

# The Effect of Land Use and Its Management Practices on Plant Nutrient Availability and Carbon Sequestration

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**Abstract:** *The problems of land degradation and low agricultural productivity in Ethiopia, resulting in food insecurity and poverty, are particularly severe in the rural highlands. Different land use practices have a varied impact on soil degradation on both physical and chemical property of soil as well as on soil carbon sequestration capacity. Few studies have examined the effects of land use on plant nutrient availability and soil carbon sequestration in Ethiopia. Therefore, this study was to investigate the effects of land use on plant nutrient availability and soil carbon sequestration in Bezawit Sub-Watershed, near Bahir Dar, Ethiopia. More specifically the study pointed out the difference between different land use type on soil water content, pH, Cation exchange capacity (CEC), organic carbon (OC), total nitrogen (TN), available phosphorus (P), exchangeable potassium (K) and sodium (Na), and the implication the farming practices on soil carbon sequestration. Soil sample were collected from the upper 15-20 cm depth of forest land, cultivated land, and grazing land. There was a significant difference for soil moisture content, soil organic carbon, total nitrogen, and soil pH among forest land, cultivated land, and grazing land. Samples from cultivated land were found to have the lowest carbon and nitrogen levels; likely a result of continuous cultivation and mismanagement of crop residue, as well as misuse of livestock dung leading to a loss of available nutrients for plant production. Furthermore, frequent practice of burning crop residues and dung has consequential implications on the environment by influencing the reserve of carbon in the soil. CEC, available P and exchangeable Na and K were statistically insignificant among the three land cover types. However, at the current level CEC is ample for all land use types. In the cultivated land, a higher value of CEC could be accounted for the addition of black carbon from the burning of crop residue. In general to increase crop productivity and to maintain soil reserve of carbon as well as*

*the nutrient cycle; it is important to sustain natural vegetation and to reinstate intensively cultivated degraded lands through best management practices.*

*Keywords:* Land use, global warming, Nutrient availability, Soil water content, pH, CEC, OC, TN, P, exchangeable K and Na

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## **1. Introduction**

Rapid population growth and long history of sedentary agriculture has changed the land use/land cover system and has been a major cause of environmental degradation on most parts of the world including Ethiopia (Feoli et al, 2002). Agricultural activities change the soil chemical, physical, and biological properties, and play the major role for soil degradation mainly due to soil fertility decline as a result of lack of nutrient inputs (Lal, 1986 cited in Alfred et al., 2008). In Ethiopia, where agriculture is the back bone of the economy (approximately 50% of GDP, 90% of foreign exchange earnings (Ethiopian Economic Association, 2002), It was estimated that half of the Ethiopian highlands' arable lands are moderately to severely degraded and nutritionally depleted due to over cultivation, over grazing, primitive production techniques, and over dependent on rainfall (Hugo et al, 2002).

Hence, soil fertility depletion is considered as the fundamental biophysical causes for declining per capita food production in sub –Saharan African countries in general (Sanchehez et al., 1997) and in particular Ethiopia. The problems of land degradation and low agricultural productivity in the country, resulting in food insecurity and poverty, are particularly severe in the rural highlands (Hagos, 2003; Nedessa et al., 2005). Soil losses from crop and grazing lands have been reported as 42 and 5 tons/ha/year respectively (Kassa, 2002; Bojo and Casells, 1995). The severity of land degradation in some parts of highlands is estimated to reach as high as to offset the gains from technical change (WDR, 2008, pp 180). Finding solutions to these problems require identifying the farming system, the environment, and understanding the society.

Many approaches can be justified to mitigate soil degradation problems. These include private incentives, integrated watershed management approach, and focus on farming systems approach in research and development (Kassan 2008). Private incentive

is provided for individuals in order to manage resources efficiently from the society point of view (WDR, 2008, pp 181). On the other hand, focusing on farming systems approach as well as watershed development approach to research and development are also a vital element to understand and implement environmentally friendly, economically feasible, and socially acceptable options. However, to implement suitable management options the fundamental element to start with is to identifying different land use patterns as well as current management trends and effects on soil physical and chemical property.

Thus, the central objective of this study was to investigate the effects of land use on plant nutrient availability and carbon sequestration in Bezawit Sub-Watershed, near Bahir Dar city, Ethiopia. More specifically the study was designed to point out the difference between different land use types on soil water content, pH, CEC, OC, TN, available P, exchangeable K and Na, and the implication on global warming by inter linking the farming system with physical and laboratory observation. So, for simplicity, this article first introduce vital parameters of soil that are essential for optimal plant growth and which are frequently affected by land use practices, finally, we devote on the result and discussion part particularly on variation on land use and management practices on the essential parameters of soil.

## **2. Soil Properties**

Soils have many variables, which have multiple types of characteristics that ultimately affect crop production and land productivity. Therefore, in order to understand the similarity, dissimilarities and relationships among different land uses, it is important to study the effects of land use on the vital physical and chemical properties of soil.

### *2.1. Water Content and Moisture Retention Capacity*

Soil water content is the basic parameter required to answer the wetness, quantity of water held in the soil, the amount of water absorbed before surface runoff started, and the amount of water a particular soil supply to maintain optimum growth (Kamara, C.S et al.,1992). The availability of soil moisture to plants is a function of water input, moisture retention and root depth of a given soil, which is governed by the inherent soil properties and management practices. In general, roots are able to readily absorb soil moisture at

field capacity, depending on mineralogy and soil structure and become less able to do so with decreasing water content to reach permanent wilting point (Russell, 1973). Furthermore, soil water content at field capacity, permanent wilting point and available water holding capacity increase with depth for the soils under different management practices (Wakene, 2001; Ahmed, 2002).

## *2.2. Soil chemical property*

In this section the most important chemical characteristics that influence soil fertility and plant growth were discussed. These are Soil pH, CEC, OC, TN, available P, and exchangeable K and Na.

### *2.2.1. Soil pH*

Soil pH is generally referred to as a “master variable” because it regulates almost all biological and chemical reactions in soil (Brady and Weil 1996). Distribution of soil pH may provide a useful index of the weathering status, potential nutrient holding capacity and fertility of soil types. Soil pH is mostly related to the nature of the parent material, climate, organic matter and topographic situation (Tamirat, 1992). The soil in high altitude and those higher slopes had low pH values, probably suggesting the washing out of solutes from these parts (Belay, 1996; Abayneh, 2001; Mohammed et al., 2005). Continuous cultivation practices, excessive precipitation, steepness of the topography and application of inorganic fertilizer could be attributed as some of the factors which are responsible for the reduction of pH in the soil profiles at the middle and upper elevation zone (Mokwunye, 1978; Ahmed 2002).

### *2.2.2. Cation Exchange Capacity (CEC)*

CEC is the ability of soil solid phase to attract or store and exchange cation nutrients with the soil solution and render them available to plants through exchange reaction (Muller-Samann and Kotschi, 1994). CEC is an important parameter of soil because it gives an indication of the type of the dominant clay minerals present in the soil and its capacity to retain nutrients against leaching. The CEC is strongly affected by the nature and amount of mineral and organic colloids present in soil. Soils with large

amount of clay and organic matter have higher CEC than sandy soil low in organic matter.

### *2.2.3. Soil Organic Carbon*

Soil organic matter (SOM) is primarily plant residues, in different stages of decomposition. The accumulation of SOM within soil is a balance between the return or addition of plant residues and their subsequent loss due to the decay of these residues by micro-organisms. Organic matter existing on the soil surface as raw plant residues helps protect the soil from the effect of rainfall, wind and sun. Removal or burning of residues exposes the soil to negative climatic impacts, and removal or burning deprives the soil organisms of their primary energy source (Bot, and Benites, 2005). Soil organic matter contains approximately 56% OC ([http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/aesa1861](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/aesa1861)). Land use change, inappropriate agricultural practice, and climate change can all lead to a net release of C from soils to the atmosphere, enhancing the problems of greenhouse gas release ([www.isric.org/ISRIC/WebDocs/Docs/GEFSOC\\_Poster\\_for\\_COP7\\_of\\_UNCCD\\_Nairobi.pdf](http://www.isric.org/ISRIC/WebDocs/Docs/GEFSOC_Poster_for_COP7_of_UNCCD_Nairobi.pdf)). Several scientists pointed out that carbon dynamics in the soil ecosystems has been one of the major factors affecting CO<sub>2</sub> concentration in the atmosphere (IPCC, 1996; Houghton, 1999; IPCC, 2001; Pacala et al., 2001). Carbon sequestration in soil organic matter is increasingly advocated as a potential win-win strategy for reclaiming degraded lands mitigating global climate change, and improving the livelihoods of resource-poor farmers (Batjes, 2001; FAO, 2001; Lal, 2002; Ringius, 2002; Bartel, P. 2004). Because, measures taken in soil management such as reduced tillage, mulching, composting, manure application, fallowing, agroforestry, diverse rotation, introducing forage legumes and grass mixtures in the rotation cycle are not only expected to increase the rate of carbon dioxide (CO<sub>2</sub>) uptake from the atmosphere but also to contribute to erosion and desertification control and enriched biodiversity increasing crop production through improving soil properties such as nutrient uptake and nutrient cycling, moisture retention, and tilth (Woomer et al., 1994, Lal et al., 1998; Lal, 1999; Lal et al., 1999; Lal, 2002; Hao et al., 2002; Swift et al., 2004; Wardle et al., 2004). Soils that form under forests tend to accumulate high levels of soil organic carbon near the surface and have lower carbon levels in the subsoil (Tamirat, 1992,

Yohannes, 1999; Mitiku, 2000; Abayneh, 2001; Ahmed, 2002). This layering of soil is primarily due to the accumulation of leaf litter and decaying wood from limbs and trees that accumulate at the soil surface. But soil layering is also a function of higher annual rainfall and the accelerated weathering process that enriches the subsoil with clay ([www.oznet.ksu.edu/library/crpsl2/MF2548.pdf](http://www.oznet.ksu.edu/library/crpsl2/MF2548.pdf))

#### *2.2.4. Total Nitrogen*

Nitrogen is one of the most essential elements that is taken up by plants in greatest quantity after carbon, oxygen and hydrogen, but it is the most frequent deficient nutrient in crop production (L. Havlin . et al., 1999). The total nitrogen content of a soil ranges from less than 0.02% in subsoil to greater than 2.5% peat soils which is attributed the general low biomass production and fast oxidation of organic matter in such climate zone L. (L.Havlin . et al., 2002). There is a strong positive relationship between soil nitrogen and soil organic matter content. Low total nitrogen content and therefore N deficiency is visible in highly weathered soils and sodic soil of arid and semi arid regions due to low organic matter content which is attributed to the general low biomass production and fast oxidation of organic matter in such climatic zones (L.Havlin . et al., 2002).

#### *2.2.5. Available Phosphorus*

Phosphorus (P) is an essential element classified as a macronutrient because of the relatively large amounts of P required by plants. One of the main roles of P in living organisms is in the transfer of energy. Adequate P availability for plants stimulates early plant growth and hastens maturity. Although P is essential for plant growth, mismanagement of soil P can pose a threat to water quality. Variability of the level of available P is related to land use, altitude, slope position and other characteristics, such as clay and calcium carbonate content (Mohammed et al., 2005). Many study shown that soil devoted to crop production lost far more P to steams than do those covered by relatively undisturbed forest or natural grass land (Brady and Weil, 2002).

#### *2.2.6. Exchangeable Potassium*

Potassium (K) is absorbed by plants in large amount than any other nutrient except N. K exists as unavailable, readily available and available forms to plant which accounts 90-98%, 1-10%, and 0.1-2% respectively (L. Havlin . et al., 1999). Available K exists in soils solution while exchangeable K is absorbed on the soil colloidal surface from where it is slowly released to soil solution so as to be available to plants. Plants then directly absorb K from soil solution where it is found in the most readily available form for plant absorption (Brady and Weil, 2002).

#### *2.2.7. Exchangeable Sodium*

According to L. Havlin . et al (1999), low sodium (Na) indicates that weathering of Na-containing minerals. Very little exchangeable and mineral Na occurs in humid region soils, where as Na is common in most arid and semi arid soils. It is an essential nutrient for halophytic plant species that accumulate salt in vacuoles to maintain turgor and growth.

### **3. Material and Method**

#### *3.1. Site Description*

The study site is located in Bezawit sub watershed near Bahir Dar city, Ethiopia. The sub watershed extends from 11033'38.11 – 11034'15.29 north to 37024'04.85 – 37024'57.54' East. The topography of the area is characterized by high ground in north and south west, where forest lands are dominating, relatively flat ground in the middle, which is dominated by cultivated land and grazing land and Blue Nile River to south east border the study area as shown in figure 1. In general the topographic variation is less than 100 meter. Excluding, the forest land and the grazing land, the cultivated land area was estimated about 11 ha. Upper part of the catchment is covered with different indigenous and exotic trees/shrubs species of varying density and conversion of vegetated area to agricultural land is also noted during field data collection. In general terms, the vegetation can be classified as scrub land forest, which is dominated by species like *Carissa edulis*, *dovyalis abyssinica*, *Lanthana camara*, *Dodonea* and sisal species. Furthermore, other tree species of various socio-economic importance like *Celtis Africana*, *Ficus spp* and *syzigium guinesse* are also observed. There is an attempt to guard

the remaining trees/bushes from encroachers by assigning guards. But, inappropriate land use is prevalent as steep slopes adjacent to the patches of vegetation are being converted to agricultural land. There is a drainage way that collects seasonal water from the catchment that further leads it to the Blue Nile River. Expansion of a gully along this water way was also observed.

The sub watershed is administered by workers from Bahir Dar city, who are organized as production cooperatives to share profit equally among the members.

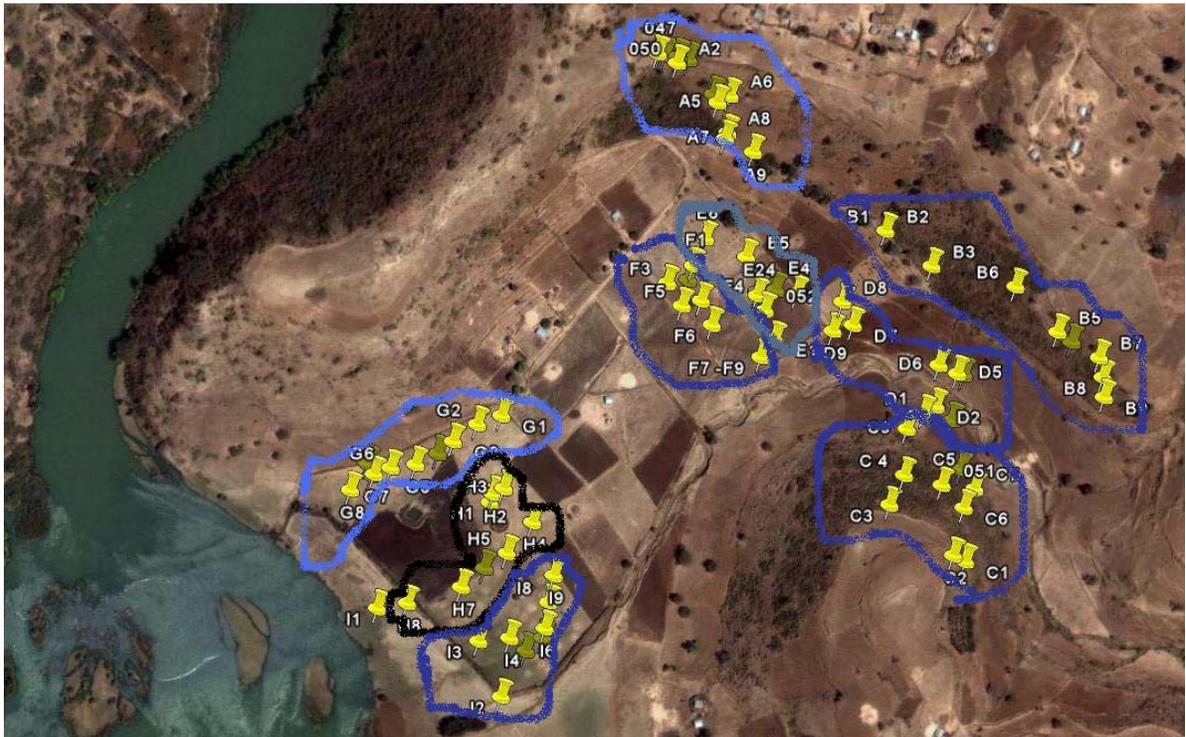


Figure 1: Bezawit Sub Watershed (source: extracted from google image)

Land use types are divided in to three parts depending on their similarities. And they are categorized as natural forest, cultivated field, and grazing land.

### 3.2. Sampling Method

We collected a total of nine composite samples (three composite samples per land use type) of soil from the upper 15 cm of soil horizon. Each composite sample is made form a pool of nine samples. Before sampling, forest litter, grass and any other materials on the

soil surface were removed. In the figure above, yellow points were GPS readings of the coordinates system where soil sample were taken. In the figure above A, B and C represents forest area, D, E and F represents cultivated area, and G, H, and I represent grazing land. The GPS, we had used to take sample points, has 7 meter plus or minus accuracy standard deviation, because of this same points seen out of their respective land use category and position. In general for the sake of simplicity we made a boundary for each composite sample location.

### *3.3. Moisture Content Analysis*

Soil moisture analysis is made using oven dried method for 24 hours with a temperature of 105 °C.

### *3.4. Laboratory Method*

Bahir Dar Soil Testing Laboratory analyzed the soil sample using the following method:

Air dried soil was pounded with pestle and mortal, and then the soil was sieved through 2mm sieve. Only soil that passed the sieve was analyzed.

PH was measured potentiometrically in the supernatant suspension of 1:2.5 ratio of soil to a 1 M KCl solution.

CEC is determined by measuring the total amount of a given cation needed to replace all the cation from a soil exchange site and it is expressed in centimoles per 100 gram soil (Cmol/100g soil). To do this saturated sample was prepared followed by an extraction of the saturation cations adsorbed on the exchangeable complex and measuring its amount. Since CEC is highly affected by pH values, it was done at a known pH value and using ammonium acetate method.

Titration method was followed to calculate percentage organic carbon. Soil organic matter is oxidized under standard conditions with Potassium dichromate in Sulfuric acid solution. A measured amount of  $K_2Cr_2O_7$  was used in excess of the needed to destroy the organic matter, and the excess was determined by titration with Ferrous

sulfate solution, using Diphenylamine indicator to detect the first appearance of un-oxidized ferrous iron.

To estimate the total organic matter content of soil from OC measurements the following equation is used: % Organic Matter = % Organic Carbon x 1.78 ([http://www1.agric.gov.ab.ca /\\$ department/deptdocs.nsf/all/aesa1861](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/aesa1861)).

The kjeldahl procedure was used to calculate percentage total nitrogen. The basic principle is that the organic matter is oxidized treating soil with concentrated sulfuric acid, nitrogen in the organic nitrogenous compounds being converted into ammonium sulfate during the oxidation. The acid  $\text{NH}_4^+$  ion in the soil is liberated by distilling with NaOH. The liberated  $\text{NH}_4^+$  will be absorbed by boric acid and back titrated with standard  $\text{H}_2\text{SO}_4$ . Potassium sulfate is added to raise the boiling point of the mixture during digestion and copper sulfate and selenium powder mixture are added as catalyst. The procedure determines all the soil nitrogen (including adsorbed  $\text{NH}_4^+$ ) except that in nitrate form.

Olsen method was used to determine available phosphorous content of the soil. The sample was extracted with sodium bicarbonate solution at pH 8.5. Phosphate in the extract is determined colorimetrically after treating it with Ammonium Molybdate-Sulfuric acid reagent with Ascorbic acid as reducing agent. The high pH of the extracting solution renders the method suitable for calcareous, alkaline or neutral soils containing Ca-phosphates because the Ca concentration in solution is suppressed by precipitation of  $\text{CaCO}_3$ , as a result the phosphate concentration in the solution will increase.

Finally, to determine the amount of exchangeable potassium and sodium, flame photometer method was used.

### *3.5. Statistical Analysis*

Statistical analysis of the data was carried out by one-way analysis of variance (ANOVA) using SPSS window version 14 software ([www.spss.com](http://www.spss.com)) at 0.05 significant levels and at 0.01. A post hoc multiple comparison tests of means was done by univariate LSD.

### *3.6. Qualitative analysis*

In addition to quantitative analysis data generated, information was collected through visual observation both infield and using photographs, as well as through informal discussions with land users.

## **4. Result and Discussion**

Households regularly collect crop residue and cattle dung for fuel and the majority of the fuel product are transported to Bahir Dar for sale to city markets (figure 2). Prior to collection, the palatable portion of the residue is grazed intensively directly from the field. This type of management practice obviously leads to a negative nutrient balance. Eventually this continuous removal of crop and manure from the farming system together with insufficient application of commercial fertilizer will lead soil productivity loss. The laboratory analysis of Bezawit soils from different land uses has confirmed this productivity loss.

The incorporation of black carbon through burning of dry vegetation is also practiced on cultivated lands in the study area. Recent research indicated that incorporation of black carbon significantly increase soil CEC (Liang, B., et al 2006). What is expected from continuously cultivated land without incorporation of black carbon is lower CEC Value, however we found that a higher CEC value for cultivated land just like forest and grazing land (table 2) and there is no significant difference between the land use types. This may be contributed as a result of black carbon addition on cultivated land as changes in soil management practices influence the amount, quality and turnover of soil organic matter of an area (Glaser et al., 2000).

There was a significant difference ( $P < 0.05$ ) for soil moisture content, soil pH, soil organic carbon and total nitrogen among the three land cover types. However, available phosphorus and exchangeable sodium and potassium were not significant similar to CEC (Table 1). The mean soil moisture content at 95% confidence interval ranged from 5.58 to 19.09 percent in natural forest, 17.07 to 19.12 percent in cultivated land, and 14.23 to 28.63 percent in grazing land (Table 2). Both cultivated land and grass

land showed a significant difference in moisture content from natural forest. Higher moisture content was relatively registered for both cultivated and grazing lands. However, there was no significant difference between each other (Table 3). The moisture content of the soil variation seems dominated by the topographic orientation and slope. On the hillside where forest lands dominated, the water content of the soil was lower. However in the area of grazing land (lowest elevation) the water content is higher. Another justification for higher water content of soil in grazing area could be attributed to subsurface water flow from the adjacent Blue Nile River and due to the prevalence of relatively smaller amount of evapo-transpiration anticipated from the pasture land. On the other hand, cultivated Land rated second in moisture content due to continues plowing and complete exposure of the upper soil horizon for solar radiation, which will result in loss of significant soil moisture. In general mean soil water content of forest land, cultivated land and grazing land were categorized as low, medium and high respectively.

Like soil moisture, the soil pH variation has a significant difference between forest land and grazing and cultivated lands. There was also insignificant difference between grazing and cultivated lands on soil pH value (Table 3), both are strongly acidic. A higher soil pH value was recorded for natural forest land. The average pH for the natural forest, cultivated land and grazing land was 5.43, 5.06 and 4.73 respectively (Table 2). A pH value of less than 5.5 is considered as a problematic for most microbial activities, and this directly influences availability of nutrients to plant (Solomon D. 2008). From this we conclude that there will be only minor problem on the availability of plant nutrient on cultivated and grassing land soils.



Figure 2: Crop Residue prepared for sell, indoor cattle fattening facility, and pasture prepared for cattle production (source : Photo by Habtamu T., June 2008)

Table 1  
ANOVA on soil chemical and water holding capacity

		Sum of Squares	df	Mean Square	F	Sig.
PH	Between Groups	0.74	2	0.37	12.26	0.008
	Within Groups	0.18	6	0.03		
	Total	0.92	8			
CEC	Between Groups	69.63	2	34.81	0.36	0.712
	Within Groups	580.13	6	96.69		
	Total	649.76	8			
OC	Between Groups	5.43	2	2.72	98.36	0.000
	Within Groups	0.17	6	0.03		
	Total	5.60	8			
TN	Between Groups	0.04	2	0.02	64.15	0.000
	Within Groups	0.00	6	0.00		
	Total	0.04	8			
Exchangeable K	Between Groups	0.23	2	0.12	2.71	0.145
	Within Groups	0.26	6	0.04		
	Total	0.49	8			
Exchangeable Na	Between Groups	0.03	2	0.01	4.05	0.077
	Within Groups	0.02	6	0.00		
	Total	0.045	8			
Moisture content percent	Between Groups	127.091	2	63.55	11.95	0.008
	Within Groups	31.91	6	5.32		
	Total	159.001	8			



Figure 3: Cultivated land soil color difference with and without black carbon (Source: Habtamu)

Table 2

Descriptive statistics on land use type

		N	Mean	Std. Deviation	Minimum	Maximum
PH	Natural Forest	3	5.43	0.12	5.30	5.50
	Cultivated Land	3	5.07	0.15	4.90	5.20
	Grazing Land	3	4.73	0.23	4.60	5.00
	Total	9	5.08	0.34	4.60	5.50
CEC	Natural Forest	3	48.13	4.62	43.80	53.00
	Cultivated Land	3	42.27	6.24	37.80	49.40
	Grazing Land	3	42.20	15.16	25.00	53.60
	Total	9	44.20	9.01	25.00	53.60
O.C	Natural Forest	3	3.32	0.06	3.27	3.38
	Cultivated Land	3	1.50	0.09	1.40	1.57
	Grazing Land	3	2.88	0.27	2.57	3.04
	Total	9	2.57	0.84	1.40	3.38
T.N	Natural Forest	3	0.28	0.00	0.28	0.28
	Cultivated Land	3	0.13	0.01	0.12	0.13
	Grazing Land	3	0.23	0.03	0.20	0.25
	Total	9	0.21	0.07	0.12	0.28
ExchK	Natural Forest	3	0.53	0.36	0.24	0.93
	Cultivated Land	3	0.24	0.01	0.23	0.24
	Grazing Land	3	0.16	0.02	0.14	0.18
	Total	9	0.31	0.25	0.14	0.93
ExchNa	Natural Forest	3	0.01	0.01	0.00	0.02
	Cultivated Land	3	0.03	0.04	0.00	0.07
	Grazing Land	3	0.13	0.09	0.04	0.22
	Total	9	0.06	0.07	0.00	0.22
Mosture content percent	Natural Forest	3	12.34	2.72	10.74	15.48
	Cultivated Land	3	18.10	0.41	17.81	18.57
	Grazing Land	3	21.43	2.90	18.45	24.23
	Total	9	17.29	4.46	10.74	24.23

Both soil organic carbon and total nitrogen significantly vary between the three land use types at  $p < 0.5$  (Table 3) and are strongly positively correlated at a 0.01 significant level ( $r = .996$ ) in the different land uses. Cultivated land had the lowest soil organic carbon and total nitrogen (Table 2). Even, it was significantly lower at  $p < 0.01$  level from both grazing and forest lands. Such great variation could be attributed to the variation in land use system.

Continuous cultivation as well as removal and burning of crop residue and dung can be attributed to the lowest value for both organic carbon and total nitrogen in cultivated lands. The continuous tilling associated with intensive cultivation has been

suggested to facilitate erosion. Erosion not only affects the level of carbon and nitrogen but also affects other nutrients and soil physical properties. Continuous cultivation and removal of crop residue and cow dung for fuel purpose may ultimately increase the level of carbon dioxide in the atmosphere and leads to ecosystem disturbance.

Table 3.

Post Hoc Tests of Multiple Comparisons of Land Use Types

LSD

Dependent Variable	(I) LandUseType	(J) Land Use Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
PH	Natural Forest	Cultivated Land	.37*	0.14	0.04	0.02	0.71
		Grazing Land	.70*	0.14	0	0.35	1.05
	Cultivated Land	Hillside	-.37*	0.14	0.04	-0.71	-0.02
		Grazing Land	0.33	0.14	0.06	-0.01	0.68
O.C	Natural Forest	Cultivated Land	1.82*	0.14	0	1.49	2.16
		Grazing Land	.44*	0.14	0.02	0.11	0.77
	Cultivated Land	Hillside	-1.82*	0.14	0	-2.16	-1.49
		Grazing Land	-1.38*	0.14	0	-1.72	-1.05
T.N	Natural Forest	Cultivated Land	.15*	0.01	0	0.12	0.19
		Grazing Land	.05*	0.01	0.02	0.01	0.08
	Cultivated Land	Hillside	-.15*	0.01	0	-0.19	-0.12
		Grazing Land	-.11*	0.01	0	-0.14	-0.07
Moisture content percent	Natural Forest	Cultivated Land	-5.76*	1.88	0.02	-10.37	-1.16
		Grazing Land	-9.09*	1.88	0	-13.7	-4.49
	Cultivated Land	Hillside	5.76*	1.88	0.02	1.16	10.37
		Grazing Land	-3.3344	1.88	0.13	-7.94	1.27

Foth and Ellis (1997) reported that soils with C:N ratio in the range of 10 to 12 provides nitrogen in excess of the microbial need. Therefore, the result obtained in all land use except for in grazing land (slightly greater than 12) are in the optimum range for active microbial activities such as humification and mineralization of organic residue (Anex 1).

Although there was no significant difference in available P between land use types, current level in the soil are enough to support plant growth (table 2). However, with the current management practice, deforestation and continuous cultivation and crop residual

removal, the existence of p in the soil is endangered for the near future. Similarly, exchangeable K exhibits a similar trend. However, its levels in the soil are not enough to support optimum plant production.

According to Bahir Dar soil laboratory rating scale exchangeable sodium was the lowest proportion in all land use types. This may be contributed the washing away of the soil with pure rain water.

## **5. Conclusions**

There was a significant difference for soil moisture content, soil organic carbon and total nitrogen and soil pH among the three land cover types. The lowest carbon and nitrogen level of soil was recorded in cultivated land. Continuous cultivation and mismanagement of crop residue as well as miss use of cow dung suggested for the lower values contributed for crop land. This consequently led to loss of available nutrient for plant production as well as to global warming by affecting soil reserve of carbon as a result of burning of crop residue and cow dung.

Cation exchange capacity, available phosphorus and exchangeable sodium and potassium were statistically insignificant among forest land, cultivated land, and grazing land. However at the current level CEC is more than enough for all land use types. Especially, in crop land a higher value of CEC could be accounted as a result of addition of black carbon.

During field work, it was observed that there are efforts to guard the forest land in the study area from encroachment. However, conversion of vegetated land to cultivation land in steeper slopes is also prevalent. Therefore, unless a solution is devised to strongly protect the hillsides covered with vegetation, the process will increase erosion hazard from the catchment. This in turn will have an adverse impact on the long term ecological balance of the area.

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#### Annex 1: Bahir Dar Soil Testing Laboratory Analysis Result

Lab code	PH (KCL)	CEC	% O.C	% T.N	Avail P(ppm)	Exch K	Exch Na	C/N
Natural Forest 1	5.5	43.8	3.38	0.28	7.77	0.93	0	12.07
Natural Forest 2	5.3	47.6	3.27	0.28	6.02	0.42	0	11.68
Natural Forest 3	5.5	53	3.31	0.28	6.27	0.24	0.02	11.82
Cultivated land 1	5.2	39.6	1.4	0.12	3.67	0.24	0	11.67

Cultivated land 2	5.1	49.4	1.52	0.13	9.52	0.23	0.02	11.69
Cultivated land 3	4.9	37.8	1.57	0.13	7.27	0.24	0.07	12.08
Grazing Land 1	4.6	48	3.04	0.25	18.51	0.14	0.13	12.16
Grazing Land 2	4.6	53.6	3.03	0.25	39.29	0.15	0.04	12.12
Grazing Land 3	5	25	2.57	0.2	8.27	0.18	0.22	12.85

% OC titration method

pH KCL(1:2.5 soil: water ratio), Avail P Olsen method, %T.N titration method