

Evaluation of 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 cation 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 types on selected physico-chemical properties of the soil in Itang- kir area.

2. Material and methods

2.1. Description of the study area

2.1.1. Location

The study was conducted at the Itang-kir area which is located in Etang special district of Gambella People National Regional State of Ethiopia. It 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, the capital city of Ethiopia and at an altitude ranging from 425 to 470 meters above sea level.

2.1.2. 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^{0}C and 15.8^{0}C, respectively.

2.1.3. 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 area is characterized by an average slope of 1 to 2% which is suitable for irrigation agriculture owing to ample availability of water. The average land holdings per farming family area is 0.5ha. Mixed crop-livestock farming system prevails in the area. Maize is the staple food crop grown in the area in rainfed agriculture. The other means on which the farming community depends to sustain their family life is mostly fishery and other livestock husbandry. Livestock is supplementary sources of food and income to the farmers in this area, like it is the case in other areas of the country.

2.2. Soil sampling and analysis

At the beginning, a general visual field survey of the area was carried out to have a general understanding of the site during the year of 2014. Two prevailing land use types (grazing and cultivated) of the area were recognized and selected for the investigation. The cultivated and grazing land use types selected for this study are found on the same sub-catchment adjoining to each other. Based on soil texture and slope class four land units were (IK1, IK2, IK3 and IK4) 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 composite soil samples from land unit one (IK1) that cover 75% of the total area of sub-catchment and two composite soil samples from other land units were collected from 0-20cm soil 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.

2.2.1. Analysis of selected soil physical properties

The particle size distribution of the soils was analyzed according to the procedure outlined by Bouyoucos (1962) with the help of the hydrometer method. The bulk density of the soil was estimated from undisturbed soil samples which were collected by using a core sampler following the procedures used by Blake (1965).The core samples was oven-dried and the bulk densities were calculated by dividing the masses of the oven dry soils by their respective volumes as they existed naturally under field conditions. The generally used average value of 2.65 gcm^{-3} was used for the particle density of the soil. Total porosity was estimated from the values of bulk density (BD) and particle density (PD) as:

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

2.2.2. Analysis of selected soil chemical properties

Measurement of soil pH was conducted using a pH meter in the supernatant suspension of 1:2.5 soils to water ratio. The electrical conductivity of soils was measured from 1:2.5 soil water suspensions by electrical conductivity meter as described by Jackson (1973). The Walkley and Black (1934) wet digestion method was used to determine soil organic carbon content and percent soil organic matter was obtained by multiplying percent soil organic carbon by a factor of 1.724 following the assumptions that organic matter is composed of 58% carbon. Total Nitrogen was determined using the Kjeldahl digestion, distillation and titration method as described by Black (1965) by oxidizing the organic matter in concentrated sulfuric acid solution (0.1N H_2SO_4). Since pH of the soil in the study area ranges from 6.86 to 8.20, available soil P was analyzed according to the standard procedure of Olsen *et al.* (1954) extraction method. Cation exchange capacity and exchangeable bases (Ca, Mg, K and Na) were determined after extracting the soil samples by ammonium acetate (1N NH_4OAc) at pH 7.0. Exchangeable Ca and Mg in the extracts were determine using atomic absorption spectrophotometer while Na and K were determined using a 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. Similarly, exchangeable sodium percentage was calculated as the percentage of exchangeable Na to the CEC of the soil. Finally extractable micronutrient cations (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.

2.3. 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.

3. Results and Discussion

3.1. Site characteristics

The study area is characterized by level to gentle slopping and categorized into four land units based on soil texture (Table 1). Accordingly, the clay texture (IK1) was characterized by nearly level to very gently sloping land (0.5-2%) which occupies more than 75% of cultivated land. Since it is located nearby the Baro River it is cultivated twice a year. The second land unit is sandy clay loam in texture (IK2) it is nearly level to gently sloping land (1–2.1%) with relatively less cultivated land and cultivated only once in a year 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.

3.2. Soil physical properties

3.2.1. Particle size distribution

The particle size distribution 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 traditional crop cultivation practices in the area had no significant impacts on the soil texture. Obviously soil texture is an inherent soil property that cannot be influenced within short period of time by management practices.

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

Land Unit	Particle size (%)				BD ($g\ cm^{-3}$)	TP
	Sand	Silt	Clay	Class		
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	55.00	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; SC= silt clay; SL= silt loam

3.2.2. Bulk density and total porosity

The bulk density values showed variation based on land use types (Table 1). The results indicated that bulk density values were higher in grazing land than cultivated lands in all land units except in IK3. The highest bulk density (1.39 g cm^{-3}) was recorded in IK4 of grazing land which has sandy loam texture, while the lowest bulk density value (1.24 g cm^{-3}) was recorded in IK1of cultivated land that has clay texture. The relatively highest bulk density values for both land use types were recorded in IK4. This is probable due to the soil compaction encountered as a result of livestock trampling and large sand proportions. Grazing land in such traditional agriculture is subject to free and year-round grazing that can compact soil and over exploited the land. The lowest bulk density values were observed in all cultivated land units except in IK3. This is might be due to the traditional tillage practices used by the local farmers' of the area. The farmers in the Itang-kir area do not use ox plough or other machinery that completely disturb soil structure. They use their own traditional tillage equipment known as '*shella*' that helps for hand plowing. The '*shella*' plowing practice do not completely destroy soil aggregate compared to other tilling methods. It is can be categorized as minimum tillage practice. This could be the reason for lower bulk density values in cultivated land use type than bulk density of grazing land. 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 organic matter 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 soil bulk density values of all the studied land units were within the acceptable range.

The total porosity of the soils showed variation among land use types like soil bulk density. 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 of eastern Ethiopia and in Bako area of western Ethiopia. Typically 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 surface soil for all the land units were very high. In terms of soil physical fertility the total porosity observed on all land units could enable the soils to provide good aeration for plants and microorganisms.

3.4. Soil chemical properties

3.4.1. Soil reaction and electrical conductivity

The highest (8.20) and the lowest (6.86) soil pH values were recorded in grazing and cultivated lands, respectively (Table 2). According to soil pH rating by Tekalign and Haque (1991), the pH 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. The lowest pH values in the cultivated land could be due to continuous removal of basic cations by harvested crops and no addition of fertilizers to replenish the nutrients. These results are in agreement with findings of 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 land. 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 values of soils in both land use types were found to be low (Table 2). For the two land use types, the highest (0.56 dS m^{-1}) and lowest (0.24 dS m^{-1}) electrical conductivity values of the soils were recorded in the grazing and cultivated land use types in (IK3, IK1), respectively (Table 2). The highest electrical conductivity value under the grazing land might be due to its highest exchangeable Na content, whereas the lowest electrical conductivity value under the cultivated land could be attributed to 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 electrical conductivity 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 electrical conductivity which sets 4 dSm^{-1} at 25 ^{0}C as the lowest values for a soil to qualify the saline soil category regardless of its pH values. Generally, the electrical conductivity values recorded 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, it is possible to say that the soil of the area is conducive for most agricultural crops production (Landon, 1991).

Table 3. Some selected soil chemical properties of land use types

Land unit	pH	EC (dS m^{-1})	OM (%)	Total N (%)	C: N	Av. P ($mgkg^{-1}$)
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; AV. P= Available phosphorous

3.4.2. Organic Matter, Total Nitrogen and C: N Ratio

Organic matter contents of the soils showed high variability among land units and slight variation among the two land use types. The organic matter content values were higher for land units of grazing land than land units of cultivated land that have similar physiographic characteristics. The organic matter content of the soils ranged from 2.10 to 4.82% for grazing land. In cultivated land use types it ranged from 1.8 to 3.81% (Table 2). The lower organic matter content of cultivated land could be due to complete removal of crop residues and continuous cultivation that accelerate rate of organic matter oxidation. The higher values of soil organic matter contents of grazing land might be attributed to the grass that grow on the site throughout the year on the land. 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 findings of this study were in agreement with the findings of Negassa (2001) and Malo *et al*. (2005), who reported less organic carbon content of the cultivated soils than grassed soils. This finding showed that cultivation depleted organic matter contents of soils by 20.95, 2.8, 15.7and14.28% in (IK1 IK2 IK3, IK4), as compared to the corresponding land units of grazing land. 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 study depicted that when the values of soil organic matter content increased, the contents of total N also increased and vice versa showing the direct relationship between organic matter contents and total N content. Taye *et al.* (2003) also reported that the incorporation of high proportion of organic matter containing decomposed materials as a major component appreciably increased the organic carbon and total N contents of soils. 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 both by land use types and soil textural class. Total N contents of soil in grazing land ranged from 0.10% to 0.29 and in cultivated land from 0.09% to 0.25 (Table 2). It declined with shift of land uses from grazing to cultivated land. Total N contents were higher in grazing land than cultivated lands in corresponding land units which again declined with increasing sand content, (0.30%) in clay textured soils to (0.10%) in the soils of sandy clay loam textural class. The considerably large losses of total nitrogen in the continuously cultivated 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). Complete removal of crop residues in such cereal based farming systems also has contributed to the depletion of soil organic matter and total N in the 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 land use and medium in cultivated land use. However, for IK3 it was rated as medium for grazing land and low for cultivated land use (Table 2).

C:N ratio of the soils has shown slight variations for land use types. The C:N ratio was slight narrower in soils of cultivated land as compared to grazing land use types except for IK1, this indicated 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 land usually have higher C and N contents than cultivated lands, because cultivation leads to losses of C and N contents. 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 C:N ratio of all land units except IK2 land unit of grazing and cultivated land use types depicted optimum C:N ratio range for active microbial activities for humification and mineralization of organic residues (Table 2).

3.4.3. Available phosphorus

The available phosphorus content of the grazing land use ranged from 16.18 to 61.29 mgkg^{-1} whereas that of cultivated land use ranged from 15.25 to 58.95 mgkg^{-1} for corresponding land units (Table 2). According to the rating suggested by Landon (1991) the available P contents of soils can be rated from high to very high for both land use types. Relatively, the maximum 61.29 and 58.95 mgkg^{-1} available P contents were recorded for both land use types in IK1 and the average pH values for IK1 were near neutral (6.8, 6.95) that indicate the low P fixation by soil colloids. According to Carrow *et al.* (2004), P-Olsen between 12 to 18 mgkg^{-1} is considered as sufficient and hence the available P in all land units were in sufficient range for optimum plant growth. It was also reported that soil P is more available in warm soil than in cool soil (Hartz, 2007). Therefore, relatively fair P availability in the soils of the study area might be favored by the warm climatic condition and soil reaction. The highest available P content observed at IK1 in both land use types in the study area might be due to the relatively high organic matter content or high inherent P content of the parent material. Engdawork (2002) reported higher average available P content (87.02 mgkg^{-1}) in the surface soil (0-18cm) of the Phaeozems soils in the Werkarya area, South Wello, Ethiopia.

3.4.4. Exchangeable bases

The results revealed that the contents of exchangeable Ca and Mg ranged from 3.21 to 9.49 and 1.91 to 4.46 cmolc kg^{-1} in grazing land whereas in cultivated land ranged from 3.18 to 7.67 and 1.75 to 3.44 cmolc kg^{-1}. Exchangeable K contents ranged from 1.38 to 2.37 cmolc kg^{-1} and from1.32 to 1.96cmolc kg^{-1} in grazing land and cultivated land, respectively. According to the ratings of FAO (2006b) the soils of the study area can be categorized into low to medium for exchangeable Ca, medium to high for Mg and very high for exchangeable K. The exchange complex was found to be dominated by Ca followed by Mg, K and Na, which could be considered as optimal 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 and also higher in land units of grazing land use type (Table 3). The higher content of exchangeable Ca and Mg could be due to the higher organic matter contents of land units of grazing land. 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 finding, several researchers reported that exchangeable bases contents of soils can be concomitant with organic matter content (Taye *et al.*, 2003; Heluf and Wakene, 2006). According to the rating suggested by FAO (2006a) exchangeable Na is high in the two land use types. Nonetheless, exchangeable Na contents were higher in the land units of grazing land than the corresponding land units of cultivated land. The highest and lowest mean values of exchangeable Na were 1.96 and 1.02 cmol (+) kg^{-1} in grazing land for IK3, IK1, respectively, and in cultivated land use the highest (1.65 cmol (+) kg^{-1}) and the lowest (0.95 cmol (+) kg^{-1}) were recorded for IK3, IK1, respectively (Table 3). Exchangeable sodium percentage of 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.

Table 4. Exchangeable bases, CEC, base saturation and ESP

Land unit	Exchangeable base ($Cmolckg^{-1}$)				CEC ($cmol(+)\ kg^{-1}$)	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	1.40	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

3.4.5. Cation exchange capacity and percent base saturation

The CEC values of the soils in the study area were affected by soil texture and land use types. The highest CEC (52.27 $cmolkg^{-1}$) was registered in land unit of grazing land use while the lowest (22.53 $cmolkg^{-1}$) was recorded in cultivated land soil (Table 3). The observed variation in the contents of 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 lower CEC in cultivated land is due to lower organic matter contents of the soils in this land use type. All land units in cultivated land use except IK2 showed lower CEC values; this could be due to continuous cropping and complete removal of crop residues that might have contributed to depletion of basic cations of soils under *shalla* cultivation as compared to the grazing land. In line with this finding, Alemayehu (2007) and Fentaw and Abdu (2011) have reported that lower CEC of soils in intensive cultivation 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 rated as high, medium, low and very low, respectively. Based on the above ratings, the CEC of soils of area can be rated as high for land unit IK1, IK2 and IK3, whereas for IK4 it is medium for both land use types.

The percent base saturation of the soils ranged from 29.8% to 39.46% for grazing land use whereas for cultivated land use it ranged from 31.8% to 37.20% in land units IK1 and IK3, respectively (Table 3). However, as per the ratings recommended by Hazelton and Murphy (2007), the value of percent base saturation of the two land use types can be rated as medium. The trends of the distribution of percent base saturation showed similarity with the distribution of CEC, exchangeable Ca and Mg, since factors that affect these soil attributes also affect the percentage base saturation. As the percent base saturation 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 to the increase to percent base saturation. Soils having percent base saturation greater than 60% are rated as fertile soil as suggested by Landon (1991). Thus based this rating percent base saturation is high when it is greater than 60, medium when 20-60, and low when it is less than 20%. Accordingly, the values of percent base saturation for soils of the area can be rated as medium for both land 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.

3.4.6. Extractable micronutrients cations (Fe, Mn, Zn and Cu)

The mean values of extractable micronutrients cations in the soils of the area ranged from 7.85 to 18.05 $mgkg^{-1}$ for Fe; 10.32 to 16.80 $mgkg^{-1}$ for Mn; 0.70 to 2.54 $mgkg^{-1}$ for Zn and 1.3 to 3 $mgkg^{-1}$ for Cu in the grazing land use whereas for cultivated land ranged from 7.42 to17.50 $mgkg^{-1}$ for Fe; 9.33 to 16.83 $mgkg^{-1}$ for Mn; 0.50 to 2.33 $mgkg^{-1}$ for Zn; 1.20 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 rate in all land use types. The concentrations of Mn in both land use types were within in the range of 9.33-16.8$mgkg^{-1}$. 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	`8.05	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

According to the critical values of DTPA extractable Fe (7.42-18.05mgkg^{-1}) as per the ratings of FAO (2006b), Fe contents in all land units of both land use types were sufficient for most crops. Mn in all land units were within adequate (>1.0 mgkg^{-1}) level for most 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 and 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). . Low concentrations of extractable micronutrients cations in land units IK2, IK3 in both land use types (except Fe, Mn) were recorded for soils of area are the reflections of the soil reaction (pH) which was in the range as neutral, moderately alkaline to strongly alkaline. In line with this, Yacob (2012) reported similar results for characterization and classification of soils at Abobo research 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.

4. Conclusions

The physical and chemical properties of soils in the study area vary from land use type to land use type. The bulk density values varied considerably based on land use types. The results indicated that bulk density values were higher in grazing land than cultivated land in all land units except in IK3. This study has depicted that soil texture also affect soil bulk density. The highest bulk density was recorded in land unit of grazing land IK4 which is the sandy loam texture, while the lowest bulk density was recorded in IK1of cultivated land use that has clay texture. This is probable due to the soil compaction encountered as a result of livestock trampling and large sand proportions. The lowest bulk density values were observed in all cultivated land units except in IK3. This might be due to the traditional tillage practices used by the local farmers'. The local farmers in the Itang-kir area do not use ox plough or other machinery that completely disturb soil structure. They use their own traditional tillage equipment known as '*shella*' that helps for hand plowing. The '*shella*' plowing practice do not completely destroy soil aggregate compared to other tilling methods. The tillage practice can be categorized as minimum tillage practice. The total porosity of the soils showed variation among land use types like soil bulk density. Total porosity increases as the bulk density decreases while it decreases as bulk density increases.

The pH 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 as neutral; moderately alkaline to strongly alkaline soil 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 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 nitrogen, respectively, compared to the grazing land use type. The highest mean value (35.65 mgkg^{-1}) of available P was recorded in grazing and the highest mean value (32. 51 mgkg^{-1}) in cultivated land. Generally the available P contents of 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, 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 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 to be 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 micronutrient cations (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, integrated soil fertility management that encompass use of both inorganic and organic fertilizers with improved germplasms and other practices that conform with local farming systems should be implemented to sustain crop production and livestock hasbandary in the area.

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