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Evaluation of the Effect of Land Use Types on Selected Soil Physico-Chemical Properties in Itang-Kir Area of Gambella Region, Ethiopia

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Abstract

Changes in land use type and soil management can have a marked effect on soil physical and chemical properties. This study was conducted at Itang-kir area which is located in Itang special district of Gambella Regional State, Ethiopia. The aim of the study was to investigate the effect of land use types on selected physico-chemical properties of the soils. Cultivated and grazing land types were considered for the study. Cultivated and grazing land use types were adjoining to each other. Based on soil texture and slope class four land units were recognized from both land use types(IK1, IK2, IK3 and IK4).A total of eighteen composite soil samples were collected from both land use types from 0-20cm soil depth for laboratory analysis. The results of the experiment revealed that both land use types had a clay, sandy clay loam, sandy clay and sandy loam texture in all land units. The highest bulk density (1.39gcm^{-3}) was observed in IK4 of grazing land and the lowest (1.24gcm^{-3}) was observed on IK1 of cultivated land. The highest soil bulk density recorded in grazing land might be resulted from livestock compaction. Soil pH (H_2O) rated as neutral to moderately alkaline for cultivated and neutral to strongly alkaline for grazing land units. For soil organic matter content the highest (4.82%) and the lowest (2.10%) were recorded in grazing land whereas the highest (3.82%) and the lowest (1.8%) were recorded in cultivated land. Total nitrogen ranged from 0.29% - 0.10% for grazing land and from 0.24% - 0.10% for cultivated land. Available P recorded in grazing land ranged from 61.29 to 16.18 and 58.95 to 15.25 mg kg^{-1}in cultivated land use type. Available P status of the two land use types is from high to very high. The high available P content of the soil may be due to parent material and soil reaction. Exchangeable bases, cation exchange capacity, percent base saturation and extractable micronutrient cations (Fe, Mn, Zn and Cu) were also higher in grazing land use compared to cultivated land. The concentration of the basic cations in the soils' exchange sites was in the order of Ca > Mg > K > Na. The highest and the lowest mean values of CEC were 52.27 and 23.20cmolc kg^{-1}in grazing land and 44.08 and 22.53 cmolc kg^{-1} on cultivated land for land units IK1 and IK4, respectively. Therefore both land use types had high CEC except on land unit IK4 which revealed medium CEC value. While the contents of extractable micronutrients were relatively higher in the grazing as compared to cultivated land use this could be rated sufficient for Fe, adequate for Mn and Zn, whereas marginal to deficient level for Cu for both land use types. From this study one can conclude that crop cultivation has led to more essential nutrients removal compared to livestock and adversely affect soil chemical properties. Therefore, integrated soil fertility management that maintain and improve physical, chemical and biological properties of soil should be implemented on cultivation land types in order to optimize and sustain crop production.

Keywords: land use type, Soil chemical properties, land units

Introduction

Soil fertility maintenance is a major concern in tropical Africa, particularly with the rapid population increase, which has occurred in the past few decades. In traditional farming systems, farmers use bush fallow, plant residues, household refuse, animal manures and other organic nutrient sources to maintain soil fertility and soil organic matter. Although this reliance on biological nutrient sources for soil fertility regeneration is adequate with low cropping intensity, it becomes unsustainable with more intensive cropping unless mineral fertilizers are applied (Mulongey and Merck, 1993).

Changes in land use and soil management can have a marked effect on the soil organic matter stock**.** Several studies in the past have shown that deforestation and cultivation of virgin tropical soils often lead to depletion of nutrients (N, P, and S) present as part of complex organic polymers. Bernoux *et al.* (1998) indicated that long practices of deforestation and/or replacement of natural forests by agroecosystem and uncontrolled overgrazing have been the major causes for soil erosion and climatic change. Since harvested trees are not replaced and, thus, expose the soil, about 1.9 to 3.5 billion tons of fertile top soils are washed away annually into rivers and lakes due to deforestation alone (Lakew*et al.*, 1998). As a result, the soil temperature rises above the tolerance level of soil microorganisms that ameliorate the soil physical and chemical properties (Bernoux*et al.,* 1998). Thus, the soils of such areas finally become almost dead (lost their fertility), showing little microbial activities and less favorable for plant growth. Since erosion removes the finer soil particles, OM and their colloids fractions, and since such materials furnish most of the microbiological activities and the base exchange capacity of the soils thereby providing ample storage for plant food, the removal of such essential particles and their colloids decrease the fertility of the soils (Assefa, 1978).

In the Ethiopian highlands, population pressure which accounts for 85% of the country's total population as well as 67% of its livestock population has pushed cultivation and livestock grazing to steep slopes and fragile lands causing serious overgrazing and soil erosion. The lowlands of the Gambella region particularly Itang special district where the present study was conducted are not exceptions of these problems. However, no little effort has been done to maintain the fertility of the soils in the area and the locally available data of soil fertility status are insufficient. As a consequence of continuous cultivation and intensive grazing of land without proper management resulted in decline in soil physical, chemical and biological properties which aggravate crop yield reduction and food shortage. Nowadays, due to increasing population pressure and shortage of new innovation in the area land, degradation and free grazing activities are being carried out on previous land which used for many years. This in turn has led to declining soil productivity and shortage of livestock fodder. Therefore, the objective of this study was.

To investigate the effect of land use system on selected physico-chemical properties of the soil in Itang- kir area.

Material and methods

Description of the study area

Location

The study was conducted at the Itang-kir, which is located in Etang special district of Gambella People National Regional State. The study area is located in the western part of Ethiopia between 8^0 2′ 00″ to $8^0$11′00″N and 34^0 12′ 00″ to 34^0 18′ 15″E. Itang-kir is situated at about 45 km from Gambella town in the West direction and at about 823 km West of Addis Abeba and at an altitude ranging from 425 to 470 meters above sea level.

Climate

The agro-ecology of Itang area falls within the hot to warm humid low land plain sub-agro ecological zone (Yeshi Ber Consultant,2003).The area is characterized by uni-modal rainfall pattern with the annual average of 1054mm.The rainy season starts at the end of April and lasts in the end of October with maximum rainfall in the months of July and August. The mean annual maximum and minimum temperatures are 38.9^0C and 15.8^0C, respectively.

Land use and farming system

The major crops grown in Itang-kir area include maize (*Zea mays L.*), sorghum (*Sorghum bicolor*), haricot bean (*Phaseolus vulgaris L.*) and horticultural crops are also grown on small-scale levels. The command area of the study area is characterized by an average slope of 1 to 2% which is suitable for irrigation development with regards to slope as well as climate conditions of the soils.

The average land holdings in the study area are 0.5ha. Maize is the major crops commonly produced under rainfed. The other means on which the farming community depends to sustain their family life is mostly fishery and small number animal husbandry. Livestock and their products are supplementary sources of food and income to the farmers in this area, like it is the case in other areas where mixed crop-livestock farming is practiced. This economic activity like the case in crop production is characterized by smallholding and its subsistence nature.

Soil sampling and analysis

At the beginning, a general visual field survey of the area was carried out to have a general view of the variations in the study area during the year of 2014. Two major land use types (grazing and cultivated) were recognized. The cultivated and grazing land use types selected for this study selected for this study are found on the same sub-catchment adjacent to each other. Based on soil texture and slope class four land units were (IK1, IK2, IK3 and IK4) were identified in cultivated and the same land units in adjacent grazing land use type.

Composite soil samples were collected from each land unit for laboratory analysis. A total of eighteen composite soil samples, three replications from IK1 and two replications from other land units were collected from 0-20cm depth. Collected soil samples were air dried, well mixed and passed through a 2mm sieve but samples for determination of organic carbon, total N, and available P were ground to pass 0.5mm size sieve.

Analysis ofselected soil physical properties

Soil texture was analyzed by the hydrometer method. Bulk density was determined from undisturbed soil samples following method (Sahlemedhin and Taye, 2000). Total porosity was estimated from the values of bulk density and particle density, with the latter assumed to have the generally used average value of 2.65 g cm^{-3}as:

$$\text{Total porosity}(\%) = (1 - \frac{\text{BD}}{\text{PD}}) \times 100$$

Analysis ofselected soil chemicalproperties

Soil chemical properties considered for this study were pH, electrical conductivity, organic carbon, total nitrogen, available phosphorous, exchangeable bases (Ca, Mg, K and Na), cation exchange capacity and extractable micronutrient cations. The pH of the soils was estimated in water and potassium chloride (1M KCl) suspension in a 1:2.5 (soil: liquid ratio) potentiometrically using a glass-calomel combination electrode (Van Reeuwijk, 1992). Electrical conductivity was measured by conductivity meter on saturated soil paste extracts obtained by applying suction Jackson (1973). To determine organic carbon, the Walkley and Black (1934) method was employed in which the carbon was oxidized under standard conditions with potassium dichromate in sulfuric acid solution. Finally, the organic matter content of the soil was calculated by multiplying the organic carbon percentage by1.724. The total nitrogen was determined using the Kjeldahl procedure by oxidizing the organic matter with Sulfuric acid and converting the nitrogen into NH_4^+ as ammonium sulfate. Determination of available phosphorous was carried out by the Olsen method using sodium bicarbonate (0.5M$NaHCO_3$) as extraction solution (Olsen *et al*., 1954).

Cation exchange capacity and exchangeable bases (Ca, Mg, K and Na) was determined after extracting the soil samples by ammonium acetate (1N NH_4OAc) at pH 7.0. Exchangeable Ca and Mg in the extracts were measured using atomic absorption spectrophotometer, while Na and K were analyzed by flame photometer (Chapman, 1965; Rowell, 1994). Cation exchange capacity was thereafter estimated titrimetrically by distillation of ammonium that was displaced by sodium from NaCl solution (Chapman, 1965). Percent base saturation was calculated by dividing the sum of the charge equivalents of the base-forming cations (Ca, Mg, Na and K) by the CEC of the soil and multiplying by 100. Percent base saturationwascomputedasthepercentageofthesumoftheexchangeablebases to the CEC of thesoil. Similarly, exchangeable sodium percentage was calculated as the percentage of exchangeable Na to the CEC of the soil. Exchangeable Micronutrientcations (Fe, Cu, Zn and Mn) were extracted by DTPA extraction method (Lindsay and Norvel, 1978) and all these micronutrients were measured by atomic absorption spectrophotometer.

Statistical analysis

Descriptive statistics was used to reveal the relationships between the two land use types. Land units were compared with each other by referring critical values for the selected physico-chemical properties of soils.

Results and Discussion

Site characteristics

The study area characterized by level to gentle slopping and categorized in into four land units based on soil texture (Table 1). Accordingly, the clay texture was characterized by nearly level to very gently sloping land (0.5-2%) with moderately deep soils, which occupied more than 75% of cultivated land takes place in this site, because it is located at the nearby the Baro river, it is cultivated twice a year because of this reason three replicated composite soil sample which make a total of six composite soil samples were augured for the two land units of IK1 of cultivated land and grazing land use types. The second land unit is sandy clay loam in texture (IK2) it was also nearly level to gently sloping land (1–2.1%) with relatively less cultivated land and cultivated only single season because relatively far from the Baro river. The third land unit is sandy clay in texture (IK3) which is cultivated only single season because a relatively far from Baro river whereas the last land unit is sandy clay texture (IK4) with similar slope position with that of IK2 and IK3 high property of sandy texture and less cultivated and livestock grazing take place in this site.

Soil physical properties

Particle size distribution

The particle-size determination showed that the soils of the study area are clay; sandy clay loam; sandy clay to sandy loam in texture. The higher clay content was observed in IK1 for both land use types that might be due to an alluvial deposition in the vicinity of Baro river. This also suggests that the crop cultivation in the area had no significant effect on the soil texture of the study area, since texture is an inherent soil property that cannot be influenced in short period of time.

Table 1. Soil texture, bulk density and total porosity of the two land use types

	Particle size (%)					
Land Unit	Sand	Silt	Clay	Class	BD (g cm^{-3})	TP
Grazing land						
IK1	21.50	31.50	47.00	C	1.25	52.80
IK2	56.00	10.00	34.00	SCL	1.34	49.40
IK3	47.00	12.00	41.00	SC	1.26	52.40
IK4	54.00	32.00	14.00	SL	1.39	47.50
Cultivated land						
IK1	22.00	32.50	48.00	C	1.24	53.20
IK2	54.00	11.50	34.50	SCL	1.29	51.30
IK3	48.00	10.80	41.20	SC	1.28	51.60
IK4	5.00	30.50	14.50	SL	1.37	48.30

Where, IK = Itang-Kir; BD = bulk density; TP = total porosity; C=clay; SCL=sandy clay loam; silt clay; silt loam

Bulk density and total porosity

The bulk density values varied in response to land use types (Table 1). The results indicate that bulk density value increased from the cultivated land to grazing land use type in all land units except in IK3. Relatively the highest bulk density (1.39 g cm^{-3}) was recorded under grazing land use type at the sandy loam textural class in IK4 land unit, while the lowest bulk density value (1.24 g cm^{-3}) was recorded on cultivated land use type of the clay textural class in IK1 land unit, (Table 1). The highest bulk density figure obtained at IK4 in two land use types this probable due to the soil compaction encountered as a result of livestock trampling and large sand proportions. Grass land in such traditional agriculture is subject to free and year-round grazing. This continuous cattle grazing and small ruminant browse puts pressure over this limited land resource due to the high stocking rate.

These might probably create unfavorable soil condition through limiting root growth and air circulation, which in turn have negative implications for agricultural productivity. In general, similar findings were also reported by Tsehaye and Mohammed (2013), but contradict with many authors Islam and Weil (2000).

However the lowest bulk density values were observed in all cultivated land use type in the study area except in IK3. The reason that can be explained the lowest bulk density value was attached to the traditionaltillage practices used by the people in the study area. The people in the Itang-ker area do not use oxen ploughed or other machinery but they used their own traditional tillage equipment known as '*shella*' plowing. The '*shella*' plowing practice may not temporarily disturb soil aggregate much compared to other plowing methods. This might be the reason for lower bulk density values in cultivated land use type than the value of bulk density in grazing land use. Similar findings were also reported by Nega (2006).

Generally, the bulk density of soils showed increasing trend from cultivated to grazing land, by 0.8, 3.87, 1.45% in IK1, IK2, IK4, respectively. Whereas the bulk density of soils on land unit IK3 of cultivated land increased by 1.56% as compared to the grazing land (Table 1). The reason may be due to difference in soil OM content among land units.

The acceptable range of bulk density is 1.3 to 1.4 g cm^{-3} for inorganic agricultural soils (Bohn *et al.*, 2001). Therefore, the bulk density values of the land units were within the acceptable range. Bulk density is one of the major physical parameters used to evaluate the physical fertility status of soils. In view of this, bulk density values of the soils in the study area were not too compact to limit root penetration and restrict movement of water and air. This indicates the existence of loose soil conditions in all land use types and, hence, good structure.

The total porosity of the soils, in general, varied with bulk density. Accordingly, total porosity increases as the bulk density decreases while it decreases as bulk density increases. The total porosity of the soils ranged between 48.3 - 53.2% and 47.5 -52.8% in the cultivated and grazing land use types, respectively (Table 1). The higher values of total porosity corresponded to the higher amount of organic matter contents and lower bulk density. Similar results were reported by Mohammed (2003) and Wakene (2001) for soils of Jelo sub-catchment in the Chercher highlands and in Bako area of western Ethiopia.Soil of grazing land is highly subjected to compaction by animal trampling and subsequently decreased porosity than soils of cultivated lands.

According to the FAO (2006b) rating of total porosity, the percent total porosity of all the land units was very high. In terms of soil physical fertility the total porosity observed on all land units could enable the soils of the study area to provide good aeration for plants and microorganisms.

Soil chemical properties

Soil reaction and electrical conductivity

Soil pH values measured in a suspension of 1:2.5 soil to water ratio (pH in H_2O) were greater than the pH values measured in the same ratio of soil by KCl solution (pH in KCl) regardless of the land units and land use types.Anon (1993) also reported the increase in soil acidity due to measurement of pH in KCl solution showing the presence of high potential acidity.

The highest (8.20) and the lowest (6.86) soil pH-H_2O values were recorded under the grazing and cultivated lands, respectively (Table 2). The lowest pH value under the cultivated land could be due to continuous removal of basic cations by harvested crops and higher microbial oxidation that produces organic acids, which provide H ions to the soil solution and thereby lowers soil pH.

These results are in agreement with those of several others (Gebeyehu, 2007; Papiernik*et al.,* 2007; Habtamu*et al*., 2009; and Fantaw and Abdu, 2011) who reported a substantial reduction of pH in surface soils subject to long-term cultivation compared to the uncultivated site.

According to soil pH classification set by Tekalign and Haque (1991), the pH-H_2O values in cultivated land use are rated as neutral to moderately alkaline and that of the grazing land use system rated as neutral to strongly alkaline reaction. Based on the pH-H_2O category, soils of the study site are suitable for most crops, since most of essential nutrients become available at pH above 5.5 (Landon, 1991).

The electrical conductivity of soils in both land use types were found to be well below unity (Table 2). Considering the two land use types, the highest (0.56 dS m^{-1}) and the lowest (0.24(dS m^{-1}) EC of the soils were recorded in the grazing and cultivated land use types in (IK3, IK1), respectively (Table 2).

The highest EC value under the grazing land might be due to its highest exchangeable Na content, whereas the lowest EC value under the cultivated land can be associated with the loss of base forming cations (Ca^+ and Mg^+) through intensive cultivation. According to the U.S Salinity Laboratory Staff (1954) classification, a soil is required to possess EC values greater than 4 dS m^{-1}in order to qualify for saline and/or saline-sodic soil. This classification is based only on the EC which sets 4 dSm^{-1} at 25 ^0C as the lowest values for a soil to qualify the saline soil category regardless of its pH values.

Generally, the EC values measured in all land units in the study site indicated that the concentration of soluble salts are far below the levels at which growth and productivity of most agricultural crops are affected therefore, is conducive for agricultural productivity (Landon, 1991).

Table 6. Soil pH, EC, OM, total N, C: N ratio and Av. P of the two land use types

Land unit	pH (H_2O)	EC (dS m^{-1})	OM (%)	Total N(%)	C: N	Av. P
Grazing land						
IK1	6.95	0.28	4.82	0.29	9.02	61.29
IK2	7.59	0.42	2.48	0.10	15.31	40.67
IK3	8.20	0.56	3.18	0.17	10.63	24.48
IK4	8.10	0.48	2.10	0.12	10.60	16.18
Cultivated land						
IK1	6.86	0.24	3.81	0.25	9.02	58.95
IK2	7.29	0.42	2.41	0.09	15.38	38.34
IK3	7.92	0.47	2.68	0.16	10.00	17.52
IK4	7.87	0.50	1.80	0.11	10.47	15.25

Where, IK=Itang-Kir; EC=Electrical conductivity; OM=Organic Matter; TN=Total nitrogen; AVP= Available phosphorous

Organic Matter, Total Nitrogen and C: N Ratio

Organic matter has an important influence on soil physical and chemical characteristics, soil fertility status, plant nutrition and biological activity in the soil (Brady and Weil, 2002).

Organic matter contents were highly affected by soil texture and slightly by land use types. The values increased from cultivated to grazing land usesoils across all land units. The organic matter content of the soils varied from 2.1 to 4.82% for grazing land. In cultivated land use types it ranged from 1.8 to 3.81% (Table 2).

The average content of soil OM among land use types , were lower in cultivated land use types as compared to that of grazing land. The difference could be attributed to the effect of continuous cultivation that aggravates organic matter oxidation. The roots of the grass and fungal hyphae in the grassland soils are probably responsible for the higher amount of total organic matter (Urioste*et al.,* 2006). The results were in agreement with the findings of Negassa (2001) and Malo et al. (2005), who reported less organic carbon in the cultivated soils than grassed soils.

The study showed that cultivation slightly depleted OM content by 20.95, 2.8, 15.7and14.28% in (IK1 IK2 IK3, IK4), as compared to the corresponding grazing land use type (Table 2). The mean depletion level of soil organic matter in cultivated land use was by 14.8% as compared to grazing land type (Table 2). This is attributed complete removal of biomass by crop harvest.

Soil analysis in this study depicted that when the values of OM content increased, the contents of total N also increased and vice versa showing the direct relationship between them. Tayeet *al.* (2003) also reported that the incorporation of high proportion of OM containing decomposed materials as a major component appreciably increased the organic carbon and total N contents.

Based on the critical level given by Berhanu (1980), the Organic matter content of land unit IK1 and IK3 was medium. Whereas, the remaining land units were rated as low for two land types.

Total N content of the soils was affected by land use and soil textural class. Total soil N at grazing land use type varied from 0.098% to 0.294 under IK2, IK1 land unit and at cultivated land use type to 0.091%to 0.245 under IK2, IK1 land units (Table 2). It declined with shift of land uses from grazing land into cultivated fields, and average total N increased from cultivated 0.597% to grazing 0.681% soils, which again declined with increasing sand content, (0.294%) in clay texture to (0.091%) in the sandy clay loam textural class soils.

The considerably large losses of total nitrogen in the continuously cropped fields could be attributed to rapid mineralization of soil organic matter following cultivation, which disrupts soil aggregates, and thereby increases aeration and microbial accessibility to organic matter (Solomon *et al.*, 2002). Reduced input of plant residues in such cereal based farming into the soils also has contributed to the depletion of soil OM and soil N in these cultivated soils. Therefore, according to critical value set by Havlin*et al* (1999), in the study area land units (IK2, IK4) are rated as low for grazing and cultivated land use types, whereas land unit (IK1) is rated as high in grazing and medium in cultivated land use type. However, for IK3 land unit it was rated as medium for grazing and low for cultivated land use types (Table 2).

C: Nratio of the soils has shown slight variations for land use types. The ratio was slight narrower in soils of cultivated land as compared to grazing land use types except for IK1 land unit, this indicate that mineralization and oxidation of organic matter is higher in cultivated soils. This is in agreement with Seeber and Seeber (2005) who reported that cultivation alters humus content and thus narrows the C/N ratio. Grazing lands usually have higher C and N contents than cultivated lands, because cultivation leads to losses of C and N. As the loss of N due to cultivation is much lower than the loss of C, the C/N ratio narrows.

Foth and Ellis (1997) reported that soils with C:N ratio in the range of 10-12 provide nitrogen in excess of microbial needs. Therefore, the result recorded in all land units except IK2 land unit of grazing and cultivated land use types indicated optimum range of C:N ratio for active microbial activities forhumification and mineralization of organic residues (Table 2).

Available phosphorus

The available phosphorus content of the grazing land use system ranged from 16.18 in (IK4) land unit to 61.29 mg kg^{-1}in (IK1) land unit, which could be categorized from high to very high level whereas that of cultivated land use type ranged from 15.25 to 58.95 mg kg^{-1}for similar land unit (Table 2), which are also similarly categorized under high to very high (Landon (1991). Relatively, the maximum 61.29 and 58.95 mg kg^{-1} available P was recorded in both land use types in (IK1) land unit where the pH values were near neutral (6.8, 6.95), with low P fixation.

According to Carrow*et al.* (2004), P-Olsen between 12 to 18 mg kg^{-1} is considered as sufficient and hence the available P in all land use was in sufficient range. It was also reported that soil P is more available in warm soil than in cool soil (Hartz, 2007). Therefore, P availability in the soils might have been favored by the warm climatic condition of the study area along with the preferred pH range. The highest content of available P observed at IK1 in both land use types in the study area is might probably due to the relatively high organic matter content or high inherent P content of the parent material. This result is in agreement with the results reported by two authors (Yacob, 2012; Teshome, 2013) that available P content of soils in the Gambella region varied from low to high range.Engdawork (2002) recorded similar result (87.02 mg kg^{-1}) of available P in the surface soil (0-18cm) of the Phaeozems soils in the Werkarya area, south Wello.The available soil phosphorus content is adequate for the optimal crop production and thus phosphorus fertilizer application is not praise worthy. This phosphorus content is accounted for moderately alkaline pH of the soil in which there is no fixation of phosphorus by either Ca or Mg and soil pH is appropriate for the availability of phosphorus.

Exchangeable bases

The results revealed that the contents of exchangeable in grazing land Ca and Mg varied from 3.21to 9.49 and 1.91to 4.46 cmolc kg^{-1}, whereas cultivated land varied from 3.18 to 7.67 and 1.75to 3.44 cmolc kg^{-1}, respectively, on the other hand exchangeable K in grazing land varied from 1.38 to 2.37 cmolc kg^{-1} and cultivated land varied from 1.32 to 1.96cmolc kg^{-1}. In accordance with the ratings of FAO (2006b) the soils are categorized under low to medium for Ca, medium to high for Mg and very high in terms of K.

The exchange complex was found to be dominated by Ca followed by Mg, K and Na, which could be considered as appropriate for plant growth. Bohn *et al.* (2001) pointed out that the cations in productive agricultural soils are present in the order $Ca^{2+} > Mg^{2+} > K^{+} > Na^{+}$ and deviations from this order can create ion-imbalance problems for plants.

The contents of both exchangeable Ca and Mg decreased in the coarser textural class soils of the two land use systems and increased in clay textural class as well as in grazing land use (Table 3). This could be probably due to the contribution of more OM by the grazing land and addition of more farmyard manure to the grazing land use types than the cultivated land use types. The lowest value obtained on the cultivated land could be also be related to influence of intensity of cultivation and abundant crop harvest with little or no use of input as reported by Singh *et al.* (1995) and He *et al.* (1999). In agreement with this, several researchers reported that exchangeable bases were highly influenced by OM content of the soil maintained due to virgin land management or added to the soil of cultivated land (Taye*etal.*, 2003; Heluf and Wakene, 2006).

According to the rating suggested by FAO (2006a) exchangeable Na is high in the two land use types. However, numerically it is higher in the grazing land use then the cultivated land types of the study area. The highest and lowest mean values of exchangeable Na were 1.96 and 1.02 cmol (+) kg^{-1} in grazing land use types at IK3, IK1respectively, and in cultivated land use the highest was 1.65 and the lowest 0.95 cmol (+) kg^{-1} were obtained at IK3, IK1 land units respectively (Table3). The highest content at IK3 land unit could be with its high pH value in the respective land unit. The possible reason for increase of exchangeable Na in the study area could be due to low leaching conditions and low erosion might have allowed exchangeable Na to settle and concentrate on the soil surface (Table 3).

Table 7. Exchangeable bases, CEC, base saturation and ESP

Land Unit	Exchangeable base (Cmolckg^{-1})				CEC(cmolkg^{-1})	PBS	ESP
	Ca	Mg	K	Na			
Grazing land							
IK1	9.49	4.46	2.37	1.02	52.27	29.80	1.95
IK2	5.37	2.05	1.38	1.07	25.82	38.20	4.14
IK3	6.32	2.96	1.98	1.96	33.50	39.46	5.85
IK4	3.21	1.91	1.4	1.34	23.20	33.80	5.77
Cultivated land							
IK1	7.67	3.44	1.96	0.95	44.08	31.80	2.15
IK2	5.33	1.92	1.32	1.00	27.75	34.48	3.60
IK3	6.11	2.34	1.96	1.65	32.40	37.20	5.09
IK4	3.18	1.75	1.32	1.28	22.53	33.30	5.68

Where, Ik=Itang-Kir; PBS=percent base saturation; ESP=exchangeable sodium percentage

Cation exchange capacity and percent base saturation

The CEC values of the soils in the study area were affected by soil texture (clay content) and by land use types.The highest CEC (52.27 cmolkg^{-1}) was registered in grazing land use types soil while the lowest (22.53 cmolkg^{-1}) was recorded in cultivated land soil (Table 3). The observed variation in the contents of soil CEC among the four land units is probably due to strong association of CEC with soil organic matter and soil texture. Basically, CEC of soil depends on the relative amounts and type of colloidal substances (OM and clay) as both provide negatively charged surfaces that play important role in exchange process (Montecillo, 1983). The low CEC in cultivated land was in line with the low organic matter contents of the soils under this land use (Tables 3). The soil CEC values in cultivated land uses decreased mainly due to the reduction in organic matter content Nega and Heluf (2009)

All cultivated land use except IK2 showed reduction in CEC value; this could be due to continuous cropping and limited recycling of crop residues that might have contributed to depletion of basic cations of soils under *shalla*cultivation as compared to the uncultivated land. In line with this finding, Alemayehu (2007) and Fentaw and Yimer (2011) have reported that the depletion of OM as a result of intensive cultivation could have attributed to the lower CEC of the soils. According to Landon (1991), the soils having CEC of > 25, 15-25 cmol (+) kg^{-1}, 5-15 cmol (+)kg^{-1} and < 5 cmol (+)kg^{-1} are classified as high, medium, low and very low, respectively.

Based on the above ratings, the CEC of the study area rated as high for land unit IK1, IK2 and IK3, whereas IK4 rated as medium status of CEC values both land use types (cultivated land and grazing land use).

The percent base saturation of the study area soils varied from 29.8% to 39.46% for grazing land use types whereas cultivated land use types it ranged from 31.8% to 37.20% on land unit IK1 and IK3 respectively (Table 3).However, as per the ratings recommended by Hazelton and Murphy (2007), the value of PBS of the two land use types classified as medium status of percent base saturation values. The trends of the distribution of PBS showed similarity with the distribution of CEC, exchangeable Ca and Mg, since factors that affect these soil attributes also affect the percentage base saturation.

The cultivated land showed lower values of cation exchange capacity and percentage base saturation except for IK1 land unit in PBS. This suggesting intensive cultivation high soil disturbance applied in the cultivated land use types than the grazing land use types. As the PBS increases, the soil pH and the availability of basic nutrient cations to plants also increases (Bohn *et al*., 2001). Previous research work conducted by Eyelachew (1999) on fertility status of some of Ethiopian soils indicated that, exchangeable bases, especially Ca and Mg ions dominate the exchange sites of most soils and contributed increase to the PBS. The present study is contradictory with two authors (Yacob, 2012; Teshome, 2013) who reported higher PBS in comparable environment with the current study area.

Soils having percent base saturation greater than 60% are rated as fertile soil as suggested by Landon (1991). Thus based on the ratings for tropical and subtropical soils, PBS is high when its values are greater than 60, medium when 20-60, and low when less than 20%.Accordingly, the values of PBS in the study area rated as medium for the two lands use types. It seems that the PBS of a soil could be more comprehensive in soil fertility assessment than the exchangeable bases and CEC because it is the actual percentage of cation exchange sites occupied by exchangeable bases.

Exchangeable sodium percentageof the soils was generally low (< 5.05%) in two land use system as compared to the critical level (>15%) that causes deterioration of soil structure and Na toxicity as described in the U.S. Salinity Laboratory Staff (1954). Hence, the current ESP levels indicate the soils are free from sodification.

Extractable micronutrients (Fe, Mn, Zn and Cu)

The mean values of extractable micronutrients cations in the soils of the study area ranged from 7.85to 18.05 mg kg^{-1} for Fe; 10.32 to 16.8 mg kg^{-1} for Mn; 0.7 to 2.54 mg kg $^{-1}$for Zn and 1.3 to 3 mgkg^{-1} for Cu in the grazing land use whereas cultivated land ranged from 7.42 to17.5 mg kg^{-1} for Fe; 9.33 to 16.83 mg kg^{-1} for Mn; 0.5 to 2.33 mg kg^{-1} for Zn; 1.2 to 2.43 mg kg^{-1} for Cu (Table 4). According to the critical value set by Jones (2003), the concentration of Mn was in medium level in all land use types. The concentrations of Mn in both land use types were within in the range of 9.33-16.8mgkg^{-1} (Table 4). This medium content of Mn could be attributed to pH of the soil where manganese becomes less available in alkaline soils.

Table 4. Extractable micronutrient cations (mg kg^{-1}) of the soils

Land Unit	Fe	Mn	Zn	Cu
Grazing land				
IK1	18.05	16.00	2.54	3.00
IK2	10.20	11.30	0.70	2.67
IK3	13.72	16.80	1.02	2.13
IK4	7.85	10.32	0.70	1.30
Cultivated land				
IK1	17.50	15.35	2.33	2.43
IK2	9.34	11.20	0.60	2.10
IK3	11.53	16.83	0.97	2.11
IK4	7.42	9.33	0.50	1.20

Where,IK=Itang-Kir

According to the critical values of DTPA extractable Fe (7.42-18.05mg kg^{-1}) as per the ratings of FAO (2006b), indicating that Fe content in all land units were sufficient for most crops. ThusMn in all land units were within adequate (>1.0 mg kg^{-1}) level for crop production, similarly Zn content in all land units were adequate (>1.5 mg kg^{-1}) level for crop production. Whereas, the available Cu values was marginal for (IK1, IK2) land units in grazing land use type but for other land units it was deficient.

The solubility and then the availability of most micronutrients are enhanced by acidic soil reaction (Havlin*et al*., 1999). Thus, low concentrations of extractable micronutrients at land units IK2, IK3 in both land use types (except Fe, Mn) were obtained in the present study area are the reflections of the soil reaction (pH) which was in the range moderately alkaline to strongly alkaline. In line with this, Yacob (2012) reported similar results for characterization and classification of soils at Aboboresearch site, Gambella region, which have comparable environment with the current study area. The results of this study are also in agreement with other earlier reports from southern (Ashenafi*et al.,* 2010; Wondwosen and Sheleme, 2011) western (Attah, 2010) Ethiopia that Cu is most likely deficient, Zn contents are variable and Mn is sufficient for highly weathered soils.

Conclusions

The physical and chemical properties of soils in the study area vary from land use types to land use types due to impact of cultivation and grazing activity.

The (pH-H_2O) of the soils ranged from 6.95 to 8.2 and 6.86 to 7.92 on grazing and cultivated land use types, respectively. In general, soils are rated asneutral; moderately alkaline to strongly alkaline pH reaction on grazing land and neutral to moderately alkaline pH in cultivated land use type.

Soil organic matter and total nitrogen contents of the cultivated land soils showed slightly lower than grazing land . From this result cultivated land use types on average depleted 14.96% and 14.97% of organic matter and total nitrogenrespectively, compared to the grazing land use type.

The highest mean value(35.65 mgkg^{-1}) of available P was recordedunder the grazing and the highest mean value (32. 51 mg kg^{-1})in cultivated land. Generally the available P contents if the soils of the study area rated as very high.

Among exchangeable bases (Ca, Mg, K and Na), the exchange complex of the soils was predominantly occupied by divalent basic cations (exchangeable Ca followed by exchangeable Mg). The exchangeable Ca and Mg were highest at IK1 in both land use types but it was lowest at IK4 land unit this might be due to coarser texture of the soil, the magnitudes of exchangeable Ca and Mg in two land use types were rated as low to medium for Ca and medium to high for Mg. The exchangeable K was found to be very high in soils in of the two land use types. Therefore, exchangeable K content is adequate for the production of most crops and K deficiency would not be expected in the soil of study area at the moment. On the other hand, the exchangeable Na was also found higher in two land use types this could be due to higher pH and low annual rainfall of the area.

The highest CEC value (52.27 cmolkg^{-1} soil) was registered at IK1 land unit of grazing land use whilst the lowest (23.2cmolkg^{-1}) was registered at IK4 of grazing land use types, whereas, cultivated land use also showed the highest(44.08 cmolkg^{-1}) and the lowest (22.53Cmol kg^{-1}) CEC values. The observed variation in the contents of soil CEC among the two land use types is probably due to strong association of CEC with soil organic matter and clay content. PBS was also showed similar trend with that of CEC. The value of PBS varied from 29.80% to 39.46% on grazing land and that of cultivated land use types varied from 31.80% to 37.20%. Therefore, it can be concluded that mean value of cultivated land use type showed reduction in CEC and PBS value by 5.95% and 3.19%, respectively as compared to soils under the grazing land use types.

The extractable micronutrients (Fe, Mn, Cu, and Zn) tended to decrease with increasing coarser textured soils. The amount of available Fe in two land use systems on (grazing and cultivated) soils was rated as sufficient for crop production; available Mn and Zn were rated as adequate level. On the other hand, available Cu contents varied between marginal (IK1, IK2) of grazing land and deficient level for the rest of land units.

Therefore, from this study it can be conclude that, governmental and non-governmental rural development programs and strategies should be flexible in responding to the various animal grazing system and new innovation for the rural community to use local resource wisely and also enhance farmers' capacityto invest in affordable integrated soil fertility management techniques.

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