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Impact of Land Use Types on Soil Degradation in Meja Watershed, Jeldu District, West Shoa, Ethiopia

Birhanu Ayana[1], Tesfaye Balemi[2] and P. Natarajan[3]

[1]*Department of Biology, Shenen Preparatory School, Jibat woreda, West Shoa Zone, Oromia Region, Ethiopia*
[2]*Department of Biology, Ambo University, P.O.Box 19, Ambo, Ethiopia,* E-mail: tesfayeb2005@yahoo.co.uk
[3]*Department of Plant Science and Horticulture, College of Agriculture and Veterinary Science, Ambo University P.O.Box 19, Ambo, Ethiopia*

Abstract

Poor land resources management with the consequence of soil degradation is the main cause of low agricultural productivity and food insecurity in the rural highlands of Ethiopia. The current study was undertaken at Meja watershed, located in the Jeldu district, Oromia region. The aim of the study was to assess the impacts of different land use types on soil quality parameters in the watershed. Soil samples collected from the upper 0-20 cm depth from cultivated, grazing and forest lands was analyzed for various soil quality parameters. The results indicated that soil parameters such as, cation exchange capacity (CEC) and organic matter (OM) content were significantly higher for forest and grazing land than for cultivated land whereas electrical conductivity (EC), total nitrogen (TN), available phosphorus (AvP), exchangeable K, Ca and Mg contents were significantly higher for forest land compared to both grazing and cultivated lands. Other soil parameter such BD was higher for cultivated land than for the other land use types. The results clearly indicated that land use types significantly influenced soil quality suggesting that a change from forest land to the other land use types aggravated soil degradation resulting in soil fertility decline in the study watershed.

Key Words: cultivated land, grazing land, Forest/plantation land, soil quality, soil degradation index

Introduction

Improper land use is being observed as a result of the challenges to increase food production to meet the demand of increased population potentially resulting in land degradation. Land degradation in turn has severe negative impact on agronomic productivity of crops, environmental quality and on food security and overall livelihood of human beings (Omotayo and Chukwuka, 2009). In Ethiopia, where agriculture is the backbone of the economy, severe food insecurity and natural resource degradation have been a challenge to the livelihood of many rural communities. The causes of land degradation in Ethiopia could be attributed to the cultivation of steepy lands, fragile nature of soils with inadequate soil conservation practices or vegetation cover, erratic and erosive rainfall patterns, declining use of fallow system, limited nutrient recycling from manures and crop residues, limited application of external sources of plant nutrients, deforestation and overgrazing (Belay, 2003; Hurni, 1988).

It has been estimated that 2 million ha of Ethiopia's highlands have been degraded beyond rehabilitation, and an additional 14 million ha are severely degraded (UNEP, 2002). The removal of vegetation cover exposes the soil to wind and water erosion. Soil compaction occurs in areas where there is excessive trampling by animals. In cultivated areas soil fertility is declining as a result of the exhaustion of soils by mono-specific cropping and reduction of fallow periods (UNEP, 2002). Although there is an overall understanding that soils of the study area are being degraded, the extent and magnitude of the degradation is, however not known. This necessitated an investigation of the extent of soil degradation in terms of soil fertility under different land use systems. A decline in soil fertility induced by change in land use system was observed in many parts of the world (Mulumba, 2004; Ayoubi *et al.*, 2011; Aghasi *et al.*, 2011). Such decline in soil fertility was mainly attributed to loss of nutrients and organic matter through soil erosion as a result of conversion, mainly of forestland to cropland. Due to the dearth of detailed information on the extent of land degradation under different land use systems in Ethiopia, sound soil reclamation practices and land use decisions by policy makers could not be implemented. It is assumed that awareness creation on the extent of land degradation among the farmers, policy makers and other stakeholders would help easy adoption of research recommendations and any decisions made by policy makers to safeguard soil from further degradation. Thus, there is a need to investigate the relationship between land use types and soil quality to further influence farmers in their decision to choose appropriate land resource management strategy in Meja Watershed. The objective of the present study was, therefore, to investigate the impacts of different land use types on soil quality based on selected physico-chemical properties of soil.

Materials and Methods

Description of the Study Area

The study was conducted at Meja watershed, Jeldu district, West Shewa Zone of Oromiya Regional State, Central Ethiopia (9° 02' 47" to 9° 15' 00" N and 38° 05' 00" to 38° 12' 16" E). The district has an undulating terrain with altitude ranging from 2,900-3,200 meters above sea level. Rainfall pattern of the area is bimodal with the main rainy season from June to September and short rainy season from February to March. Mean annual rainfall ranges from 1800 to 2200 mm. The maximum and minimum temperature ranges from 17 to 22^{o}C (District's Agriculture and rural development office annual Report of

2009, unpublished). The farming system of the study area is mainly rain fed. The soil is clay and clay-loam type, but the riverbed has a loam and sandy-loam type of soil (Hurst *et al*., 1959 cited in Dereje, 2010).

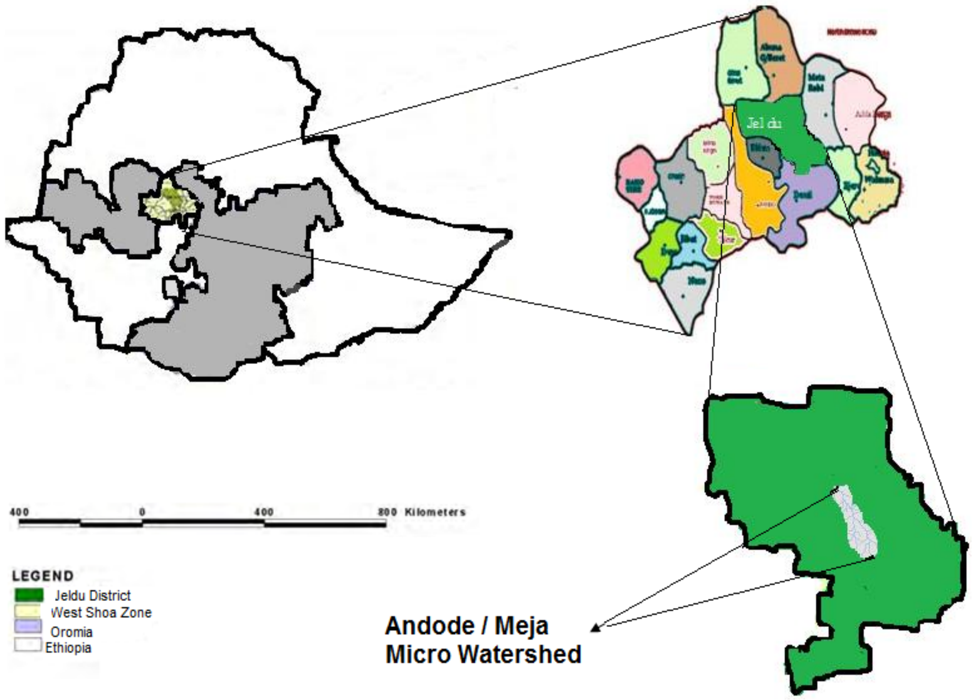

Figure 1: Map of the study location

Soil sampling and analysis

Soil samples were collected from three land use types (cultivated, grazing and forest/plantation lands) in the watershed, to assess the status of soil degradation. Soil samples were taken from the top soil (depth of 0-20 cm) from each land use type in a zigzag manner using an Auger. The composite sample from each land use type was separately ground into fine tilth using mortar and pestle, homogenized and sieved through 2 mm sieve. A separate undisturbed soil sample for bulk density determination (BD) was collected by a core sampler (cylindrical metal sampler) from the same site.

The soil was analysed for selected soil chemical properties, such as soil pH, electrical conductivity (EC), soil organic matter content (OM), total nitrogen (TN), available phosphorous (AvP), cation exchange capacity (CEC) and basic exchangeable cations. Soil pH and electrical conductivity of soil samples were determined at 1:2.5 (soil: water suspension) using pH meter and portable conductivity meter, respectively according to Black (1965). The Walkley and Black (1934) wet digestion method was used to determine soil carbon content and percent soil OM was calculated by multiplying percent soil OC by a factor of 1.724 with the assumptions that OM is composed of 58% carbon. Total nitrogen was determined using Kjeldahl method according to Black (1965). Available P in soil was analyzed according to the standard procedure of Olsen *et al.* (1954). Cation exchange capacity (CEC) and exchangeable bases (K, Ca and Mg) were determined after extracting the soil samples by ammonium acetate (1N NH4OAc) at pH 7.0. Exchangeable Ca and Mg in the extracts were determined using atomic absorption spectrophotometer, while K was determined by flame photometer (Chapman, 1965; Rowell, 1994). Cation exchange capacity was estimated titrimetrically by distillation of ammonium that was displaced by sodium from NaCl solution (Chapman, 1965).

Physical degradation was assessed using bulk density. Bulk density of undisturbed soil sample was determined using core sampler (cylindrical metal sampler) (Blake, 1965) and determining the mass of solids and the water content of the core, by weighing the wet core, drying it to constant weight in an oven at 105^{0}C for 24 hours and reweighing after cooling. Bulk density was then calculated from the measurement of the bulk volume, using the core length and the diameter of the cutting edge of the sampler.

$$BD = \frac{Weight\ of\ sample\ (gm)}{Volume\ of\ sample\ cm^3} \ldots\ldots\ldots\ldots (1)$$

Volume of sample = π r^{2}h………… (2)

Where: π = 3.14, r = radius of internal diameter of the core sampling tube, h= height of core sampler tube.

Determination of soil degradation index: the soil degradation index (DI) was computed by the procedure of Islam and Weil (2000) as cited in Mulugeta (2004). To compute DI, the difference between mean values of each soil quality parameter under cultivated and grazing lands, and the baseline values of similar soil quality parameter for forestland were computed and expressed as a percentage of the value under the forestland. These percentage changes were summed across all soil quality parameters to compute the cumulative DI value for each land use types, which was used as an overall index of soil degradation or improvement.

$$DI = \frac{F - I}{I} \times 100\% \ldots\ldots\ldots\ldots (3)$$

Where DI = Degradation index

F= the mean value of soil quality parameter for cultivated land or grazing land

I = the mean value of soil quality parameter for soil from forestland

Data analysis

The data obtained from the analysis of soil sample was subjected to a one-way analysis of variance (ANOVA) using SAS statistical software version 9.2. Mean separation was done using Tukey test at a significance level $\alpha = 0.05$.

Results and Discussion

Effect of land use type on soil bulk density, pH, EC and CEC

Bulk density of the soil (BD; g/cm^3) was significantly affected ($P<0.001$) by land use types. The soil samples taken from cultivated land showed significantly higher bulk density ($1.01 g/cm^3$) as compared to the soil samples collected from both grazing and forest/plantation lands (Table 1 below). However, there was no significant difference in BD between soils drawn from grazing land and forest/plantation land. Likewise, Igwe (2001) reported that soils of the arable land have the highest BD (1.83 mg m^{-3}) and soils of native forest land the lowest BD (1.58 mg m^{-3}). The compaction of the top soil of the cultivated land by livestock during grazing after harvest and during fallow period and intensive agricultural practices might be the reasons for the higher BD in the case of cultivated land. This was in line with the results of Lal (1986) who reported that the BD of soils from pasture and crop land, at two sampling depths (0-10 cm and 0-20 cm), were significantly different from that of forest land, the value being higher for crop and pasture land. Such differences might be ascribed to the compaction of topsoil due to overgrazing in the case of pasture land and the use of heavy machinery or intensive agricultural practices in the case of crop land. The lowest BD in the current investigation in forest/plantation land was most probably ascribed to its higher soil organic matter content than the other land use types (Table 3) since organic matter and bulk density are negatively correlated. Likewise, Aweto and Dikinya (2003) reported that the lower bulk density under the canopy of trees in forest land was presumably due to the effect of litter addition to soil under the canopies, which has resulted in organic matter build-up in soil under the canopies relative to level of the organic matter in the soil outside the canopies.

Table 1: Effects of land use types on selected soil physical and chemical properties in Meja watershed

Treatments	0-20cm									
	Soil Parameters									
	BD (gm/cm^3)	pH	EC (μ/cm)	SOM (%)	TN (%)	A P (ppm)	CEC (cmol kg^{-1})	Ex K (cmol kg^{-1})	Ex Ca (cmol kg^{-1})	Ex Mg (cmol kg^{-1})
Cultivated land	1.01^a	5.07^c	86.7^c	4.23^b	0.35^c	3.0^b	39.4^b	0.42^b	18.01^c	1.99^c
Grazing Land	0.87^b	5.36^b	102.5^b	7.74^a	0.42^b	2.0^c	45.7^a	0.31^c	22.06^b	3.64^b
Forest/plantation land	0.81^b	6.23^a	186.0^a	7.76^a	0.46^a	5.8^a	45.9^a	1.51^a	28.02^a	6.00^a

The analysis of variance (ANOVA) for soil pH revealed that there was a significant difference ($p<0.001$) among the land use types. The pH value of soil taken from forest/plantation land was the highest (6.23) and that of the cultivated land was the lowest (5.07) (Table 1). Soil taken from forest/plantation land showed significantly higher pH value than soil from other land use types (Table 3). Similar soil pH trend was reported by Gebeyaw (2007) for the different land use types under study in Maybar areas of south Wello zone of Ethiopia. According to him, the highest (6.82) and the lowest (5.83) soil pH values were recorded for forest and cultivated lands, respectively. The lowest pH value of soil taken from the cultivated land in the present investigation might be due to the uptake of basic cations by the plants and its removal along with the harvestable parts, intensive cultivation that enhanced leaching of basic cations and drainage to streams in runoff generated from accelerated erosions. It may also be due to higher organic matter decomposition in cultivated land that leads to organic acids production, which ultimately acidifies the soil. Additionally, the lowering of the pH value of this soil might be due to the reduction of soil OM which lowered the buffering capacity of soil acidity. Likewise, Tesema (2008) stated that the low pH in cultivated field was probably due to continuous removal of basic cations by crops, intensive cultivation and washing away of exchangeable bases by rill and sheet erosion. The relatively higher pH value in forest/plantation soil was attributed to the presence of relatively higher total exchangeable bases and higher CEC (Table 1) than in the cultivated land and also due to the highest soil OM content (Table 1). Generally, the soils of cultivated land and grazing land were strongly acidic whereas that of forest/plantation land were slightly acidic according to the standard rating of SSSA (1997).

Results also showed that the electrical conductivity (EC, $\mu s.cm^{-1}$) of the soils was significantly influenced by land use types ($p<0.001$). Mean EC values of 86.75, 102.5 and 186 were recorded for cultivated, grazing and forest/plantation lands, respectively (Table 1). Forest/plantation land showed significantly higher EC value when compared to both grazing and cultivated lands whereas grazing land showed significantly higher EC value than cultivated land (Table 1). The lowest EC value for cultivated land might be associated with the loss of base forming cations (Ca^{++} and Mg^{++}) following deforestation and intensive cultivation. Doerge (1999) attributed the difference in EC of the soil taken from different land uses types to difference in soil moisture contents, salinity levels, temperatures and cation exchange capacities of the soil.

The Cation exchange capacity (CEC; cmol kg^{-1}) of soils was significantly affected ($p< 0.001$) by land use types. The mean CEC values of the soils in the studied watershed stand at 39.4, 45.7 and 45.9 for cultivated land, grazing land and forest/plantation land, respectively (Table 1). The result indicated that there was a high significance difference in CEC of soil taken from forest/plantation and grazing land as compared to the soil taken from cultivated land (Table 1). Likewise, Woldeamlak and Stroosnijder (2003) cited in Gebeyaw (2007), have reported that CEC value was highest in soils under forest land and lowest under cultivated land. The lowest mean CEC observed in the cultivated lands might be due to loss of basic cations (Mg and Ca) by crop harvest and soil erosion. The relatively higher mean value of CEC recorded in the present study for soils taken from grazing land and forest/plantation land was probably due to their higher organic matter content compared to that of cultivated land. Since clay and colloidal OM have the ability to absorb and hold positively charged ions, the high cation exchange capacity was expected. So, the existence of higher OM under forest/plantation and grazing lands and their non-significance difference in their soil OM content made them to have a relatively higher CEC content in the present study. This is in agreement with the report of Unger (1997). According to him, the soils under various types of agricultural land uses contained less organic matter content, total nitrogen, exchangeable bases and cation exchange capacity (CEC) than similar soils under natural vegetation. Gardiner and Miller (2004) also indicated a decrease in soil OM substantially lowers the amount of CEC to the soil. Even if the mean CEC value of cultivated land in the present study was lower than that of grazing and forest/plantation lands due to its lower OM content, the figure (CEC value) was not as such bad because of its relatively higher percentage of clay content than the other land use types (Table 1). A decrease in soil pH (Table 1) might be also the cause for the lowering of CEC of the soil under cultivated land. The same finding was reported by Gardiner and Miller (2004).

Effect of land use types on soil OM, TN and AvP

Organic matter (OM) (%) content was significantly ($P<0.001$) affected by the land use types. The soil OM content was highest (7.76%) for soil drawn from the forest/plantation land and lowest (4.23%) for soil taken from the cultivated land (Table 1). The result indicated that there was significant difference in soil OM content between cultivated land and grazing land as well as between cultivated land and forest/plantation land. However, there was no significant difference between grazing and forest/ plantation lands (Table 1). According to Tan (1996) rating of organic matter, the soil OM content of both grazing and forest/plantation lands of the present study was very high while that of cultivated land was medium. The lowest OM content for the cultivated land in the present study might be due to higher OM decomposition associated with sufficient aeration, inadequate fertilization with manures, OM removal by erosion, removal and burning of crop residues. This result agrees with the report of Roose and Barthes (2001) who reported that periodic tillage operation with insufficient soil and water management practices in cultivated land may be responsible for the significantly lower soil organic matter content. The report of Lewandowski (2002) cited in Solomon (2008) also confirmed the results of the present study. He reported that continuous cultivation becomes the major causes of most OM losses. The present study also confirmed the reports of Brown and Lugo (1990), Spaccini *et al*. (2001) and Wu and Tiessen (2002) who all observed a comparable loss of soil OM and TN due to cultivation of forest and pasture lands. Soil OM at the depth of 0-20 cm for cultivated soils was lower than that of forest and pasture soils by 49.5% and 47.9%, respectively at similar soil depth. Similarly, after 18 years of cultivation of farm land, soil TN decreased by 51% and 47.7%, respectively compared to the forest and pasture soils. The lower carbon/OM content in cultivated soils could also be attributed to lower residue return to the soil, as a significant portion of dry matter production are removed in harvested material (Golchin et al., 1995). Likewise, Mulugeta (2004) reported that the decline in SOC and total N, although commonly expected following deforestation and conversion to farm lands, might have been exacerbated by the insufficient inputs of organic substrate from the farming system due to residue removal and burning on the farm fields. On the other hand, the greater OM in the forest/plantation soils was due to higher production, accumulation and decomposition of litters and low physical soil loss (Islam et al., 1999 and Descheemaeker et al., 2006). Similarly, forest/plantation soil had the highest soil OM because the soil was not tilled or exposed to erosion.

Results also showed that total nitrogen (TN) (%) was significantly affected by the different land use types ($P<0.001$). The TN (%) content of soil was 0.46%, 0.42%.and 0.35% for soils taken from forest/plantation, grazing and cultivated land, respectively (Table 1). According to soil TN content rating by Barber (1984), the soils taken from the forest/plantation and the grazing land in the present study fall in "very high" and that of the cultivated land fall in "high" class. Soil taken from forest/plantation land showed significantly higher TN value than soil from other land use types (Table 1). The relatively lower TN content in the current investigation for cultivated land might be associated with the reduction in soil OM content. This statement is supported by the findings of Yeshitela and Bekele (2002), who also reported that the TN content of the soil in different communities vary with the amount of organic matter; the TN being higher in soils with higher organic matter content and lower in soils having lower organic matter content. Moreover, continuous cropping (or the removal of large quantities of nutrients from the soil) without applying additional organic matter such as manure and inorganic fertilizer, removal/burning of crop residue, and accelerated erosion might also be the cause of reduced soil TN content in cultivated land. Our reasoning is in agreement with reports of Mullar-Harvey et al. (1985) and Girma (1998) who also concluded that the lower levels of organic carbon and TN content in cultivated soils might have resulted from a combination of lower C inputs because of less biomass C return on harvested land and greater C losses because of aggregate disruption, increased aeration by tillage, crop residue burning and accelerated soil erosion. The report of Mulugeta (2004) cited in Gebeyaw (2007) also revealed that the levels of soil OC and TN in the surface soil (0-10 cm) were significantly lower, and declined increasingly with cultivation time in farmlands, compared to the soil under the natural forest. Su *et al*. (2004) also found out that even short-term cultivation had a significant influence on soil C, N and soil biological properties of soil when compared to the native grasslands soils.

The result of available phosphorus (AvP; ppm) of soils was significantly affected ($p<0.001$) by land use types. The highest (5.81 ppm) and the lowest (2 ppm) AvP content of soil was observed in the soil taken from the forest/plantation and the grazing lands, respectively (Table 1). According to Tisdale *et al.* (1997) rating of AvP levels, the AvP of the soils of the land use types in the studied watershed fall in the medium, low and very low range for forest/plantation, cultivated and grazing lands, respectively. Soil taken from grazing land showed significantly lower AvP value than soil from other land use types (Table 1). The relatively lower content of AvP content in the soils taken from cultivated and grazing lands as compared to that of forest/plantation land was probably due to plant uptake (for cultivated land) and losses through soil erosions. This present finding draw support from reports of Murphy (1968) and Eylachew (1987) who both reported that the AvP under most soils of Ethiopia declined by the impacts of fixation, abundant crop harvest and soil erosion. It also agrees with Mekuria (2005) who reported that the conversion of natural vegetation to cropland was an important cause of the decline in soil available phosphorous content. The higher AvP content in the soil drawn from cultivated land as compared to that of the grazing land was probably due to the application of diammonium phosphate (DAP) fertilizer by farmers. Likewise, Gebeyaw (2007) reported that even though the OM content of the cultivated land was lowest compared to the other land use types, the higher AvP content in cultivated compared to grazing land in the present study could be due to the application of diammonium phosphate (DAP) fertilizer on the cultivated land. The higher AvP in forest/plantation land as compared to the other land use types on the other hand could probably be attributed to the accumulation of litter fall to forest soil. Silver (1994) has also found a high correlation between litter fall and soil phosphorous which supports our present finding.

Effect of land use types on soil basic exchangeable cations (K^+, $Ca^{++}$and Mg^{++})

Exchangeable potassium (K^+; cmol kg^{-1}) content in soils of the studied watershed was significantly affected ($P<0.001$) by land use types. Exchangeable potassium was lowest (0.31) in grazing land and highest in the forest/plantation land (1.51) (Table 1). The results revealed that the exchangeable K^+ of soil taken from forest/plantation was significantly higher than that of both cultivated and grazing land (Table 1). The relatively lower exchangeable K^+ contents in the present investigation in soils taken from the cultivated and the grazing lands compared to that of the forest/ plantation land might be due to its removal through harvested and grazed parts of the plants from the cultivated and grazing lands, respectively. The application of acid forming fertilizers to the cultivated land might be another major factor for reduction of exchangeable K^+ in the cultivated soil, since H^+ ion competes for the K^+ binding site leading either to its leaching loss or favoring its uptake by the plants. This suggestion is also in agreement with the reports of Baker *et al*. (1997) and Wakene (2001) who reported that the application of acid forming fertilizers was a major factor affecting the distribution of K^+ in soil systems mainly by enhancing its depletion especially in tropical soils. On the other hand, the relatively higher exchangeable K^+ content in soil taken from cultivated land compared to that of grazing land might be due to continuous cultivation which most likely exposed the K rich parent materials to further weathering and subsequently the release of exchangeable potassium. Chadwick et al. (1999) reported that weathering favoured by frequent tillage, exposes the fixed K of soil to further weathering making exchangeable K^+ remarkably higher in farm lands than in other land use types which supports our suggestion. On the other hand, the highest exchangeable K^+ content in the soil drawn from forest/ plantation land might be related to its high pH value (Table 1) and this finding was also in agreement with reports of Mesfin (1996) who observed high exchangeable K under high pH tropical soils.

The exchangeable calcium (Ca^{++}; cmol kg^{-1}) was significantly ($P<0.001$) affected by land use types. The highest (28.02) and the lowest (18.01) exchangeable Ca^{++} contents were observed in the soils taken from forest/plantation and the cultivated lands, respectively (Table 1). Gebeyaw (2007) has reported similar status of exchangeable Ca^{++} reduction in cultivated land. The lower exchangeable Ca^{++} in the present finding in cultivated land could be attributed to the reduction of soil pH and excessive leaching due to continuous cultivation. This agrees with the findings of Dudal and Decaers (1993) who stated that continuous cultivation, application of acid forming inorganic fertilizers, excessive leaching as a result of high rainfall, high exchangeable and extractable soil Al content and low pH results in low Ca and Mg contents and hence in Ca and Mg deficiencies. Similarly, Saikhe *et al*. (1998) stated that continuous cultivation and use of acid forming inorganic fertilizers deplete exchangeable Ca and Mg.

Exchangeable magnesium (Mg^{++}; cmol kg^{-1}) content was also significantly ($P<0.001$) affected by land use types. The exchangeable magnesium content was highest (6) in the soil drawn from the forest/plantation land and lowest (1.99) in the soil taken from the cultivated land (Table 1).The cause for the decline in exchangeable magnesium in cultivated land was the same as that of exchangeable calcium. The lowest exchangeable magnesium value obtained in the cultivated land could also be related to the influence of intensive cultivation and abundant crop removal with harvestable parts with little or no use of input as reported by Singh *et al*.(1995) and He *et al*. (1999).

Soil degradation index

The degradation indices (DI) (%) for selected soil properties under different land use types were summarized in Table 2.

Table 2: Degradation indices (DI) of selected soil properties as influenced by land use types

Soil Property	Mean values of soil attributes for the land use types Forest/plantation land	Grazing land	Cultivated land	Degradation Indices (%) Grazing land	Cultivated land
BD	0.81	0.88	1.01	8.64*	24.69*
pH	6.22	5.36	5.07	-13.83	-18.49
SOM	7.76	7.74	4.23	-0.26	-45.49
TN	0.46	0.42	0.35	-8.70	-23.91
AvP	5	2	3	-60	-40
CEC	45.92	45.68	39.38	-0.52	-14.24
Cumulative soil degradation indices				-74.67	-117.44

* *The value is taken as negative*

In the computation of degradation index (Table 2), the negative value indicated deterioration of soils in terms of the typical soil property considered. The results of computation of degradation index indicated that soil under both cultivated and grazing lands showed deterioration in all the soil parameters studied. Except with AvP, which was severely deteriorated in grazing land (-60%), the other parameters were more severely deteriorated in the soil obtained from cultivated land than from grazing land. It can be observed that soil OM, AvP, BD and TN were the most deteriorated soil parameters with values of -45.49%, -40% , -24.69% and -23.91%, respectively for cultivated land. However, soil CEC was the least deteriorated soil parameter with values of -14.24% for cultivated land. Likewise, AvP and soil OM were the highest and the least deteriorated soil parameters with -60% and -0.26% values, respectively for grazing land. Generally, soil under grazing land cumulatively deteriorated by -74.67 whereas it deteriorated by -117.44for cultivated land. The major reasons for the deterioration of soil attributes (both chemical and physical) under cultivated land were removal of nutrients through continuous cropping, removal of crop residue, low levels of fertilizer application and poor soil and rainwater management practices.

Conclusion

The attributes of the soils under the cultivated lands showed overall change towards the direction of loss of their fertility compared to the soil attributes of the adjacent forest/plantation and grazing land soils. Hence, major declines were observed for soil pH, electrical conductivity (EC), organic matter (OM), total nitrogen (TN), cation exchange capacity (CEC), exchangeable Ca and exchangeable Mg more in cultivated land than the other land use types. The average values of other selected soil physico-chemical properties under the cultivated, grazing and forest/

plantation lands showed changes in bulk density (1.01,0.87,and 0.81g/cm), AvP (3, 2 and 5.81 ppm) and exchangeable K (29.98, 25.7 and 60.73 ppm) respectively for the watershed. These variations of soil physicochemical properties between land use types indicate the risk to the sustainable crop production in the area. Therefore, the expanding population in the study areas will have to seek strategies to secure food and a sustainable solution that better addresses soil managements.

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