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RESEARCH PAPER

Spatial Variability and Status of Selected Physico-Chemical Properties of Soil in Different Land Use Types: The Case of Kiramu District, East Wollega Zone, Oromia

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Abstract

Determining spatial variability and status of selected soil properties is important for the evaluation of agricultural land management practices and planning of sustainable soil management of specific land uses types. This research work was carried out in Kiramu district of Oromia Region, western Ethiopia to investigate spatial variability and status of selected physico-chemical properties of soils under different land uses. The natural forestland was used as control group to assess status of soil properties by comparing with the cultivated land, which was further stratified in to mid high land and semiarid land based on topography and climate. Representative soil samples (0-30)cm depth were collected randomly from each land uses and analyzed for the selected soil physico-chemical properties., The particle size distribution sand was the dominant fraction in all of the soil of the land uses and sand, silt, clay, bulk density and soil moisture content ranged from 51 to 65%, 15 to 23%, 18 to 28%, 0.96 to 1.38 g cm^{-3}and 5.28 to 17.95%, respectively. The soil pH varies from slightly acidic to strongly acidic (6.09 to 5.19, exchangeable Ca, Mg, K and Na respectively ranged from (6.61 to 13.98cmol (+) kg^{-1}), (2.67 to 6.30cmol (+)kg^{-1}), (0.27to 1.14cmol(+) kg^{-1})and (0.03 to 0.13cmol(+) kg^{-1}). Moderate to very high CEC (18.30 to 49.09cmol(+) kg^{-1}), low to moderate PBS (28.52 to 57.33%), low to high in OM (2.24 to 7.38%) and total N (0.11 to 0.37%), very low to low, Available P (2.35 to4.21) ppm and Available(6.78 to 18.06) ppm were recorded. Exchangeable acidity ranged from 0.07 to 1.41 while soil C: N ranged from 11.61 to 11.63. The coefficient variability of soil properties among the land use type were more pronounced in chemical properties than in physical properties. The spatial variability of soil properties indicates that they were strongly affected by natural and anthropogenic factors as well as soil management practices. It was recommended that there is a need for appropriate interventions and special attention to improve on land management practices for sustainable productivity of soils in different land use types in present study area.

***Key Words:** Kiramu district, land uses, management practices, soil properties, spatial variability.*

Introduction

In Ethiopia, agriculture is long-term capital on which the nation builds and grows (Sumner, 2000). It provides an employment to 85% of the population, contributes 90% of the total export earnings, supplies over 70% of the total raw materials required by industries and accounts for 60% of the country's gross domestic product (CSA, 2019 This indicates that agriculture is the main economic sector in the majority of the countries in the world and the world's population (Ahmed, 2002).In order to maintain the agricultural sector, determining spatial variability of soil based on their physico-chemical properties is important for ecological modeling, sustainable agriculture and management of natural resources (Wang, 2009). Spatial variability is a term indicating changes in the value of a given property over space (Ettema and Wardle, 2002) Literatures revealed that the spatial characteristics of soils depend on climatic conditions topography, type of vegetation and land uses anthropogenic factors (Wang et al., 2009;Patilet al., 2010;Wangand Shao, 2013). Thus, having information on the spatial variability and the interactions between soil properties is essential for understanding these ecosystem processes and planning sustainable soil management alternatives for specific land use (Ziadat and Tamimeh, 2013). Furthermore, conversions of an area from natural ecosystem to cultivated land may be the reason of soil degradation and decreases of quality. Because, land uses have significant influences on soil quality indicators particularly at the surface horizons. Several studies also revealed, intensive cultivation and use of acid forming inorganic fertilizers for the past three decades in western Ethiopia affected soil pH, CEC, total N and OC, different forms of P and exchangeable bases. This implies that soil physical and chemical properties are strongly influenced by soil management systems and changes in land use types (Wakene and Heluf, 2003, Achalu et.al. 2012, Abraham et.al. 2019, Achalu and Teshome, 2019).

The soils of the present study area have been continuously cultivated and have great impact on the soil physical and chemical properties in different land uses types. Evaluating and investigating the status of land uses and management practices requires the knowledge of soil spatial variability and understanding the relationship of soil properties under different land uses. However, there is limitation of knowledge and detail information about spatial variability of soil physico-chemical properties and effects of conversion of natural ecosystem to cultivated lands that has been increasing in the recent years in the area. Hence, there is a critical need to investigate the soil physico-chemical properties in Kiramu District, East Wollega, Oromia zone, western Ethiopia.

Materials and Methods

Descriptions of Experimental Sites

The study was conducted at Kiramu district of East Wollega zone in Oromia National Regional State, western Ethiopia. It is located about 470 km away from Addis Ababa, and about 140 km north of Nekemte town, the zonal capital of East Wollega in the Nekemte-Bahir Dar main road.

According to ERA (2013) final ESIA Document for Nekemte–Bure project, the study area has two agro ecological zone arid (Gammoojjii) and due mid altitude agro ecology (Baddadaree) zone, which accounts about 42.7% and 57.3%, respectively. Similarly, its altitudinal difference ranging between 1500-2300 m.a.s.l., effective mean annual temperature between 15 - 20 oC, and its mean annual rainfall is in between 1000 to 1600 mm. The main economic activities of the study area are mixed farming system that includes animal rearing and cultivation. Crops mainly grown in the area are cereals (Maize and Finger millet), oil seed crops (Niger seed), and different types of horticultural crops. In addition to crop production, Cattle, Goats, Sheep and poultry are also the other income sources and wealth of farmers. According to ERA (2013), of soil naming, the dominant soils in the district are Dystric and Eutric-cambisols and Dystric, and Haptic Nitisols. Additionally, the soil type in the study area is that black cotton accounts 5%, Red clay 15% and lime accounts about 85%. According to Kiramu Agricultural Office (2017), an assessment of the land use in woreda showed that 0.97% of its land is forestland, 8.24% grazing land, 82.29% cultivated land and the remaining 8.5% includes non-cultivated water bodies, swampy and rocky mountain areas, different services and others. Nole wetland and Gurangoye forests (30 hectares) are some of the biologically important location in the Kiramu district.

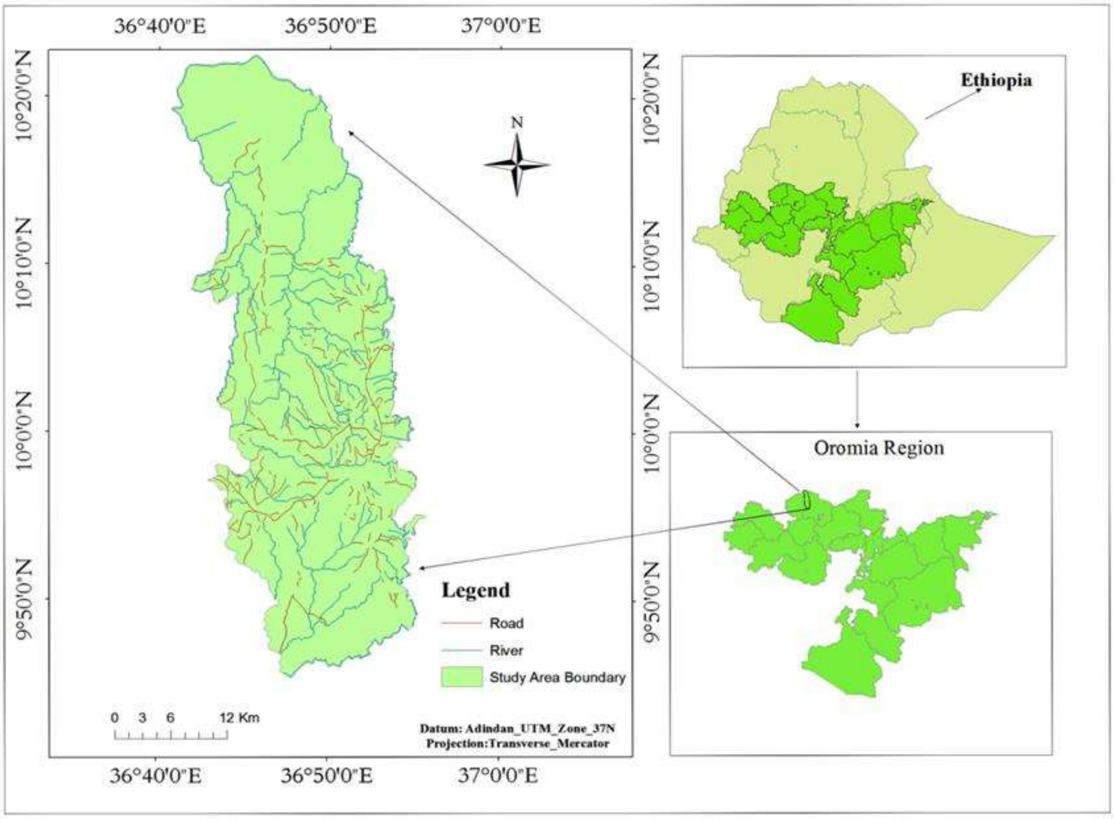

Figure1.General Location Map of the Study Area.

Sites Selection and Soil Sampling Technique:

Preliminary field observation and a reconnaissance soil survey with purposive sampling method were carried out to identify representative land use types, topography and climate in the district. Sampling sites was stratified in to two major representative land use types: cultivated land and natural forestland and cultivated land further classified in to mid altitude (*Baddadaree*) its altitudinal difference ranging between 1990-2211 m.a.s.l and semiarid (*Gammoojjii*) its altitudinal difference ranging between 1447-1535 m.a.s.l based on climate and topography (elevation) by using GPS. Forestland representatives' sample (Gurangoye and Gurawatino) covered with indigenous natural forest and can be used as a control group. Sampling procedure used wasfield based or directed soil sampling method in which 10-15 cores were taken from every 20 or more acres(≥ 80,000 m^2) of field (USDA - NRCS, 2017) and composite soil sample was performed by combining soil from several locations prior to analysis. Undisturbed core and disturbed composite surface soil samples at a soil depth of 0-30cm were collected from each representative land uses, by using soil augur in zigzag and random pattern. Then composite soil sample of about 1Kg was properly combined and prepared for each representative land uses and sealed with plastic bags together with a tag. Totally three composite soil samples were collected

Laboratory Analysis of Soil physical and chemical Properties:

The well-mixed soil sample was brought to the laboratory. The Soil samples collected were air-dried and ground to pass through a 2 mm size sieve in preparation for the analysis of all soil properties except for soil OM and total N. For the analysis of soil OM and total N, the soil samples were further passed through 0.5 mm sieve. Determination of soil particle size distribution was carried out by the Bouyoucas hydrometer method as described by (Okalebo et al., 2002). Soil moisture content was determined by the gravimetric method that must consider the actual soil moisture content as described by (Sparks et al., 1996).Soil bulk density was measured from undisturbed soil samples collected using a core sampler, which was weighed at field moisture after drying the pre-weighed soil core samples to constant weight in an oven at 1050C as per the procedures described by(Black,1965).Total N was determined using the micro-Kjeldahl digestion, distillation and titration procedure as described by (Bremner and Mulvaney,1982).

Available P was analyzed using Olsen method as described by (Olsen and Sommers, 1982). Exchangeable bases (Ca, Mg, K and Na) were extracted using 1M NH4OAc solution at pH 7. The extraction of Ca and Mg ions were determined using AAS while K and Na were determined by flame photo meter as described by (Rowell, 1994). To determine the cation exchange capacity (CEC), the soil samples were firstleachedwith1M ammonium acetate (NH4OAc), extracted (ammonium ion standard) soil samples with 10% NaCl solution. The amount of ammonium ion in the percolate was determined by the Kjeldahl procedure and reported as CEC (Hesse, 1972).Total exchangeable acidity was determined by saturating the soil samples with 1M KCl solution and titrated with 0.02M HCl as described by (Rowell,1994). The effective CEC is calculated as the sum of exchangeable bases and exchangeable acidity, the percent acid saturation (PAS) was calculated as the ratio of the exchangeable acid and as percentage of CEC. The percent base saturation (PBS) was computed from the sum of the exchangeable bases (Ca, Mg, K and Na) as percentage of CEC (Baruahand Barthakur, 1997). Finally, Ca/Mg and Mg/K ratios were calculated by computation.

Data Analysis

Data analysis was carried out using SPSS statistics version 20 and subjected to Analysis of Variance (ANOVA) following the General Linear Model (GLM) procedure of Statistical Analysis System (SAS) version 9.2 (SAS, 2008) Pearson's simple correlation coefficient and significant means were separated using Least Significant Difference (LSD) at < 0.05 and < 0.01) was used to compare and separate for significant means.

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Results and Discussion

Status of Selected Soil physical Properties of Different Land Use Types

Particle size distribution analysis of the top soils (0-30 cm) from the present study area revealed that sand was dominant fraction (51-65%) in all of the land use types (Table 1). This was followed by silt (23%) and clay (18%) in forestland whereas it was followed by clay and silts for cultivated mid high land and cultivated semi-arid land (Table 1). According to Hazelton and Murphy (2007), the soils of the study area are characterized by low-level of clays in forestland and cultivated mid high land, moderate level of clay in cultivated semi-arid land, while low level of silt and very high level of sand in all land use types. The lower level of clay fractions in both forest land and cultivated mid high land of top soil might have been attributed to relatively higher rate of down ward erosion or destruction of clay in the top soil (Siddique et al., 2014) and slow rate of weathering process. The moderate level of clay fraction in cultivated semi-arid land might be due to the climatic variation that is supported by the observation of Agoumé and Birang(2009) that reported a significant difference on the clay, silt and sand fractions of the soil and attributed the differences to variations in climatic condition. There was non-significant difference on soil particle size distribution of the soil with respect to land use. This suggests that the different land use types did not have effect on the soil texture of the study area, since texture is an inherent soil property that not influenced in short period of time. Similarly, Shepherd, et al.(2000) reported that non- significant effect of land-use systems on soil particle size distribution. Following the particle size distribution, the textural class of the study area were sandy loam in top (0-30 cm) soil of the forestland and cultivated mid high land that indicating the homogeneity of soil forming processes and their similarity in parent material(Foth,1990) while sandy clay loam in cultivated semi-arid land(Table 1).The high sand fraction in the study locations could be attributed the parent material dominant in the area, which is sand since the texture of the soil is highly influenced by the parent material over time (Oguikeand Mbagwu, 2009). Negatively and significantly relationship of clay with sand (-0.67) fractions were observed, however negative and insignificant correlation of clay with silt (-0.03) fractions were observed.

Table 1.Measured mean Values of selected soil physical properties in different land use types of the study area.

Depth	Land uses	Parameters						
		Sand	Silt	Clay	St :Cy	Texture	SMC	BD
0-30 cm	FL	59	23	18	1.28	SL	17.95	0.96
	CMHL	65	15	20	0.75	SL	5.29	1.10
	CSAL	51	21	28	0.75	SCL	17.63	1.38

FL=forestland; CMHL=cultivated mid high land; CSAL=cultivated Semi-arid land; BD=bulk density; SMC=soil moisture content; SL=sandy loam; SCL=sandy clay loam; St: CY=silt to clay ratio.

Silt clay ratio in the top soil (0-30cm depth) was low and 1.28, 0.75 and 0.75 for soils of forest, cultivated arid and cultivated mid altitude land, respectively (Table1).Relatively higher clay fraction and lower silt to clay ratio recorded in the cultivated land of both locations is attributed to the impact of deforestation and farming practices. This finding is in agreement with Achalu et al.(2012)who reported that due to difference in management practices and selective erosion in cultivated land resulted higher clay fraction in the cultivated land than the remaining land use system. The soils under different land use types and location differed in their soil moisture content. The variation may be due to difference in their organic matter content, which is lowest (5.29%) in cultivated mid high land and highest in forestland (17.95%) (Table1). In line with Ebtisam and Dardiry (2007) mentioned in (Achalu et al, 2012) that attributed the variation in SOM and clay contents of land uses. The soil moisture content was highly positively and significantly relationship with silt (0.77*), CEC (0.81**) and OM (0.78*).

The bulk density value of top (0-30cm) soil ranged from 0.96g/cm3, 1.10 g/cm3 and 1.38 g/cm3 in forest, cultivated mid high land and cultivated semi-arid land, respectively (Table 2).The lowest bulk density observed in soils of the forest land could be attributed to the high organic matter contents as was reported by Eyayu et al. (2009); Mojiri et al. (2012). In addition, the bulk density of the studied forest soils was fallen with the specified range as was suggested by White (1997) who revealed that bulk density is < 1 g cm-3 in high organic matter soils and largely affected by land uses.

Thus, the mean value of bulk density of the soils of cultivated semi-arid cultivated mid highland increased by 43.5% and 15%, respectively from the soils of forest land (Table2).

Table 2.Variability in soil physical properties among different land uses. (Mean±SE)

Land use types		soil physical properties					
		Sand	Silt	Clay	St: Cy	BD	SMC
Forest land		59.00	23.00	18.00	1.28	0.96	17.95
Cultivated mid high land		65.00	15.00	20.00	0.75	1.10	5.29
Cultivated semi-arid land		51.00	21.00	28.00	0.75	1.38	17.62
TOTAL	Range	22	13	17	1.08	0.45	14.84
	Mean	58.33	19.67	22.00	0.93	1.16	13.62
	Std. error	2.74	1.47	1.84	0.11	0.06	2.12
	Std. deviation	8.22	4.42	5.52	0.33	0.17	6.35
	LSD (0.05)	0.29	0.44	0.52	0. 92	0 .02	0 .76
	CV (%)	**14.09**	**22.47**	**25.09**	**35.48**	**14.66**	**46.62**

The high bulk density recorded in cultivated semi-arid land could be attributed to difference in parent material, soil type, climate and topography. This is in line with Reuter et al.((2005) reported that bulk density and temperature significantly higher at lower elevations. The overall bulk density showed negative but not significant correlation with soil OM (-0.38).Thus, the study indicated that as the organic matter increases the bulk density of soil decreases that is required for the proper growth of the plants. In agreement with the findings, Pravin et al. (2013) indicated inverse relationship between soil organic matter and bulk density of soil horizons.

Status of Selected Soil Chemical Properties of Different Land Use Types:

The average surface soil (0-30cm) pH-H2O values of the soils were 5.19, 5.64 and 6.09 in cultivated semi-arid land, forest land and cultivated high land respectively (Table 3). According to Tekalign (1991) the pH-H2O range of the studied soils results showed that the soils were slightly acidic, moderately acidic and strongly acidic in cultivated mid high land, forest land and cultivated semiarid land, respectively. The lower pH at the surface layer of the forestland than cultivated mid high land could be the presence of higher content of organic matter in the soil. The lowest pH value in soils of the cultivated semi-arid land could be attributed to the removal of basic cations by harvested crops and surface runoff, the use of fertilizers especially those supplying nitrogen, higher microbial oxidation that produces organic acids, which provide H+ to the soil solution and, thereby, lowers soil pH. This is in agreement with Busari et al. (2005) who explained in warm humid climate, it is likely to be thoroughly oxidized, well leached, and comparably low calcium because of leached out and due to the amount of materials removed at previous harvests, amount and type of fertilizer normally used. In line with this finding, the least significant difference ($p \leq 0.05$) test showed significant differences in pH-H2O between cultivated mid high land and cultivated semi-arid land use types. Thus together with climate, the nature and properties of parent materials are the most significant factors influence the pH value of the soil.

Table 3. Measured mean values of pH (H2O), pH (KCl), Ex. Al and PAS in different land uses of the study area.

Depth	Land uses	Soil Chemical parameters				
		pH- H2O	pH -KCl	ΔpH	Ex. Al.	PAS
0-30 cm	FL	5.64	4.48	1.16	0.07	0.34
	CMHL	6.09	4.61	1.48	0.12	1.09
	CSAL	5.19	3.92	1.27	1.41	10.24

FL=forestland; CLMHL=cultivated mid high land; CSAL=cultivated semi-arid land; Ex. Al=exchangeable acidity; PAS=percent of acid saturation.

In all of the identified land use types of the representative soil, soil pH-H2O values were consistently greater than the pH-KCl by about 1.16 to 1.48 units(Table 3), indicating the existence of net negative charges on the exchange complex. The lower soil pH-KCl values could also indicated the presence of substantial quantity of exchangeable hydrogen ion as outlined by Mulugeta and Sheleme (2011). This is related to the presence of weather able minerals in the soil that indicated high potential acidity (Heluf and Wakene,2006).It was also explained differences between pH-H2O and pH-KCl higher than 1.0 indicated that an acidification process is in progress in all studied soils (Ozgoz et al., 2013).

Exchangeable Acidity and Percent of Acid Saturation:

There was great variation on exchangeable acidity and acid saturation of the soils under the different land use types of topsoil (0-30cm). The highest exchangeable acidity value obtained from soils of cultivated semi-arid land (1.41) and followed by cultivated mid high land (0.12). The high soil exchangeable acidity in the cultivated semi-arid land might be associated with the occurrence of lower soil pH. Reports also indicated that exchangeable acidity is a function of soil pH composed of compounds such as Al(OH)2+ and weak organic acid ions held at the colloidal surfaces of the soil (Hinrich et al., 2001). Strong negative correlation (r = -0.67) between exchangeable acidity and soil pH (Table 6). Significant ($p \leq 0.05$) differences in exchangeable acidity among the land use types. Relatively, the highest acid saturation were recorded in cultivated semi-arid field (10.24%) and followed by cultivated mid high land (1.09) whereas the lowest was in forestland (0.34) that showed similar trend with Ex.Al (Table 3).

Table 4.Variability in pH, EC, Ex.A and PAS among different land uses of the study area. (Mean ±SE)

Land use types		Soil Chemical Parameters			
		pH-H_2O	pH-KCl	Ex. Al	PAS
FL		5.64	4.48	0 .12	0 .34
CMHL		6.09	4.61	0 .07	1.09
C SAL		5.19	3.92	1.41	10.23
TOTAL	R	5.19-6.09	3.92-4.61	0.07-1.41	0.34-10.23
	X	5.64	4.34	0.53	3.82
	SE	0.17	0.21	0.22	1.700
	SD	0.51	0.64	0.67	4.83
	LSD (0.05)	0 .20	0 .81	0 .64	0 .78
	CV (%)	**9.04**	**14.75**	**126.64**	**126.64**

FL=forestland; CLMHL=cultivated mid high land; CSAL=cultivated semi-arid land; Ex.Al = exchangeable acidity; PAS = percent of acid saturation; R=range; X=Mean; SD=standard deviation;

In general, the differences in level of acid saturation at both locations of cultivated land more probably due to topographic condition, the management factor and the intrinsic character of the soils. There was a less significant ($p \leq 0.05$) difference in acid saturation among the land use types. Strong positive correlation of exchangeable acidity with PAS (0.99**) while strong negative correlation with PBS (-0.80*) The inverse relationship of exchangeable acidity and PAS with PBS could be due to deforestation and intensive cultivation, which leads to the higher exchangeable acidity content in soils of cultivated lands than the other land use (Baligar et al., 1997; Achalu et al., 2012).In general, the highest status of acidity on cultivated semi-arid field indicated the marked influence of tillage activities, soil parent material and removal of basic cations by crop uptake whereas the better soil condition on cultivated mid high land soils signify the importance of agricultural management practices such as supplying animal manure, dung and crop rotation.

Exchangeable Bases, CEC and Percent of Base Saturation:

The exchangeable bases varied markedly due to differences in land use systems (Table 5).The highest total exchangeable bases (20.81cmol (+)/kg) was recorded on forestland soils followed by cultivated semi-arid land (12.37cmol (+)/kg) and cultivated mid high land soil(10.49 cmol (+)/kg).As per the ratings of FAO (2006), the exchangeable calcium (Ca) was high under forest land (13.98cmol (+)/kg)whereas moderate under cultivated mid high land (7.44cmol (+)/kg) and cultivated semi-arid land (6.61cmol (+)/kg). The exchangeable Mg was high under forestland(6.30cmol (+)/kg) and cultivated semi-arid land(4.59cmol (+)/kg) while moderate under cultivated mid high land (2.67cmol (+)/kg).The exchangeable K was low, moderate and high in soils of cultivated mid high land(0.27cmol (+)/kg), forestland(0.41cmol (+)/kg)and cultivated semi-arid land(1.14cmol (+)/kg), respectively while the exchangeable Na was low under all land use types (Table5). Concentrations of exchangeable cations in the study area were generally in the order of Ca>Mg>K>Na (Table 5). This might have resulted from the strong energy of adsorption of Ca, making it typically more abundant as an exchangeable cation than are Mg, K or Na (Foth, 1990). The finding was in line with (Bohn et al., 2001) who reported Ca followed by Mg, K and Na, indicating productive agricultural soils, dominated the exchange complex.

Table 5.Measured mean values of exchangeable cations and exchange properties of soil in different land uses of the study area (0-30 cm).

Land uses	Parameters									
	Ex.Ca	Ex.Mg	Ex.K	Ex .Na	TEB	CEC	ECEC	Ca/Mg	Mg/K	PBS
	-------------------------cmol(+)kg^{-1}--------------------------							-------ratio------		(%)
FL	13.98	6.30	0.41	0.13	20.81	49.09	20.88	2.22	15.48	42.39
CMHL	7.44	2.67	0.27	0.11	10.49	18.30	10.61	2.79	9.92	57.33
CSAL	6.61	4.59	1.14	0.03	12.37	43.36	13.78	1.44	4.01	28.52

FL=forestland; CMHL=cultivated mid high land; CSAL=cultivated semiarid land; Ex.Ca=exchangeable calcium; Ex. Mg=exchangeable magnesium; Ex.K=exchangeable potassium; Ex.Na=exchangeable sodium; TEB=total exchangeable bases; CEC=cation exchange capacity; ECEC=effective cation exchange capacity; PBS=percent of base saturation.

Compared to cultivated land the relatively higher concentrations of exchangeable Ca, Mg, and Na contents recorded in soils of forestland (Table 5) could be due to crop harvest, erosion and leaching of basic cations from top soils of cultivated land. The highest content of Ca2+in forestland might be attributed to leaves from plant falls and microbial activities common in this land use. The concentration of exchangeable Mg2+in the land use was higher (sufficient) than the critical level of 0.5 cmol/kg soil as suggested by (Landon, 1991); a concentration less than this value would require an application of magnesium limestone accordingly. The total exchangeable bases decline in cultivated mid high land might be showing the high concentration of the Fe2+ ions in the soil. Similarly, He et al. (1999) reported that domination of soil by extractable Al3+ and Fe2+ ions in the top soils of cultivated land resulted in relatively lower contents of Ca and Mg ions in the soil. In addition it might be related to intensive and continuous cultivation, high level erosion and removal of base cations during crop harvest that enhanced the depletion of soil nutrients.The higher concentration of exchangeable K in soils of cultivated semi-arid land might be due to the presence of wood ash in the soil. However, the lowest value of exchangeable K in cultivated soil of mid high land might be related to intensive cultivation, erosive nature of the soil (sandy soil), and removal of base cations during crop harvest that enhanced its depletion. Therefore, in cultivated fields of mid high land, it is deficient (0.27cmol(+) kg-1) when compared to 0.38cmol (+) kg-1 which is established to be critical level of exchangeable K for most crops (Barber, 1984).This is contrary to the old-age generalization that Ethiopian soils are rich in K. Also, Heluf and Wakene (2006) observed that continuous and intensive cultivation and use of acid forming inorganic fertilizers affected the distribution of K in the soil and enhanced its depletion. Similarly, exchangeable sodium was almost negligible in all land use types. This might be because of the small energy of adsorption of Na, it is more likely exist in the soil solution and be removed from the soil by leaching (Foth, 1990).More over since the concentration of exchangeable Na+ did not exceed 1cmol (+)/kg soil (Landon, 1991), the soil in the study area would not be regarded as sodic soil. The pH also showed that the soil is acidic. Thus, the concentrations of basic cations in the soil provide a very good assessment of soil fertility because individual cations are an indication of nutrient status and balance (Siddique et al., 2014).Significant (p≤0.05)differences in total exchangeable bases among the land use types and forest soils had significantly higher exchangeable bases (p<0.01) than soils under the cultivated land use types of both locations. Generally, variations in the distribution of exchangeable bases depends on the mineral present, particle size distribution, degree of weathering, soil management practices, climatic conditions, degree of soil development, the intensity of cultivation and the parent material from which the soil is formed (Heluf and Wakene, 2006).

Table 6. Variability in exchangeable cations and exchange properties of soil among different land uses of the study area (mean±SE)

Land use types		Parameters								
		Ex.Ca	Ex.Mg	Ex. K	Ex. Na	TEB	CEC	ECEC	Ca/Mg	PBS
FL		13.98	6.30	0.41	0.13	20.81	49.09	20.93	2.23	42.6
C MHL		7.44	2.67	0 .27	0.11	10.49	18.30	10.56	2.87	57.77
CSAL		6.61	4.59	1.14	0.03	12.37	43.36	13.78	1.45	28.70
TOTAL	R	9.06	4.49	1.05	0.14	11.58	37.06	11.61	1.98	41.18
	X	9.34	4.52	0.61	0.09	14.56	36.92	15.09	2.18	43.02
	S E	1.19	0.54	0.14	0.02	1.61	4.81	1.56	0.24	4.46
	SD	3.56	1.63	0.41	0.05	4.83	14.42	4.68	0.71	13.38
	LSD (0.05)	0 .23	0.01	0.10	0.35	0.05	0.06	0.01	0.10	0.02
	CV (%)	38.12	36.06	67.21	55.56	33.17	39.06	31.01	32.57	31.10

FL=forest land; CMHL=cultivated mid high land; CSAL=cultivated semiarid land; R=range; X =mean; SE =standard error; SD =standard deviation;

The average values of cation exchange capacity were 49.09cmol (+)/kg for soils of forestland, 43.36cmol (+)/kg for soils of cultivated semi-arid land and18.30cmol (+)/kg for soils of cultivated mid high land (Table5). According to the rating suggested by Hazelton and Murphy (2007), the mean CEC value of the soils of the study area ranged from moderate for soils of cultivated mid high land (18.30cmol (+)/kg) to very high in soil of forest land (49.09cmol(+)/kg) and cultivated semi-arid land (43.36cmol(+)/kg).The soils of forestland and cultivated semi-arid land have higher CEC than soil of cultivated mid high land probably because of the presence of higher organic matter contents of the land use types. This is in agreement with Adeboye et al.(2011); Yihenew and Getachew (2013) who indicated that high organic matter and clay contents increase CEC in soils. Also, McAlister et al. (1998) justified that CEC of soils varies with the changes of clay percentage, the type of clay, soil pH and amount of organic matter. The observed reductions in the mean soil CEC values of the considered land use types due to conversion of forest lands into cultivated lands accounts 11.69% (for cultivated semi-arid land) and 62.73%(for cultivated mid high land), respectively in top soils of the study area (Table 5). This showed that the soil CEC values in the cultivated land uses of both locations decreased mainly due to the reduction in OM content. In agreement with this, strong positive and significant correlation (0.86**) of CEC with soil OM. Similarly, significant ($p \le 0.05$) differences in CEC among the land use types. Thus, the findings of the present study concur with Woldeamlak and Stroosnijder (2003) who reported highest CEC value in soils of forestland and lowest under cultivated land.

Following the variation in exchangeable bases and cation exchange capacity, the base saturation percentage (PBS) of the soils in the study area showed considerable variability among the land use types (Table 5).Accordingly the highest PBS was recorded under cultivated mid high land field (57.33%) followed by forestland (42.39%) and cultivated semi-arid land (28.52). As per rating of Hazelton and Murphy (2007) PBS content of the studied soils was moderate under forestland (42.39) and cultivated mid high land (57.33) whereas low under cultivated semi-arid land(28.52) . According to Landon (1991), soils having greater than 60% base saturation are rated as fertile and potentially productive soils. The Ca to Mg ratio in the three land use types (Table 5) was low with values ranging from 1.44-2.77when compared with a normal range of 3.1-5.1 for productive soils. This ratio indicated that the Ca content in the soil solution is low when compared to the Mg content irrespective of the land use type. On the other hand, the Mg/K contents were high (>1.2) with values ranging from 4.01 (cultivated semi-arid land) to 15.48 (forestland) when compared with a critical level of 1.2 for productive soils (Landon, 1991).

Organic Matter, Total Nitrogen and Carbon to Nitrogen ratio:

The organic matter (OM) contents were 7.38, 4.20 and 2.25%in the soils of forestland, cultivated semi-arid land and cultivated mid high land respectively (Table 7). As compared to the soil of forestland, the amount of soil OM in cultivated mid high land and cultivated semi-arid land has depleted by 69.59 and 56.87%, respectively (Table 4). As per the rating of Tekalign (1991) the OM contents of the soils in forest, cultivated semi-arid land and cultivated mid high land use types were rated as high, moderate and low, respectively. Higher quantity of OM in forestland soil is mainly due to the addition of more plant residues on its surfaces, as compared to the cultivated land use types of both locations.

The low content of organic matter in the cultivated mid high land fields might be associated with increased rates of mineralization of OM mainly caused by the continuous and intensive tillage activities, increased soil temperatures due to exposure of the soil surface, and the removal of plant residue. The result was in agreement with Yihenew and Getachew (2013) who reported that lowest organic carbon was registered in cultivated land and highest in the natural forestland. Continuous and intensive cultivation reduced the organic matter content of the soil to a larger extent and increasing SOM decomposition rates, as reported by Gebyaw (2015). Forest clearing followed by conversion into grazing and agricultural land uses in tropical ecosystems brought about remarkable decline of the soil OM stock (Achalu et al., 2012).

Table7. Measured mean value of organic matter, total N, available P and available K of soil in different land uses of the study area.

Depth	Land uses	Parameters					
		OC (%)	OM (%)	TN (%)	C/N	Av.P Olsen(ppm)	Av.K (ppm)
0-30 cm	FL	4.28	7.38	0.37	11.61	2.36	6.78
	CMHL	1.30	2.25	0.11	11.63	4.21	6.95
	CSAL	2.44	4.20	0.21	11.60	2.35	18.06

FL=forest land; CMHL=cultivated mid high land; CSAL=cultivated Semi-arid land; OC=organic carbon; OM=organic matter; C/N=carbon nitrogen ratio; Av. P=Available phosphorus; Av. K=Available potassium

Also, Yihenew (2002) reported that most cultivated soils of Ethiopia are poor in their organic matter content due to low amount of organic materials applied to the soil and complete removal of the biomass from the field. Soil OM contents under the land use types were significantly ($p \leq 0.05$) varied. In general, the highest organic matter content was recorded at the surface layer of the natural forestland soils, while the lowest was observed on the cultivated land soils. In line with the variations in OM content, total nitrogen also exhibited some degree of variability among soils of the land use types. Consequently, the total N content in the surface of the soils of the study area were: 0.37% for soils of forest land, 0.21% for soils of cultivated semi-arid land and 0.11% for soils of cultivated mid high land (Table 7). According to Tekalign (1991), the total N content of the soils is categorized under low for soils of cultivated mid high land, medium for soils of cultivated semi-arid land and high for soils of forest land.

Table 8.Variability in organic matter, total N, available P and available K of soil among different land uses of the study area (mean±SE).

Land use types		OM (%)	TN (%)	C: N	Av. P (ppm)	Av. K (ppm)
Forest land		7.38	0.37	11.63	2.36	6.78
cultivated mid high land		2.25	0.11	11.62	4.21	6.95
cultivated semi-arid land		4.20	0.23	11.63	2.35	18.06
TOTAL	Range	6.04	0.30	0.05	2.40	13.49
	Mean	4.61	0.23	11.63	2.97	10.60
	SE	0.77	0.04	0.01	0.32	1.89
	SD	2.31	0.12	0.02	0.95	5.66
	LSD (0.05)	0.01	0.01	0.72	0.98	0.85
	CV (%)	50.10	52.17	0.17	31.99	53.40

The principal cause for lower contents of total N in the cultivated mid high land could be attributed to intensities of erosion, intensive and continuous cultivation, the N leaching problem, biomass removal during crop harvest and insufficient replenishment through manure or fertilizers. In consent with Bahami et al.(2010); Heshmati et al. (2011); Taye (2011);Mojiri et al. (2012) reported considerable loss of total nitrogen from soils following conversion of land from forest to cultivated land due to harvest removal, leaching, and humus losses associated with cultivation. In contrast, greater TN contents of the forest soils are probably due to decomposition, higher litter production and N fixation by the leguminous acacia species. This is in line with Hall (2008)explained that the highest total N under forestland might be because of decaying plant and animal matter and nitrogen compounds produced by thunderstorms. The trends of total N generally showing the strong relationship between OM and total N as indicated by the positive and very highly significant (1.00**) correlation (Table 11), indicating the strong influence of organic matter on TN content. Therefore, organic matter (OM) and the TN were highly affected by the different land use systems particularly in the surface horizons. In consent with Meysner et al. (2006) indicated that as much as 93 to 97% of the total N in soils is closely associated with OM. In supporting of this finding, the least significant difference ($p \leq 0.05$) test has shown significant differences in OM and TN among the land use types.

The average carbon nitrogen ratio values recorded in the soil of the study area were 11.6, 11.61and 11.63 for soils of cultivated arid land, forestland and cultivated mid high land, respectively (Table 5).According to Brady and Weil (2008) the C: N ratio in soils of arable soils commonly ranges from 8: 1 to 15: 1 and the average is between 10:1 to 12:1. Thus, the obtained C: N ratio values of the soils could be considered within the range reported averagely 10:1 to 12: 1. In line with this, the C: N ratio was fall in the range of medium in all land use types of the study area (Gavilak, 1994). Relative to forestland, the narrow carbon to nitrogen (C: N) ratio at the cultivated semi-arid land may be due to the effect of higher microbial activity that result in relatively fast decomposition of OM due to increased temperature and more CO2 evolution than in the high topographic position. Regarding this, similar results were observed by (Abbasi et al., 2007; Achalu et al., 2012). In line with this, correlation analysis has also shown positive ($r = 0.20$) of C: N with OM.

Available Phosphorus and Available Potassium:

The concentration of available phosphorus recorded in the soils of the study area under different land use were4.21ppm (the highest) under cultivated mid high land, 2.36ppm for forestland and2.35ppm (the lowest) under cultivated semi-arid land (Table 7).The available phosphorus in the present study was very low under forest land and cultivated semi-arid land while low under cultivated mid high land(Havlin et al.,1999).Tekalign and Haque (1991)also supported this finding by indicating that the critical values for Olsen P were established to be 8.5ppm for some Ethiopian soils. Consequently, the available P concentration of the soils in the study area was below the critical level, which exist in low proportions and it is below the requirements even for the low demanding crops. Even though the OM content of the cultivated mid high land was lowest, Av.P content was highest under the cultivated mid high land than the other land use types relatively. This could be due to the application of animal manure and Di-ammonium phosphate (DAP) fertilizer on the cultivated mid high land in line with the explanation made by Woldeamlak (2003); Gebeyaw (2007).The very low available P status in the cultivated semi-arid land and forestland soils could be associated with the low pH, high exchangeable acidity and phosphorus fixation. Hence, these soils with relatively high exchangeable acidity can have the acidic cations such as exchangeable Al, H, and oxides of Al and Fe that could fix the soluble P in the soil solution. Positive correlation (0.61) of available P with soil pH but negative correlation (-0.50) with soil exchangeable acidity (Table 11).To summarize the Available P deficiency in soils of the study area may be due to the inherent low-P status of the parent material and erosion loss. Gebeyaw (2006) also reported that the Available P in most soils of Ethiopia is low due to P-fixation, crop harvest, and erosion by water.

Available K significantly varied with land use types, higher in soil under the cultivated semi-arid land (18.06ppm) followed by the cultivated mid high land (6.95ppm) and forestland (6.78ppm) use types (Tables 7and 8). As described by Marx et al.(1996) the available Potassium in all land uses were below the critical level (<150ppm).Relatively, the lowest available Potassium was registered on forestland could be probably due to soil losses by leaching and lower levels of Av. K in sandy soils. The observed highest concentration of Available K under the cultivated semi-arid land was attributed to relatively high in clay and organic matter and the burning of wood, which resulted in, increased of the available K.

Variability in Soils

Physico-Chemical Properties: The results in (Table 2, 4, 6, 8, 9 and 10) showed the variation of the physical and chemical properties of the soil among the different land uses. As a standardized measure of the variance, the coefficient of variation (CV) was used to describe the shape of a frequency distribution of the observation (Nielsen and Wendroth, 2003).Variation among soil physical properties of the different land use types were summarized and presented using coefficient of variation in Tables 2 and 9.

Table 9.Variability of physical properties among different land uses of the study area

No	Group	CV (%)	Soil physical properties
1	Least variable	< 15	sand and bulk density
2	Moderate variable	15-35	silt and clay
3	Highly variable	> 35	silt clay ratio and soil moisture content

According to (Wilding, et.al., 1994) coefficient of variance (CV) ranking (Table 9) the soils of the study area indicated that silt- clay ratio and soil moisture were the highly variable soil physical properties, observed silt and clay fractions were moderately variable, whereas sand and bulk density were the least variable among different land uses. The results in Tables 4, 6, 8 and 10 showed the variation of the chemical properties of the soil among the land use types. According to Wilding, et al.(1994) coefficient of variance (CV) ranking (Table 10) the soils of the study area analyses revealed that pH (H2O), pH (KCl) and carbon-nitrogen ratio had the least variation (CV<15%). Similarly, Sun et al.(2003)documented that pH the least CV. In addition, previous researches also depicted low coefficients of variation for pH compared to the other soil properties (Abu and Malgwi,2011).

Table 10.Variability of chemical properties among different land uses of the study area.

No	Group	CV (%)	Soil chemical properties
1	Least variable	< 15	pH (H_2O), pH (KCl),C/N
2	Moderate variable	15-35	EC, TEB, ECEC, Ca/Mg, PBS, Av. P
3	Highly variable	> 35	Ex. A, PAS, Ex.Ca, Ex. Mg, Ex. K, Ex. Na, CEC, clay (CEC), Mg/K, OM, TN,Av. K

The moderately variable soil chemical properties with CV (15-35%) were: EC, TEB, ECEC, Ca/Mg, PBS and Av. P; whereas, the highly variable soil chemical properties with CV>35% were: Ex.A, PAS, Ex. bases (Ca, Mg, K, Na), CEC, Mg/K, OM, TN and Av. K among the different land use types of the study area (Table 10). These are mostly properties that can easily be altered by varied land use types and management practices occurring within the study area. Similarly, Udoh et al. (2007) reported the significant variability in some soil physicochemical properties due to influence of land use, cultural and management practices. Generally, variability of soil properties among the land use types were more pronounced in chemical properties than in physical properties. The least varied physical property was found to be sand (CV=14.09%) and C: N ratio (CV=0.17%) had least variability in chemical properties (Table 2). The physical and chemical properties that had the highest variability within the soils are SMC

(CV=46.62%) and PAS (CV=126.44%), respectively (Table 9 and 10).

Relationships of Soil Physico-Chemical Properties: This relationship among the soil physico-chemical properties with different land uses in pearson correlation matrix (Table 11). The clay content had a significant positive correlation with BD (0.82**), Ex. A (0. 83**), PAS (0.85**), Av.K (0.83**) and Ex. K (0.78*) and negatively significantly correlated with sand(-0.67*) fractions and Ex. Na (r= -0.82**), however, negatively non-significant relationship with silt (-0.03), pH-H2O (r=-0.67), Ex.Ca (r= -0.59) and PBS (r=-0.62). The silt had a significant positive correlation with SMC(0.77*), Ex. Mg (0.77*), CEC (0.86**),TN (0.71*) and OM (0.72*)and insignificant positive correlation with EC(r=0.63) and TEB(r=0.59).However it had significant negative correlation with Av. P(-0.86**) and non-significant positive relation with PBS(r=-0.63).Sand fraction had positive and significant correlation with pH-H2O (0.84**)and PBS (0.69*), however positive non-significant correlation with porosity(0.50),Ex. Na (0.58) and Av. P(0.50). Moreover, it had negatively and significantly relationship with Ex. K (-0.70*), Ex. A(-0.68*), PAS(-0.68*) and Av. K (-0.65*), however negatively insignificantly related with BD (-0.50), SMC (-0.58) and CEC (-0.50). Significant negative correlations of bulk density with Ex.Ca (-0.75*) and Ex. Na (-0.94**), however, significant positive correlation with clay (0.82**), Ex. K (0.88**), Av. K (0.94**), Ex. A (0.94**) and PAS (0.94**) of soil as in (Table 11).While correlation between bulk density and pH-H2O (-0.52) was negative but not so significant. This is in line with Shaffer (1998) that observed highest correlation between pH and BD at 0 to 15 cm, but he did not indicate the reasons. From correlation analysis (Table 11) it was observed that soil moisture content highly positively and significantly relationship with silt (0.77*), EC (0.81**), Exch. Mg (0.87**), CEC (0.95**), TEB (0.66*), Ex. K (0.60*), OM (0.78*), however negatively and significantly related with Available P (-0.93**) and PBS (-0.79**).

The soil pH-H2O was positively significantly correlated with sand (0.84**), PBS (0.66*), available P (0.61*) and Ex.Na (0.72*) which indicated that availability of P and Na+ were dependent on soil acidity, however negative and significant correlation was observed with Ex. A (-0.67*), PAS (-0.67*), Exch. K (-0.69*) and Av. K(-0.62*). The EC had a positive significant correlation with silt (0.63*), SMC (0.81**), Ex. Ca (0.80**), Ex. Mg (0.92**), TEB (0.91**), CEC(0.86**) and OM(0.97**) and a negative significant correlation with Av. P(-0.72*).PAS had a significant positive correlation with clay (0.85**), BD (0.94**), Ex. A (0.99**), Ex.K (0.98**) and Av. K (0.99**) whereas a significant negative correlation with sand, (-0.68*), pH-H2O (-0.67*),Ex.Na(-0.94**) and PBS(-0.80**).Organic matter was correlated positively significantly with most of soil properties (Table 11) such as silt (0.72*), SMC (0.78Ex. Ca (0.84**), Ex. Mg (0.96**), TEB (0.95**), TN (1.00**) and CEC (0.86**) under different land uses. It, however, negatively significantly correlated with Av. P (-0.75*). Expectedly, OM was highly positively correlated with TN (1.00**), indicating the availability of nitrogen as influenced by the soil organic matter. Similarly, CEC was correlated positively significantly with most of the soil properties silt (0.86**), SMC (0.95), Ex. Mg (0.89**), TEB (0.73*) and OM (0.86**),however, it negatively significantly correlated with PBS (-0.77**) and Av. P (-0.95**). Ex.Ca was correlated positively significantly with EC(r=0.80*), TEB (0.96**) and OM (0.84**), while it was negatively significantly correlated with bulk density (-0.75**). Furthermore Ex. Mg was correlated positively significantly with silt (0.77*), SMC (0.87**), EC (0.92**), Ex. Ca (0.75**), TEB (0.91**), CEC (0.89**) and OM (96**), however negatively significantly correlated with Av. P (r= -0.81**).Av.P was correlated positively significantly with PBS (0.83**), however it correlated negatively significantly with Ex. K (-0.58*).Available K had positively significantly correlation with Ex. A (r= 1.00**) whereas it had negatively significantly correlation with Ex.Na (-0.92**) and PBS (-0.80**).In general, the correlation matrix analysis showed that Av. P, Av. K, pH, TN, OM, CEC, PBS, SMC, EC, Mg+2 and Ca2+ are fundamental elements since they are significantly correlated with most of soil properties (Assefa and Van Keulen, 2009). The negative correlation of most of selected soil properties with clay and sand fraction may be attributed to the parent materials from which sand and clay fractions are formed (Thapa andYila, 2012).

CONCLUSIONS

The assessment of soil spatial variability is very important to know what and where proper corrective action and site-specific management is needed for future generation to sustain life. Particle size distribution of the soil revealed that sand was the dominant fraction (51-65%) in all of the soil of the land use types.. The bulk density value of top soil in the study area ranged from 0.96g/cm3, 1.10 g/cm3 and 1.38 g/cm3 in forest, cultivated mid high land and cultivated semi-arid land, respectively that showed variability with respect to land use type and location. The average pH-H2O values of the top soils were 5.19, 5.64 and 6.09 in cultivated semi-arid land, forestland and cultivated high land, respectively. The highest exchangeable acidity value obtained from soils of cultivated semi-arid land (1.41) and the lowest exchangeable acidity was registered in soils of forestland (0.07). The high soil exchangeable acidity in the cultivated semi-arid land could be associated with the occurrence of lower soil pH. With regard to exchangeable bases, Concentrations of exchangeable cations in the study area were generally in the order of Ca>Mg>K>Na. The CEC varied within a range of 18.30(for soils of cultivated mid high land) to 49.09cmol (+) kg-1(for soils of forestland) at the surface layers of the soil. Similar to exchangeable bases and cation exchange capacity, the base saturation percentage of the soils in the study area showed considerable variability among the land use types. The average carbon nitrogen ratio values recorded in the soil of the study area were varied from 11.60(cultivated arid land) to 11.63(cultivated mid high land). The C:N ratio was fall in the range of medium (average) in all land use types of the study area. The available P concentration was below the critical level, which exists in low proportions. Generally, as the comparison has been made among the land use types, the selected soil physico-chemical properties vary regularly and irregularly from place to place. The assessments made on spatial variability and status of selected soil properties from different land use types and topography, the variation is observed at surface layers of the soil as indicated by quantitative values discussed in the results and discussion section. The variation in soil properties caused by both intrinsic and extrinsic factors is resulted in variation to crop yield. Therefore, having the knowledge of spatial variability and status of selected soil properties is very important for sustainable farming, site-specific management and sustainable crop production.

Conflict of Interests:

The author declare that there is no conflicts of interest

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References

Abbasi MK, Zafar M, Khan SR. (2007). Influence of different land-cover types on the changes of selected soil properties in the mountain region of Rawalakot Azad Jammu and Kashmir. Nutrient Cycling Agroecosystem, 78:97–110

Abdrahman Shafi , Achalu Chimdi and Teshome Yitbarek , 2019. Effects of soil and water Conservation practices in selected soil physico-chemical properties: The Case of Ezha District, Southern Ethiopia, Journal of Biology, Agriculture and Healthcare, Volume.9(7); 6-14.

Abu, S.T. and Malgwi, W.B. (2011).Spatial Variability of Soil Physico-Chemical Properties in Kadawa Irrigation Project in Sudan Savanna Agro ecology of Nigeria. International JournalofAgriculturalResearch,6, 714-735. (http://dx.doi.org/10.3923/ijar.2011.714.7) Accessed on November 15, 2017.

Achalu Chimdi and Teshome Bekele, 2019.Impacts of Land Use Types on Selected Soil Properties: The Case of Dire Enchini District, West Showa Zone, Oromia Regional Sate, American-Eurasian Journal of Agriculture and Environmental Science.Volume,19 (5): 372-385

Achalu Chimdi, Heluf Gebrekidan Kibebew Kibret and Abi Tadesse, 2012.Status of selected physico-chemical properties of soils under different land use systems of Western Oromia, Ethiopia. Journal of Biodiversity and Environmental Science Volume 2(3): 57-71

Adeboye, M., Bala, A., Osunde, A., Uzoma, A., Odofin, A., and Lawal, B. (2011). Assessment of soil quality using soil Organic carbon and total nitrogen and microbial properties in tropical agro ecosystems. Journal of Agricultural Science ,Volume, 2,34–40.

Agoumé, V. and Birang, A. M..(2009). "Impact of land-use systems on some physical and chemical soil properties of an Oxisol in the Humid Forest Zone of Southern Cameroon."Tropicultura, volume.27, pp.15-20.

Ahmed Hussen. (2002). Assessment of Spatial Variability of some physicochemical properties of soils under different elevations and land use systems in the western slopes of mount chilallo, Arsi.(Published M.Sc. Thesis).Alemaya University, Ethiopia, 111p.

Assefa, A. and Van Keulen, H. (2009).Modeling soil nutrient dynamics under alternative farm management practices in the Northern Highlands of Ethiopia, Soil Tillage Research, 103, 203–215.

Bahrami, A., Emadodin, I., Atashi, M. R., & Bork, H. R. (2010). Land use change and soil degradation: A case study, North of Iran. Agriculture and Biology Journal of North America, 1(4), 600-605.

Baligar, V.C., Pitta, G.V.E., Gamma, E.E.G., Schafter, R.E., Filho, A.F., and Clark, R.B. (1997). Soil acidity effects on nutrient use efficiency in exotic maize genotypes. Plant and Soil 192:9-13.

Barber, S. (1984). Soil nutrient bioavailability mechanistic approach. John Wiley and Sons,

Inc. New York 398p.

Baruah TC, Barthakur HP. (1997). A Text Book of Soil Analysis 1st ed. Vikas publishing House Pvt Ltd, New Delhi, India 334.

Black CA. (1965). Methods of soil analysis part II. American Society of Agronomy, Madison, Wisconsin, USA 374-399.

Bohn, H., Mcneal, B.L. and O'connor, G.A. (2001).Soil Chemistry.3rd ed. John Wiley and Sons, INC, pp.207-233.

Brady, N. C., & Weil, R. R. (2008).The nature and properties of soils (14th ed.). The Iowa State, India: PVT.Ltd.

Bremner JM, Mulvaney CS. (1982).Nitrogentotal. In: Page, A. L., Miller, R. H. and Keeney, D.R.(eds). Methods of soil analysis, Vol.2.American Society of Agronomy, Madison, Wiscosin, p. 595-624.

Busari, M.A. F.K, Salako, R.A, Sobulo, M.A. Adetunji,andN.J.Bello. (2005). Variation in soil pH and maize yield as affected by the application of poultry manure and lime. In: Managing Soil Resources for Food and Sustainable Environment. Proc. 29th. Annual. Conference of Soil Science Society of Nigeria, 139-142.

Abbasi MK, Zafar M, Khan SR. (2007). Influence of different land-cover types on the changes of selected soil properties in the mountain region of Rawalakot Azad Jammu and Kashmir. Nutrient Cycling Agroecosystem, 78:97–110

Abdrahman Shafi , Achalu Chimdi and Teshome Yitbarek , 2019. Effects of soil and water Conservation practices in selected soil physico-chemical properties: The Case of Ezha District, Southern Ethiopia, Journal of Biology, Agriculture and Healthcare, Volume.9(7); 6-14.

Abu, S.T. and Malgwi, W.B. (2011).Spatial Variability of Soil Physico-Chemical Properties in Kadawa Irrigation Project in

Sudan Savanna Agro ecology of Nigeria. International JournalofAgriculturalResearch,6, 714-735. (http://dx.doi.org/10.3923/ijar.2011.714.7) Accessed on November 15, 2017.

Achalu Chimdi and Teshome Bekele, 2019.Impacts of Land Use Types on Selected Soil Properties: The Case of Dire Enchini District, West Showa Zone, Oromia Regional Sate, American-Eurasian Journal of Agriculture and Environmental Science.Volume,19 (5): 372-385

Achalu Chimdi, Heluf Gebrekidan Kibebew Kibret and Abi Tadesse, 2012.Status of selected physico-chemical properties of soils under different land use systems of Western Oromia, Ethiopia. Journal of Biodiversity and Environmental Science Volume 2(3): 57-71

Adeboye, M., Bala, A., Osunde, A., Uzoma, A., Odofin, A., and Lawal, B. (2011). Assessment of soil quality using soil Organic carbon and total nitrogen and microbial properties in tropical agro ecosystems. Journal of Agricultural Science ,Volume, 2,34–40.

Agoumé, V. and Birang, A. M..(2009). "Impact of land-use systems on some physical and chemical soil properties of an Oxisol in the Humid Forest Zone of Southern Cameroon."Tropicultura, volume.27, pp.15-20.

Ahmed Hussen. (2002). Assessment of Spatial Variability of some physicochemical properties of soils under different elevations and land use systems in the western slopes of mount chilallo, Arsi.(Published M.Sc. Thesis).Alemaya University, Ethiopia, 111p.

Assefa, A. and Van Keulen, H. (2009).Modeling soil nutrient dynamics under alternative farm management practices in the Northern Highlands of Ethiopia, Soil Tillage Research, 103, 203–215.

Bahrami, A., Emadodin, I., Atashi, M. R., & Bork, H. R. (2010). Land use change and soil degradation: A case study, North of Iran. Agriculture and Biology Journal of North America, 1(4), 600-605.

Baligar, V.C., Pitta, G.V.E., Gamma, E.E.G., Schafter, R.E., Filho, A.F., and Clark, R.B. (1997). Soil acidity effects on nutrient use efficiency in exotic maize genotypes. Plant and Soil 192:9-13.

Barber, S. (1984). Soil nutrient bioavailability mechanistic approach. John Wiley and Sons,

Inc. New York 398p.

Baruah TC, Barthakur HP. (1997). A Text Book of Soil Analysis 1st ed. Vikas publishing House Pvt Ltd, New Delhi, India 334.

Black CA. (1965). Methods of soil analysis part II. American Society of Agronomy, Madison, Wisconsin, USA 374-399.

Bohn, H., Mcneal, B.L. and O’connor, G.A. (2001).Soil Chemistry.3rd ed. John Wiley and Sons, INC, pp.207-233.

Brady, N. C., & Weil, R. R. (2008).The nature and properties of soils (14th ed.). The Iowa State, India: PVT.Ltd.

Bremner JM, Mulvaney CS. (1982).Nitrogentotal. In: Page, A. L., Miller, R. H. and Keeney, D.R.(eds). Methods of soil analysis, Vol.2.American Society of Agronomy, Madison, Wiscosin, p. 595-624.

Busari, M.A. F.K, Salako, R.A, Sobulo, M.A. Adetunji,andN.J.Bello. (2005). Variation in soil pH and maize yield as affected by the application of poultry manure and lime. In: Managing Soil Resources for Food and Sustainable Environment. Proc. 29th. Annual. Conference of Soil Science Society of Nigeria, 139-142.

CSA.(2019).Ethiopian Agricultural Sample Enumeration. Central Statistical Authority. Ethiopia.

Ebtisam I, Dardiry El. (2007).Soil available water as affected by some soil physicochemical properties in salt affected soils. Australian Journal of Basic and Applied Sciences1, 220-225.

ERA.(2013). Tender Document for Nekempt–Bure Road Design Build- Maintenance

Project Final ESIA. (www.ethioinfra.com) Accessed on March 06, 2017.

Ettema, C. H., and D. A. Wardle.(2002). Spatial soil ecology. Trends in Ecology and Evolution 17(4): 177-183.

Eyayu, M., Heluf, G., Tekaliign, M., & Mohammed, A. (2009). Effects of land use change on selected soil properties in the TeraGedam Catchment and adjacent agro-ecosystems, Northwest Ethiopia. Ethiopian Journal of Natural Resources, 11(1), 35-62.

Foth, H.D. and B. G. Ellis.(1997). Soil fertility, 2nd Ed. Lewis Publishers, Boca RatonFlorida.290P.

Gavilak, R.G, D.A. Horneck and R.O. Miller.(1994). Plant and soil reference methods for the Eastern Region.

Gebeyaw T. (2007). Soil Fertility Status as Influenced by Different Land Uses in Maybar Areas of South Wello Zone, North Ethiopia. M.Sc. Thesis. Haramaya University, Ethiopia, p 71

Gebeyaw T. (2015). Assessment of farmers' perceptions about soil fertility with different management practices in small holder farms of Abuhoy Gara Catchemnt, Gidan District, North Wollo.

Gebeyaw, T. (2006). Soil Fertility Status as Influenced by Different Land Uses in Maybar Areas of South Wello Zone, Ethiopia [M.S. thesis], Haromaya University, Haromaya, Ethiopia.

Hazelton PA, Murphy BW. (2007). Interpreting Soil Test Results: CSIRO Publishing: Melbourne.

He, Z.L., Alva, A.K., Calvert, D.V., Li, Y.C. and Banks, D.J. (1999).Effects of N fertilization of grapefruit trees on soil acidification and nutrient availability in a Riviera Fine Sand. Plant Soil 206: 11-19.

Heluf Gebrekidan and Wakene Negassa. (2006).Effect of land use and management practices on chemical properties of some soils of Bako areas, western Ethiopia. Ethiopian Journal of Natural Resources, 8(2), 177-197.

Heshmati, M., Abdu, A., Jusop, S., and Majid, N. M. (2011). Effects of Land use practices on the organic carbon content, cation exchange capacity and aggregate stability of soils in the Catchment Zones. American Journal of Applied Sciences, 8(12), 1363-1373. http://dx.doi.org/10.3844/ajassp.2011.1363. 1373

Hesse, P.R..(1972). A textbook of soil chemical analysis. John Murry Limited, London, Great Britain. 470p.

Hinrich L.B., Brian, L.M. and O'Connor George, A. (2001).Soil Chemistry, John Wily & Sons, Inc., New York.

Kiramu Agricultural Office, 2017

Kimminis, J.P. (1997). Forest ecology: A Foundation for sustainable management, 2ndEd.The University of British Columbia.Prentice Hall, Upper Saddle River, New Jersey.

Landon, J. R. Ed., Booker. (1991). Tropical Soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics, Longman Scientific and Technical, New York, NY, USA.

Liu, X., K. Zhao, J. Xu, M. Zhang, B. Si and F. Wang.(2007). Spatial variability of soil organic matter and nutrients in paddy fields at various scales in southeast China. Environmental Geology 53:1139–1147.

Marx, E.S., Hart, J. and Stevens, R.G. (1996). Soil testing interpretations guide. Oregon State

University Extension Service, US Department of Agriculture, USA.

McAlister, J. J., Smith, B. J., and Sanchez, B. (1998). Forest clearance: impact of land use change on fertility status of soils from the Sao Francisco Area of Niteroi, Brazil, Land Degradation and development. Volume 9, 425–440.

Meysner, T., L. Szajdak and KU.(2006). Impact of the farming systems on the content of biologically active substances and the forms of nitrogen in the soils.Agronomy Research. Volume 4(2): 531-542.

MoA. (1995). Land Use Systems and soil conditions of Ethiopia by Land use Study and

Rural Technology promotion Department Addis Abeba Ethiopia, 60p.

Mojiri, A., Aziz, H. A., and Ramaji, A. (2012). Potential decline in soil quality attributes because of land use change in a hill slope in Lordegan, Western Iran. African Journal of AgriculturalResearch,Volume 7(4),577-582.

MulugetaDemiss and ShelemeBeyene. (2011). Characterization and classification of soils along the toposequence of KindoKoye watershed in southern Ethiopia.MoA. Addis Ababa, Ethiopia. East Africa Journal of Science.4 (2):65-77.

Nielsen, D.R. and Wendroth, O. (2003).Spatial and Temporal Statistics: Sampling Field Soils and Their Vegetation. Catena Verlag, Reiskirchen. Geosciences Publisher, Germany.

Oguike, P. C. and Mbagwu, J. S. C. (2009). "Variations in some physical properties and organic matter content of soils of coastal plain sand under different land use types." World Journal of Agricultural Science. volume. 5, pp. 63-69

Okalebo, J.R., K.W. Gathua and P.L. Womer. (2002). Laboratory methods of sol and plant analysis: A working manual, 2nd Ed. TSBF-CIAT and SACRED Africa, Nairobi, Kenya. 128p.

Olsen, S. R. and Sommers, I. E. (1982).Soil available phosphorus. In: D. L. Sparks, A. L. Page, P.A. Hennke, K. H Loppez, E.N. Solanpour and M.E Summers (2nd ed.). Methods of Soil Analysis, Part 2. Agron., Mono. ASA and Soil Science. Society of America Madison, USA.

Ouhadi, V.R. and A.R. Goodarzi.(2007). Factors impacting the electro conductivity variations of clayey soils.Iranian Journal of Science & Technology, Transaction B, Engineering. 31(B2), pp.109-121.

Özgoz E, Gunal H, Acir N, Gokmen F, Birol M &Budak M. (2013). Soil quality and spatial variability assessment of land use effects in a TypıcHaplustoll. Land Degradation & Development. DOI: 10.1002/ldr.1126

Pravin R. Chaudhari, Dodha V. Ahire, Vidya D. Ahire, ManabChkravarty and SarojMaity. (2013). Soil Bulk Density as related to Soil Texture, OrganicMatter Content and available total Nutrients ofCoimbatore, Soil International Journal of Scientific and Research Publications, Volume 3, www.ijsrp.org

Reuter, H. I., Kersebaum, K. C., &Wendroth, O. (2005).Spatial and temporal variability of soil properties with respect to relief information.Proceedings of Precision Agriculture 05, Academic Publishers, the Netherlands.

Rowell, D.L.. (1994). Soil science: Method and applications. Addison Wesley Longman Limited, England. 350p.

Shaffer, M.J. (1998). "Estimating Confidence Bands for Soil – Crop Simulation Models," Soil Science. Society of American Journal Vol. 52, pp. 1782-1789.

Shepherd, G., Bureh, R. J., and Gregory, P. J. (2000). "Land use affects the distribution of soil inorganic nitrogen in smallholder production systems in Kenya. Biology and Fertility of Soils, volume. 31, pp. 348-355.

SAS (Statistical Analysis System). 2008.SAS user's guide: Statistical released version 9.2. SAS. Institute Int. Cary NC. USA.

Siddique, M. D., Noor-E-Alam, M. M., Islam, M. D., Halim, A., Kamaruzzaman, M. D., Sul 10 tana, J., and Karim, D. (2014).Mapping of Site-Specific Soil Spatial Variability by Geostatistical Technique for Textural Fractions in a Terrace Soil of Bangladesh, Journal of Bioscience and Agriculture Research (JBAR).

Sparks, D. L., A. l. Page, P.A. Helmke, R.H. Loeppert, P.N..Soltanpour, M.A. Tabatabai, C.T. Johnson, and M. Sumner (Eds).(1996). Methods of soil analysis: Part 3—chemical methods. Book Series Number 5. Soil Science. Society of America. Madison, WI, USA.

Sumner, M. E. (Ed). (2000). Handbook of soil science.CRC Press, Boca Raton, Florida.

Sun, B., Zhou, S. and Zhao, Q. (2003). Evaluation of Spatial and Temporal Changes of Soil Quality Based on Geostatistical Analysis in the Hill Region of Subtropical China. Geoderma, 115, 85-99. (http://dx.doi.org/10.1016/S0016-7061 (03)00078-8)Accessed on December 04, 2017.

Tekalign T. (1991). Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13.International Livestock Research Center for Africa, Addis Ababa.

Thapa, G. B. and Yila, O. M.(2012). Farmers' land management practices and status of agricultural and in the Jos Plateau, Nigeria, Land Degradation. Development., 23, 263–277.

Udoh, N.U. Ndaeyo, K.O. Harold. (2007). Fertility status and Variability of some soils developed from different parent materials in the humid region of Nigeria, Proceedings of the 31st Annual Conference of Soil Science Society of Nigeria, NAERLS, ABU, Zaria, Nigeria 13th – 17th November 2006, pp. 79-85.

USDA-NRCS, 2017

Wakene Negassa and Heluf Gebrekidan. (2003). The impact of different land use systems on

soil quality of Western Ethiopian Alfisols: Bako Agricultural Research Center; West

Shoa, Alemaya University, Ethiopia.

Wakene Negassa, Kefyalew Negisho, Friesen, D.K., Ransom,J., Abebe Yadessa. (2001).

Determination of optimum farmyard manure and NP fertilizers for maize on farmers'

field: Seventh Eastern and Southern Africa Regional Maize Conference 11th-12th.

February 2001. Pp. 387-393.

Walkely, A. and Black, C. A. (1934).An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method, Soil Science., 37, 29–38.

Wang YQ and Shao MA.(2013). Effect of different types of land use on soil moisture and bulk density. Journal of Bijie University 32(8):123–128

Wang, Z.M., K.S. Song, B. Zhang, D.W. Liu, X.Y. Li, C.Y. Ren, S.M. Zhang, L. Luo and C.H. Zhang.(2009). Spatial variability and affecting factors of soil nutrients in croplands of Northeast China: a case study in DehuiCounty.. Plant Soil and Environment 55: 110–120.

White, P. F., Oberthur, T., and Sovuthy, P. (1997). Soils used for rice production in Cambodia. A manual for their recognition and management. Manila (Philippines): International Rice Research Institute.

Wilding, L. P., Bouma, J., and Boss, D. W. (1994)."Impact of spatial variability on interpretative modeling. In: Bryant R. B. and R. W. Arnold. Quantitative Modeling of Soil Forming Process."Soil Science Society of American journal, Special Publication, volume. 39, pp. 61-75.

Woldeamlak, B. and Stroosnijder, L. (2003).Effects of agro-ecological land succession on soil proper ties in the Chemoga watershed, Blue Nile Basin, Ethiopia, Geoderma, 111, 85–89.

Yihenew Gebreselassie. (2002). Selected chemical and physical characteristics of soils of Adet Research Center and its testing sites in Northwestern Ethiopia; Ethiopian Journal of Natural Resources. Ethiopian Society of Soil Science, Vol. 4(2):199-215. Addis Ababa, Ethiopia

Yihenew, Gebresilassie., and Getachew, A. (2013). Effects of different land use systems on selected physicochemical properties of soils in Northwestern Ethiopia. Journal of Agricultural Science, 5(4), 112-120.

Ziadat, F. M. and Taimeh, A. Y. (2013).Effect of rainfall intensity, slope and land use and antecedent soil moisture on soil erosion in an arid environment, Land Degrad. Dev., 24, 582–590, doi:10.5194/se-6-383-2015.Accessed on March 06, 2017.