DOI: https://doi.org/10.24297/jaa.v15i.9572

Role of Land Use Dynamic Nature and Their Influence on Soil Physico-Chemical Properties in Various Watersheds in Ethiopia

Amare Bitew

College of Agriculture and Natural Resource, Department of Soil Resource and Watershed Management, Bonga University, P.O.Box 334, Bonga, Ethiopia

*Corresponding author's email: -amarebitew2019@gmail.com

Abstract

Land-use changes have remarkable effects on the dynamics of soil properties. The lowest mean of bulk density, the highest fraction of clay, soil pH, soil organic matter, total nitrogen, available phosphorus, cation exchange capacity, and exchangeable base were recorded in forest land. Also, soil depth data might fluctuate with increasing soil depth. This variation might be due to inappropriate land use management led to disturbance of soil nutrient status, indicating that the soil condition in the cultivated land and plantation forest is getting below the condition of soils under natural forest and grazing lands. Therefore, needs immediate intervention to protect the remnant natural forest and to replenish the degraded soil properties proper land use plans and soil water conservations are important to enhance and sustain soil fertility and agricultural productivity.

1. Introduction

Global economic and environmental stability are significantly jeopardized by alterations in land use and land cover. These fluctuations are primarily driven by the complex interplay between biophysical factors and human actions within specific spatiotemporal contexts (Turner et al., 1995). Land-use change in Africa accounts for a conversion of 75 million hectares of forest to agriculture and pasture between the years 1990 and 2010 (FAO, 2010). Supplementary, in West Africa, nearly 13 million hectares of original forest were lost over the same 30-year period and the remaining forest is fragmented and continues to be under threat (FAO, 2010).

Ethiopia boasts considerable natural resources, and agriculture serves as the backbone of its economy (Gete et al., 2006). The sector contributes a significant 42% to the country's gross domestic product (GDP) and provides employment for around 85% of the workforce (CSA, 2015). However, a longstanding challenge concerns the ongoing degradation of natural resources, dating back centuries (Hurni et al., 2010). This poses a significant threat to the sustainability of Ethiopia's vital agricultural sector.

This was indicated by many researchers who have studied land use and land cover change at the local level, mostly on a catchment scale (Alemayehu, 2010). For instance, Mengistie *et al.* (2015) investigated a significant reduction of natural forest cover and grasslands, but an increase of croplands between 1973 and 2012 in Munessa, Shashemene landscape of the Ethiopian highlands. Eleni *et al.* (2013) also showed a significant decrease in natural woody vegetation of the Koga catchment since 1950 due to deforestation despite an increasing trend in Eucalyptus tree plantations after the 1980s. In line with this, Woldeamlak (2002) revealed an increase in Eucalyptus plantation forest cover at a rate of 11 ha per annum in Chemoga watershed Northwest Ethiopia.

Consequently, land-use changes have remarkable effects on the dynamics of soil properties (Biro *et al*., 2013). Land-use changes from forest cover to cultivated land or other land-use type may reduce the input or organic residues that lead to a decline in soil fertility (Muñoz-Rojas *et al*., 2015), and increased rates of erosion (Biro *et al*., 2013), loss of soil organic matter and nutrient (Saha and Kukal, 2015), and accelerated the rate of soil degradation (Barua and Haque, 2013).

Similarly, Eyayu and Mamo (2018) reported that Land use/cover change, mainly the conversion of natural forests to agricultural land use type and settlement, is the most widely practiced activity in northwest Ethiopia. Such changes and the continuous use of land-use types for cultivation, and grazing purposes for centuries resulted in the loss of soil nutrients, particularly in the highlands where soil erosion is more severe (Betru, 2003; Eyayu *et al*., 2010; Eyayu and Mamo, 2018).

In line with this, Alemayehu and Assefa (2016) also, reported that changes in land use/cover change (LULC) lead to a significant change in soil physical, chemical, and biological properties. It reduces organic matter content, cation exchange capacity, and basic exchangeable cations, mainly through diminished litter production, bigger erosion rates, and faster decomposition of organic matter by oxidation. For this reason, numerous agricultural soils (particularly in total N and available P) in the tropics are currently below their possible production levels (Fleskens and Stringer, 2014; Carreiras *et al.,* 2014; Fleskens *et al*., 2014).

The sustainability of agricultural systems hinges upon the prudent management of soil resources. However, soil quality and quantity are susceptible to rapid decline due to diverse factors (Alemayehu & Sheleme, 2013). Consequently, agricultural practices necessitate a fundamental understanding of sustainable land-use principles, particularly soil management. Achieving success in soil management and maintaining soil quality is contingent upon comprehending how soil responds to evolving land-use practices over time. This growing emphasis on soil quality assessment stems from the heightened awareness of its critical role within the Earth's biosphere. Soil functions not only as the foundation for food and fiber production but also plays a vital role in upholding environmental quality at local, regional, and global scales (Negassa, 2001).

It is crucial to understand the impact of land-use change on soil physico-chemical properties at the watershed level to establish appropriate management options for sustaining soil health and restoring degraded lands. Therefore, this paper aims to review the pattern of land use dynamics and its effect on selected soil physical and chemical properties in various watershed levels in Ethiopia.

2. Concept of Land Use Land Cover Change

Land cover and land use are the two interrelated ways of observing the earth's surface (Duhamel, 2011). The former represents the biophysical state of the earth's surface and immediate subsurface, while the latter indicates the manner human population manipulates the biophysical attributes of the land and the purpose for which land is used (Adane *et al.,* 2016). The relationship between land use and land cover can be described as a change in land use that can affect and be affected by the land cover; however, the change in either of them is not necessarily the product of the other. Single land-use systems may correspond to a single land cover or it may involve several distinct covers (Briassoulis, 2011).

Land use and land cover change is the modification of the Earth's surface (both water bodies and terrestrial areas) through human activities. Land use and land cover change can also be expressed as any biophysical change of land covers like vegetation cover and water bodies and improper use of land for different activities; for example, for grazing, cropping, and irrigation (Quentin *et al.,* 2006).

Therefore, changes in land use and land cover can be grouped into two categories as conversion and modification (Adane *et al.,* 2016). Land use and land cover conversion refer, to change from one land use and land cover to another, for example, wetland and water bodies to agricultural fields, forest to residential and industrial areas, cropland, and grassland. Modification of LULC refers to some alteration of the same land use and land cover or it is a gradual change of land use and land cover; for instance, dense forest to open forest, open forest to a scattered tree. Furthermore, land use and land-cover changes vary in spatial extent and time. The spatial extent of land-use and land-cover change indicates the location or place where there is a change whereas temporal change refers to the variation of changes from time to time with their attribute.

2.1. Impacts of Land Use Land Cover Change

The most spatially and/or economically important human uses of land internationally include cultivation in various forms, livestock grazing, settlement and construction, reserves and protected lands, and timber extraction (Robert Walker, 2004; Bello et al. 2016). These and other land uses have cumulatively transformed land cover on a global scale. The consequences have been significant not only for land cover but for many aspects of local,

regional, and global environments, including climate, atmospheric composition, biodiversity, soil condition, and water and sediment flows (Robert Walker, 2004; Bello et al. 2016). Land use land cover change is one of the main drivers of environmental change (Joseph *et al.,* 2010). Despite the social and economic benefits of LULC change, this conversion of LULC usually has an unintended consequence on the natural environment (Leh *et al.,* 2011). It influences the basic resources of land, including mainly, the soil resource.

2.2. Effect of Land Use and Soil Depth on Soil Physical Properties

The physical properties of soils determine the different functions of soil and vary activities upon the soil resources. It determines their adaptability to cultivation and the level of biological activity that can be supported by the soil (Iqbal *et al*., 2012; USDA, 2014). Soil physical properties also largely determine the soil's water-holding capacity and air-supplying capacity to plants (Abiyot and Alemayehu, 2016). Even though different soil physical properties are either dynamic or inherent soil fertility, many soil physical properties change with changes in land use types and management practices. These have included the intensity of cultivation, the presence or absence of crop residues and animal manures on cultivated land, the instrument used for cultivation, and the application of organic and inorganic fertilizers (White, 2006). The most important physical properties of the soils that were influenced by land-use change and soil depth would include soil texture, soil bulk density, porosity, and soil moisture content.

2.2.1. Soil texture

Soil texture is the proportion of sand, silt, and clay particles with a varying range of their size in

diameter. Sand particles range in size from 0.05 to 2.00 mm, silt ranges from 0.002 to 0.050 mm, and the clay fraction is made up of particles smaller than 0.002 mm in diameter. Particles larger than 2.0 mm are referred to as rock fragments and are not considered in determining soil texture, although they can influence both soil structure and soil-water relationships (Brady and Weil, 2008). The soil texture is usually affected by land-use dynamics, as evidenced by different studies. For instance, particle size distributions in the soils of North Central Highlands of Ethiopia varied significantly as a result of the main effects of land use types (Nahusenay and Kibebew, 2016). The highest silt and sand fraction were observed on cultivated land as compared to the other land use types in *Alket Wonzi* Watershed, Northwest Ethiopia (Meseret *et al.,* 2015). Thus, the highest sand content recorded under cropped land could be due to the intensive cultivation and crop residue harvest.

Different studies showed the effect of soil depth on soil properties. Mulugeta *et al*. (2019) reported a higher sand content at the surface (0-20 cm) soil layer, whereas higher silt and clay were recorded in the subsurface (20-40 cm) of the soil layer in Kuyu district, Ethiopia. The reason might be due to the preferential removal of clay particles and their downward movement into the subsurface soil layer through the process of clay migration. Similarly, Tsehaye and Mohammed (2013) reported lower clay and higher sand content were found in the surface layer and higher clay contents were found in the subsurface layer of cultivated land than the other adjacent natural forests, plantation forests, and grazing lands. Additionally, Mengistu *et al*. (2017) stated that the clay content of cultivated land was increased from the surface to the subsurface soil layer due to the long period of cultivation. This might be attributed to the selective removal of clay particles by processes of erosion, leaving behind the sand fraction in situ and its downward migration through the soil profile.

2.2.2. Bulk density (BD)

Bulk density is the oven-dry weight of soil per unit volume expressed in g cm^{-3} (Hazelton and Murphy, 2007) and indicates the compactness of the soil (Debela *et al*., 2011). The soil bulk density value was significantly affected by land use and soil depth. Considering the main effects of land use type, the highest (1.37 g cm^{-3}) mean value of bulk density was recorded on the cultivated land and the lowest (1.10 g cm^{-3}) mean value was found under the grassland (Mulugeta *et al.,* 2019*)*. The reason for the lowest soil bulk density of the grassland could be due to the higher clay content, soil organic matter, and less disturbance of the soil under grassland. The higher bulk density of soil in cultivated land might be due to the practice of ploughing in cultivated soil, which tends to lower the quantity of soil organic matter and expose the soil surface to direct strike by raindrops.

Similarly, Teshome *et al*. (2013) found the highest bulk density under cultivated land compared to the adjacent grazing and forest lands at a soil depth of 0-20 cm in *Abobo Area*, Western Ethiopia. Islam and Weil (2000) and Evrendilek *et al*. (2004) also reported soils under cultivated lands had higher bulk densities than natural forest and grassland soils with an associated decrease in porosity. The study results of Woldeamlak and Stroosnijder (2003), Mulugeta (2004) revealed the bulk density of the cultivated soils was higher than the bulk density of the forest soils. For good plant growth, bulk density should be below 1.4 g cm^{-3} for clay and 1.6 g cm^{-3} for sandy soils (Landon, 1991).

Additionally, Eyayu and Mamo (2018) reported an increase in bulk density by 27.50 and 40.20% as natural forests changed into cultivated and grazing land-use types, respectively at Agedit Watershed, Northwest Ethiopia. The associated changes in bulk density to changes in soil organic matter content due to the plowing and overgrazing, and the tampering effects of animals, harvesting of crop residue that increased exposure of soil to direct temperature and precipitation in both grazing and cultivated lands. Paradoxically, Abiyot and Alemayehu (2016) found that a higher bulk density in the grassland compared to the adjacent bare land and rehabilitated land at a soil depth of 0-10 cm, 20-30 cm, and 30-40 cm.

2.2.3. Total porosity (TP)

Porosity defined as the ratio of the total volume of pore space to the total volume of soil is an index of the relative pore space in the soil. The total porosity of the soil usually lies between 30% and 70% and may be used as a very general indication of the degree of compaction in the soil in the same way as bulk densities are used (Nega and Heluf, 2013).

The finding Getahun and Bode (2015) reported among different land-use types the highest total porosity was observed under the soils of the forest land. This is attributed to the relatively lower animal trampling while the lowest porosity was the result of higher animal tracking in the soils of grazing land-use types. A decline in total porosity in the soils of grazing and cultivated land use types as compared to soils of natural forest is attributed to a reduction of pore size distribution and it was also closely related to the magnitude of soil organic matter loss which depending on the intensity of soil management practices (Achalu *et al*., 2012). This was expected as porosity was inversely related to the bulk density of soils and affected by the bulk density of soils.

This authors Ota *et al.* (2018) also reported the highest mean value of TP under forest lands and the lowest under grazing lands suggesting the trampling effect of cattle increasing bulk density while at the same time reducing total porosity and water infiltration. This might be due to soil bulk density and soil total porosity which are inversely related which has huge implications for runoff and soil erosion losses.

On the other hand, the porosity of soil decreases with increasing soil depth which is attributed to the accumulation of organic matter in surface soil under natural forest in Achefer District Northwestern Ethiopia (Yihenew and Getachew, 2013). Habtamu *et al.* (2014) also studied the highest total porosity observed on the surface layer of forest land while the lowest on the surface layer of grazing land, which might be due to high organic matter in forest land and compaction with high bulk density in grazing land at *Wujiraba* watershed, North-western Highlands of Ethiopia. Table 2 provides additional details and supporting data for the key findings identified in the preceding discussion.

Table 1: Mean values of selected physical properties of soils as affected by different land uses.

Land use	Sand	Silt	Clay	Particle size Si/Cl	distribution (%) Textural class	BD (g/cm^{3})	TP (%)
Forest	34^{d}	41b^{c}	26^{a}	1.57^{c}	Clay loam	1.21^{d}	0.53^{a}
Grazing land	36b^{c}	45^{a}	19^{c}	2.42^{b}	Clay loam	1.5^{b}	0.44^{b}
Cultivated outfields	46^{a}	$_{4\,3}$ab	11^{d}	3.9^{a}	Sandy loam	1.62^{a}	0.32^{d}
Homestead	36^{b}	$_{41}$bc	23^{a}	1.8^{c}		1.41^{c}	0.43^{c}
Mean	38.01	42.37	19.71	2.42		1.45	0.43
SE (±)	0.39	0.54	0.47	0.28	Clay loam	0.05	0.01
F	69.24	4.69	61.13	46.14		24.86	16.09
Sig	***	*	***	***		***	***

Source:(Bufebo & Elias, 2020)

2.3.4. Soil Moisture content

Soil moisture is one of the sources of water available to plant growth. Excessive volumes of water in soil retard plant growth and make drainage essential. Soil moisture content can be described in terms of weight of water per unit weight of soil or volume of water per unit volume of soil. It is influenced by many factors for example soil texture, soil depth, soil structure, and temperature (Iseraelsen and Hansen, 1962). The soil under different land-use differed in their water content both at field capacity and permanent wilting point. This was a due difference in their sand, silt, and clay fractions. The higher soil moisture content was detected at field capacity, permanent wilting point, and available water content under cultivated land as compared to forest and grazing land might be due to its higher clay content in cultivated land (Achalu *et al.,* 2012).

However, Melku *et al.* (2019) reported the highest soil moisture content was found under natural forests as compared to grazing and cultivated land. In support of this finding; Fantaw *et al.* (2015) also, revealed that the soil moisture content was higher under enclosure than open grazing land use due to the higher soil organic carbon and decrease the bulk density of soils. This was might show that cultivation deteriorates soil structural aggregation reducing the soil water retention capacity (Wakene, 2001).

Different studies showed the effect of soil depth on soil properties. For instance, Soil moisture content was significantly variated with soil depth in some studies such as (Fantaw *et al.*, 2015; Mengistu *et al.,* 2017; Melku *et al.*, 2019). The Soil moisture content is higher in subsurface soil because of the relatively higher fine particle fractions (silt + clay) in the subsurface soil giving a better moisture-holding capacity.

In addition, the presence of less evaporation from the sub-soil coupled with increased downward water movement through gravity could have contributed to the increased amount of soil moisture with depth. These findings also agreed with Wakene (2001), Ahmed (2002) also reported that soil water content at field capacity, and permanent and available water holding capacity was found to increase with depth for soils under different management practices in Bako area and Arisi, Ethiopia.

2.3. Effect of Land Use and Soil depth on Soil Chemical Properties

Soil chemical features are the most crucial among the factors that determine the soil's ability to supply nutrients to plants and microorganisms. The chemical processes that take place in the soil impact the processes that lead to soil formation and the accumulation of soil fertility. Minerals passed down from the soil's parent materials over time release chemical elements that undergo various alterations and conversions within the soil (Zajícová *et al.,* 2019). The most critical chemical traits that were affected by changes in land use and soil depth would encompass soil acidity (pH), soil organic matter (SOM), total nitrogen (TN), accessible P, and CEC, as well as exchangeable bases **(**Ca2+, Mg2+, K+, and Na+).

2.3.1. Soil reaction (pH)

Soil pH, a fundamental parameter indicative of acidity or alkalinity, reflects the concentration of hydrogen (H+) ions in the soil solution. Lower pH values correspond to increased acidity, while higher values signify a shift towards alkalinity. Notably, a change of one unit in pH equates to a tenfold alteration in H+ activity, highlighting its profound impact on soil chemistry. As a critical soil property, pH provides valuable insights into fertility, ecosystem function, land-use suitability, and potential environmental hazards. Its primary determinants include the nature of the parent material, prevailing climatic conditions, organic matter content, and topographic features (Alemu et al., 2016).

Analysis of soil pH (H2O) across land-use types in northeast Wellega, Ethiopia, revealed statistically significant differences (Gebeyaw, 2015; Alemayehu & Assefa, 2016; Eyayu & Mamo, 2018). Notably, forest soils exhibited the highest mean pH values, indicative of a neutral to slightly acidic state. Conversely, cultivated and grazing lands displayed markedly lower pH, classified as acidic, with deviations of 0.4 and 0.7 units, respectively, relative to the forested reference (Alemayehu & Assefa, 2016). These findings underscore the profound influence of land-use practices on soil acidification, potentially impacting nutrient availability and ecosystem function within the region.

Similarly, Gebeyaw (2015) reported that soil pH (H_2O) values were reduced by 0.3 and 0.99 units due to land-use changes from the natural forest into grazing and cultivated land-use types, respectively at Maybar lake Watershed in North Ethiopia. This was due to depletion and removal of basic cations as a result of continuous soil disturbance and hence soil erosion, and Loss of base-forming cations down the soil profiles through leaching, depletion of basic cations due to crop residue harvest, and continuous use of ammonium-based fertilizers such as diammonium phosphate ($(NH4)_2HPO4$) in cultivated fields (Eyayu and Mamo, 2018).

In the Antra Watershed in the Northwestern Highlands of Ethiopia, the mean soil pH was higher in the surface layer of forest and lower in the surface layer of cultivated and grazing land (Habtamu, 2018). This variation is attributed to high organic matter with organic anions in the forest land and continuous removal of basic cations by harvested crops and animal grazing in the cultivated and grazing lands, respectively.

Furthermore, the low pH in cultivated lands might be also because of the very high leaching of basic cations and clay particles from the exposed surfaces of cultivated lands and H^+ ion released by nitrification of $NH4^+$ sourced chemical fertilizers, legume roots during N2 fixation (nitrification), and roots of crops to soil solution with low OM contents on the surface layer of cultivated land. A soil pH value was increased from surface to subsurface soil depths at *Agedit* watershed Northwestern Ethiopia (Eyayu and Mamo, 2018). This could be along with the soil depth there was an increasing basic cation which increases soil pH from top to down soil depth which shows pH and basic cation strong and positive relationship to each other.

Contrastingly, the aforementioned concept, as indicated by Nega and Heluf (2013), Gebyaw (2015), and Mugeta et al. (2019), denotes a decrease in soil pH values with increasing soil depth. This phenomenon may be attributed to the diminishing levels of Ca and Mg ions with soil depth, leading to a decline in soil pH across different soil layers. The adsorption of basic cations such as Ca2+ and Mg2+ ions onto the colloidal complex results in the replacement of H+ and Al3+ ions, consequently reducing the percentage of acid saturation and causing an elevation in the pH of the soil solution. Furthermore, the higher organic matter content observed in the surface soils across all land-use types could also contribute to this trend. Humified organic matter can tightly bind with aluminum ions, thereby diminishing their activity in the soil solution, ultimately elevating soil pH and reducing soil acidity.

2.3.2. Total nitrogen (TN)

Nitrogen (N) is one of the most essential elements that are taken up by plants in the greatest quantity next to carbon, oxygen, and hydrogen, and is considered to be one of the key crop growth limiting factors in the sub-humid Ethiopian highlands (Solomon et al., 2006). Nitrogen (N) is an essential element in plants due to its key role in chlorophyll production, which is fundamental for the photosynthesis process. Additionally, nitrogen is part of various enzymatic proteins that catalyze and regulate plant growth processes (Sinfield et al., 2010). The total soil nitrogen (TN) content showed significant variation under soils of different land-use types. The higher total nitrogen contents were recorded in natural forests and the lower in cultivated land (Nega and Heluf, 2013; Meseret et al., 2015). Similarly, the decline of TN in cultivated and grazing lands as compared to natural forests could be attributed to rapid mineralization of SOM following cultivation and grazing which disrupts soil aggregates and thereby increases aeration and microbial accessibility to SOM (Dawit et al., 2002).

Furthermore, several authors indicated that Ethiopian cultivated lands have insufficient total nitrogen due to high leaching loss, crop removal, loss of organic materials, and inadequate application of N fertilizers(Yifru and Taye, 2011; Abebe and Endalkachew, 2012; Nega and Heluf, 2013). Generally, the organic carbon content and total N under forest land were higher than those under cultivated and grazing land-use types in the high land of Ethiopia (Teshome *et al.,* 2013).

On the other hand**,** the highest mean total soil N was recorded on the surface layer of forest land and the lower in the subsurface layer of cultivated land use type which might be due to a high OM content with a high microbial population in the rhizosphere of forest land, and its rapid oxidation/mineralization with nitrate leaching in cultivated land, respectively. In line with this in all land-use systems, total N decreased with increasing soil depth which might be again due to the reduction in OM contents, microbial biomass, and N mineralization down the profile at *Antra* Watershed, Northwestern Highlands of Ethiopia (Habtamu, 2018). Similarly, Nega and Heluf (2013) also reported that total nitrogen declined with increasing depth from the surface to subsurface soils, respectively.

2.3.3. Soil organic matter (SOM)

Soil organic matter (OM) consists of deceased plants, animals, microbes, and fungi or their components, as well as animal and microbial excretions in various stages of decomposition. Ultimately, these materials break down into humus, which exhibit relatively stable characteristics in the soil (Getahun and Bobe, 2015). This study also indicated that in comparison to forest land use, the quantity of soil organic matter is lower in grazing and cultivated land use in *Loma Woreda*, Southern Ethiopia.

Similarly, the decline in SOM contents in the cultivated land could be attributed to the effect of continuous cultivation that aggravates organic matter oxidation and insufficient inputs of organic substrates from the farming system due to residue removal and zero crop rotation (Gebeyaw, 2015; Eyayu and Mamo, 2018)**.** In line with this argument Meseret *et al*. (2015) also reported Soil organic matter (SOM)) content showed significant variation under soils of different land-use types with higher contents and lower recorded in natural forest and cultivated land-use types, respectively.

Parallel with this author, Achalu *et al*. (2012) reported that relative to forest land, percent OC contents in soils of cultivated and grazing land-use types are lower. The depletion of soil OC was higher in cultivated land than in grazing land-use types. This is attributed to the fact that cultivation increases soil aeration which enhances decompositions of SOM and most of the percent SOM produced in soils of cultivated land use type is removed with harvest causing its reduction in values of OC content which in turn an increased in soil bulk density and decreased soils total porosity. Similar to this study, Teshome *et al.* (2015) also, reported that the soil OM content of cultivated land was depleted as compared to the forest land at *Abobo Area*, Western Ethiopia.

In agreement with the above finding, different reports indicate that most cultivated soils of Ethiopia are poor in organic matter content (Tilahun *et al.,* 2009; Getahun *et al*., 2014). This was due to the conversion of forest land use type to other forms of land use type may decrease the stock of OC due to changes in soil moisture and temperature regimes, and succession of plant species with differences in quantity and quality of biomass returned to the soil. In addition to this due to the low amount of organic materials applied to the soil and complete removal of the biomass from the field. In general, the conversion of soil natural forests into agricultural fields (cultivated and grazing land) in tropical ecosystems is known to bring about a remarkable depletion of the SOM stock (Nega and Heluf, 2013; Eyayu and Mamo, 2018).

In the case of soil depth, a higher amount of SOM was recorded on the surface of all land-use types. This was due to the continuous accumulation of non-decayed and partially decomposed plant and animal residues on the surface soil of different land-use types in Agedit watershed Northwestern Ethiopia (Eyayu and Mamo, 2018). Similarly, the highest value of soil OM content was recorded on the surface soil layer of forest land and the lowest in the subsurface soil layer of grazing land at Kuyu district central highland of Ethiopia (Mulugeta *et al*., 2019). The decline of soil OM content in the grazing land might be due to overgrazing and the heavy compactness of the soil by livestock trampling. This could in turn hamper an accumulation of soil OM at both the surface and subsurface soil layer.

This above finding was also in agreement with different individuals Tilahun and Asefa. (2009), Lalisa *et al*. (2010), Iqbal *et al.* (2012), Lechisa *et a*l. (2014) reported the soil OM decreased with increasing soil depth, with more accumulation on the upper surface soil layer. Similarly, Alemayehu and Sheleme (2013) found that soil OM decreases with increasing soil depth and it was higher in grassland compared with adjacent *maize* and *Enset* (*Ensete ventricosum* L.) land at the soil depth of 0-10 cm and 15-30 cm at Sodo Zuria Woreda of Wolaita zone Southern Ethiopia. This might be due to the roots of the grass and fungal hyphae in the grassland soils are probably responsible for the higher amount of soil OM.

2.3.4. Available phosphorus (Av. P)

Phosphorus (P) is the most critical essential element next to nitrogen, in influencing plant growth and production across the world (Nega and Heluf, 2013). Unlike N, it is not supplied through biochemical fixation but must come from other sources to meet plant requirements. Hence, its deficiency is directly related to food security issues, especially in the tropics, where severe soil degradation is responsible for the serious deterioration in soil quality (Solomon *et al*., 2006).

The mean value of available phosphorus was significantly higher in forest land followed by grazing and cultivated land use types at Gindeberet district, West Showa Zone, Ethiopia (Lechisa *et al*., 2014). In line with the finding Mulugeta *et al.* (2019) reported the highest available P was recorded on the forest land and the lowest was recorded on the grazing land use types at Kuyu district, Central highland of Ethiopia. This high content of available P in the forest land could be due to the high content of soil OM resulting in the release of organic phosphorus thereby enhances available P under forest lands.

Additionally, Getahun and Bobe (2015) reported available soil P of the forest land was significantly higher as compared to that of grazing and cultivated land use type soils at Loma Woreda Dawuro Zone in Southern Ethiopia. The very low available P status in the cultivated and grazing land soils could be associated with the low pH and high exchangeable acidity. Hence, these soils with relatively high exchangeable acidity can have acidic cations such as exchangeable Al, H, and oxides of Al and Fe that could fix the soluble P in the soil solution.

In the case of soil depth, the finding Abad *et al*. (2014) reported the higher available P were in forest land compared to pasture land and cultivated land at 0-30 cm soil depth. In line with this argument Lechisa *et al.* (2014) also reported the higher available P was recorded in the forest land than the adjacent cultivated and grazing land-use type at a soil depth of 0-10 cm, 10-20 cm, and 20-30 cm. According to these authors Mengistu *et al*. (2017) also, reported that the highest and the lowest soil available P contents were recorded at the surface soil layer of the cultivated land and the subsurface soil layer of the grassland, respectively. The key findings discussed above are further detailed and supported by the data presented in Table 2.

Table 2: Main effects of land use types and soil depths on selected soil chemical properties

Treatments	pH (H_2O)	OC (%)	OM (%)	TN (%)	Av.P(ppm)
			Land use types		
Natural forest	6.42^{a}	1.75^{a}	3.02^{a}	0.16^{a}	9.37^{a}
Grazing land	5.93^{b}	1.48^{b}	2.56^{b}	0.13^{b}	6.46^{b}
Cultivated land	5.69^{c}	1.20^{c}	2.06^{c}	0.09^{c}	6.60^{b}
Plantation forest	5.51^{c}	1.22^{c}	2.11^{c}	0.11^{cb}	5.90^{b}
LSD (0.05)	0.24	0.21	0.36	0.025	1.87
P-value	**	**	**	**	**
SEM(±)	0.09	0.11	0.18	0.01	0.54
CV (%)	3.29	11.99	11.99	16.07	21.31
			Soil depth(cm)		
0-20	5.76^{a}	1.59^{a}	2.73^{a}	0.15^{a}	7.43
20-40	6.01^{b}	1.24^{b}	2.13^{b}	0.11^{b}	6.73
LSD (0.05)	0.17	0.15	0.26	0.017	1.32
P-value	**	**	**	**	NS
SEM(±)	0.11	0.09	0.15	0.01	0.55
CV (%)	3.29	11.99	11.99	16.07	21.31

Source: (Molla et al., 2022)

2.3.5. Cation Exchange Capacity (CEC)

Cation exchange capacity (CEC) is a measure of the soil's ability to retain and supply cation nutrients and is expressed in cent moles of charge per kilogram (Cmol $(_{+})$ kg^{-1}). Probably the most important and distinctive property of soils is that they can retain ions and release them slowly to the soil solution and plants. The cation exchange capacity (CEC) implies the capacity of soil for ion exchange of cations between the soil solid and the soil solution (Ross *et al*., 2008).

According to findings, Lechisa *et al.* (2014) reported that Cation exchangeable capacity was showed significant variation in different land-use types at *Gindeberet district*, Western Oromiya Ethiopia. This author showed that the highest cation exchangeable capacity was observed in the forest followed by grazing land while the lowest was observed in cultivated land-use types. Similarly, Teshome *et al.* (2013) suggested that the CEC of soil was higher in forest land as compared to that of the adjacent grazing and cultivated land-use type at *Abobo Area*, Western Ethiopia.

In line with this above author, Mulugeta *et al*. (2019) reported the CEC means values under grass, cultivated, forest, and grazing land use types were 38.5, 33.2, 41.7, and 30.1 cmol $(_{+})$ kg^{-1}, respectively at Kuyu district, Central highland of Ethiopia. The higher and lower CEC in forest and grazing land might be due to the presence and absence of soil organic matter or high soil organic matter in forest land while it was less in grazing land at *Kuyu* district, Ethiopia. Besides, the amount and types of clay particles are also the determinant factor on the CEC of soil under different land-use types. Additionally, in this finding, Achalu *et al*. (2012) also, reported that higher CEC of clay in the soils of forest land followed grazing and cultivated land-use types. The variability in the percent CEC of clay across the land-use types is attributed to the variation in their SOM contents at Western Oromia, Ethiopia.

In the case of soil depth finding, Habtamu (2018) the highest CEC was recorded on the surface layer of forest land while the lowest on the surface layer of cultivated land use types at *Antra* watershed, Northwestern Highlands of Ethiopia. This variation might be due to high OM content and pH on the surface layer of forest and low OM, high leaching and uptake of basic cations as well as leaching of clay particles from cultivated land with lower pH. The authors Teshome *et al*. (2013) reported that conversion of natural forest to shrub, grazing, and cultivated lands caused losses of CEC in the magnitude of 30, 38, and 50%, respectively, in the surface soils at *Abobo* Area, Western Ethiopia.

2.3.6. Exchangeable base (Ca^{+2}, Mg^{+2}, $K^{+,}$ Na^{+})

The amounts of exchangeable bases (Ca^{+2}, Mg^{+2}, $K^{+,}$ Na^{+}) are important properties of soils as these do not only indicate the existing nutrient status but can also be used to assess balances amongst cations (Abiyot and Alemayehu, 2016).

The exchangeable Ca^{2+} and Mg^{2+}content were significant variations under different land-use types in some reporters (Achalu *et al.*, 2012; Teshome *et al.,* 2013; Getahun and Bobe, 2015; Alemayehu and Assefa, 2016). For example, Getahun and Bobe (2015) reported that exchangeable Ca^{2+} and Mg^{2+}content in cultivated lands were lowest as compared to natural forests. This might be due to their continuous losses in harvested parts of plants (both grain and straw) and leaching of basic cation from the topsoil of cultivated land-use types.

Similarly, Achalu *et al.* (2012) also reported that exchangeable Ca^{2+} and Mg^{2+}contents were declined when forest land changed to cultivated lands in Western Oromia, Ethiopia. As one move from forest to agricultural soils, the exchangeable bases readily decreased showing the declining dominance of basic cations in the exchange complex of the soil colloids. Generally, the difference of exchangeable base (Ca^{2+}, and Mg^{2+}) was due to the recognized in leaching losses, low content in the parent rock and the proportion of clay minerals as well as the conversion of forest land to other land use types at *Alket Wonzi* watershed Northwest Ethiopia (Meseret *et al.,* 2015).

In the case of soil depth, Getahun and Bobe (2015), Eyayu, and Mamo (2018) reported that the contents of both exchangeable Ca and Mg increased with soil depth in different land-use types. The reason for the increasing trend of exchangeable Ca and Mg with soil depth could be associated with an increase of clay particles in the sub-surface than the surface soils of the land use type. The clay mineral components of soil have negatively charged sites on their surfaces which adsorb and hold positively charged ions.

Similarly, the concentration of exchangeable K^{+} and Na^{+} contents are affected by different land-use types in some reporters (Teshome *et al.*, 2013; Getahun and Bobe, 2015; Gebeyaw, 2015). The concentration of exchangeable K^{+} and Na^{+} content in cultivated and grazing lands were lower as compared to natural forest. This was due to their continuous losses in the harvested parts of plants (grain, stems, roots, leaves, fruits stumps, and straw) and leaching of basic cations from topsoils of cultivated land use types (Getahun and Bobe, 2015). In addition, Gebayaw (2015) also reported that exchangeable K^{+} content is higher in a natural forest as compared to grazing and cultivated land-use types.

However, exchangeable Na^{+} content in grazing land was higher as compared to natural forest and cultivated land-use types. This variation 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. For a more comprehensive understanding of the key findings discussed above, please refer to the data presented in Table 3.

Table 3: Main effects of land use type and soil depth on exchangeable base and cation exchange capacity

Treatment	Exchangeable bases ($cmol_c kg^{-1}$)				CEC($cmol_c kg^{-1}$)
	C Ca	Mg	Na	K	
	Land use types				
Natural forest	32.07^{a}	8.24^{a}	0.68^{a}	1.06^{a}	46.93^{a}
Grazing land	22.67^{b}	3.56^{b}	0.46^{b}	0.58^{b}	41.80^{b}
Cultivation land	18.56^{cb}	3.48^{b}	0.37^{cb}	0.42^{cb}	33.17^{c}
Plantation forest	16.37^{c}	3.17^{b}	0.33^{c}	0.35^{c}	36.68^{c}
LSD (0.05)	3.41	1.24	0.13	0.20	3.71
P-value	**	**	**	**	**
SEM(±)	1.44	0.43	0.05	0.07	1.11
CV (%)	12.27	21.74	23.07	26.16	7.55
Soil depth(cm)					
0-20	21.11^{a}	4.13^{a}	0.43	0.53^{a}	40.78
20-40	23.72^{b}	5.10^{b}	0.49	0.67^{b}	38.52
LSD (0.05)	2.41	0.88	0.093	0.14	2.62
P-value	*	*	NS	*	NS
SEM(±)	2.08	0.71	0.05	0.09	1.75
CV (%)	12.27	21.74	23.07	26.16	7.55

Source:(Molla et al., 2022)

Future Perspectives

Based on this empirical overview the following recommendations are suggested:

- Further studies of the remote sensing-based findings with datasets from primary or secondary sources would help find driving forces of land-use changes and their detailed consequences as well as looking for alternative solutions for conservation and management problems and designing future development strategies.
- To conserve soil resources, it needs the highest attention of policymakers as well as land-use planners to concentrate their efforts on land management strategies based on the land-use system.
- Awareness creation among the society on optimum use of natural resources, practicing appropriate conservation systems, minimizing driving forces such as population pressure and land-use change and their respective benefits is so important for sustainable land resource management.
- Furthermore, special emphasis should be given to improve lands management practices for sustainable productivity of soils by exercise integrated soil fertility management, such as combining organic and inorganic fertilizer applications.
- For the future, further work on slope gradient and detailed soil profile studies should be added to give a clear picture regarding the study area.

Compete of Interest

The authors declared that there is no competing of interest.

Funding

This review work did not receive any direct funds from any organization.

References

Abad R, Hassan K, Esmaeil H. 2014. Assessment of the effects of land-use changes on soil physicochemical properties in Jafarabad of Golestan province Iran. *Environment, Pharmacology and Life Sciences*, 3: 296-300.

Abate S. 2011. Evaluating the land use and land cover dynamics in *Borena Woreda* of South Wollo Highlands of Ethiopia. *Journal of Sustainable Development in Africa*, 13(1): 87-107.

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 in Agro-ecosystems*, 78: 97-110.

Abebe N, Endalkachew K. 2012. Physicochemical characterization of Nitisol in Southwestern Ethiopia and its fertilizer recommendation using NuMaSS. *Global Advanced Research Journal of Agricultural Science,* 1(4): 66-73.

Abebe S. 2018. Assessment of land use and land cover change using GIS and Remote Sensing techniques: A case study of *Dendi* District, Oromiya Regional State of Ethiopia. *Journal of Environment and Earth Science,* 8(1): 123-128.

Abiyot L, Alemayehu A. 2016. Study on selected soil physico-chemical properties of rehabilitated degraded bare land: the case of Jigessa rehabilitation site, Borana zone, Ethiopia, *Global Journal of Advanced Research.* 3: 345-354.

Achalu C, Heluf G, Kibebew K, Abi T. 2012. Status of selected physicochemical properties of soils under different land use systems of Western Oromia, Ethiopia. *Journal of Biodiversity and Environmental Sciences (JBES*), 2(3): 57-71.

Adane M. 2016. Land use/land cover changes and associated driving forces in bale eco-region, Ethiopia. The Msc thesis submitted to school of natural resource and environmental studies, Hawassa University Wondo Genet College of forestry and natural resources, Hawassa University, Wondo Genet, Ethiopia.

Ahmed H. 2002. Assessment of spatial variability of some physicochemical characteristics of soils under different elevations and land use systems in the slopes of Mount *Chilalo* in *Arisi* Ethiopia. MSc. Thesis in Alemaya University, Ethiopia. 104pp.

Alemayehu A, Assefa A. 2016. Effects of land use changes on the dynamics of selected soil properties in Northeast Wollega Ethiopia. *Journal of soil science*, 2: 63-70.

Alemayehu K, Sheleme B . 2013. Effects of different land use systems on soil physical and chemical properties in Sodo Zuria Woreda of Wolaita zone Southern Ethiopia. *Journal of Soil Science and Environment Management,* 4(5): 100-107.

Alemayehu M. 2010. Synthesis of Research on Land Use and Land Cover Dynamics in the Ethiopian Highlands .Unu-Land Restoration Traiing Programme. Keldnaholt, 112 Reykjavik, Iceland . final project

Alemu L, Tekalign M, Wassie H, Hailu S. 2016. Assessment and Mapping of Status and Spatial Distribution of Soil Macronutrients in Kambata Tembaro Zone, Southern Ethiopia. *Advances in Plants and Agriculture Research*, 4(4):144.

Barua SK, Haque SM. 2013. Soil characteristics and carbon sequestration potentials of vegetation in degraded hills of Chittagong, Bangladesh. *Land Degradation and Development*, 24: 63-71.

Belay T. 2002. Land-cover/land-use changes in the derekolli catchment of the South Welo Zone of Amhara Region, Ethiopia. *Eastern Africa Social Science Research Review*, 18(1), 1-20.

Bello IK, Sodiya AK , Solanke PA. 2016. Public Land Acquisition and Land Use Change Problems in Ogun State. International Journal of Management Science and Business Administration, 2(8):34-41

DOI: 10.18775/ijmsba.1849-5664-5419.2014.28.1004 URL: http://dx.doi.org/10.18775/ijmsba.1849-5664-5419.2014.28.1004

Berhanu S. 2016. Assessment of soil fertility status of vertisols under selected three land uses in *Girar Jarso* District of North Shoa Zone, Oromia National Regional State, Ethiopia. *Environmental Systems Research*, 5(1): 18p.

Betru N. 2003. Soil and water conservation program in Amhara National Regional State. In: Proceeding of the Conference on the Natural Resource Degradation and Environmental Concerns in the Amhara National Regional State: Impact on Food Security, pp. 109-125. (Tilahun Amede ed.). The Ethiopian Society of Soil Science (ESSS), Addis Ababa, Ethiopia.

Birhan A, Assefa A. 2017. Land use and land cover changes and their environmental implications in the *Gelana* sub-watershed of Northern highlands of Ethiopia. *Environmental system research*, 6(7): 2-12.

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

Birru Y, Anteneh A, Tadele A. 2013. Expansion of Eucalyptus Woodlots in the Fertile Soils of the Highlands of Ethiopia: Could It Be a Treat on Future Cropland Use? *Journal of Agricultural Science;* 5(8):1916-9760.

Birru Y. 2003. Soil and water conservation technologies, transfer and adoption by the smallholder farmers in the Amhara Region. Tilahun Amede (ed.). In: Proceedings of the Natural Resource Management Conference, Natural Resources Degradation and Environmental Concerns in the Amhara National Regional State: Impact on food security. July 24–26, 2002, Bahir Dar, Ethiopia.

Black CA. 1965. *Methods of soil analysis*, Part I, American Society of Agronomy. Madison, Wisconsin, USA, 1572pp.

Brady N, Weil R. 2008. *The Nature and Properties of Soil. 14th edition,* Upper Saddle River, NJ: Prentice Hall.

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

Briassoulis H. 2011. Factors Influencing Land Use Land Cover Change. *Journal of Land Use, Land Cover and Soil Science*1. 1. Am. Soc. Agro., Inc.,Madison, Wisconsin. Classification and Evaluation of the Phosphorus status. MSc Thesis, Alemay University.

Bufebo, B., & Elias, E. (2020). Effects of Land Use/Land Cover Changes on Selected Soil Physical and Chemical Properties in Shenkolla Watershed, South Central Ethiopia. *Advances in Agriculture*, *2020*. https://doi.org/10.1155/2020/5145483

Carreiras M, José A, Ferreira D, Valente S, Fleskens L, Gonzales-Pelayo O, Ritsema CJ. 2014. Comparative analysis of policies to deal with wildfire risk. *Land Degradation and Development, 25*: 92–103.

Çelik I. 2005. Land use effects on organic matter and physical properties of soil in a southern Mediterranean highland of Turkey. *Soil and Tillage Res. 83*: 270-277. http://dx.doi.org/10.1016/j.still.2004.08.001

Chapman HD. 1965. Cation exchange capacity. *In*: C.A. Black, L.E. Ensminger and F.E.Clark (Eds). Methods of soil analysis. *Agronomy,* 9: 891-90.

CSA (Central Statistical Agency). 2015. The Federal Democratic Republic of Ethiopia Central Statistical Agency Population estimation and census in Ethiopia.

Dawit S, Lehmann J, Tekalign M, Florian F, Wolfgang Z. 2002. Phosphorus forms and dynamics as influenced by land use changes in the sub-humid Ethiopian highlands. *Geoderma*, 105: 21-48.

Day PR. 1965. *Particle Fraction and Particle Size Analysis*. In: Methods of soil analysis, Black, C.A. (Ed.). American Society Agronomy, Madison, *WI, USA*, 9: 545-567.

Debela H, Jesse T, Zemede A, Nyangito M. 2011. Physico-chemical soil properties of semi-arid Ethiopia in two land use systems: Implications to crop production. *International Journal of Agricultural Research*, 12(6): 840-84.

Duhamel C. 2011. Land Use and Land Cover, Including their Classification. *Journal of land use, land cover and soil sciences I.*

Eleni Y, Wolfgang W, Michael EK, Dagnachew L, Günter B. 2013. Identifying Land Use/Cover Dynamics in the Koga Catchment, Ethiopia, from Multi-Scale Data, and Implications for Environmental Change. *International Journal of Geo-Information*, 2: 302-323.

Evrendilek F, Celik I, Kilic HC. 2004. Changes in soil organic carbon and other physical Soil properties along adjacent Mediterranean forest, grassland, and cropland Ecosystems in Turkey. *Journal of Arid Environments,* 59: 743-752.

Molla, E., Getnet, K., & Mekonnen, M. (2022). Land use change and its effect on selected soil properties in the northwest highlands of Ethiopia. *Heliyon*, *8*(8), e10157. https://doi.org/10.1016/j.heliyon.2022.e10157

Eyayu M, Mamo Y. 2018. The effects of land use types and soil depth on soil properties of *Agedit* watershed Northwestern Ethiopia. *Ethiopian Journal of Science and Technology*, 11(1):39-56.

Eyayu M, Heluf G, Tekalign M, Mohammed A. 2009. Effects of land use change on selected soil properties in the *Tana Gedam* Catchment and adjacent agro-ecosystems North-west Ethiopia. *Ethiopian Journal of Natural Resources*, 11(1): 35-62.

Eyayu M, Heluf G, Tekalign M, Mohammed A. 2010. Patterns of land use/cover dynamics in the mountain landscape of *Tana Gedam* and Adjacent Agro-Ecosystem, Northwest Ethiopia. *SINET: Ethiopian Journal of Science,* 33(2): 75–88.

Fantaw Y, Getachew A, Abdu A. 2015. Soil property variations in relation to exclosure and open grazing land use types in the Central Rift Valley area of Ethiopia, *Environmental System Research*, 4(17): 2-11.

Fantaw Y, Ledin S, Abdu A. 2007. Changes in soil organic carbon and total nitrogen contents in three adjacent land use types in the *Bale* Mountains, Southeastern Highlands of Ethiopia. *Forest Ecology and Management*, 242: 337-342.

Fleskens L, Stringer LC. 2014. Land management and policy responses to mitigate desertification and land degradation. *Land Degradation and Development, 25*: 1–4.

Fleskens L, Nainggolan D, Stringer LC. 2014. An exploration of scenarios to support sustainable land management using integrated environmental socio-economic models. *Environmental Management, 54*: 1005-1021.

FAO (Food and Agriculture Organization). 2006a. Plant nutrition for food security: A guide for integrated nutrient management Food and Agriculture Organization, Fertilizer and Plant Nutrition Bulletin 16. FAO, Rome.

FAO (Food and Agriculture Organization). 1998. Guidelines on Land Evaluation for Rain fed Agriculture. Soils Bulletin No.52, FAO, Rome, Italy.

FAO (Food and Agriculture Organization) of the United Nations. 2010. Global Forest Resources assessment Main report; FAO Forestry Paper 163, Food and Agriculture Organization of the United Nations, Rome.

Gautam AP, Webb EL, Shivakoti GP, Zoebisch MA. 2003. Land use dynamics and landscape change pattern in a mountain watershed in Nepal. *Agriculture, Ecosystems and Environment,* 99: 83-96.

Gebeyaw T. 2015. Assessment of soil fertility variation in different land uses and management practices in *Maybar Lake* Watershed, South Wello Zone, North Ethiopia. *International Journal Environmental Bioremediation and degradation*, 3(1): 15-22.

Getachew F, Heluf G, Kibebew K, Birru Y, Bobe B. 2011. Analysis of land use/land cover changes in the *Debre-Mewi* watershed at the upper catchment of the Blue Nile Basin, Northwest Ethiopia. *Journal of Biodiversity and Environmental Sciences (JBES),* 1(6):184-198.

Getahun B, Bobe B. 2015. Impacts of land use types on selected soil physico chemical properties Loma *Woreda* Dawuro Zone in Southern Ethiopia. *Journal of Science and technology and arts research*, 4(4): 40-48.

Getahun H, Mulugeta L, Fisseha I, Feyera S. 2014. Impacts of land uses changes on soil fertility,carbon and nitrogen stock under smallholder farmers in Central highlands of Ethiopia: Implication for sustainable agricultural landscape management around Butajira Area. New York Science *Journal,* 7 (2): 27-44.

Gete Z, Menale K, Pender J, Mahmud Y. 2006. Stakeholder Analysis for Sustainable Land Management (SLM) in Ethiopia: Assessment of Opportunities, Strategic Constraints, Information Needs, and Knowledge Gaps. Environmental Economics Policy Forum for Ethiopia (EEPFE), Pp. 4-91.

Habtamu A. 2018. Effects of land use systems on soil fertility at *Antra* watershed, *Chilga* District, Northwestern Highlands of Ethiopia. *Universal Journal of Agricultural Research*, 6(6): 194-208.

Habtamu A, Heluf G, Bobe B, Enyew A. 2014. Fertility status of soils under different land uses at *Wujiraba* watershed, North-western highlands of Ethiopia. *Agriculture of Forestry and Fisheries*, 3(5): 410-419.

Hazelton P, Murphy B. 2007. Interpreting soil test results. What do all the numbers mean? 2nd ed, CSIRO Publishing.

Heluf G, Wakene N. 2006. Impacts of land use and management practices on chemical properties of some soils of *Bako* area in Western Ethiopia. *Ethiopian Journal of Natural Resources,* 8(2): 177-197.

Hurni H, Solomon A, Amare B, Berhanu D, Ludi E, Portner B, Birru Y, Gete Z. 2010. Land degradation and sustainable land management in the highlands of Ethiopia.

Hurni H. 1985. An ecosystem approach to soil conservation. Pages 759-771 in El-Swaify, M. Sa, Wc and A. Lo, editors. Soil Erosion and Conservation. Society of America, Ankey, Iowa.

Iqbal M, Khan A, Raza K, Amjad M. 2012. Soil physical health indices, soil organic carbon, nitrate contents and maize growth as influenced by dairy manure and nitrogen rates. *International Journal of agriculture and Biology*, *14: 20-28.*

Iseraelsen OW, Hansen VE. 1962. Irrigation principles and practices: New York, Wiley.

Islam K.R. and Weil R.R. 2000. Land use effects on soil quality in a tropical forest ecosystem of Bangladesh. *Agriculture, Ecosystems and Environment*, 79: 9-16.

Joseph M, Maitima JM, Olson SM, Mugatha S, Mugisha, Mutie IT. 2010. Land Use Changes, Impacts and Options for Sustaining Productivity and Livelihoods in the Basin Of Lake Victoria. *Journal of Sustainable Development in Africa*: 12:3. Clarion University of Pennsylvania, Clarion, Pennsylvania.

Lakew D, Menale K, Benin S, Pende J. 2006. Land degradation and strategies for sustainable development in the Ethiopian high lands: Amhara Region, Socio- economic and policy Research Working Paper 32. p14. ILRI, Nairobi, Kenya.

Lalisa A, Herbert H, Monika S. 2010. Effects of Land use types on soil chemical properties in smallholder farmers of Central Highland Ethiopia. *Ekologia (Bratislava),* 29(1): 1-14.

Landon J. 1991. Booker tropical soil manual: A handbook for soil survey and Agricultural landscape position. *International Journal of Soil Science,* 2(2): 128-134.

Lechisa T, Achalu C, Alemayehu A. 2014. Dynamics of soil fertility as influenced by different land use systems and soil depth in Gindeberet district, west Showa Zone, Ethiopia. *Agriculture, Forestry and Fisheries,* 3(6): *489-494.*

Leh M, Bajwa S, Chaubey I. 2011. Impact of Land Use Change on Erosion Risk: An Integrated Remote Sensing, Geographic Information System and Modeling Methodology. *Land Degradation and Development.* John Wiley and Sons, Ltd.

Mekonnen G. 2015. Characterisation of Agricultural Soils in Cascape Intervention Woredas of Amhara Region. *Soil Specialist*, Ethiopia.

Melku D, Awdenegest M, Asfaw K. 2019. Effects of Land Uses on Soil Quality Indicators: The Case of *Geshy* Sub catchment, *Gojeb* River Catchment, Ethiopia. *Applied and Environmental Soil Science,* 11pp.

Mengistie K, Thomas S, Demel T, Thomas K. 2015. Drivers of land use/land cover changes in Munessa Shashemene landscape of the south-central highlands of Ethiopia. Environmental Monitoring and Assessment, 187 (7):1-17

Mengistu C, Kibebew K, Tarekegn F. 2017. Influence of different land use types and soil depths on selected soil properties related to soil fertility in Warandhab area, Horo Guduru Wallaga Zone, Oromiya, Ethiopia. *International Journal of Environmental Sciences and Natural Resources,* 4(2): 1-11.

MWAO (Merawi Woreda Agricultural Office). 2019. Annual reported data on land use systems. *Unpublished document*, Ethiopia.

Meseret M, Addis K, Eyayu M. 2015. Assessing the physical and chemical properties of soil under different land use types. *Journal of Environmental and Analytical Toxicology*, 5:1-5.

Mohammed A, Leroux PAL, Barker CH, Heluf G. 2005. Soil of *Jelo* micro-Catchment in the Central Highlands of Eastern Ethiopia Morphological and Physiochemical Properties. *Ethiopian Journal of Natural Resources*, 7(1): 55-81.

Mulugeta L. 2004. Effects of land use changes on soil quality and native flora degradation and restoration in the highlands of Ethiopia: Implication for sustainable land management. PhD Thesis Presented to Swedish University of Agricultural Sciences, Uppsala. 64p.

Mulugeta T, Asmare M, Wondwosen T. 2019. Effects of land use types on selected soil physical and chemical properties Kuyu District, Ethiopia. *Eurasian Journal of Soil Science,* 8(2): 94–109.

Muluneh W. 1994. Population pressure, land use change and patterns of agricultural productivity in Ezan Wollene and Cheha Wereda s Sabat bet Guragheland. Unpublished MA Thesis, Department of Geography, Addis Ababa University, Addis Ababa, Ethiopia.

Muñoz-Rojas M, Jordán A, Zavala LM, De La Rosa D, Abd-Elmabod SK, Anaya-Romero M. 2015. Impact of land use and land cover changes on organic carbon stocks in Mediterranean soils (1956–2007). *Land Degradation and Development, 26*: *168–179.*

Nahusenay A, Kibebew K. 2016. Effects of land use, soil depth and topography on soil physicochemical properties along the topo-sequence at the *Wadla Delanta Massif*, North central Highlands of Ethiopia. *Environment and pollution published by Canadian Center of Science and Education,* 5(2): 57-68

NMA (National Meteorological Agencey). 2019. Temperature and rain fall data of Merawi. *Unpublished document*, Bahir dar.

Nega E, Heluf G. 2013. Effect of land use changes and soil depth on soil organic matter, total nitrogen and available phosphorus contents of soils in Senbat Watershed, Western Ethiopia. *Asian Research Publishing Network Journal of Agricultural and Biological Science,* 8(3): 206-212.

Negassa W. 2001. Assessment of important physicochemical properties of Dystric Udalf (Dystric Nitosols) under different management systems in Bako area, Western Ethiopia. A thesis presented to School of graduate studies, Alemaya University, Ethiopia.

Olsen SR, Cole FS, Watanable L, Dean CV. 1954. Estimation of variable phosphorus in soil by extraction with sodium bicarbonate, USDA Circular, 939: 1-19.

Ota H O, Aja D, Agama IK, Okolo CC, Ogbodo E N, Mbah CN. 2018. Effect of Land Use Types and Slope Gradient on Soil Physico-Chemical Properties in Upper Eyiohia River Watershed Afikpo North, Southeastern Nigeria. *Academic Research Journal of Agricultural Science and Research*, 6(8), 475-487,

Quentin F., C. Jim C. Julia H. Carole. and S. Andrew. 2006. Drivers of land use change, Final Report: Matching opportunities to motivations, ESAI project 05116, Department of Sustainability and Environment and primary industries, Royal Melbourne Institute of Technology, Australia.

Rahman MM, Csaolovics E, Koch B, Kohl M. 2006. Interpretation of Tropical Vegetation Using Land sat ETM+ Imagery.

Robert W. 2004. Theorizing Land-Cover and Land-Use Change: The Case of Tropical Deforestation. *International Regional Science Review.* 27(3):247–270.

Ross D, Matschonat G, Skyllberg U. 2008. Cation exchange in forest soils: the need for a new perspective. *European Journal of Soil Science,* 59: 1141-1159.

Saha D, Kukal ZP. 2015. Soil structural stability and water retention characteristics under different land uses of degraded 5 lower Himalayas of North-West India. *Land Degradation & Development,* 26: 263–271.

Sahlemedhin S, Taye. 2000. Procedures for soil and plant analysis, National Soil Research Centre. *Ethiopian Agricultural Research Organization in Ethiopia*, 110pp.

SAS. 2002. SAS System Version 9 for Microsoft Windows, SAS Institute Inc, Cary, NC, USA.

Sinfield JV, Fagerman D, Colic O. 2010. Evaluation of sensing technologies for on-the go detection of macronutrients in cultivated soils. *Computers and Electronics in Agriculture*, 70(1):1-18.

Solomon D, Tarekegn F, Zech W. 2006. Phosphorus forms and dynamics as influenced by land use changes in the sub-humid Ethiopian highlands. *Journal of Soil Science*, 105: 21-48.

Sun P, Xu Y, Yu Z, Liu Q, Xie B, Liu J. 2016. Scenario simulation and landscape pattern dynamic changes of land use in the Poverty Belt around Beijing and Tianjin: A case study of Zhangjiakou city, Hebei Province. *Journal of Geographical Sciences,* 26(3), pp. 272-296.

Tamirat T. 1992. Vertisols of the Central Highlands, Ethiopia – Characterization, Classification, and Evaluation, of the Phosphorus status. MSc Thesis, Alemaya University.

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

Temesgen G, Tafa T, Mekuria A, Abeyou W. 2017. Evaluation and prediction of land use/land cover changes in the *Andassa* watershed, Blue Nile Basin, Ethiopia. *Environmental system research,* 6(17):1-15.

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

Tilahun C, Asefa T. 2009. Assessment of soil organic matter under four land use systems in Bale Highlands, Southeast Ethiopia. *World Applied Sciences Journal,* 6(9): 1231-1246.

Tsehaye G, Mohammed A. 2013. Effects of land-use/cover changes on soil properties in a dryland watershed of Hirmi and its adjacent agro ecosystem: Northern Ethiopia. *International Journal of Geosciences Research*, 1(1): 45-57.

Turner BL, Skole D, Snderson S, Fishcher G, Fresco LO, Leemans R. 1995. Land Use and Land Cover Change. *Science/Research Plan*.35:7. Stockholm and Geneva.

Ufot U, Iren O, Chikere N C. 2016. Effects of land use on soil physical and chemical properties in Akokwa area of Imo State, Nigeria, 2(3): 273-278.

USDA (United States Department of Agriculture). 2014. Natural Resources Conservation Services New Jersey. Soil Physical and Chemical Properties.

Wakene N, Heluf G. 2003. Forms of phosphorus and status of available micronutrients under different land use systems of Alfisols in *Bako* area of Ethiopia. *Ethiopian Journal of Natural Resource*, 5(1): 17-37.

Wakene N. 2001. Assessment of important physicochemical properties of Dystric Udalf (Dystric Nitosols) under different management systems in *Bako* area, Western Ethiopia (Published MSc thesis). Alemaya University, Alemaya, Ethiopia.

Walkley A, Black IA. 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.

White R. 2006. Principles and Practice of Soil Science. The Soil as a Natural Resource 4th Edition. Black well publishing, 363p.

Woldeamlak B. 2002. Land covers dynamics since the 1950s in the *Chemoga* watershed, Blue Nile Basin in Ethiopia. *Ethiopia Mountain Research and Development*, 22(3): 263-269.

Woldeamlak B, Stroosnijder L. 2003. Effects of agro-ecological land use succession on soil properties in the *Chemoga* watershed, Blue Nile basin in Ethiopia. *Ethiopian Geoderma*, 111:85-98.

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

Yihenew G, Getachew A. 2013. Effects of different land use systems on selected physical and chemical properties of soils in Northwestern Ethiopia. *Journal of Agricultural Science*, 5(4): 114-117.

Zajícová K, Chuman T. 2019. Effect of land use on soil chemical properties after 190 years of forest to agricultural land conversion. *Soil and Water Research*, 10(1): 72-215.