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RESEARCH ARTICLE

CHANGES IN LAND USE ON SOIL PHYSICOCHEMICAL PROPERTIES: THE CASE OF SMALLHOLDERS FRUIT-BASED LAND USE SYSTEMS IN ARBA MINCH, SOUTHERN ETHIOPIA

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ABSTRACT

Fruit-based land use systems and their effects on physicochemical properties of soils were assessed in Abaya-Chamo Basin of Gamo Gofa Zone, Southern Ethiopia. The study area lies between6°30' to 6°38' N and 37°33' to 37°37' E and altitude of 1200 masl. The physiography is characterized by flat plain under forest and cultivation. A survey was carried out using semi-structured techniques. Land use systems including maize, natural forest, monoculture banana field, and mixed banana and mango fields were identified. Twelve composite soil samples were made from120 random samples collected from the four land-use types. Organic Carbon (OC) and Total Nitrogen (TN) in the surface soils of maize field declined by 61 and 59%, respectively, compared to natural forest during the past 30-40 years. Similarly, OC and TN were reduced by 48.5 and 55.5% in banana and 34 and 52% in mixed fruit cropland fields, respectively, when compared to their contents under natural forest. Likewise, the depletion of CEC in the banana and the maize fields were 32 and 13%, respectively, as compared to the CEC in the forest land. Total nitrogen and Available Phosphorous (AP) contents correlated positively and highly significantly ($P \leq 0.01$) with OC and Electrical Conductivity (EC). Generally, OC, TN, PBS, exchangeable K, Ca and Mg, available P, Mn and Fe contents decreased in cultivated land-uses, whereas buildup of OC and TN were obtained in forest lands. The available micronutrients especially Fe and Cu were influenced by the difference in landuse management. These soil properties were positively and highly significantly correlated with TN and OC contents. Therefore, management practices that improve soil quality such as the inclusion of leguminous specious should be employed when converting the land to crop production.

INTRODUCTION

Understanding soil properties and their productiveness under different landuse systems has proved useful for sustainable development and efficient utilization of limited land resources (Buol *et al.,* 2003). Likewise, soil is an important non-renewable land resource determining the agricultural potential of a given area. Agricultural activities change the soil chemical, physical and/or biological properties. Also core constraints in relation to land use include: depletion of organic matter due to widespread use of biomass as fuel, depletion of macro and micro-nutrients, removal of topsoil by erosion, change of soil physical properties, and increased soil salinity (IFPRI, 2010). The environmental consequences of changes in the state of cover affect the original driving forces through the environmental impacts feedback loop. Transformation of one system into another of different species of plantation resulting from changes in land use and management can affect soil structure, soil organic carbon and other nutrients reserve (such as N, P, S) (Yeshanew *et al.*, 2004). Long-term tillage practices reduced soil carbon by 30-50% (Mitchell *et al.*, 2000) and reduction of total nitrogen, exchangeable Ca^{2+} and Mg^{2+} (Saikhe *et al.*, 1998). The authors also demonstrated that loss of 1% organic carbon resulted in a loss of 2.97 cmol (+) /kg soil of negative charges, which is mostly due to intensive soil cultivation. In Southern Ethiopia, there is limited evidence-base for sustainable soil management practices (Tuma, 2007). Indigenous crop production and soil and water conservation are commonly practiced by smallholder farming communities in the lowland areas of Abaya Chamo Lake Basin over the past several decades. The vegetation distribution in Arba Minch area has been changed greatly over time because of high population pressure and subsequent deforestation. The majority of land use changes are related to agricultural use, including pastures and its implications for soil fertility and its management (Lambin *et al*., 2003). The land use patterns in the Abaya-Chamo basin of Gamo Gofa Zone were substantially changed through time with modern irrigation interventions and subsequent infrastructure development such as road facility and market-based economic system during the last 30-40 years. Smallholders' agriculture is the primary stimulus to generate employment and income, reduce poverty,

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promote industrialization and ensure a dynamic and self-sustaining growth through the use of modern agricultural inputs (FDRE, 2010). Fruit-based multi-tier cropping systems, dominantly banana production, exist in Gamo Gofa, particularly around Arba Minch area, which is within the High Potential Perennial Zone (MoA, 1995). Specifically, a mixture of perennial fruit crops (dominantly bananas and mangoes) together with monoculture banana farming, and subsistence cereal cropping are the dominant landuse types in the study area. Themajor indicators used in evaluation of potential soil fertility by the Ethiopian Minstry of Agriculture (MOA, 1995) include: soil organic matter (OM), cation exchange capacity (CEC), soil pH, soil texture, and available phosphorus (AP). However, additional standard soil fertility attributes such as nitrogen (N)and Potassium (K) are also important parameters in terms of plant growth, crop production and microbial diversity and function (Doran and Parkin, 1994). Soil OM is very important fraction of the soil because of its high CEC and nutrients' retention against leaching losses. Hence, land use and type of vegetation must be taken into account when relating soil nutrients with environmental conditions (Ramesh *et al.,* 2007), and in characterizing soil nutrients stocks. Despite the great economic importance of the traditional fruit-based landuse systems in the area, limited studies have been carried out. Improved farming methods such as mulching, intercropping, and shifting cultivation were also well practiced in the ACB. Previous study on soils of the area was conducted by Murphy (1968), which mainly focused on the fertility status of surface soils. The author indicated that the soils were neutral in reaction, contain between 1.3% and 2.3% OM, 0.05% to 0.11% TN, and were high in available phosphorus. The soils were also high in calcium and well supplied with magnesium and varied in texture from sandy loam to silty clay. At present, approximately 80% of the study area is under cultivation, as people mainly depend on agriculture to meet their basic needs. Realizing the seriousness of the problems and considering the decreasing productivity, the present investigation was initiated to evaluate the influence of different land useson soil physicochemical properties.

MATERIALS AND METHODS

Descriptions of the study area

The study was conducted in Southern Nations, Nationalities and Peoples` Regional State (SNNPRS), at about 495 km south of Addis Ababa. The site is found near Lake Abaya in the Rift Valley Lakes Basin particularly in Abaya-Chamo basin. It is located between 6°30' to 6°38' N and 37°33' to 37°37' E and altitude ranging from 1179 -1223 masl, covering about 3,244 ha (Figure1). The study area is found in the semi-

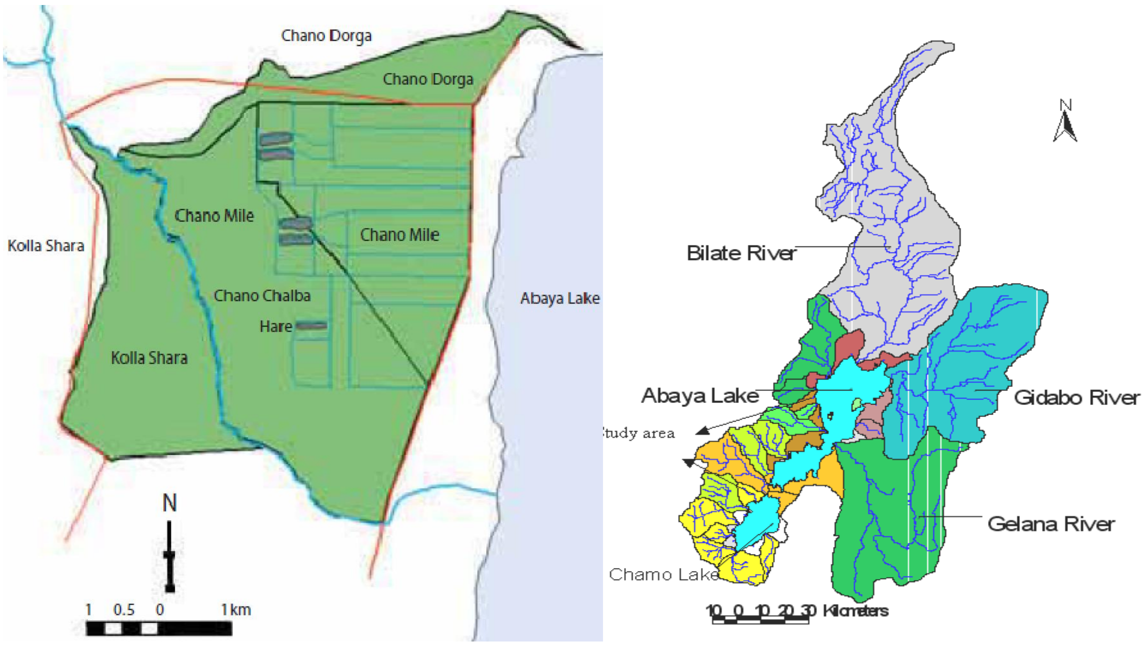

Figure 1. Location Map of the Study area (4 selected Villages/Kebeles) in Abaya-Chamo basin

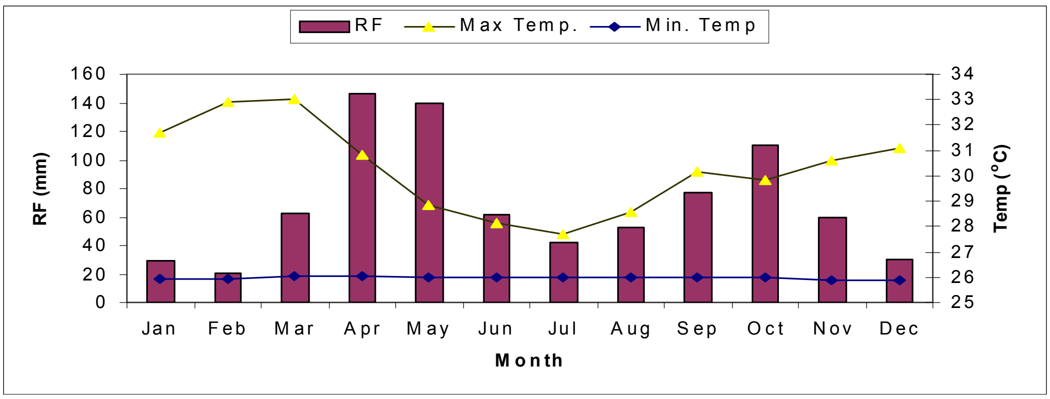

Figure 2. Rainfall and Temperatures of (1992-2007) Abaya Chamo basin average

arid agroecology of the country with native vegetation of comprised steppe-like in nature with some bunch grass and short shrub and trees (Murphy, 1968). The Length of Growing Period (LGP) of the area is 61 days (Lemma, 1996) implying that evapotranspiration is by far greater than rainfall and the need for supplement irrigation water to grow different crops. The long-term weather information at Arba Minch Meteorological station (from 1992-2007) revealed that the rainfall pattern is a bimodal type with a total rainfall of 830 mm per annum, and the mean minimum, mean maximum and average temperatures are 14.1, 27.9 and 20.6 ^{0}C, respectively (Figure 2). The geology and geomorphology of the Rift Valley occurred from Miocene to Pleistocene deposits (King and Brachall, 1975). The topography pattern of the area is composed of flat plain in the north west of Abaya Lake and the Rift Valley escarpment hills in the west and north. The parent materials of Abaya Chamo Basin are alluvium along river and lacustrine along lake which are derived from the rocks (GME, 1975; EMA, 1975).

Primary Data Collection and Land Use Classification

Semi-structured questionnaires were used to gather information about landuse, history of cultivation, cropping patterns, soil management, soil moisture management, flooding history, tenure system, agro ecological zonation, population pressure, etc. In addition, observation, discussion and interviews were made at each Kebele level. Discussions were focused on overall performance, history of the respective landuse systems and institutional aspects. Participants were community elder groups, village administration members, development agents, selected household heads, and water development committee. The focal group discussions were made with 10-12 people per village. With respect to the farm level, five adjacently located farm owners were interviewed in order to know the farm history. Field survey was carried out to collect data on the current landuse systems and the physiognomic vegetation classification system in accordance with FAO (1995 and 2006), and secondary data were collected from respective Kebele offices.

Soil sampling and laboratory analysis

One hundred twenty random soil samples (0-30 cm) were collected from four land use types and 12 composite were made. The samples were air dried and passed through 2-mm sieve. For determination of OC and TN, a 0.5 mm sieve was used. Particle size analysis was carried out by the modified sedimentation hydrometer procedure (Bouyoucos, 1951). The pH was determined in H_2O (pH-H_2O) and 1M KCl (pH-KCl) using 1:2.5 soil to solution ratio using pH meter as outlined by Van Reeuwijk (1993). Organic Carbon (OC) content of the soil was determined using the wet combustion method of Walkley and Black as outlined by Van Ranst *et al.* (1999). Soil Total Nitrogen (TN) was analyzed by wet-oxidation procedure of the Kjeldahal method (Bremner and Mulvaney, 1982). The Available Phosphorus (AP) content was analyzed using the Olsen method as outlined by Van Reeuwijk (1993). Exchangeable bases and the Cation Exchange Capacity (CEC) were determined by using the 1M ammonium acetate (pH 7) method according to the percolation procedure (Van Reeuwijk, 1993). The exchangeable Ca and Mg in the leachate were measured by Atomic Absorption Spectrophotometer (AAS), whereas exchangeable K and Na were measured by flame photometer. Available micronutrients (Fe, Mn, Zn, and Cu) were extracted by diethylenetriaminepentaacetic acid (DTPA) as described by (Tan, 1996) and were measured by AAS.

Statistical Analysis

Simple Nested Design procedure was carried out for the selected soil physicochemical properties using SPSS Version 12 (SPSS, 2001) statistical program to compare the effects of the different landuse types. Separation of the means of the soil properties was performed using Bofforni significance test. Additionally, simple linear correlation was employed to evaluate the relations of various soil physiochemical characteristics.

RESULTS AND DISCUSSION

Land Use Types and History of Cultivation in Abaya Chamo Basin

The vegetation distribution in the Abaya Chamo Basin has been changed greatly over time because of high population pressure and subsequent deforestation. The study provided information on major changes in crop cultivation during the last 30-40 years. The natural forests were converted to cereal and cotton cultivation during the 1970s-1990s whereas the smallholders' perennial fruit crops cultivation progressively increased starting after1990 and replaced the previous annual cropping system with settlement expansion and cultivation. Small part of the border area near Lake Abaya was covered with natural forest, whereas the top of mountains that was previously covered by grass and bushes was deforested. In the escarpment between lowland catchment and highland areas, the scattered trees were also leaving their original place to the new generation of human population because of shortage of farmland in the nearby highlands, absence of other alternative livelihood diversification strategies to rural-urban migrants, and rampant rural poverty and unemployment. The results revealed that there are 5,351 households with a total population of 19,674 (596 people/km^2). The whole population benefits from the Hare irrigation scheme. About 2588 ha (80% of the total area) was used for agricultural purpose, of which 262 and 1962ha were used for non-irrigated and irrigated agriculture, respectively. The cultivated lands are further subdivided as annual cropland (1227.6 ha; 47%) and perennial cropland (1361 ha; 53%). Forest and grasslands cover 270 and 168 ha, respectively. The rest of the area (217 ha) is occupied by the housings and other infrastructures. The higher cash crop production by the shift to monoculture of banana and mango was reported from the respective Kebele agricultural offices. As a result, there was a breakthrough in production and transforming the livelihoods of the 62% inhabitants from survival level to elevated way of life by introduced banana based farming practices in the irrigated neighborhood. Fast changes are taking place in farming systems, individual crops, peoples' lifestyles, breaking the traditional systems. For instance, improved farming methods such as mulching, intercropping, and shifting cultivation were also well practiced. Four dominant landusetypes (LUTs) were selected, based on the information obtained through assessment conducted and field observations made during the survey. Monoculture banana and mixed Mangoes and Banana farming were the dominant LUTs in three kebeles (Chano Chalba, Kola

Shara and Chano Dorga),whereas subsistence farming system of maize, sorghum, cotton and other pulse crops was common in Chano Mile Kebele (Figure 1). In accordance with Jarvis and Hodgkin (2000), farmers shape the distribution and degree of diversity for the crops both directly through selection, and indirectly through management of biotic and abiotic agroecosystem components. Additionally, farmers residing at distant to watercourse adopted crop diversification and agroforestry practices to minimize water scarcity constraints and risk of monocropping. Crop diversification is a successful approach to achieve water, food and nutrition security, income growth, poverty alleviation, employment generation, thoughtful use of land and water, sustainable agricultural development and environmental improvement (FAO, 1995; FAO, 2006). Crop yields vary amongst Kebeles in the schemes due to differences in access to irrigation water, land holding, soil fertility, and crop management. Accordingly, crop productivity varies from 144-219 qt/ha for banana, 7-22 qt/ha for cotton and 22-29 qt/ha for maize in the irrigation schemes. Case study reports have shown that increased cash crop production, reduced food shortages, improved standard of living are results of using irrigation water schemes by targeted communities' (Thompson, 1991; Adem, 2001).

Influence of Changes in Land Use Types on Properties of the Surface Soils

The LUTs were generally found within slope range between almost flat (1%) and slightly sloping (2%). The soils of land uses were young and derived from alluvium deposits having low runoff and high permeability.

Table 1. Physicochemical properties of surface soil (0-30cm) as influenced by LUTs in Abaya Chamo basin

Soil and Land Use Relationship Dependent variable (Identifiers)	Landuse type means pair wise comparison					Independent variable effects	
	X CrMa	XNF	XFrBa	XFrBaMa	Std.error	Adjusted R square	Interaction effects
pH: H_2O (1:1.25)	6.77	6.93	7.10	7.00	0.21	0.02	No interaction
pH: KCl (1:1.25)	5.40	5.83	5.87	5.53	0.25	0.16	No interaction
EC (dS/m)	0.11	0.51	0.16	0.13	0.06	0.19	Land use effect
Sand (%)	11.33	15.0	15.00	20.33	3.89	o.18	No interaction
Silt "	47.33	57.33	52.67	48.67	2.99	0.49	Land use effect
Clay "	41.33	27.67	32.33	31.00	2.16	0.65	Land use effect
Na ($cmol_c kg^{-1}$)	0.19	0.36	0.19	0.12	0.05	0.65	Land use effect
K "	1.12	3.34	3.04	1.55	0.52	0.68	Land use effect
Ca "	39.92	38.49	29.74	34.30	2.88	0.52	Land use effect
Mg "	14.17	14.86	10.80	9.76	1.27	0.65	Land use effect
Sum (cations)	55.40	57.05	43.77	45.72	3.44	0.64	Land use effect
CEC ($cmol_c kg^{-1}$)	55.87	45.67	46.33	49.27	4.28	0.27	No interaction
PBS (%)	99.33	99.99	95.00	95.67	12.32	0.32	No interaction
TN "	0.12	0.45	0.12	0.14	0.07	0.68	Land use effect
OC "	1.32	4.77	1.79	1.71	0.75	0.68	Land use effect
C/N "	11.33	10.33	16.00	12.67	1.63	0.49	Land use effect
AP ($mg\ kg^{-1}$)	20.21	49.27	57.04	26.70	12.42	0.45	Land use effect
Fe ($mg\ kg^{-1}$)	9.69	12.34	15.46	13.61	1.67	0.47	Land use effect
Mn"	10.75	9.21	12.27	13.18	1.80	0.16	No interaction
Zn "	0.60	1.13	1.20	0.8	0.47	0.68	No interaction
Cu "	1.10	0.69	1.13	1.10	0.10	0.68	Land use effect

X= mean values; CeMa= Cereal Maize;FrBa= Fruit Banana; FrBaMa= Fruit Banana and Mangoes Mix; NF= Natural Forest

Physical properties

The highest silt content (57.3%) was recorded under forest and was significantly ($P \leq 0.05$) higher than that of maize field (47.3%). On the other hand, the clay content of maize field (41.3%) was significantly ($P \leq 0.05$) higher than that of natural forest (27.7%), banana field (32.3%), and mixed fruit cropland (31.0%) (Table1). This could be due to the deposition of fine-grained materials by rivers on the flood plain areas, where coarse textured particles remained in watercourse (levees) and more finely textured soil particles were transported to basin areas. In line with the present finding, FAO (2001) reported that the classical arrangement of soil particles in the flood plains is in the order of coarsely textured particles on the levees and more finely textured soils in basin areas further away from the river. The clay content was negatively correlated with TN, OC, Ca, Mg, PBS, and AP (Table 2) indicating that nutrients are much more likely to be attracted to adsorption sites on the clay than in relatively coarse textured soils. Additionally, organic matter associated with the coarser fraction is also more labile and the first to be affected by changes in land-use and soil management (Solomon *et al.*, 2002).

Chemical properties

The pH-H_2O values of soils varied from 6.77 to 7.10 (Table 1). The lowest value (6.77) was observed in the maize field, whereas the highest value (7.10) was recorded in banana field. According to Tan (1996), the pH range of the soils is neutral to near neutral, which is preferred range for most crops. The pH-H_2O values showed that there is no toxicity of aluminum, manganese and hydrogen, and hence the availability of nutrients such as K, Ca, and Mg especially in soils is not impaired (FAO, 2001). Similarly, the mean pH-KCl values of the soils ranged from 5.40 to 5.87 in the maize and banana fields, respectively and in all surface soils ΔpH (pH-H_2O -pH-KCl) values were positive, ranging from 1.10 to 1.47. Soil pH determination using KCl solution shows the presence of high potential acidity and weatherable minerals (Uehara and Gilman, 1981; Anon, 1993). Positive ΔpH values indicate the presence of net negative charges in soils; which increases the ability to hold onto cations at negatively charged sites within the soil and show the presence of high potential acidity and weatherable minerals (Buol *et al.*, 2003). The mean EC values varied among the four LUTs ranging from 0.11 to 0.51 dS/m, but remained within the optimum levels for cultivation of all LUTs (Table 1). The probable reason for low level of EC in cultivated lands might be due to the soil management practices that did not employ use of inorganic chemicals, which increase soil salinity (Clark *et al.*, 1998). Positive and very high correlation (r= 0.84***) was found between EC and exchangeable Na (Table 2). However, the exchangeable Na content and thereby the ESP values of the soils were low for all LUTs indicating the absence of sodicity in the studied soils (Table 1). The OC values decreased from 4.77 under natural forest to 1.32 in maize field (Table 1). The OC value under cultivated land was rated as low to medium (Tekalign, 1991) showing that continuous cultivation of soils enhances depletion of organic matter. The changes in TN during the last 30-40 years were found to be 69, 73 and 74% for mixed farm, monoculture banana and maize fields, respectively. The decline in TN could be attributed to the loss of organic matter due to continuous cultivation. Under continuous cultivation, soil OM declines approximately by 50% in 40 to 70 years, depending on the environment and the quantity of residue returned to the soil (Havlin *et al.*, 1999). Changes in management can also affect soil structure, OC, and other nutrients (Yeshanew *et al.*, 2004). Comparable losses of OC and nutrients due to cultivation of forest soils have been reported by David *et al.* (2006) where the differences were attributed to the effect of continuous cultivation that aggravates OC oxidation.

The TN content of soils under natural forest was very high (0.45%) in accordance with the rating of Havlin *et al.* (1999) and significantly different ($P \leq 0.05$) from all other LUTs, whereas the low TN value (0.12%) was recorded in maize field (Table 1). TN was positively and very highly correlated (r=0.99***) with OC (Table 2). The low levels of OC and TN in cultivated soils might have been the result of low biomass return to harvested land, greater C losses due to aggregate disruptions, increased aeration by tillage and crop residue burning all causing oxidation of organic material. This result is in conformity with the findings of Solomon *et al.* (2002) who indicated that loss of OC and TN is due to cultivation and tillage which increase aeration and oxidation of them. In contrast, greater OC and TN contents of the natural forest soils than the other land uses could probably be due to litter production and N fixation by the leguminous Acacia species. The C:N of the land uses followed the order; virgin land (10.3) <maize field (11.3), mixed fruit cropland (12.7) < monoculture banana field (16.0) showing the C:N ratios in soils of cultivated lands are higher compared to those under natural forest. The soil OC and TN associated with the annual crop management appeared to be more sensitive to changes in land use management compared with that of perennial crop system. It is generally accepted that C:N ratios between 8 and 12 (10:1) are considered to be the most favorable, implying a relatively fast mineralization of nitrogen from the organic materials (Ramesh *et al.*, 2007). Accordingly, the C:N ratios in the soils of the site indicate ideal conditions for plant growth.

The available Phosphorus (AP) contents followed the order: banana field >natural forest > mixed fruit cropland > maize field (Table 1) and were very high in accordance with Cottenie (1980) who rated AP (Olsen) contents as very low (<5), low (5-9), medium (10-17), high (18-25) and very high (>25mg kg^{-1}). The highest AP levels in the area might be due to irrigation/flooding in the alluvial flood plain that increase mineralization of organic P through solubility of Ca phosphate in calcareous soils (Havlin *et al.*, 1999). The exchangeable K levels ranged from 1.12 to 3.34 $cmol_c(+)kg^{-1}$(Table 1), which were high to very high in accordance with FAO (2006) whereby exchangeable K was rated as very low (< 0.2), low (0.2-0.3), medium (0.35-0.6), high (0.6-1.2) and very high (>1.2).The recommended threshold level of exchangeable K for most of the crops is 0.3-0.6 $cmol_c(+)\ kg^{-1}$. Thus, K is not a limiting mineral element to crop productivity for all studied LUTs, as was also generally accepted that response to K fertilizers is likely when a soil has an exchangeable K value of < 0.2$cmol_c(+)\ kg^{-1}$ soil and unlikely when it is above 0.4 $cmol_c(+)\ kg^{-1}$ soil (Anderson, 1973).

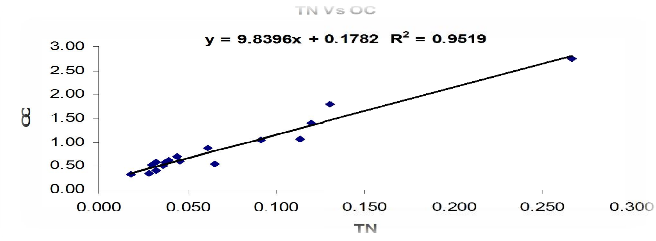

Figure 3. Relationships between TN and OC of surface soils in Abaya Chamo basin

The lowest level of K in cropland as compared to natural forest indicates increased losses of K during conversion of forest land into cropland due to run-off and removal of crop residues. In general, the K content of a given soil depends on the climatic condition, degree of soil development, the intensity of cultivation and the parent materials from which the soil is formed and particle size distribution. Soils formed from sedimentary materials are generally low in K content, while soils formed from crystalline rocks contain relatively high K (Buol *et al.*, 2003). The mean exchangeable Ca in the surface soils of the studied LUTs ranged from 29.96 to39.92 $cmol_c\ (+)\ kg^{-1}$ (Table 1). Exchangeable Ca was rated as very low (<2), low (2-5), medium (5-10), high (10-20) and very high (>20) by FAO (2006) and the recommended threshold level of Ca^{2+} for most crops is 5-10 $cmol_c\ (+)\ kg^{-1}$. Accordingly, the exchangeable Ca in all soils was very high indicating low bondage of Ca^{2+} to phosphorus since both Ca and AP are at very high ranges in neutral and near neutral soil pH levels. Our results also showed that Mg^{2+} content was high to very high in all LUTs with values ranging from 9.76 to14.86 $cmol_c(+)\ kg^{-1}$ (FAO, 2006) suggesting that the soils possess high inherent supply of Mg. The soils of all LUTs had very high cation exchange capacity (CEC) ranging from 45.67to55.87 $cmol_c\ (+)\ kg^{-1}$(Landon, 1991). The high CEC of the soils retain high level of nutrients including K^+, Ca^{2+} and ammonium (NH_4^+) for optimum production of most cultivated crops. It is generally accepted that soil OM is responsible for 25-90% of the total CEC of surface mineral soils (Oades *et al.*, 1989). CEC values in excess of 10 $cmol_c(+)kg^{-1}$ are considered satisfactory for most crops (FAO/IIASA/ISRIC/ISS-CAS/JRC, 2012). Percent base saturation (PBS) of the soils was very high ranging from 95 to 100 (Table 1), indicating the presence of calcareous soil material and excess soil nutrients in the soil. Soils with high PBS are considered more fertile since many of the “bases” contributing to PBS are plant nutrients. PBS is also directly related to soil pH and represents the relative availability of many positively charged nutrients (Cations) such as Ca^{2+}, Mg^{2+}, and K^+ (Bandle and Meisinger, 2002). The

Table 2. Pearson's correlation matrix of surface soil properties (0-30cm); Abaya-Chamo basin

Treat	Fe	Mn	Zn	Cu	EC	Silt	Clay	Na	K	Ca	Mg	CEC	PBS	TN	OC	AP
Fe	1	0.54	-0.29	-0.3	0.06	0.15	-0.26	0.02	0.11	-0.24	-0.05	-0.48	0.19	-0.03	0.04	0.17
Mn		1	-0.65*	0.12	-0.5	-0.5	0.41	-0.66*	-0.66*	0.29	-0.23	0.02	-0.03	-0.49	-0.46	-0.52
Zn			1	0.07	0.55	0.42	-0.23	0.56	0.65*	-0.36	0.16	-0.38	0.19	0.54	0.56	0.82***
Cu				1	-0.74**	-0.68*	0.73**	-0.54	-0.36	-0.38	-0.63*	0.52	-0.74**	-0.74**	-0.74**	-0.18
Ec					1	0.74**	-0.78**	0.84***	0.69*	0.05	0.55	-0.58	0.66*	0.98***	0.98***	0.61*
Silt						1	-0.64*	0.61*	0.75**	-0.02	0.59	-0.52	0.57	0.69*	0.72**	0.64*
Clay							1	-0.75**	-0.66*	-0.03	-0.32	0.54	-0.53	-0.76**	-0.75**	-0.45
Na								1	0.70*	-0.1	0.58	-0.60*	0.58	0.75**	0.74**	0.55
K									1	-0.4	0.23	-0.47	0.29	0.61*	0.64*	0.87***
Ca										1	0.47	-0.06	0.56	0.12	0.08	-0.57
Mp											1	-0.52	0.81***	0.47	0.46	0.08
CEC												1	-0.82**	-0.52	-0.56	-0.54
PBS													1	0.63*	0.63*	0.2
TN														1	0.99***	0.56
OC															1	0.61*
AP																1

, **, * Significant at 0.05, 0.01 and 0.001 P levels,*

concentration of available micronutrients in the surface soils were found to be Fe>Mn> Cu> Zn (Table1). The mean values of available micronutrients in the soils ranged from 9.69 to 15.46 $mgkg^{-1}$ for Fe; 9.21 to 13.18 $mgkg^{-1}$for Mn; 0.60 to 1.20 $mgkg^{-1}$for Zn and 0.69 to 1.13 $mgkg^{-1}$for Cu and only available Cu and Zn were significantly ($P \leq 0.05$) affected by LUTs (Table 1). Furthermore, the amounts of Fe, Mn and Cu in surface soils were sufficient compared to that of Zn, which was marginal to sufficient, and may not be deficient for crop production. This is in agreement with various works, which stated that Zn contents are variable, and Fe and Mn contents usually at an adequate level in Ethiopian soils (Desta, 1982; Fisseha, 1992). The solubility and availability of micronutrients is largely influenced by clay content, soil pH, SOM, CEC, phosphorus level in the soil and tillage practices (Fisseha, 1992). Cu in the soil is adsorbed on clays and complexed with soil OM, thus inducing its retention and immediate unavailability for plant use. The available Fe and Cu were influenced by land use changes. The available Mn and Zn in the surface soils were not significantly varied may be due to complex formation with organic compounds that protects their leaching (FAO, 2006).

Influence of Changes in Land Use Management on Dynamic Soil Properties

The soil quality is a combination of inherent and dynamic soil properties. Landuse management practices provide the basis for evaluating quality and sustainability of dynamic/ management–dependent soil properties. Significant differences among land use were observed in terms of OC, TN, C:N, EC, and available Cu (Table 1). Also, the statistical analysis revealed that most of the soil physicochemical properties such as EC, %silt, %clay, exchangeable bases (Na, K, Ca, Mg), TN, OC, C:N, AP and Fe were significantly influenced by land use management practices (Table 1) indicating land use management factors largely determine changes in soil properties. Most of the soil properties considered in this study was influenced by differences in land use management (conversion of it from natural forest to cultivation). Changes in dynamic soil properties including organic matter, soil structure, bulk density, and water and nutrient holding capacity, depend on land management practices 'influence (Jenny, 1941). Nearly four times increment in soil OM and TN were obtained in the natural forest over 30-40 years period. Murphy (1968) reported that the soil OM and TN contents of the natural forest site were 2.32 and 0.11%, and the respective values increased to 9.04 and 0.45% at present. On the other hand, inappropriate land management aggravated the rate of degradation of these soil properties. The temporal changes in TN was similar to those of OC content for surface soils with a depletion rate of about 2.4% per year for maize field; 2.4 to 2.1% for monoculture banana, and 2.3 to 2.1% for mixed fruit crop land when compared to the virgin land. The TN and OC differed significantly between land uses and decreased with cultivation time. The changes in soil that decrease its productivity for crop plant may follow from three processes: cropping, erosion and leaching. These may adversely affect the physical condition and/or the chemical composition of the soil. Inappropriate land management affects basic processes such as erosion, soil structure and aggregate stability, water and nutrient holding, leaching, carbon sequestration, and other similar physical and biochemical processes (Saikhe *et al.,* 1998; Maddonni *et al.,* 1999). Processes in the soil depend on many factors such as land use systems, soil types, topography, and climatic conditions (Jenny, 1941). There was no significant influence of land use management change on some soil properties such as soil pH, %sand, CEC, PBS, Mn, and Zn contents (Table 1) indicating, at least, some of the stable soil properties are not responsive to land use management. IIASA (2006) also showed that CEC and particle size were not responsive to land use management effects. In general, soil functions depend on both stable and dynamic soil properties. The difference between management–dependent and inherent soil properties vary at temporal scales ranging from months and years to centuries (Jenny, 1941) and at spatial scales from millimeters to hundreds of kilometers. Over a sufficient time period, practices that affect dynamic soil properties and stable soil properties will change. This is because land attributes are based on (1) climatic factors, (2) internal soil properties (temperature-regime, moisture regime, effective depth, pH, EC), and (3) external soil properties (slope, occurrence of flooding, erosion and soil accessibility) (Lal, 1996).

Conculision and Recommendation

The soil properties considered in this study were mainly influenced by differences in land use management (Table1). The depletion of OC and TN from the surface soils of maize field compared to natural forest was 61 and 59%, respectively. Similarly, respective depletion of 48.5 and 55.5% in banana field and 34 and 52% in mixed fruit cropland were recorded for OC and TN within the past 30-40 years. The soil OC and TN associated with the annual crop management appeared to be more sensitive to changes in land use management compared with that of perennial crop management. Likewise, the depletion of CEC of surface soils from the banana field and the maize field was 32 and 13%, respectively, as compared to the CEC under the natural forest. The available micronutrients, especially Fe and Cu, were also influenced by different land-use systems (Table 2). Generally, chemical properties such as PBS, exchangeable K, Ca and Mg, AP, Mn and Fe contents were high under virgin land as compared to cultivated LUTs. Nutrients concentrations and most of soil properties showed NF >FrBa>FrBaMa>CeMa. Long fallow period and reestablishment of deep-rooted perennial plants improved soil productivity and reduced nutrients removal from the system. For instance, substantial quantities of OM were returned to the soil and the soil was protected against erosion in the banana fields. This was attributed to there-growth of banana from underground shoots, if the above ground parts of the plant are destroyed, whereas annual crops leave the soil bare and susceptible to erosion. Management practices that increase OC and TN in the system should be included, when the land is continuously cultivated. Further studies on selection of appropriate leguminous specious that bring N to the system, nutrient flows and soil-plant analysis are also recommended to draw sound conclusion.

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