Int.J.Curr.Res.Aca.Rev.2021; 9(02): 110-117

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 9 Number 02 (February-2021)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2021.902.007

The Effects of Land Use Change on Soil Organic Matter incase of Gotonouma Micro Watershed, Wondo Woreda Oromia Regional States

Gutema Godana[1*] and Zenebe Reta[2]

[1]*HawwassaUniversity, Hawssa, Ethiopia*
[2]*Mettu University, Mettu, Ethiopia*

**Corresponding author*

Abstract

There is decrease in soil organic matter in different land use systems like cultivated land of wheat, grazing land and forest land. The practice of continuous tillage, overgrazing and deforestation tends to reduce the soil organic matter content of the soil. The aim of this study was, the effect of land use change on soil organic matter in case of Gotonouma micro-watershed. The types of land use considered were: cultivated land of wheat, forest land and grazing land. The soil samples were taken from these three different land use systems with two replication. The soil samples were labeled and transported to laboratory for analysis of soil organic carbon. After analysis of soil organic carbon in laboratory by using Walkley & Black (1934) method, the soil organic matter was determined. The result showed that the soil organic matter content is significantly different among land uses changes. It is observed that the soil organic matter under grazing land is more susceptible to reduction than that of cultivated and forest lands. The effects of land use change (conversion) from forest to cultivated land &, grazing land and from cultivated land to grazing land were discussed. It's recommended that there should be advanced soil conservation measures.

Article Info

Accepted: 12 January 2021
Available Online: 20 February 2021

Keywords

Land use change, Organic matter.

Introduction

A land use/land cover changes that involves conversion of natural forests to farm lands and open grazing is widely practiced in the highland of Ethiopia. The effect of such land use/ land cover changes on soil resources of the country, particularly through soil erosion have reported in many scientific literature (Hurni, 1993; EFAP, 1994; Hawando, 1997). Most soils especially in developing countries are not managed properly and used intensively (Herweg *et al.,* 1999; Kutter *et al.*,1997). Ethiopia has soil degradation problem that constrained agricultural productivity and ecosystem services. Soil loss accounted a rapid loss of SOC and soil nutrient that limit crop production particularly in the Ethiopian highlands (Gete *et al.,* 2010).

Productive land use is largely depending on the properties of soil under different management (Doran and Zeiss, 2000). Land use alter inherent soil properties through interacting with factor of soil forming process such as climate, vegetation, topography, parent material and time (Jenny,1994). The massive soil loss in the country

is caused its susceptibility to erosion due to mountainous land scape coupled with mismanagement, intense rainfall and cultural practice of the farming community that leave the soil base after harvest (Powell *et al.*, 1995; Taddese, 2002)

The concept of soil losses due to erosion is closely linked with processes of soil chemical (loss of nutrient through vegetation removal, erosion leaching), physical and biological degradation (decline soil humus content) (Young, 1997; Eyasu, 2002). Deforestation followed by subsequent change in land use systems results in soil degradation as well as loss of biodiversity (Mellese and Mesfin, 2008; Markos, 2001). The reduction of suitable agricultural land has affected agricultural activities and farmers became highly vulnerable to climate change, persistent drought and declining of per-capita food production in Ethiopia (FAO,2008; NMSA, 2001).

Land degradation in Ethiopia is characterized by soil loss, soil nutrient depletion, deforestation and overgrazing (Dahlberg *et al.*, 2008). Deforestation has been held as one of the major factors contributing to land degradation through exposing the soil for erosion, nutrient depletion and reducing soil organic matter (Badege, 2001; Bekele, 2006).

In Ethiopia very few studies (Ashagarie *et al.*, 2005; Mulugeta, 2004; Wakene and Elufe, 2004) have considered the effects of different land use/ cover changes and their associated soil management practices, on soil physical and chemical properties.

Few studies quantify SOC and nutrient losses from different land uses. Tilahun and Assefa (2008), indicated that soil lost 42% and 59% of their SOC stock in Bale Highlands due to conversion from forest to crop land and from grass land to crop land respectively. In western Ethiopia a study showed decrease in SOC by 79% from its original content when the natural forest was converted to farmlands (Wakene and Huluf, 2003). Significance loss of SOM and nutrient due to land use change were also reported in southern and central Ethiopia (Mulugeta and Fisseha, 2004; Fantaw and Abdu, 2011).

Ethiopia being a large country with large biophysical and socio-economic diversity. These previous studies were less adequate to describe the SOM associated to land use and land cover changes in the study area.

Statement of the problem

Soil nutrient depletion and deforestation are related problems in the northern part of Ethiopia in areas 1500m a.s.l. (Lakew etal,.2000). Removal of forest contributes to land degradation and soil for erosion. Thus, about 1.9 billion tons of fertility top soil have been washed away annually in to rivers and lakes (Lakew*et al.*, 2000). On the other hand, soil fertility depletion represents the underlying problems, outcome of overgrazing and deforestation in the country which affect farm productivity and income (Tilahun, 2003). The previous studies in the watershed have even been focused on rehabilitation of degraded land (Getachew, 1990) and water resource and management assessment (McHugh, 2006). Taking such point as a problem to get understand the effect of land use change on SOM and the role of land use systems in improving SOM. In the study area there is decreasing in SOM in different land use systems such as cultivated land, grazing land and forest land due to the practice of continuous tillage, overgrazing and clearing of forest for agricultural land which caused soil erosion and reduction of the fertility status of soil due to the removal of SOM on upper layer of the soil. Therefore this study was designed with the proceding objectives.

The overall objective of the study wasto assess the effect of land use systems on soil organic matter in case of gotonouma micro-watershed and spesifiaclly the study focuses on the following objectives.

To determine soil organic matter content via taking soil samples from cultivated, grazing and forest lands.

To compare and contrast soil organic matter content of these three different land use systems

To recommend the suitable land use systems for the area.

Materials and Methods

Description of the Study Area

The study area is located at 263 km to the south of Addis Ababa and 13 km to the south east of shashemene town on the eastern escarpment of the Ethiopian Rift Valley (Betru, 2006) and 1.5 km to the west of the WGCF-NR in the Wondo Woreda, Oromia Regional state. It geographically located at $7^0$06'N to $7^0$11' Latitude and $38^0$05'to $38^0$07'Longitude. The climatic condition of the study area is woynadegaagro-climatic prevails (zone) (Dessie and Kinlund, 2007). The rainfall of Wondo is bimodal distribution with main rainy season between July and October which account for 69% of the total annual rainfall and short rainy season between March and May which supplies 31% of the total annual rainfall. The mean annual rainfall is 1182mm and the highest rainfall is recorded in August. The mean monthly.

The topography of the Wondo is mountain dominated with 43.5% mountains, 36.25% flat areas and the rest is covered by undulating terrain (Tola, 2005). The area is comprised of places with highly varying elevation ranging between 1600m asl and 2580m asl (Teshale, 2003; Tola, 2005; Erikson and Stern, 1987). The higher altitude and steep slopes support natural forest and lower altitude and the gentle terrain consists mainly farmland. The main cereal crops grown in the area are maize, teff (*Eragrostis tef*), ensete (*Ensete ventricossum*) are stable food for the areawhile chat (chataedulis), sugarcane and various fruit are the major cash crops (Tola, 2005).

The major type of soil in the study area is mollic Andosols (FAO, 1998), formed from late tertiary volcanic parent materials (Anon, 1973). Andosols are important in localized area in east Africa (Buresh *et al.*, 1997) are common and agriculturally important in the rift valley region of Ethiopia and some highland borderingit. The soil in the study area has the following properties in the top 0-20cm depth: a PH of 6; OC of 30gkg^{-1}; plant availability of P of 12mgkg^{-1}; CEC of 24cmolckg^{-1}; bulk density of 1.10gcm^{-3}; and a loamy texture with 46% sand, 32% silt and 22% clay (Teklay and Malmer, 2004; Teklay *et al.*, 2005).

Instruments

Soil Sample Collection Method

Site selection, Soil sampling and Sample preparation

Before starting the actual field work, a field visit was carried out to get a general view of the size and designate blocks. The data was collected from the selected site. In this study two blocks with three land use systems were considered. The land use systems to be considered were farm land of wheat, natural forest land and grazing land. In each of two blocks, soil sample were taken with two replication from the two depths through an experimental plot design of 15m X 15m square area. The two replication were bulked; so the average were taken for SOM determination for each of the two depths interval; 0-15cm & 16-30cm. Representative, intact soil sample were collected with a manual core sampler of 10cm height and 7.2cm diameter from each land use systems for SOM. The sample were collected from four corners in square of 15m X 15m plot, with one at the centre by separating it in to two depths interval. The collected soil sample were labelled, baggedand transported to the laboratory for the preparation and analysis of SOC by following the standard laboratory procedure. The soil sample were air-dried, grinded and made to pass through a 2mm diameter sieve.

Laboratory Analysis of Soil Organic Carbon

Soil organic carbon was determined based on the wet oxidation method as described by Walkley and Black (1934), while the percentage organic matter of the soil was determined by multiplying the percent of organic carbon by a factor of 1.724.

%SOM=%OC X 1.724

Data Analysis

The data analysis was performed through the analysis of variance (ANOVA) for one factor Completely Randomized Design (CRD) with land use as factor using the General Linear Model (GLM) procedure of the statistical analysis system (SAS Institute, 2002) mean separate was done by using the Least Significance Difference (LSD) at

5% probability level when the ANOVA showed significant effects.

Results and Discussion

Determination of Soil Organic Matter Content

The soil organic matter is significantly differed among land use systems at 5% significance level. The SOM under forest land was higher than grazing land and cultivated land of wheat. The lowest concentration was under grazing land. The SOM across the replication were lower except the farm land, the SOM in the first replication were lower than in the second replication. But in the second replication the SOM under forest land and grazing land are higher. The interaction effects between these all three land use systems were significant. Generally can said that based on the result analysis, the SOM content under farm land of wheat, grazing and forest lands were quietly different at 5%.

Deforestation of forest followed by conversion in to managed agro-ecosystem has induced a significant depletion in the stock of SOM. Analysis of variance (ANOVA) revealed SOM content under various land use types (systems) were significantly different from each other(Table 2). This implies that land use types and corresponding soil management practices affected the direction and extent of its change. The least significance difference (LSD) test also demonstrated SOM content under grazing land and cultivated land were significantly lower at 5% than the organic matter content of soil under forest land. The highest soil organic matter content were observed in the forest land while least were in grazing land (Table 2).

Most of the lands in the study area were previously covered by forest then it were converted to cultivated and graze lands to increasing food and feed for human and animals. The crop-livestock mixed farming system of the area also caused the increase in the livestock population, which triggered the conversion of some portion through insignificant amount of forest land to grazing land. Since the economical benefit from eucalyptus has also grown, many farmers are designating portion of their land for eucalyptus plantation. Different studies indicate that such abrupt transition from one land use to other land use system has several effects; such as ecological imbalance, soil erosion and soil nutrient (Zeleke and Hurni, 2000: Bewket, 2003).

The result of the present study is agreement with other studies (Dawit *et al.,* 2002; Merino *et al.,* 2004; John *et al.,* 2005; Heluf and Wakene, 2006; Gebeyew, 2007) who reported an increasing of SOM concentration in the order of grazing land soil < crop land soil < forest land soils.

The Effect of Forest Land Conversion to Grazing Land

Significantly higher organic matter was found in forest land. According to Veld Lamp(1994), found that the conversion forest land to grazing lands caused a declined in SOM. Loss of SOM results in the release of carbon dioxide to the atmosphere. The increment of the CO_2 concentration in the atmosphere will increase the global temperature.

Deforestation of forests followed by conversion in to grazing land has induced a significant depletion in the soil organic matter. Analysis of variance (ANOVA) revealed SOM content under various land use types / systems were significantly differing from the other. The finding indicated that soil under the forest had higher soil organic matter than that of under grazing land. This due to less disturbance of soil surface, reduction of surface run-off & wind erosion, high decomposition rate, improved activities of soil biota and etc, in the forest land. But in the grazing land the opposite is true.

Therefore, changing of forest land to the grazing land was results in declining of SOM. According to Harvey *et al.,* (1985), the significantly lower values of soil organic matter in grazing land compared to forest land is related to the low biomass return back to the soil because the majority of above ground biomass is losses due to intensive free grazing.

Table.1 Materials used during soil sampling from field.

Materials	Purposes
Core sampler	take sample from whole soil
Hammer	inserts core sampler in to soil
Wood	keep soil volume
Plastic bags	store collected soil
Rope	measure block of soil sample
Knife	Properly remove soil from core sample
Ruler	measure the depth
Shovel	clean the soil surface

Table.2 Soil Organic Matter of different land uses

Land use	Organic Matter
Forest land	10.18
Cultivated land	7.57
Grazing land	7.49

Table.3 One-way analysis of variance (ANOVA) for Soil Organic Matter

Source of variance	Degree of freedom	Fcal.	F(critical) 5%
Land use	2	17.69	9.55

The Effect of Forest Land Conversion to Farm Land

Soil from cultivated land had lower values of soil organic matter than of forest land. The changing of land uses from forest to cultivation depletes the nutrients and soil organic matter. Cultivation of soil reduces organic matter by facilitating interaction of physical, chemical and biological soil processes that increases the decomposition rate of soil organic matter (Solomon *et al.,* 2000: Amsalu *et al.,* 2007). This reduction was also noted in Kosmas *et al.,* (2000), in which a deterioration of soil fertility in continuously cultivated soil compared to soils under forest.

The study was explained that the soil organic matter under the forest was higher than farm land of wheat. The change of land use of forest followed by agricultural induces the depletion of SOM. These results are comparable to other similar comparative studies as impacts of continuous cropping. Solomon *et al.,* (2002) observed decline of total soil organic matter due to deforestation followed by continuous cropping for 25-30 years at 0-20cm soil depth in the southern Ethiopia. The decreased in soil organic matter is attributed to low inputs organic matter, low return from crop residues and tillage practice which aerates the soil and break up soil aggregates (Aghasi *et al.,* 2010: Bekele, 2006).

The Effects of Farm Land Conversion to Grazing Land

The conversion of land use of farm to grazing land results the decline of soil organic matter. There is a tendency throughout the world to overstock grazing land above its carrying capacity. Overgrazing destroys the most palatable and useful species in the plant mixture and reduces the density of the plant cover, thereby increasing the erosion hazard and reducing the nutritive value and the carrying capacity of the land. In the study area the cultivated land followed to grazing land reduces the SOM due to overgrazing, compaction & structural disturbance of soil, increasing of soil erosion. It's known that in the area there is shortage of land due to rapid population growth. So, this results in competition among human population and animals on natural resources especially on land. Finally it caused overgrazing problem.

Based on the determination of soil organic matter under different land use change of the area: the following conclusions are drawn:-

The SOM determined under various land use systems like grazing, cultivated and forest lands were quietly different. The soil organic matter content of the grazing land was lower than the SOM under cultivated and forest lands. The effect of deforestation came in to view to more in plain sight and a consequence of clearing forest for agriculture is the disappearance of the litter layer which leads to the reduction of soil organic matter content. Human activities (biomass burning, application of fertilizer and herbicide, transfer of species, continuous plowing of land and etc) and also flooding (run-off) are the major reducing agents of soil organic matter content under cultivated land use system. The decomposition rate is varied under cultivated, grazing and forest land use systems due to difference of decomposer, human and animal impact on decomposition is especially prominent. The management practices such as tillage, selection of crops, cropping sequences and fertilizer can alter decomposition rates by their effects on soil moisture. The SOM content of the cultivated land use is considered to be as inflated as a result of being short of additional plant residues. The SOM content under grazing land was declined as a result of overgrazing.

Based on the study's finding the following are recommended:

It is important to use agro-forestry practices in the cultivated land use. The suggested agro-forestry practices are ally cropping and crop rotation.

The cultivars should use fertilizers and herbicides in proper manner.

In the forest land use there should be conservative approaches to the soil organic matter.

Avoid extreme fire wood collection for that, it may reduces additional plant residues to the top soil. There should be advanced practices of pruning and thinning to reduce tree competition for light, water and nutrient.

The farmers should leave the crop residues on cultivated land in order to improve soil microbial activities and increasing soil organic matter.

The Government organization and NGO should give awerness to the societies on the effects of overgrazing on soil properties and climate change.

References

Alemayehu, M., (2010). Synthesis of research on land use and land cover dynamics in the Ethiopian highlands.

Azene, B., (2007). Useful trees and shrubs for Ethiopia.

Badege, B., (2001). Deforestation and Land degradation in Ethiopian highlands.

Bekele,L., (2006). Impacts of exotic tree plantation on carbon and nutrient dynamic in abandoned farm soil of south west Ethiopia.

Bekele,M. and Birhanu,L., (2001). State of forest genetic resource in Ethiopia.

Brady N.C. &weil R.R, (2002). The Nature and Properties of Soil 11th and 13thEdition. Practice Hall, NJ. 960p.

Chaterjee,C.S., (2011). Mitigation Climate Change through Agriculture.

Cross, P.(2003). The Butterflies of Wondo Genet: Introduction to the Butterflies of Ethiopia, Addis Ababa, Ethiopia.

Doran, J. and Zeiss, M., (2000).Soil Health and Sustainability Managing a Biotic Component of Soil Quality.

Dahlberg, E., Ekbom, A., Menale, K. and Mahmud, Y., (2008). Ethiopia Environment and Climate analysis.

Dessie,G. and Kinlund,P. (2007). Khat Expansion and Forest in Wondo Genet, Ethiopia.

EFAP, (1994).Ethiopia Forestry action programs. The Challenge for development Ministry of National Resource and Environmental protection, Addis Ababa, Ethiopia.

Erikson, H. & Stern, M. (1987). A Soil study at Wondo Genet, Forestry Resource Institution, Ethiopia.

Eyasu, E,.(2002). Farmers Perception of soil fertility change and management.

Food and Agricultural Organization of the United Nation (FAO,), (1998). World Soil Resource reports 84.

Fantaw, Y. and Abdu,A., (2011). Soil property change following conversion of acacia wood land in to grazing and farmlands in the Rift Valley of Ethiopia.

FRA, (2009). The Global forest resource assessment remote sensing survey.

Getachew,A., (1990). Review ofsoil conservation and future research direction in sirinka, north eastern Ethiopia.

Gete,Z., Getachew, A., Dejene,A. and Scahidur, R.,(2010). Fertilizer and soil fertility potential in the Ethiopia.

Hartemink, A., Veldkamp, T., and Zhangue, B., (2008). Land covers change and soil fertility decline in triopical region.

Herweg, K., Steiner, K. and Slaats, J., (1999). Sustainable land management guidelines for impact monitoring.

Houghton,R.A.,(1994). The Worldwide extent of land use change.

Houghton, R.A., (2003). Revised estimates of the annual net flux of carbon to the atmosphere from change in land use and land management.

Hawando, T. (1997). Desertification in Ethiopia Highlands. RALA report No. 200. Norwegian Church AID, Addis Ababa, Ethiopia.

Hurni, H. (1993). Land Degradation, Famines and Resources Scenarios in Ethiopia.

Kern, J.S., (1994). Spatial pattern of soil organic in the contiguous United States.

Kutter, A., Nachtergaele, F. and Verheye, W., (1997).The new FAO approach to land use planning and management, and its application in sierra León.

Lambin, E.F., Geist, H.J, and Lepers, E., (2003). Dynamics of land use and land cover change in tropical region.

Lakew, D., Manale, K., Benin, S. and Pender, J., (2000). Land degradation and strategies for sustainable development in the Ethiopian Highlands: Amharan region.

Mulugeta, L. and Fisseha, I., (2004). Soil carbon stocks and turnovers in various vegetation type and arable land along on elevation gradient in southern Ethiopia.

Mulugeta, L., Karltun, E. and Olsson, M., (2004). Assessing soil chemical and physical property responds to deforestation and subsequent cultivation in small holders farming systems in Ethiopia.

NMSA, (2001).Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC).

Priess, J., Koning, G.H.J., and Veldkamp, A. (2001). Assessment of interaction between land use change carbon nutrient fluxes in Ecaudor Agricultures.

Rasmussan,P.E., and C.R. Rhode, (1988)." Long term tillage and nitrogen fertilization effects on organic carbon and nitrogen in a semiarid soil".

Reusing, M., (2000). Change detection of natural high forest in Ethiopia using remote sensing and GIS techniques.

SAS, (2002). SAS Institute Inc., Cary, NC.USA.

Stewark, B.A., R.Lal, and S.A. El-Swaify.(1991).Sustaining the resource base of expanding world agriculture.

Tilahun, A. (2003).Opportunities and challenge in reserving land degradation. Natural resource degradation and environmental concerns in the Amhara Regional State.

Tilahun, C. and Asefa, T., (2009). Assessment of Soil Organic Matter under four land use systems in the major soil of Bale Highlands, South East Ethiopia.

Tsvetkova, O. (2007). Spatial and Temporal dynamics of land use impacts on water quality in watershed systems.for determining OC in soils. Soil Science 63: 251-263

Walkely, A., and Black, I.A., (1934). An examination of the Degtjareff method

Weil, R.R., P.W. Benedetto, L.J.Sikora and V.A. Bandel, (1988). Influence of tillage practical on phosphorus distribution and forms in three Utisols.

Yao, M., Augui, P., Konate, S., Tondoh, J., Tano, Y., Abbadie, L. and Benest, D., (2010). Effects of land use type on soil organic carbon and nitrogen dynamic in Middle East of Cotdevore.

Young.A., (1997). Agroforestry for soil management, 2nd Edition.CAB international, Wallingford.

How to cite this article:

Gutema Godana and Zenebe Reta. 2021. The Effects of Land Use Change on Soil Organic Matter incase of Gotonouma Micro Watershed, Wondo Woreda Oromia Regional States. *Int.J.Curr.Res.Aca.Rev*. 9(02), 110-117. doi: https://doi.org/10.20546/ijcrar.2021.902.007