiopia. Statistical Bullet in. 388 (2).

[6] Day, P. R., 1965. Particle size analysis. In: Black CA (ed) Methods of soil analysis. Part1: Physical and mineralogical methods, vol. 9. Am. Soc. Agro. Inc., Madison, WI.545–566

[7] E. Sakin, 2012. Relationships between of Carbon, Nitrogen Stocks and Texture of the Harran Plain Soils in South eastern Turkey. *Bulgarian Journal of Agricultural Science*, 18 (No4) 2012, 626-634 Agricultural Academy

[8] Eyasu, E., 2002. Farmers' Perceptions of Soil Fertility Change and Management. SOS-Sahel and Institute for Sustainable Development, Addis Ababa, Ethiopia.

[9] FAO, 2006. World reference base for soil resources: a framework for international classification, correlation and communication. Rome: FAO. 103p.

[10] Feller, C., M. H. Beare, 1997. Physical control of soil organic matter dynamics in the tropics. Geoderma.,79:69-116.

[11] Pereira, M. G., Valladares, G. S., Anjos, L. H. C. D., Benites, V. D. M., EspíndulaJr, A. and Ebeling, A.G., 2006. Organic carbon determination in histosols and soil horizons with high organic matter content from Brazil. *Scientia Agricola*, *63*(2), pp. 187-193.

[12] Habtamu A., 2014. Fertility Status of Soils under Different Land uses at Wujiraba Watershed, North-Western Highlands of Ethiopia. *Agriculture, Forestry and Fisheries*, 3(5), p.410. Available at:http://www.science publishing group. com/journal/paperinfo.aspx?journalid=119&doi=10.11648/j.af f.20140305.24.

[13] Huang, B. etal., 2007. Temporal and spatial variability of soil organic matter and total nitrogen in an agricultural ecosystem as affected by farming practices.,139, pp. 336–345.

[14] Hurni, H., 1993. Land degradation, famine and land resource scenarios in Ethiopia. In' World soil erosion and conservation.'(EdD Pimentel). Press Syndicate, University of Cambridge, Cambridge.

[15] Itanna, F., Olsson, M. and Stahr, K., 2011. Effect of Land Use Changes on Soil Carbon Status of Some Soil Types in the Ethiopian Rift Valley. *Journal of the Drylands*, *4*(1), pp.289-299.2.

[16] Lemenih, M., Lemma, B. & Teketay, D., 2005. Changes In Soil Carbon And Total Nitrogen Following Reforestation Of Previously Cultivated Land., 28(2), pp.99–108.

[17] Mathewos, A., 2008. Ethnobotany of Spices, Condiments and Medicinal Plants in Loma and Gena Bosa Woredas of Dawuro Zone, Southern Ethiopia. A Thesis Submitted to the School of Graduate Studies in Addis Ababa University in Partial Fulfilment of the Degree of Masters in Biology (Dry land Biodiversity), 120p.

[18] Plante, A. F., R. T. Conant, C. E. Stewart, K. Paustianand J. Six, 2006. Impact of soil texture on the distribution of soil organic matter in physical and chemical fractions. Soil Science Society American Journal, 70(1): 287–296

[19] N. Wakeneand G. Heluf, 2003. Influence of land management on morphological, physical and chemical properties of some soils of Bako,Western Ethiopia. Agropedology.13: 1-9.

[20] Six, J., C. Feller, K. Denef, S. M. Ogle, J. C. Moraes Sa, and A. Albrecht. 2002. Soil organic matter, biota and aggregation in temperate and tropical soils—Effects of no-tillage. Agronomie 22: 755–775.

[21] Soils, E., 1997. Manual of soil analysis methods. *RiodeJaneiro*.

[22] Taylor, C., Group, F. & Xavier, F. A. S.,2009. Soil Organic Carbon and Nitrogen Stocks under Tropical Organic and Conventional Cropping Systems in North eastern Brazil., (January2008), pp. 2975–2994.

[23] Tedesco, M.J., G.Gianello, C.A.Bissani, H.Bohnen, andS.I. Volkweis.1995. Ana´lisedesolo, plantaseoutrosmateriais, 2nded. Portoalegre: Universidade Federal do Rio Grande do Sul.

[24] W, Semahugne, 2008., 2008. Land use change sand soil organic carbon and soil nitrogen in the North-western Highlands of Ethiopia. Thesis submitted to Institute of Forest Ecology University of Natural Resources and Applied Life Sciences,V ienna.,(July).

[25] Yeomans, J. C., and J. M. Bremner.1988. A rapid and precise method for routine determination of organic carbon insoil. Communications in Soil Science and Plant Analysis 19:1467–1476.

[26] Y. Zhihui, B. R. Singh, and S. Hansen, 2007. Aggregate associated carbon, nitrogen and sulfur and their ratios in long-term fertilized soils. Soil and Tillage Research. 95: 161-171.