POLISH JOURNAL OF SOIL SCIENCE
VOL. LV/1 2022 PL ISSN 0079-2985

DOI: 10.17951/pjss/2022.55.1.19-35

DESTA EKERO*, WASSIE HAILE*, ALEMU LELAGO**,
MESFIN BIBISO**

EFFECTS OF DIFFERENT LAND USE TYPES ON SOIL PHYSICO-CHEMICAL PROPERTIES IN WOLAITA ZONE, ETHIOPIA

Received: 02.04.2021
Accepted: 02.04.2022

Abstract. Soils are obviously inconstant and their properties are changing across land use types. Essential soil physico-chemical assets impact the performance of soil and, therefore, information on soil property is important. The objective of the study was to determine effects of different land use systems on soil physico-chemical properties in Wolaita zone, southern Ethiopia. Soil samples were collected from three different land uses, enset (*Ensete ventricosum*), tef (*Eragrostis tef* (Zucc.) Trotter) and grass lands. Each replicated three times and the composite sample was taken. All the properties are significantly different and determined using appropriate methods. Soil pH, electrical conductivity, total nitrogen, texture, organic matter and phosphate in soil were determined experimentally to study the effects of land use on them. Changes in soil properties in dissimilar land usage forms at two pits (0–15 and 15–30 cm) were detected on various soil properties significant to crop growth. Enset fields had higher pH (5.80), electrical conductivity (EC (0.14 dS/m)), available P (35.25%) and Zn (8.64 mg/kg), exchangeable K (3.12 Cmol(+Kg) which is ascribed due to the input of dung, while tef fields had lowest average K (1.38 cmol (+kg) and Mg (1.89 cmol(+kg), cation exchange capacity (CEC (20.21 cmol(+kg)), total N (0.13%) and OC (1.76%). Most of the physico-chemical properties of the study region were significantly influenced by the different land uses. The evidence derived from the current study will support in mounting maintainable and environmentally constant land use management strategies for the

* Hawassa University, School of Plant and Horticultural Sciences, Ethiopia. Corresponding author: destaeker@gmail.com
** Wolaita Sodo University, College of Natural Sciences, Ethiopia.

study region. Consequently, supplementary comprehensive studies that include soil characterization and field experiment on crop nutrient requirement should be conducted to test the effect of land use forms on soil physico-chemical properties in terms of sustainable use of the land.

Keywords: enset (*Ensete ventricosum*), grass, soil nutrient, soil properties, tef (*Eragrostis tef* (Zucc.) Trotter)

INTRODUCTION

Physico-chemical features of diverse soils differ in space and period due to distinctions in topography, climate, physical weathering processes, vegetation cover, microbial activities, and several other biotic and abiotic variables (Paudel and Sah 2003). The assets of dehydrated soil along with its kind have a great significance in agriculture (Ahire *et al*. 2013). Land-use alterations from forest cover to cultivated land may introduce organic residues that lead to deterioration of soil fertility (Guimaraes *et al*. 2013), improvement of soil erosion rate (Biro *et al*. 2013), loss of soil organic matter and nutrients (Wang *et al*. 2012).

Changes in land cover density and intensification of agriculture aggravate the leaching rate of soil organic matter and nutrients (Alam *et al*. 2017) and an accelerated rate of land degradation (Zajícová and Chuman 2019). The cliché is also true, for example, integrated management of arable soil is the key to deal with most complex soil properties, thereby maintaining the land cover dynamics (Alam *et al*. 2014). Soil is not merely significant for agriculture but also valuable for living organisms. Characteristic soil physico-chemical properties influence the activities of soil and hence, understanding of soil property is essential (Sumithra *et al*. 2013).

In Ethiopia, stress on landscape permanence is enormously great due to the sharp rise in the population density (Thiemann *et al*. 2005, Wassie and Shiferaw 2011). Increasingly growing population causes exhaustive terrestrial consumption and forest clearance for cultivation even in areas that are not useful for agriculture (e.g. steep hill slopes or marginal land) (Belay 2003, Thiemann *et al*. 2005) and this accelerates soil erosion. Regardless of this, smallholder farmers on compactly populated uplands of the country produce everything from the soil and very small remains to re-invest in soil fertility replacement for the following year (IFPRI 2010). All these farming practices could have brought instabilities to the environments principally on soils by disturbing the constant natural biogeochemical processes of nutrient cycling, causing rapid depletion of plant nutrients (Yengoh 2012) and derives for change in the landscape characteristics (Binyam 2015, Yihenew *et al.* 2015). Consequently, accepting the landscape structures of farminglands and soil managing practices at local level are helpful to verify the possible and limits of the soils.

In Ethiopia, there is growing awareness that soil nutrient reduction from agro-ecology is a very serious problem connected with crop production constraints (Stoorvogel and Smaling 1990, Stoorvogel *et al*. 1993). A variation in land use, poor soil managing, geography of the area and socioeconomic situation can negatively affect the possible use of an area and may eventually lead to land degradation and loss of yield. Loss of arable land due to soil degradation is a wide range occurrence in the highlands of Ethiopia, which accounts for 45% of Ethiopian total land area and 66% of the total land area of Amhara region (Lakew *et al*. 2006). Low soil fertility was stated as one of the main factors affecting crop assembly in west part of Amhara region (Yihenew 2002, 2007).

Classification of soils is also valuable to simplify technology transference and information interchange between soil scientists, decision-makers, planners, researchers and agricultural extension advisors (Ashenafi *et al*. 2010). It is important to arrange the soils into groups or categories on the base of their characteristics (Jones *et al.* 2013). There are two internationally known soil classification systems used to classify soils, namely the United States Department of Agriculture (USDA) Soil Survey Staff – Soil Taxonomy (SSS 2014) and World Reference Base for Soil Resources (WRB 2006). The World Reference Base for Soil Resources (WRB) is a universally accepted comprehensive soil classification system that enables people to accommodate their national classification system.

In Ethiopia, about 19 soil types are identified throughout the country. The big proportion of the country's land mass is covered by Lithosols (14.7%), Nitisols (13.5%), Cambisols (11.1%), Regosols (12%) and Vertisols (10.5%) (EMA 1988). Therefore, different studies cared out on soil classification of in Wolaita zone, For example, the Ethiopian Mapping Authority (EMA 1988) characterized the soils of Wolaita areas as Eutric Nitosols, whereas Mesfin (1998) reported sesquioxidic and moderately to intensely acidic soils. Abayneh and Berhanu (2006) showed the presence of Rhodic Nitisol, and Fikre (2003) similarly described the existence of Alfisols around the same area. In addition, according to Mulugeta and Sheleme (2010), Ultisols, Inceptisols and Entisols are present around Wolaita area on diverse topography.

Land use and soil managing practices affect the soil nutrients and related soil processes, such as erosion, oxidation, mineralization, and leaching, etc. (Celik 2005, Liu *et al*. 2010). As a result, it can modify the processes of transport and redistribution of nutrients. In non-cultivated land, the nature of vegetative cover is a factor manipulating the soil organic carbon content (Liu *et al*. 2010). Soil properties such as texture, pH and soil organic matter correlate highly with landscape position. For instance, a research report by Shimeles (2012) in Wollo (Ethiopia), showed an increasing trend of soil pH and exchangeable bases with decreasing slope. In northwestern Ethiopia, Yihenew *et al.* (2015) reported higher mean values of total nitrogen (TN), organic matter (OM) and cation exchange capacity (CEC) on lower than upper slope. Fantaw and Abdu (2011) also indicated significant variations in soil organic carbon (SOC), total N, exchangeable cations (CEC) and percentage base saturation (PBS) on varied altitudinal ranges of the Bale Mountains, Ethiopia.

Therefore, this study was conducted with the objective to investigate the influence of different land use types and soil depths on selected soil physical-chemical properties and organic matter in Wolaita zone of southern Ethiopia.

MATERIALS AND METHODS

Description of the study area

The study was conducted in selected districts of Wolaita zone. The study districts or woredas were purposefully selected. The districts are Humbo, Damot Gale and Damot Sore Woredas. The study area is located between 037°35'30" – 037°58'36"E and 06°57'20" – 07°04'31"N and the elevation ranges between 1,473 to 2,873 m above sea level (m.a.s.l). In the years 2006–2016, mean annual precipitation of the study area was about 1,355 mm. The area has a bimodal rainfall pattern and about 31 and 39% fall during autumn (March–May) and summer (June–August) seasons, respectively. The mean monthly temperature for the last ten years (2006–2016) ranges from 17.7 to 21.7°C with an average of 19.7°C (NMA 2016).

According to traditional agro-ecological zone classification of Ethiopia, the area is predominantly characterized by mid highland agro-ecology. Besides, small portion of highlands in Damot Gale and Sodo Zuria districts and very small pocket lowland areas in Damot Sore districts are identified.

Eutric Nitisols associated with Humic Nitisols are the most prevalent soils in Wolaita zone (Tesfaye 2003). These are dark reddish brown soils with deep profiles. Agriculture in the study area is predominantly smallholder mixed subsistence farming and is dominantly rainfed. Continuous cultivation without any fallow periods coupled with complete removal of crop residues is a common practice on cultivated fields. Farmers in the study area use DAP, urea and farmyard manure (FYM) as sources of fertilizers (Fanuel 2015).

The major crops grown in the study area include tef (*Eragrostis tef* (Zucc.) Trotter), maize (*Zea mays L.*), bread wheat (*Triticum aestivum L.*), haricot bean (*Phaseolus vulgaris L.*), field pea (*Pisum sativum L.*), potato (*Solanum tuberosum*), sweet potato (*Ipomea batatas*), taro (*Colocasia esculenta*), enset (*Ensete ventricosum*) and coffee (*Coffea arabica*). The vegetation is dominated by eucalyptus trees (*Camaldulensis spp.*). Remnants of indigenous tree species such as croton (*Croton macrostachyus* Hochst. ex Rich.), cordia (*Cordia africana* Lam.), Erythrina spp., podocarpus (*Podocarpus falcatus*) and Juniperus (*Juniperus procera*) are also present (Fanuel 2015).

Soil sample collection

Soil samples were collected from the selected districts of Wolaita zone for the chemical and physical analysis from different land uses at 0–15 and 15–30 cm depth and replicated three times for the different sampling points for each land use. Soil samples were collected from three different land uses, enset, tef and grass lands. Each replicated three times and eight composite samples were collected. The samples were carefully labeled and packaged and taken to the laboratory. The soils were ground and passed through a 2-mm sieve and used for the analysis.

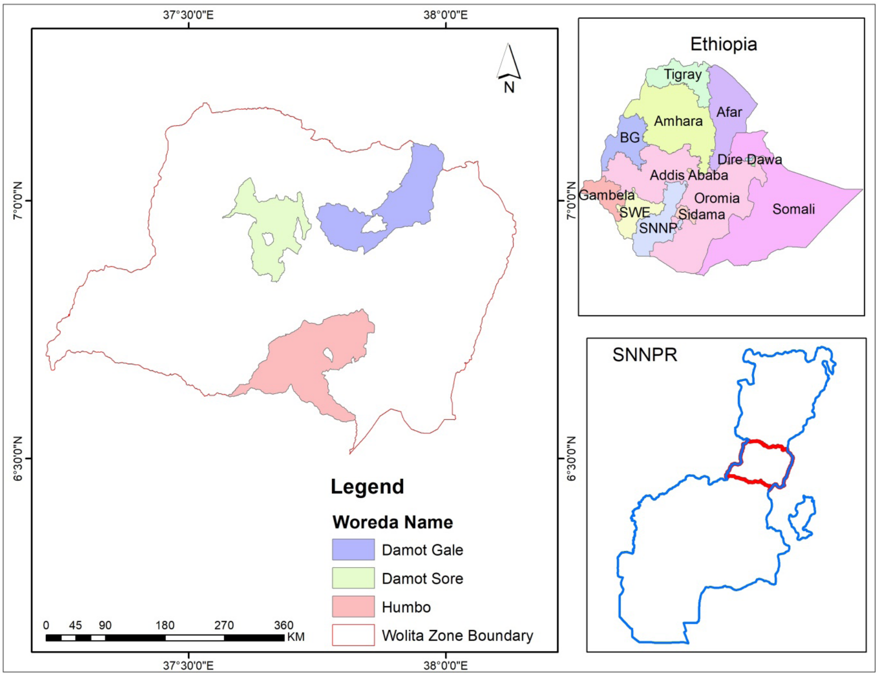

Fig. 1. Location of the study area

Physico-chemical analysis

Experiments were performed for the determination of chemical constituents of soil and some of its physical properties for the assessment of type and quality of soil. Soil pH, electrical conductivity, total nitrogen, bulk density, texture, organic matter, soil colour, moisture and phosphate in soil were determined experimentally to study the soil nature. The collected samples were air-dried and passed through a 2-mm sieve to remove large particles, debris and stones. The sieved samples were analyzed for pH in 1:1 soil to water ratio using the Coleman's pH meter. Organic carbon was determined by the Walkley and Black (1934) procedure. Organic matter was estimated as organic carbon multiplied by 1.724. Total nitrogen was determined by the micro Kjeldahl method, while available phosphorus was extracted by Bray's P1 method and read from the atomic absorption spectrometer. Mehlich III extractant was used to extract aluminum (Al), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), sulfur (S), iron (Fe), manganese (Mn), copper (Cu), boron (B), and zinc (Zn) (Mehlich 1984). The concentration of nutrients was determined by inductively-coupled plasma-atomic emission spectrometry (ICP-AES). The use of ICP-AES has increased as the use of multi-element soil extractants becomes more popular (Pierzynski *et al*. 2008). CEC was calculated based on the concentration of exchangeable cations, Al and H. Textural analysis was conducted using the hydrometer method. The suspension was mixed thoroughly using a rod with a disk on the end. The rod was lifted out and the time was noted. After approximately 10 seconds, the hydrometer was slowly inserted into the cylinder. The readings were recorded at the base of the meniscus at 30, 50, 70, and 90 seconds after lifting the rod out of the suspension.

Statistical analysis

The soil data that were collected from laboratory was statistically analyzed using the analysis of variance (ANOVA) procedures. The treatment means were separated using the least significance difference (LSD) method at the 5% level of probability.

RESULTS AND DISCUSSION

Different land use types affect the physico-chemical properties of the soil. Comparatively higher sand content was noted in grassland soils (Fig. 2) followed by that of enset and tef fields in the top 0–15 cm depth, while in the 15–30 cm depth, silt was found to be higher in ensetland (Fig. 7) soils followed by tef and grass lands (Table 1). On the other hand, higher content of clay (Fig. 4) was recorded in 0–15 cm depth of tef farms. Although texture is inherent property, this might be attributed to accelerated weathering as a result of disturbance during constant cultivation, as was also concluded by Boke (2004) from the result obtained from the nearby site. The soil texture of the different land use types (Fig. 3, Fig. 5, and Fig. 6) and the upper layers of the different horizons were found to be the same except for that of grassland soil (15–30 cm depth), which was clay loam. This advocates that the different land use types did not have effect on the soil texture of the study area. Subsequently, texture is an intrinsic soil property that is not affected in short period of time. The absence of protective vegetation covers in the surface soil of cultivated land and grasslands soil directly contributes to the removal of soil finer particles size as it reduces the organic matter that flocculate soil aggregates and increase soil loss in erosion (Wasihun 2021).

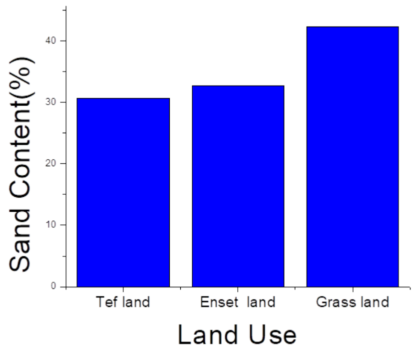

Fig. 2. Sand content of land uses at 0–15 cm.

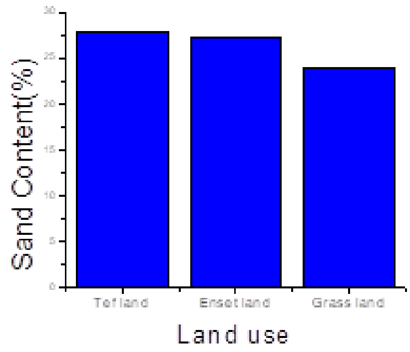

Fig. 3. Sand content of land uses at 15–30 cm

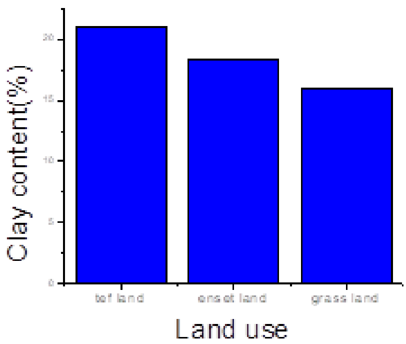

Fig. 4. Clay content of land uses at 0–15 cm

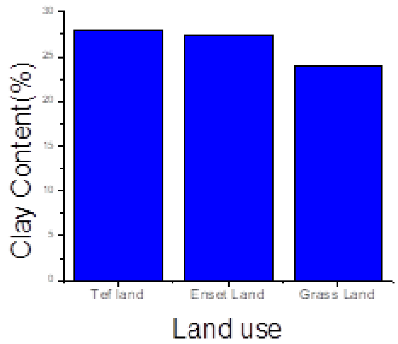

Fig. 5. Clay content of land uses at 15–30 cm

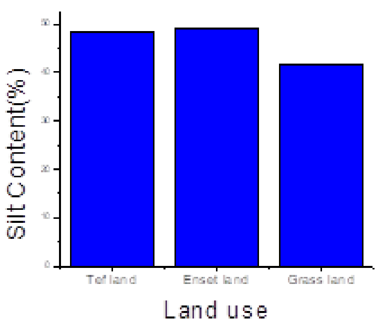

Fig. 6. Silt content of land uses at 0–15 cm

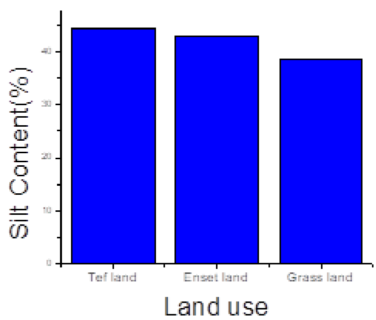

Fig. 7. Silt content of land uses at 15–30 cm

Table 1. EC, pH, sand, silt and clay properties of the soil at 0–15 and 15–30 cm depth under different land use systems

Land use	pH	EC (dS/m)	Sand (%)	Silt (%)	Clay (%)
0–15 cm					
Tef	5.50	0.07	30.66	48.33	21.00
Enset	5.80	0.14	32.66	49.00	18.33
Grass	5.60	0.08	42.33	41.66	16.00
15–30 cm					
Tef	5.40	0.06	26.66	44.33	28.00
Enset	5.60	0.09	29.66	43.00	27.33
Grass	5.50	0.07	37.33	38.66	24.00

The pH value under enset was found to be the maximum followed by tef in both sampling depths. The soil pH could be categorized as slightly acidic under enset and tef fields, while that of grassland was moderately acidic, following the classification labled by Brady and Weil (2002). The maximum values of pH under enset in both depths could be due to greater values of exchangeable bases as a result of addition of house wastes and wood residue to enset fields. This is marked from the positive correlation between pH and the exchangeable bases in both depths. The result of these findings is in line with several findings such as Wasihun *et al*. (2015) and Mengistu and Dereje (2021), who reported lower soil pH values under cultivated lands as compared to uncultivated areas.

Comparatively greater EC values at both depths were noted in the enset farms followed by grass land. Even if the EC values were unimportant, significant differences ($p \leq 0.05$) were attained under the different land uses. The organic carbon content of the soils varied from 2.03% to 3.29% for 0–15 cm depth. At 15–30 cm depth it ranged from 1.76 to 2.12% (Table 2). Significant differences ($p \leq 0.05$) in OC content of soils were observed among the different land use systems. The roots of the grass and fungial hyphae in the grassland soils are possibly accountable for the higher amount of total organic matter (Urioste *et al*. 2006). The results were in promise with the outcomes of Negassa (2001) and Malo *et al*. (2005), who reported less organic carbon in the cultivated soils than grassland soils. At both depths, enset farms had higher OC content as compared with the tef farms. A similar result by Getahun et al. (2014) showed that higher OC and TN under the soil of enset farms as compared to other land uses in Butajira in the central highlands of Ethiopia. Thus, the highest organic fraction of grassland is potentially with the highest reservoir for plant essential nutrients of nitrogen, phosphorus, and sulphur compared to cultivated lands (Kedir 2020).

Table 2. Some chemical properties of the soil at 0–15 and 15–30 cm depth under different land use systems

Land use	TN	OC	Av. P	Fe	Mn	Zn	Cu
	%		mg/Kg				
0–15 cm							
Tef	0.17	2.03	13.33	20.65	25.54	7.92	0.340
Enset	0.21	2.33	35.25	56.63	22.62	8.64	0.321
Grass	0.28	3.29	3.46	43.38	45.34	8.62	0.442
15–30 cm							
Tef	0.13	1.76	5.03	25.82	25.21	8.22	0.28
Enset	0.17	1.93	9.14	17.12	24.46	8.47	0.29
Grass	0.18	2.12	1.14	34.84	29.53	6.40	0.28

This might be due to the use of home rubbish, which also increased total N content of enset farms. Zeleke *et al*. (2004) reported intensification in OC by 11 and 67% to incorporation of crop residues in Humbo and Alaba. Most of cultivated soils of Ethiopia are poor in organic matter content due to low amount of organic matter applied to the soil and complete removal of biomass from the field (Dereje 2020).

The mean available P content was significantly ($p \leq 0.05$) different among the land use systems. In all topographic locations and both depths, maximum value of available P was found under enset homesteads followed by tef and grassland soils (Table 2). The higher available P content at both depths under enset is likely the magnitude of long-term use of compost and house wastes and the related rise in microbial activity. Materechera and Mkhabela (2001) have also informed that organic matter impact P in soil solution by complexing P from adsorption site in ligand exchange and increase the mobility of inorganic P, particularly in acid soils, by decreasing chemical activity of iron and aluminum. The results were also consistent with the results of Boke (2004) who found high available P under enset in soils of Kokate and Adilo areas and concluded that coverting of organic P into available P through mineralization, addition of manure and crop residue to enset crop may have coated the reaction surfaces of the soil particles and prevent or delay P sorption, and thereby increase P solubility. Relatively higher content of available P found under tef farms when compared to that of grassland soils could be due to the continuous application of phosphorus fertilizer as was also reported by van der Eijk *et al*. (2006). Available phosphorous in all land use systems decreased with increasing soil depth. This could be due to the increased clay and reduced OM content with increasing depth of the soil. Organic compounds in soils increase P availability by the formation of organophosphate complexes that are more easily assimilated by plants, anion replacement of H_2PO_4 from adsorption sites the coating of Fe/Al oxides by humus to form a protective cover and reduced phosphorus fixation.

Moreover, decomposing of OM releases acids that increase the solubility of calcium phosphates (Yihinew and Getachew 2013).

Higher total nitrogen (TN) was observed in grassland fields followed by that of enset at both depths. This could be related to the higher organic matter content in the soils of grassland. There was also significant correlation (r = 0.94***) and (r = 0.50*) between organic carbon and total nitrogen at 0–15 cm and 15–30 cm depth, respectively. This shows that the contribution of OC to total N is high (Urioste *et al*. 2006). The results of the present study were in contrast to that of Boke (2004) who obtained relatively higher content of both organic carbon and total nitrogen from enset land use systems than that of the grasslands. The author attributed the higher concentration of total nitrogen under enset land use systems to the higher organic matter content as a result of manure addition. The current finding is in line with several findings such as Yifru and Taye (2011), Teshome *et al*. (2013) and Ufot *et al*. (2016) who reported that soil under cultivation have low TN as compared to uncultivated soils.

The values of exchangeable Na were found to be highest under enset followed by grass at 0–15 cm depth (Table 3), while at 15–30 cm depth higher available Na was recorded in grass land soils followed by that of tef fields. Although there were differences in available Na concentration of the soils of the different land use systems, their ESP values were below the critical level (15%). For the three land uses and both depths, the concentration of exchangeable potassium (K) followed the trend of enset field > grass land > tef farms. This may be due to the fact that the low soil pH under the crop land would leads to a decrease in soil base saturation, through immobilization of the exchangeable bases, and may result in soil exchangeable bases depletion over time (Kedir 2020).

High exchangeable K in 0–15 cm under enset fields is likely the result of the addition of house refuse and wood ash supply, whereas low exchangeable K concentration in tef farms could be due to the effect of continuous cultivation and crop removal. This result is supported by previous findings that indicate intensity of weathering, cultivation and use of acid forming inorganic fertilizers affect the distribution of K in the soil system and enhance its depletion (Malo *et al*. 2005). The soil cation exchange capacity values in the agricultural land use showed decline trend mainly due to the reduction in organic matter contents compared to adjacent land use system (Wasihun 2021).

The exchangeable calcium (Ca) was highest under enset field (Table 3), whereas lower concentrations of exchangeable Ca were found under tef and grass in 0–15 and 15–30 cm depths, respectively. The exchangeable magnesium (Mg) concentrations followed a similar trend when compared to Ca under different land use systems. Higher and lower values of exchangeable Mg were found under enset and tef fields, respectively. The low exchangeable Ca and Mg observed under tef farms might be due to leaching, soil erosion and crop harvest, as was also reported by Negassa (2001). Similar finding have been reported by Getahun and Bobe (2015).

Table 3. Some chemical properties of the soil at 0–15 and 15–30 cm depth under different land use systems

Exchangeable cations						
Land use	Na	K	Ca	Mg	CEC	PBS
cmol(+kg)						%
			0–15 cm			
Tef	0.082	1.88	10.02	1.89	20.40	57.06
Enset	0.169	3.12	10.43	2.85	22.94	83.54
grass	0.131	2.26	13.64	3.15	27.25	63.84
			15–30 cm			
Tef	0.13	1.38	9.40	2.38	20.21	63.46
Enset	0.10	2.54	11.04	2.64	22.26	70.32
Grass	0.15	1.52	7.80	2.60	23.98	51.02

The percentage of base saturation (PBS) of soils under different land use systems showed significant differences. At 0–15 cm depth, the highest PBS was recorded under enset fields followed by grassland, whereas at 15–30 cm depth, the highest value was found under enset followed by that of tef (Table 3). The highest PBS found under the enset field at both depths indicates that the fertility status of enset field is higher compared to that of the other land use systems. According to Urioste *et al*. (2006), addition of organic matter increases the amount of exchangeable bases. Moreover, intensive cultivation and continuous use of inorganic fertilizers in the cultivated fields that enhance loss of base cations through leaching, erosion and crop harvest (Negassa 2001). This may be due to the fact that the low soil pH under the crop land would lead to a decrease in soil base saturation, through immobilization of the exchangeable bases, and may result in soil exchangeable bases depletion over time (Kedir 2020).

Relatively, highest cation exchange capacity (CEC) values were observed under grassland followed by that of enset at both sampling depth (Table 3). In accordance with the organic carbon content, CEC values of the soil decreased consistently from grassland to enset and tef. This was also evident from the positively and highly correlation ($r = 0.91^{***}$) and ($r = 0.41$) of CEC with organic carbon for 0–15 and 15–30 cm depths, respectively. The depletion of organic carbon as a result of intensive cultivation had, therefore, reduced the CEC of the soils under tef land use. These results were in agreement with pervious findings of Boke (2004) and Negassa (2001). In line with this, Gao and Change (1996) reported that continuous cultivation decreases soil OM and resulted in CEC reduction in the cultivated land when compared to uncultivated land. Moreover, Nega and Heluf (2009) reported that CEC of a soil depends on the relative amounts and type of colloidal substances (organic matter and clay) as both provide negatively charged surfaces that play an important role in exchange process. Particularly organic matter plays an important role in exchange process, because it provides more negatively charged surfaces than clay particles do (Dereje 2020).

The micronutrients status of the soils was influenced by different land use systems (Table 2). Significant variations ($p \leq 0.05$) in available Fe at the 15–30 cm depth and Mn in 0–15 cm depth were observed among different land use systems. The highest available Fe was measured under enset followed by grassland at 0–15 cm depth. In 15–30 cm depth, the highest Fe was obtained in grassland soils followed by that of tef. In spite of the significant variation observed, available Fe was in a sufficient level for plant growth under all land use systems based on the Fe rating established by Havlin *et al*. (1999). The high variability of micronutrients among land use types could be probable due to differences in cultural soil management practices in a given area, land use, OM application. Fisseha (1996) reported similar phenomena as a result of exploring micronutrient status of thee Ethiopian Vertisols landscapes. Heluf and Wakene (2006) also reported that micronutrients were highly influenced by different land use systems and significant variation was observed among the different land use systems (Wasihun 2021).

At both depths, available Mn concentrations were higher in grassland soils followed by that of tef fields (Table 1). According to the nutrient toxicity level suggested by Lindsay and Norvell (1978), the concentration of Mn was at the toxic level in all land use systems, as the concentrations of Mn in both layers were greater than 21.87 mg/kg compared to the critical level of 5 mg/kg. This higher content of Mn could be attributed due to pH of the soil where Mn becomes more available in acidic soils. Highest concentration of available Zn was found on the surface layer (0–15 cm depth) of enset field followed by grassland soils whereas in the lower depth (15–30 cm depth), the highest available Zn concentration under enset was followed by tef land use. The concentrations of available Zn in all land use systems were within adequate level as indicated by Havlin *et al*. (1999). At the 0–15 cm depth the concentration of available Zn in the tef farms was the lowest as compared to the other land use systems. According to Negassa (2001), low Zn concentration in farm fields might be due to continuous harvesting of crop, organic matter oxidation, removal of the topsoil by sheet and rill erosion that is aggravated by tillage activities. Available Cu values were not affected by the different land use systems. At 0–15 cm depth, however, relatively highest available Cu content was observed in grassland soils (Table 2). This could be due to the relation of copper with organic carbon. According to Havlin et al. (1999), the concentrations of available Cu in all land use systems were in deficient range, except for grassland soils at depth of 0–15 cm, where concentration falls under the medium level. This result is in agreement with the findings of Mengistu and Dereje (2021) who reported lower available micronutrients in the soils of cultivated land compared to other land-use types.

CONCLUSIONS

In overall, the evidence made from the current study on the effect of land use types on selected soil physico-chemical properties might be supportive for proper management of land in the area. Changes in soil properties in different land use types at two depths (0–15 and 15–30 cm) were detected in the case of various soil properties significant to crop growth. Enset fields had higher pH (5.80), electrical conductivity (EC (0.14 dS/m)), available P (35.25%) and Zn (8.64 mg/kg), exchangeable K (3.12 cmol(+kg) which is ascribed due to the input of dung, while tef fields had the lowest average K (1.38 cmol (+kg) and Mg (1.89 cmol(+kg), cation exchange capacity (CEC (20.21 cmol(+kg)), total N (0.13%) and OC (1.76%).

Describing the spatial changeability of soil nutrients in relation to site properties such as climate, land use, topography and other variables is significant for accepting how the environment works and measuring the effects of further land use change on soil properties (Wang *et al*. 2001). Most of the physico-chemical properties of the study area were significantly influenced by the different land uses. The evidence made from the current study will support in mounting maintainable and environmentally constant land use management strategies for the study area. Therefore, supplementary comprehensive studies that include soil characterization and field experiment on crop nutrient requirement should be conducted to test influence of land use types on soil physico-chemical properties in terms of sustainable use of the land.

REFERENCES

[1] Abayneh, E., Berhanu, D., 2006. *Soil survey in Ethiopia: The past, present and future*. Proceedings of the seventh conference of the Ethiopian Society of Soil Science on Soils for Sustainable Development Goals.

[2] Ahire, D.V., Chaudhari, P.R., Ahire, V.D., Patil, A.A., 2013. *Correlations of electrical conductivity and dielectric constant with physico-chemical properties of black soils*. International Journal of Scientific and Research Publication, 3(2): 1–16.

[3] Alam, M., Islam, M., Salahin, N., Hasanuzzaman, M., 2014. *Effect of tillage practices on soil properties and crop productivity in wheat-mungbean-rice cropping system under subtropical climatic conditions*. The Scientic World Journal, 2014: 437283.

[4] Alam, M., Salahin, N., Islam, S., Begum, R., 2017. *Patterns of change in soil organic matter, physical properties and crop productivity under tillage practices and cropping systems in Bangladesh*. The Journal of Agricultural Science, 155: 216–238.

[5] Ashenafi, A., Abayneh, E., Sheleme, B., 2010. *Characterizing soils of Delbo Wegene watershed, Wolaita Zone, Southern Ethiopia for planning appropriate land management*. Journal of Soil Science and Environmental Management, 1(8): 184–199.

[6] Belay S., 2003. *Integrated watershed management approach to sustainable land management (experience of SARDP in East Gojjam and South Wollo)*. In: T. Amede (Ed.), Proceedings of the conference on the Natural Resource Degradation and Environmental Concerns

in the Amhara National Regional State: Impact of Food security (pp. 127–136). 24–26 July 2002, Bahir Dar. The Ethiopian Society of Soil Science (ESSS). Addis Ababa, Ethiopia.

[7] Binyam, A., 2015. *The effect of land use land cover change on land degradation in the highlands of Ethiopia*. Journal of Environment and Earth Science, 5: 1–12.

[8] Biro, K., Pradhan, B., Buchroithner, M., Makeschin, F., 2013. *Land use/land cover change analysis and its impact on soil properties in the northern part of Gadarif region, Sudan*. Land Degradation and Development, 24(1): 90–102.

[9] Boke, S., 2004. *Soil phosphorus fractions as influenced by different cropping systems in Andosols and Nitosols in Kembata-Tembaro and Wolayta Zones, SNNPRS*. MSc Thesis. Alemaya University.

[10] Brady, N.C., Weil, R.R., 2002. *The Nature and Properties of Soils* (13th ed). Prentice Hall, Upper Saddle River, New Jersey.

[11] Celik, I., 2005. *Land-use effects on organic matter and physical properties of soil in a southern Mediterranean highland of Turkey*. Soil and Tillage Research, 83: 270–277.

[12] Dereje, G., 2020. *Effect of land use types on selected soil physical and chemical properties at sire morose sub watershed, central highland of Ethiopia*. International Journal of Engineering Research and Technical Research, 9(05).

[13] EMA (Ethiopian Mapping Authority), 1988. *National Atlas of Ethiopia*, Addis Ababa, Ethiopia.

[14] Fantaw, Y., Abdu, A., 2011. *The effect of crop land fallowing on soil nutrient restoration in Bale Mountains, Ethiopia*. Journal of Science and Development, 1: 43–51.

[15] Fanuel, L., 2015. *Soil spatial variability analysis, fertility mapping and soil plant nutrient relations in Wolaita Zone, Southern Ethiopia*. PhD dissertation. Graduate School, Haramaya University, Harar, Ethiopia.

[16] Fikre, M., 2003. *Pedogenesis of major volcanic soils of the southern central rift valley region, Ethiopia*. MSc thesis. University of Saskatchewan. Saskatoon, Canada.

[17] Gao, G., Change, C., 1996. *Changes in cation exchange capacity and particle size distribution of soil as associated with long term annual application of cattle feed lot manure*. Soil Science, 161: 115–120.

[18] Getahun, B., Bobe, B., 2015. *Impacts of land use types on selected soil physic-chemical properties of Loma Woreda, Dawuro Zone, Southern Ethiopia*. Science, Technology and Arts Research Journal, 4(4): 40–48.

[19] Getahun, Y., Zebene, A., Solomon, Z., 2014. *Wood production and management of woody species in homegardens agroforestry: the case of smallholder farmers in Gimbo district, south west Ethiopia*. International Journal of Natural Sciences Research, 2(10): 278–283.

[20] Havlin, J.L., Beaton, J.D., Tisdale, S.L., Nilson, W.L., 1999. *Soil Fertility And Fertilizers: An Introduction to Nutrient Management* (6th ed). Prentice Hall, Upper Saddle River, New Jersey. 499 p.

[21] Heluf, G., Wakene, N., 2006. *Impact of land use and management practices on chemical properties of some soils of Bako area, Western Ethiopia*. Ethiopian Journal of Natural Resources, 8: 177–197.

[22] IFPRI (International Food Policy Research Institute), 2010. *Fertilizer and soil fertility potential in Ethiopia constraints and opportunities for enhancing the system*. Working Paper, July, 2010, Washington DC, USA.

[23] Jones, A., Breuning-Madsen, H., Brossard, M., Dampha, A., Deckers, J., Dewitte, O., Gallali, T., Hallet, S., Jones, R., Kilasara, M., Le Roux, P., Micheli, E., Montanarella, L., Spaargaren, O., Thiombiano, L., Van Ranst, E., Yemefack, M., Zougmore, R. (Eds)., 2013. *Soil Atlas of Africa*. EC, Publications Office of the European Union, Luxemborg. 176 p.

[24] Kedir, J., 2020. *Effects of different land use system on physico chemical properties of soil in Wudma sub watershed district, southern Ethiopia*. Global Advanced Research Journal of Agricultural Science, 9(6): 151–159.

[25] Lakew, D., Menale, K., Benin, S., Pende, J., 2006. *Land degradation and strategies for sustainable development in the Ethiopian high lands: Amhara region*. Socio-economic and Policy Research Working Paper 32. ILRI, Nairobi, Kenya. 14 p.

[26] Lindsay, W.L., Norvell, W.A., 1978. *Development of a DTPA soil test for zinc, iron, manganese, and copper*. Soil Science Society of America Journal, 42(3): 421–428.

[27] Liu, X.L., He, Y.Q., Zhang, H.L., Schroder, J.K., Li, C.L., Zhou, J., Zhang, Z.Y., 2010. *Impact of land use and soil fertility on distributions of soil aggregate fractions and some nutrients*. Pedosphere, 20(5): 666–673.

[28] Malo, D.D., Schumacher, T.E., Doolittle,. J.J., 2005. *Long-term cultivation impacts on selected soil properties in the northern Great Plains*. Soil and Tillage Research, 81: 277–291.

[29] Materechera, S.A., Mkhabela, T.S., 2001. *Influence of land-use on properties of a ferralitic soil under low external input farming in southern Swaziland*. Soil and Tillage Research, 62: 15–25.

[30] Mehlich, A., 1984. *Mehlich III soil test extractant: A modification of Mehlich II extractant*. Communications in Soil Science and Plant Analysis, 15: 1409–1416.

[31] Mengistu, T., Dereje, T., 2021. *Impact of land use types and soil depths on selected soil physicochemical properties in Fasha District, Konso Zone, southern Ethiopia*. Journal of Soil Science and Environmental Management, 12(1). http//doi.org/10.5897/JSSEM2020.0815.

[32] Mesfin, A., 1998. *Nature and Management of Ethiopian Soils*. Haramaya University of Agriculture, Ethiopia.

[33] Mulugeta, D., Sheleme, B., 2010. *Characterization and classification of soil along the toposequence of KindoKoye watershed in southern Ethiopia*. East Africa Journal of Sciences, 4(2): 65–77.

[34] Nega, E., Heluf, G., 2009. *Influence of land use changes and soil depth on cation exchange capacity and contents of exchangeable bases in the soils of senbat Watershed, western Ethiopia*. Ethiopian Journal of Natural Resources, 11(2): 195–206.

[35] Negassa, W., 2001. *Assessment of Important Physicochemical Properties of Nitosols under Different Management Systems in Bako Area, Western Ethiopia*. MSc. thesis, Alemaya University, Alemaya. 109 p.

[36] NMA (National Meteorological Agency), 2016. Hawassa, Ethiopia.

[37] Paudel, S., Sah, J., 2003. *Physicochemical characteristics of soil in tropical sal (Shorea robusta Gaertn.) forests in eastern Nepal*. Himalayan Journal of Sciences, 1(2): 107–111.

[38] Pierzynski, G.M., Sharpley, A.N., Kovar, J.L., 2008. *Methods of phosphorus analyses for soils, sediments, residues and water: Introduction*. In: J.L. Kovar, G.M. Pierzynski (Eds.), Methods for Phosphorus Analysis for Soils, Sediments, Residuals and Waters (pp. 1–4, 2nd ed.). Southern Cooperative Series Bulletin No. 408.

[39] Shimeles, D., 2012. *Effectiveness of soil and water conservation measures for land restoration in the Wello area, northern Ethiopian highlands*. Ecology and Devt Series No. 89, Doctorial Dissertation, Universality of Bonn, Germany.

[40] SSS (Soil Survey Staff), 2014. *Keys to Soil Taxonomy* (11th ed). United States Department of Agriculture Natural Resources Conservation Service. 346 p.

[41] Stoorvoge, J.J., Smaling, E.M.A., 1990. *Assessment of soil nutrient depletion in sub-Sahara Africa*. Rep. no. 28: 1983–2000, vol. 1–4. Winand Staring Ctr, Wageningen, pp. 1983–2000.

[42] Stoorvogel, J., Smaling, E., Janssen, B., 1993. *Calculating soil nutrient balances in Africa at different scales*. Fertilizer Research, 35: 227–235.

[43] Sumithra, R., Thushyanthy, M., Srivaratharasan, T., 2013. *Assessment of soil loss and nutrient depletion due to cassava harvesting: A case study from low input traditional agriculture*. International Soil and Water Conservation Research, 1(2): 72–79.

[44] Tesfaye, B., 2003. *Understanding farmers: Explaining soil and water conservation in Konso, Wolaita, and Wollo, Ethiopia*. PhD Thesis, Wageningen University and Research Center, the Netherlands.

[45] Teshome, Y., Heluf, G., Kibebew, K., Sheleme, B., 2013. *Impacts of Land use on selected physicochemical properties of soils of Abobo Area, Western Ethiopia*. Agriculture, Forestry and Fisheries, 2(5): 177–183.

[46] Thiemann, S., Schütt, B., Förch, G., 2005. *Assessment of erosion and soil erosion processes a case study from the northern Ethiopian highland*. Topics of Integrated Watershed Management, 3: 173–185

[47] Ufot, U.O., Iren, O.B., Chikere, N.C.U., 2016. *Effects of land use on soil physical and chemical properties in Akokwa Area of Imo State Nigeria*. International Journal of Life Sciences Scientific Research, 2(3): 273–278.

[48] Urioste, A.M., Hevia, G.G., Hepper, E.N., Anton, L.E., Bono, A.A., Buschiazzo, D.E., 2006. *Cultivation effects on the distribution of organic carbon, total nitrogen and phosphorus in soils of the semiarid region of Argentinian Pampas*. Geoderma, 136: 621–630.

[49] van der Eijk, D., Janssen, B.H., Oenema, O., 2006. *Initial and residual effects of fertilizer phosphorus on soil phosphorus and maize yields on phosphorus fixing soils. A case study in south-west Kenya*. Agriculture, Ecosystems & Environment, 116(1–2): 104–120.

[50] Walkley, A., Black, C.A., 1934. *An examination of Degtjareff method for determining soil organic matter and proposed modification of the proposed modification of the chromic acid titration method*. Soil Science, 37: 29–38.

[51] Wang, J., Fu, B., Qiu, Y., Chen, L., 2001. *Soil nutrients in relation to land use and landscape position in the semi-arid small catchment on the loess plateau in China*. Journal of Arid Environments, 48(4): 537–550.

[52] Wang, B., Xue, S., Liu, G.B., Zhang, G., Li, G., Ren, Z., 2012. *Changes in soil nutrient and enzyme activities under different vegetations in the Loess Plateau area, Northwest China*. Catena, 92: 186–195.

[53] Wassie, H., Shiferaw, B., 2011. *Response of Irish potato (Solanum tuberosum) to the application of potassium at acidic soils of Chencha, Southern Ethiopia*. International Journal of Agriculture and Biology, 13(04): 598.

[54] Wassihun, M., 2021. *Land use changes and their effects on soil physical and chemical properties in Abolworeda Gambella Regional State*. Journal of Resources Development and Management, 75(21). https://doi.org/10.7176/JRDM/75-01

[55] Wasihun, M., Muktar, M., Teshome, Y., 2015. *Evaluation of the effect of land use types on selected soil physico-chemical properties in Itang-kir Area of Gambella Regional, Ethiopia*. Journal of Biology, Agriculture and Health Care, 5(11).

[56] WRB (World Reference Base), 2006. *A framework for international classification, correlation and communication*. World Soil Resources Report 103 (68 p). Food and Agriculture Organization of the United Nations, Rome.

[57] Yengoh, G.T., 2012. *Determinants of yield differences in small-scale food crop farming systems in Cameroon*. Agriculture and Food Security, 1: 19.

[58] Yifru, A., Taye, B., 2011. *Effects of land use on soil organic carbon and nitrogen in soils of Bale, Southeastern Ethiopia*. Tropical and Subtropical Agroecosystems, 14(1): 229–235.

[59] Yihenew, G.S., 2002. *Selected chemical and physical characteristics of soils of Adet Research Center and its testing sites in northwestern Ethiopia*. Ethiopian Journal of Natural Resources, 4: 199–215.

[60] Yihenew, G.S., 2007. *Evaluation of nitrogen and phosphorus as yield-limiting nutrients for maize grown on Alfisols of Western Amhara*. Ethiopian Journal of Natural Resources, 9(1): 155–170.

[61] Yihenew, G.S., Fantanesh, A., Solomon, A., 2015. *The effects of land use types, management practices and slope classes on selected soil physico-chemical properties in Zikre watershed, North-Western Ethiopia*. Springer Open Journal of Environment System Research, 4: 1–7.

[62] Yihenew, G.S., Getachew, A., 2013. *Effects of different land use systems on selected physico-chemical properties of soils in North Western Ethiopia*. Journal of Agricultural Science, 5(4). http://dx.doi.org/10.5539/jas.v5n4p112.

[63] Zajícová, K., Chuman, T., 2019. *Effect of land use on soil chemical properties after 190 years of forest to agricultural land conversion*. Soil and Water Research, 14: 121–131.

[64] Zeleke, T.B., Grevers, M.C.J., Si, B.C., Mermut, A.R., Beyene, S., 2004. *Effect of residue incorporation on physical properties of the surface soi1 in the South Central Rift Valley of Ethiopia*. Soil and Tillage Research, 77: 35–46.