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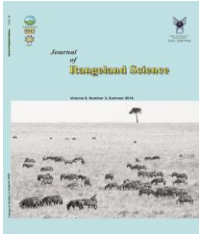

Research and Full Length Article:

Effects of Land Use and Land Cover changes on Soil Organic Carbon and Total Nitrogen Stocks in the Olesharo Catchment, Narok County, Kenya

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Abstract. Land Use and Land Cover Change (LULCC) is the most prominent cause of Soil Organic Carbon (SOC) variability in any landscape. Kenyan Arid and Semi-Arid Lands (ASALs) have been facing extensive land use/ cover changes in the last three decades prompting a review on the impacts it has on soil quality and consequently on land degradation. This study was carried out in 2016 in Olesharo Catchment, Narok County, one of the prominent ASALs of Kenya. The main objective of the study was to study how the different lands use types within the catchment affects SOC and Total Nitrogen (TN) stocks in the catchment. Using LandSat imageries, four land use types were identified: Shrubland (SH), Agricultural Land (AG), Grasslands (GR) and BareLands (BL). Disturbed and undisturbed soil samples were taken from 30 x 30m plots randomly distributed for each of the Land use type (LUT) at 0-15 cm and 15-30 cm depths for the analysis of SOC/ and TN stocks. The study showed that the means of SOC in land use types were significantly different ($P<0.05$). Shrublands registered the highest mean total of 31.26 Mg C ha^{-1} which was significantly higher than GR (13.54 Mg C ha^{-1}) and BL (12.85 Mg C ha^{-1}). In terms of TN mean values, SH was the highest (4.22 Mg N ha^{-1}) while BL was the lowest (1.6 Mg N ha^{-1}). Similarly, the mean SOC and TN stocks in the surface layers (21.38 Mg N ha^{-1}) were significantly higher than the sub-surface (18.74 Mg N ha^{-1}) layers indicative of the stocks decreased as depth increased. The results suggest that land use types have influence on soil properties and their management can contribute to sustainable land management to mitigate negative effects of climate change.

Key words: Soil carbon stocks, Land use and land cover changes, Climate change

Introduction

Change in Land Use and Land Cover (LULCC) is the leading cause of soil degradation and specifically loss of soil organic carbon (SOC) in the world (Jobaggy and Jackson, 2000). According to Kamoni *et al*. (2007), Kenya is expected to lose 140 Teragram (Tg) C by 2030 if the current trend of change in land use and climate continues. Sustainable management of soil, and especially Soil Organic Carbon (SOC), is considered beneficial to soil functions that support plant productivity and most recently in the fight against global climate change. Occupying only 10% of the soil, SOC consists of organic compounds less than 2mm in size (Lal, 2008) which include plant, animal and microbial residues at all levels of decomposition that are highly enriched in carbon. Soil organic carbon has significant influence on soil physical, chemical and biological characteristics such as nutrient cycling, soil structure and aggregation, water retention, as well as immobilizing pollutants and heavy metals.

Soil organic carbon is influenced by climate variables, topographical positions, lithological, biotic variables (flora and fauna) and human induced factors. Land use change is the most prominent cause of SOC decline in soils responsible for 12-20% of greenhouse gases emissions (Van der Werf *et al*., 2009). Over the recent years, research has shown that the capacity of soil to sequester carbon is second only to oceans with a capacity of 1500 Pg to 1 m depth (1 Pg =1015g) and releases only 4 % of it annually (Li *et al*., 2015). This potential scenario to offset global warming has led to linking anthropogenic activities like land use and cover changes management in acting as carbon storage capacities.

Soil nitrogen studies have become popular in recent studies, primarily in agricultural landscapes. This is because of the increase usage of synthetic fertilizer used by farmers in the sub-Saharan Africa (Were *et al*., 2015). There has been a livelihood shift from pure or sedentary pastoralism to agro pastoralism within the drylands of Kenya which has altered nitrogen fluxes in the ecosystem. Defined consequences of increase use of N-based fertilizers to the atmosphere have been observed especially with the rise of nitrous oxide emissions (Nie *et al*., 2013). In native vegetation such as grasslands, the N-cycle is balanced by the controlled denitrification and volatilization of N compounds. However, poor grazing management alters this cycle leading to low soil-plant N uptake resulting to erosion of nitrogen based compounds to waterways causing eutrophication (Galloway *et al*., 2008).

Land use /cover changes have become prominent in the Kenyan rangelands due to increase of demographical pressures of both human and livestock as well as local and exogenous opportunities and constraints (Mganga *et al*., 2011). Therefore LULCC has led to soil erosion which is a dominant feature in the Olesharo catchment that has deep gullies stretching over 4 km and 25 m wide and 15m deep (Khalif, 2015). Previous studies using processed LandSat imageries in Olesharo catchment show that the area is characterised by grasslands, shrublands with pockets of agricultural land and bare land. These images show how the land use/cover types have changed over three decades of 1988, 2000 and 2011 (Konana, 2017- working paper).

Changes in land use/cover types have impact on soil properties. One such property and the main focus of this study is change in SOC stocks. The prevailing hypothesis is that a change from forest land to cropland or pastures leads to a decline of SOC stocks because of the decline in biomass production; root mass in dominant vegetation and increasing turnover rates. However, this is also dependant on soil moisture, topological position and type of soil. In contrast, other LUC may lead to an increase in SOC, for instance, conversion from agricultural land to pasture or afforested (Were *et al*., 2015).

Although there have been numerous researches done on carbon stocks, comprehensive data is still scarce on some ecosystems on a local scale as well as national carbon inventories. This study focuses on assessing soil carbon and total nitrogen stocks under four land cover types in Olesharo catchment; shrublands, grasslands, agricultural lands and bare lands. Total nitrogen was also considered in this study because of the intricate linkages between carbon and nitrogen cycles.

Materials and Methods

Description of study site

The study was carried out in Suswa location, Narok County located in the southwest of Kenya. The county lies between longitudes 34°45'E and 36°00'E and latitudes 0°45'S and 2°00'S (Fig. 1). The topography ranges from a plateau with altitudes ranging from 1,000 - 2,350 m a.s.l. at the southern parts to mountainous landscape (3,098 m. a.s.l) at the apex of Mau escarpment in the north (Ruto, 2015). The catchment is found within Agro-Climatically Zones (ACZ) IV which is semi-humid to semi-arid. Suswa area has steep gradient and volcanic-ash soils, mainly Andosols, which are prone to erosion (Gachene *et al.*, 2014). There are visible patches of bare land that have developed due to overgrazing. The Suswa hill is dominated by an intricate network of deep gullies reaching to 4km in length, 25m deep and widths of over 30m (Khalif, 2015).

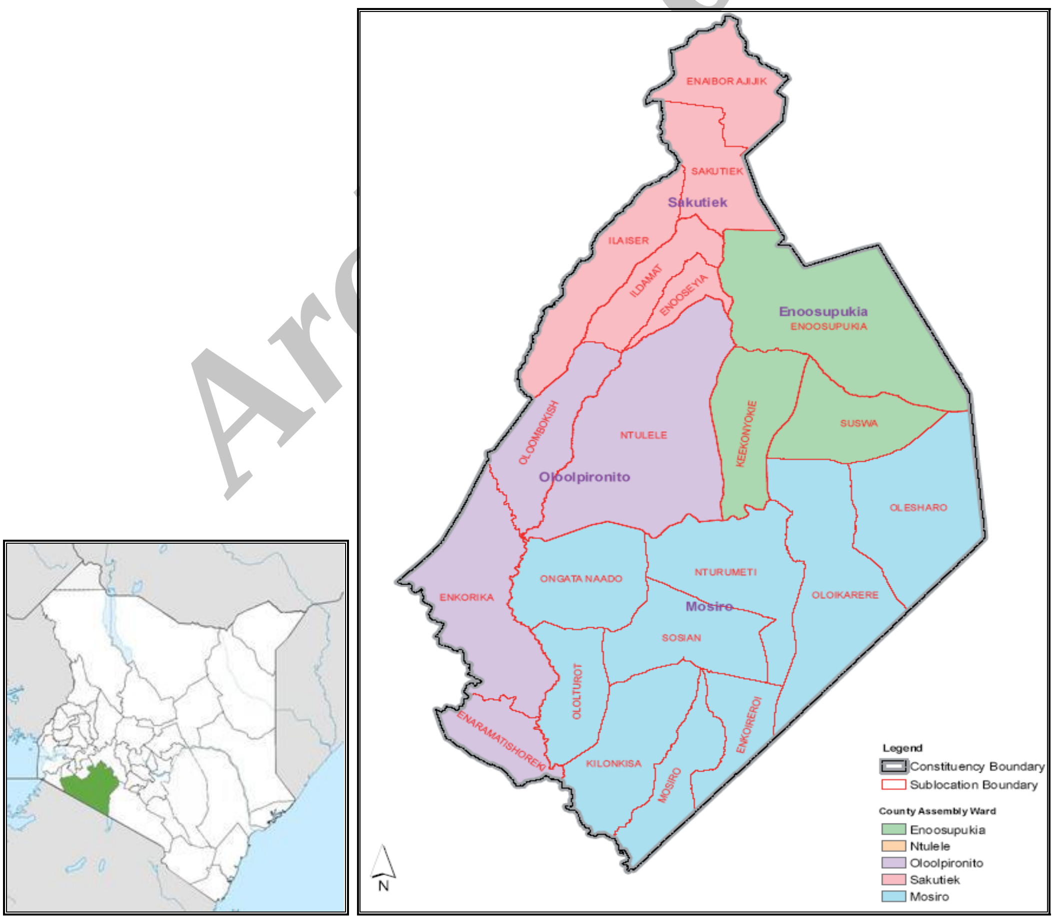

Fig. 1. The study area in Narok county **(**Source**:** Narok District Environment Action Plan 2009-2013)

Land use

Narok County has diverse land use types spanning the agroecological zones that occur in the area. The catchment is found within the Narok County which is predominantly a semi-arid climate. Olesharo is found within the lower elevations of the County where there is a prominent transition from pastoralism to agropastrolism. The area is dominated by shrubland Effect of land use and land cover types on SOC and TN concentrations. *Cordia ovalis, Croton dichogamus, Carissa edulis* and *Tarchonanthus camphoratus* (Table 1). (Fig. 2) represents the LandSat imagery of the catchment showing different types of land use types along the landscape. Croplands have grown in the recent decade as a way to diversify production due to the changing climate. Farming is a monocrop of maize (Kenyan staple crop), and / or an intercrop of maize and beans. Sheep, goats and beef/ dairy cattle is the predominant livelihood activity, with bee keeping in selected households. The area is also populated with wildlife which is exploited for tourism and ecotourism. The community land has now been partitioned therefore wildlife and livestock mobility is curtailed; this in turn has had severe detrimental effects on soil erosion.

Table 1. Land use/cover change in Mount Suswa Catchment (1985-2011)

Land use/cover	1985 Area (Km^2)	%	2000 Area (Km^2)	%	2011 Area(Km^2)	%	%change 1985-2000	%change 2000-2011	%change 1985-2011
Built up Area	0.77	0.19	0.91	0.24	1.30	0.32	+18.18	+42.86	+68.83
Agricultural Land	1.00	0.02	15.33	3.81	23.16	5.76	+1433	+51.08	+2216
Shrubland	231.1	57.4	170.6	42.4	237.8	59.1	26.18	+39.39	+2.90
Bare land	1.21	0.30	12.44	3.11	2.46	0.61	+928.1	+405.69	+103.3
Grassland	166.71	41.45	188.92	46.97	137.68	34.2	+13.32	-27.12	-17.41

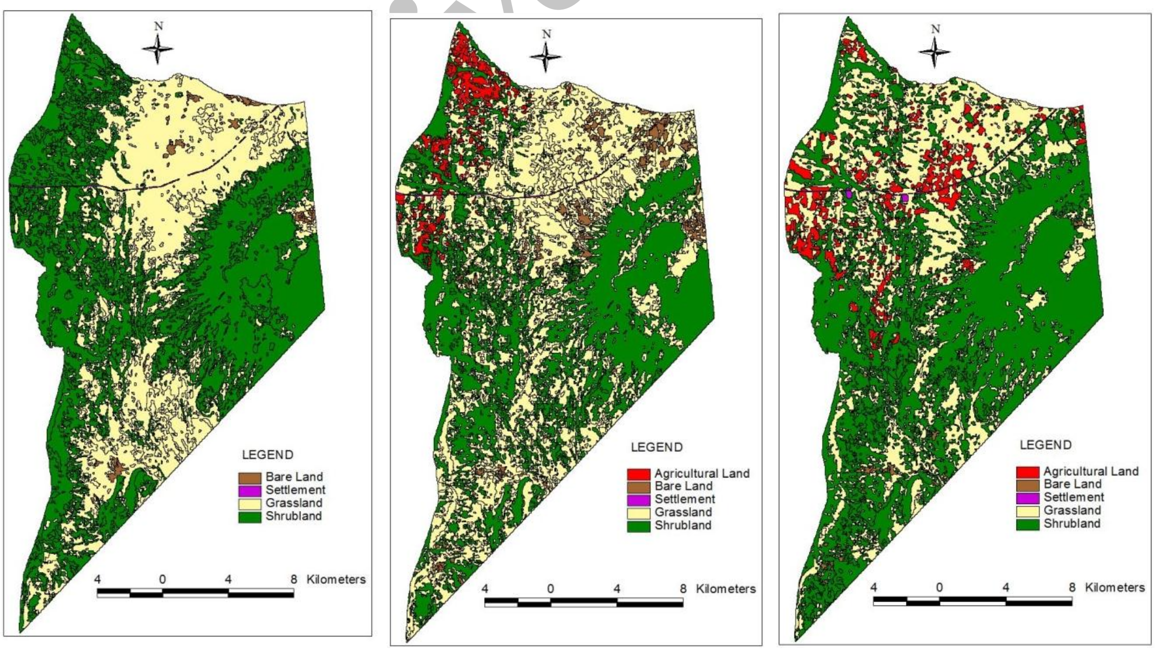

Fig. 2. LandSat imagery of land use/cover types map in year 1985, 2000 and 2011 from Table 1 of Olesharo Catchment: Source: (Konana, 2017)

Sampling method

In September 2016, sites were selected to minimize soil variability. Six plots per each LUT of 30 x 30m were randomly selected and laid on the different land use types. Disturbed soil samples were collected from each corner and one at the centre at two depths, 0-15 cm and 15-30 cm, using an auger. Consequently, all the samples collected at each depth per plot were combined to make a composite of 500g. For dry bulk density, cylindrical core rings (5 cm dimensions) were used to collect undisturbed samples per depth from each plot centre. Geographical position and elevation of each plot were also recorded. Forty eight soil samples per land use were collected making a total of 192 samples.

Physical and chemical soil analysis

The soil samples were air-dried, ground and sieved through a 2mm sieve to remove any visible plant residues. Concentration of SOC was estimated through the Walkley-Black wet oxidation method (Nelson and Sommers 1982), TN% through Kjeldahl digestion method (Bremner and Mulvaney, 1982). For bulk density, the samples in the core rings were oven dried at 105◦C for the standard 48 hours, and determined by dividing the weight of the dry soil by volume of the core rings. Soil texture was determined through the hydrometer method after dispersing soil with sodium hexa-metaphosphate solution to eliminate organic matter (Day and Luthin, 1956) (Equation 1).

The SOC and TN stocks were calculated using the equation

$$SOCst = \frac{SOC}{100} \times BD \times D \times 100 \quad \text{(Eq. 1)}$$

Where:

SOCst is the soil organic carbon stock (Mg C ha^{-1});

SOC is the soil organic carbon concentration (%), which is then converted to gC g^{-1} soil;

BD is the bulk density (g cm^{-3});

D is the depth (cm); which we multiply by 100 to change from g C / cm^2 to Mg C /ha^{-1}.

For TN stock the SOC was substituted with TNst Mg N/ha^{-1} (Were *et al*., 2015).

Statistical analysis

Analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) for comparison of means were performed using software SAS 9.1.3. The statistical significance was determined at $P<0.05$.

Results

Effect of land use types on SOC and TN concentrations

Result show that the highest SOC (2.23%) and TN (0.35%) percentages were recorded under shrublands while the C/N rations were not significantly different (Table 2).

Percentage of SOC and TN were low in all the four land use types. Results show that there was a significant difference between SOC percent in shrubland and Agricultural lands as compared to the GR and BL. Grasslands and bare-lands were not significantly different from each other ($p< 0.05$). Soils in the shrublands registered high SOC % followed by agricultural land while grasslands and bare lands had the least (0.76%). For TN, the shrubland had the highest amount (0.35%) though not significantly different from agricultural lands. However, the two LUTs were significantly different from bare lands and grassland. The bare lands had the lowest TN of (0.08%) which was not significantly different from the grasslands. In all the land use types, the SOC and TN concentrations were higher on the surface (0-15 cm) than in the subsurface (15-30 cm).

Table 2. Means of SOC%, TN% concentrations and C/N ratios in different LUTs

Land use types	0-15cm			15-30cm		
	SOC%	TN%	C/N	SOC%	TN%	C/N
Grassland	0.886 [a]	0.167 [a]	5.29 [a]	0.787 [a]	0.126 [ab]	6.24 [a]
Shrubland	2.226 [c]	0.349 [b]	6.38 [a]	1.890 [c]	0.207 [c]	9.11 [a]
Agricultural land	1.413 [b]	0.281 [b]	5.01 [a]	1.408 [b]	0.188 [bc]	7.46 [a]
Bareland	0.756 [a]	0.112 [a]	6.70 [a]	0.669 [a]	0.075 [a]	8.81 [a]
$LSD_{0.05}$	0.25	0.12	3.75	0.32	0.07	7.17

SOC- soil organic Carbon; TN- Total Nitrogen; C/N- Carbon Nitrogen ratio
Means down the same column with different letters indicate highly significant (P<0.05)

Effect of land use types on SOC and TN stocks

Total average SOC stocks in Mg/ha (1 Mg =1000 Kg) in the different land use types is presented in Fig. 3. The bare lands surface soil had the lowest SOC_{st} of 13.64 Mg C ha^{-1} (1.1 t ha^{-1}) while the shrubland had the highest 33.78 Mg C ha^{-1}. Grassland had low stocks of 14.98 Mg C ha^{-1}, while agricultural lands had 23.13 Mg C ha^{-1}. For the sub surface layer, shrubland had stocks of 28.77 Mg C ha^{-1} ± 0.54 followed by 22.04 Mg C ha^{-1} ± 0.46 in Agricultural lands. Grassland exhibits 12.09 Mg C ha^{-1} and the least is bare land having recorded 12.05 Mg C ha^{-1}. At both depths, there was no significant difference in SOCst between bare land and grassland, however there was a significant difference between SH, AG and the BL/GR.

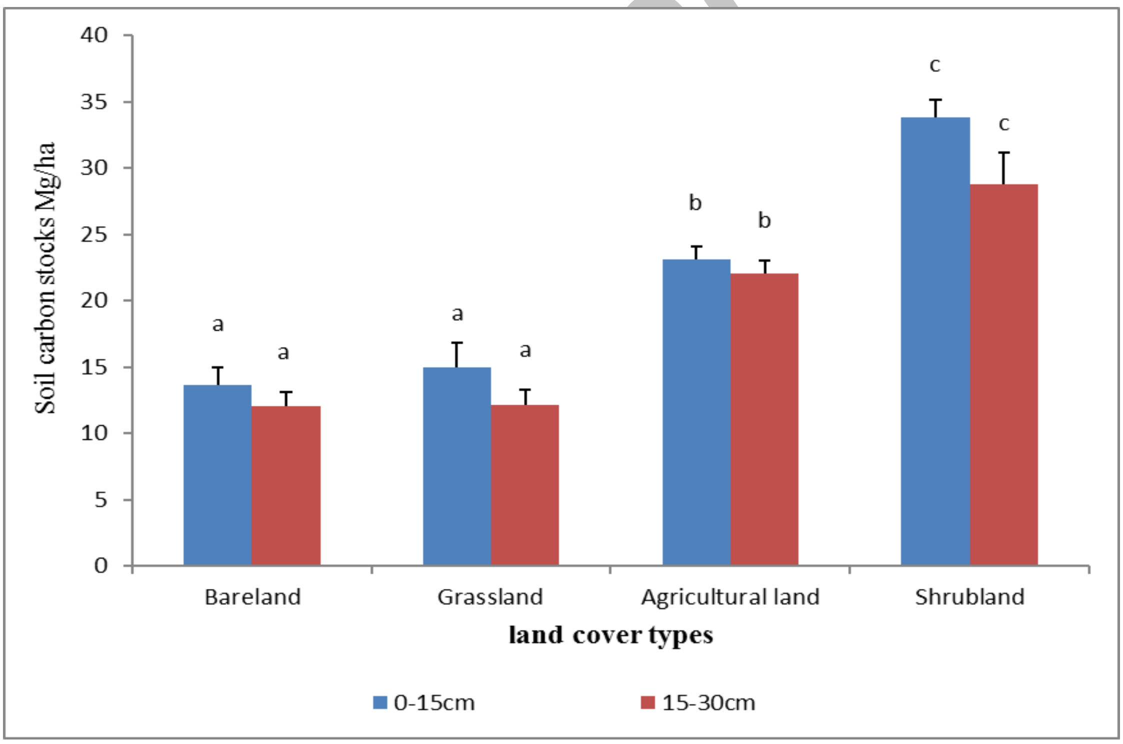

Fig. 3. Total carbon stocks under different land cover types. Note:
Means in the same colour with different letters indicate highly significant (P < 0.05)

There was no significant difference in TNst; between SH and AG, as well as between GR and BL. However SH and AG were significantly different from GR. Fig 4 shows significantly higher TN stocks in SH (5.29 Mg N ha^{-1}) in the upper layer and lowest in BL at 1.89 Mg N ha^{-1}. Generally the upper horizon had higher TN than in the lower horizons across all the land use types.

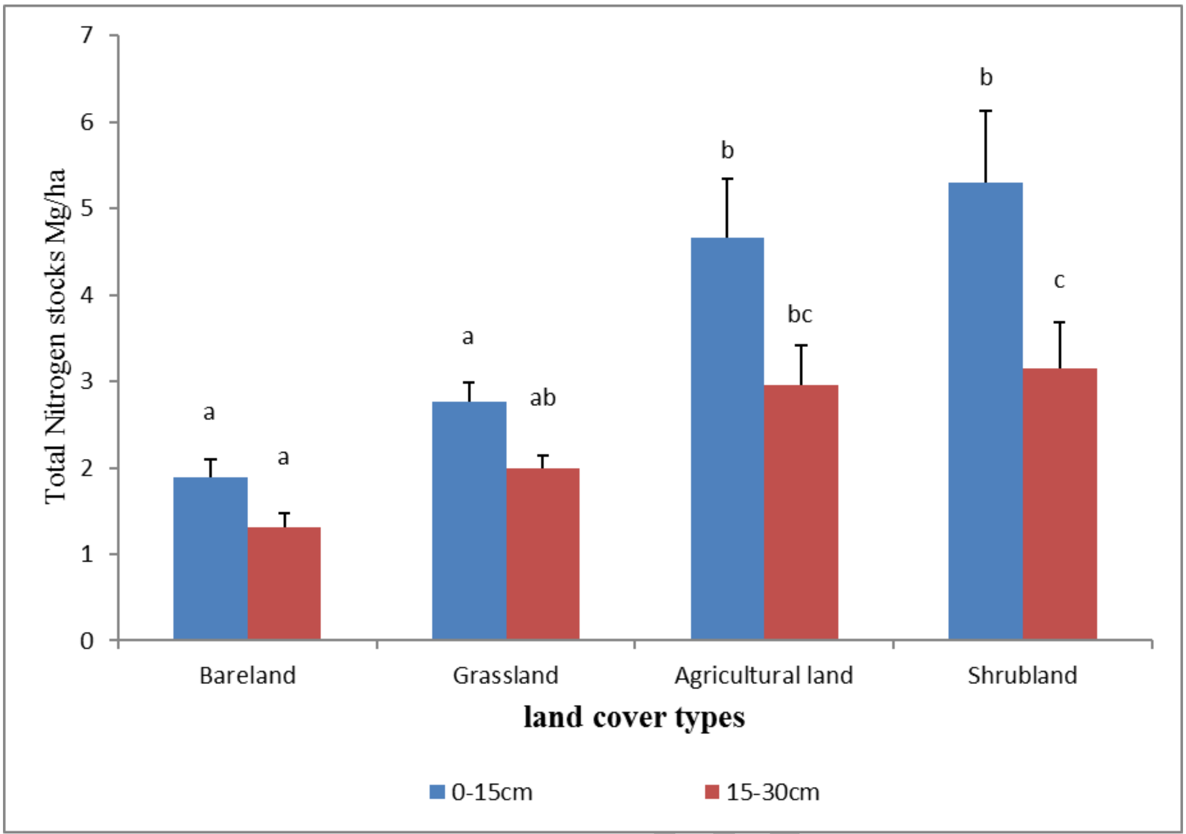

Fig. 4. Total nitrogen stocks under different land cover types. Means in the same colour with different letters indicate highly significant ($p < 0.05$)

Effect of land use types on SOC and TN stocks in whole area of Olesharo catchment

The highest amount of SOCst per the area occupied is shrubland with 1,487,501 tons C in 237.81 km^2 and the lowest is bare land with 789 tons C in 2.46 km^2. All the Land use types were significantly different from each other, with agricultural land having 14,273 tons C in 23.16 Km^2 and grassland with 372,699 tons C in 137.68 km^2 (Table 3).

For total nitrogen, the highest values were in shrubland with 200,711 tons N and the lowest is bare land with 789 tons N. All the land uses were significantly different from each other.

Table 3. Total amount of SOC and TN stock in different land use types based on acreage

Land use types	Land use mean Km^2	Total SOCst 0-30cm depth (Mg C ha^{-1})	Total TNst 0-30cm (Mg C ha^{-1})	Total SOC/LU (Tons C)	Total TN/LU (Tons N)
Grassland	137.68	27.07	4.76	372,699 c	65,535 c
Shrubland	237.81	62.55	8.44	1,487,501 d	200,711 d
Agricultural land	23.16	45.17	7.61	14,273 b	17,624 b
Bare land	2.46	25.69	3.21	6,319 a	789 a

SOCst- soil organic Carbon stock; TNst- Total Nitrogen stock

Means down the same column with different letters indicate highly significant ($P<0.05$)

Discussion

Effect of land use types on SOC and TN concentrations

The average values of 1.6% SOC is below that observed by Batjes (2004) working in on a SOC inventory in Kenya which ranged from 4.6-4.7 % for Agro-Climatical Zones (ACZ) IV. The lowest SOC% was observed in the bare lands, which can be attributed to low above ground litter production that provides substrates for mineralization. Similarly studies done by Kurgat *et al.* (2011) in northern Kenya showed that bareland exhibited low SOC due to low moisture availability as well as poor soil structure that would increase microbial population (Allen *et al*., 2010). Other studies also show high SOC concentrations can be attributed to shrub canopies which are consistent with their high litter cover and soil moisture content (Stavi *et al* ., 2008). Some of the shrubs found in the catchment area; *Albizia gummifera, Cordia ovalis, Croton dichogamus, Carissa edulis* and *Tarchonanthus camphoratus* (Reed *et al.,* 2009). In the ASALs of Kenya, Dabasso *et al*. (2014) showed that soils in shrubland had 38% of C as opposed to 32% that of grassland. Comparable results by Fu *et al*. (2010), elucidate that SOC concentrations are lower in croplands that had been converted from native vegetation due to increase in soil temperature and evaporation rates from crop harvesting.

The SOC in agricultural land was higher than grassland and this could be attributed to the stubble (maize stocks) left on the farm as also observed during the time of sampling. The farmers also practiced intercropping of maize and beans with fertilizer and animal manure application. This provides litter at different stages of decomposition. Solomon *et al*. (2000) found that farming techniques that leave material on the farm after harvesting controls carbon fluxes whereby increasing carbon inputs. The litter controls soil moisture and temperature attracting large populations of microorganisms and improves soil properties.

Grasslands unexpectedly had 16% SOC and TN (18%) lower than shrubland. This may be attributed to overgrazing, decreasing soil fertility and biodiversity within the catchment. Verdoodt *et al*. (2010) working in the Njemp flats of Kenya showed that low SOC in open community grazing lands are as a result of low herbaceous biomass production as a result of poor grazing management. Comparable results were reported by Batjes (2004), in soil inventory done for Kenya that reported that grassland had lower SOC due to lower net primary productivity (NPP) as compared to shrubland within the same Agro-Climatical Zones. These results are contrary to other studies which indicate that grasslands contain higher SOC than croplands and shrublands in North America (Franzluebbers, 2010). They attribute the increase to the high rates of turnover of less recalcitrant material than shrubland and sustainable grazing management practice.

Effect of land use types on SOC and TN stocks

Higher SOC (Fig. 3) and TN stocks (Fig. 4) were recorded in the shrubland compared to all the other land cover types. This may be attributed to higher litter input and soil moisture found under the canopies within the shrubs. Consequently, the microclimate created encourages microbial action on the litter leading to high organic carbon content in the soil which improves soil aggregate stability. The average SOCst in the shrubland are similar to those obtained under the Global Environmental Facilities (GEF) SOC study by Kamoni *et al*. (2007) which ranged from 0-18 t ha^{-1}. The area under shrubland has been fenced by local communities in order to control grazing within the catchment. Studies that elucidate effects of enclosures on SOCst have shown there is a significant increase of SOC and TN stock due to controlled harvest of biomass (Mureithi *et al*., 2014). Since the shrubland occurs in the high altitudes areas of the catchment, there have been several measures to control erosion using physical measures like cut-off dams, semi-circular bunds, gunny bag check dams, water retention ditches and retention dams. These structures have encouraged infiltration and enhanced soil moisture content leading to soil organic carbon build up.

A study done by Dabasso (2014) in northern Kenya and Mganga *et al*. (2011) in Kibwezi showed similar results between shrubland and grassland. They attributed the results to higher herbaceous cover which facilitated higher residue turnover compared to the grasslands. However, divergent results have also been registered. For example, Derner *et al*. (2006) working in the North American plains reported that areas under continuous heavy grazing had more organic carbon than areas that were lightly stocked. They linked this result to higher root biomass that was found under high grazing areas. In the current study, the results show that the land cover type and controlled grazing do affect the SOCst.

Unexpectedly, grassland had lower SOCst compared to shrubland and agricultural land (Fig. 3). This may be linked to the uncontrolled grazing within the catchment. The subsequent disruption of carbon inputs and excessive harvesting of above ground biomass by livestock alters the C cycle within the ecosystem. This excessive removal of herbaceous material has also led to exposure of the surface to harsh temperature and surface runoff, which further aggravates the situation. According to other studies, this exposure hastens the litter turnover rates, leading to soil organic matter oxidation, expediting CO_2 release into the atmosphere.

In the grasslands of northern Kenya, Muya *et al.* (2011) reported that low SOCst has been as a result of soil compaction, pulverization, particle soil dispersion, low organic inputs, high pH and high exchangeable sodium percentage. Further, the catchment has low and variable precipitation, with high solar radiation (Jaetzold *et al.*, 2010) which discourages SOC build up. Agricultural land showed relatively high SOC over grassland but lower than shrubland and can be attributed to the stubble remains on the farms and animal manure use. This is consistent with studies that aim to use sustainable agricultural practices to reduce CO_2 by reduced or no tillage; use of crop residues; intercropping and mixed cropping (Chivenge *et al*., 2007; Batlle-Aguilar, 2010). A recent study in Brazil showed the increase of SOC in integrated crop-livestock management systems where crops, especially soybeans and grasses were planted together to reduce rangeland degradation and provide incentives for dryland conservation (Batlle-Bayer, 2010).

The total nitrogen stocks were highest in shrubland and lowest in bareland (Fig. 4). Grasslands unexpectedly showed low TNst than agricultural land or shrubland. This is in contrast with the findings of Frank *et al*. (2004) working in Yellowstone National park that show grazing increases TNst through animal faecal matter and urine that are deposited on the surface. The current study area is under intense gully erosion that has resulted in general degradation of the area. Works done in the Tibet highlands showed grasslands that experience erosion register general low TNst (Nie *et al*., 2013). Besides, high TNst would be registered if the amount of input by animals exceeds that which is taken away. Moreover, due to high temperatures and low precipitation, nitrogen volatilization from NH_3 which is the loss of nitrogen as free ammonia (NH_3) could have contributed more to loss of N from the study sites.

The SOCst and TNst in all land use types decreased with an increase in depth. This is attributable to reduction of litter fall rich in organic matter inclusive of root exudates and leachates which are often found on surface horizons. There is minimal rainfall in the area with steep slopes and therefore leaching is not a factor. The lower concentrations and stocks of SOC in the subsurface soils thus correlate to the corresponding bulk density values observed within the different LUTs (Demessie *et al*., 2013).

Shrublands had the highest total SOC and TN amounts based on its acreage and stocks. This is attributable to the large acreage and little area change that has occurred on it for the last three decades (Konana, 2017). Moreover this may be attributed to minimal grazing on the shrubland which are found in steep topography and preference to the grasslands found in gentler slopes. This is in contrast to results found by Muya *et al*. (2011) who observed less SOC stocks in the higher slop position as opposed to lower. This however was due to low soil cover on the upper slope positions due to disturbance. In the shrubland of Olesharo, there is minimal disturbance therefore increasing litter on the surface. Grasslands on the other hand, have lower SOC and TN stocks per the acreage. This may be due to the overall overgrazing and exposure to erosion mechanisms.

Conclusions and Recommendations

The study shows that land use/cover type has influence on SOC and TN distribution in the catchment. Despite being in the same catchment, different land use types had significantly different SOCst where shrubland exhibited high levels of SOC which could be attributed to higher litter deposition, soil moisture content, C: N root ratio and grazing management. From the total acreage, the difference in total SOC and TN from each LUTs is evident. The study has also elucidated that overgrazing has severe impacts on SOC and TNst loss which provides for an indicator for soil quality and soil degradation within the catchment. The study reinforces the results of other studies in the same area that link land use change with the development of the deep gully network within the catchment. Furthermore, the results give a deeper understanding on the potential use of land use and its management to sequester carbon in line with global strategies to address the negative effects of climate change.

From this study, it is recommended that proper holistic grazing strategies should be employed by the pastoral communities to counter the deleterious effect of overgrazing within the catchment. Due to the dynamism of land use change coupled with the steep topography, effective soil conservation strategies should be put in place especially in the agricultural lands, which based on the current practices, seems to be a good sink for SOC. The study also recommends use of SOC modelling to predict future trends of SOC losses under the different land use types and different climatic scenarios in order to influence policy.

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اثرات تغییر کاربری و پوشش زمین بر کربن آلی خاک و ذخایر نیتروژن کل در حوضه آبخیز Olesara، شهر Narok، کشور کنیا

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چکیده. تغییر کاربری و پوشش زمین یکی از مهمترین علل تغییرات کربن ذخیره خاک در هر منطقه است. زمین‌های خشک و نیمه خشک کنیا در سه دهه گذشته با تغییرات گسترده‌ای در مورد کاربری صورت گرفته است و تجربه‌های مختلفی در مورد اثرات آن بر کیفیت خاک و تخریب زمین را نشان داده است. این مطالعه در سال ۱۳۹۵ در حوضه آبخیز Olesharo، شهر Narok، از کنیا انجام شد. هدف از این مطالعه بررسی تاثیر تغییرات کاربری اراضی و پوشش زمین بر میزان ذخایر کربن خاک و کل نیتروژن خاک در حوضه آبخیز بود. با استفاده از تصاویر ماهواره لندست، چهار نوع کاربری زمین شناسایی شد: ۱- بوته‌زار، ۲-اراضی کشاورزی، ۳-گراسلندها و زمین‌های فاقد پوشش گیاهی، سپس از این مناطق بطور جداگانه نمونه‌های خاک از دو عمق ۱۵-۰ و ۳۰-۱۵ سانتی‌متری از داخل پلاتهای ۳۰×۳۰ متری برای تجزیه و تحلیل میزان ذخایر کربن و نیتروژن خاک به صورت تصادفی برداشت شدند. نتایج مطالعه نشان داد که در سطح احتمال پنج درصد میزان ذخیره کربن در این نوع کاربری‌ها متفاوت و معنی‌دار بودند. در این میان کاربری بوته‌زارها بیشترین مقدار ذخیره کربن خاک به میزان ۳۱/۲۶ تن در هکتار داشتند که به طور معنی‌داری بیشتر از مقدار کربن ذخیره شده در کاربری گراسلند به میزان ۱۳/۵۴ تن و نیز بیشتر از زمین‌های فاقد پوشش گیاهی به میزان ۱۲/۸۵ تن در هکتار بود. همچنین مقدار نیتروژن کل در کاربری بوته‌زارها به میزان ۴/۲۲ تن در هکتار بالاترین و در اراضی فاقد پوشش گیاهی به کمترین مقدار خود یعنی ۱/۶ تن در هکتار رسید. از طرفی میزان کربن آلی خاک و نیتروژن کل در عمق لایه اول یعنی ۱۵-۰ سانتی‌متری به میزان قابل توجهی یعنی ۲۱/۳۸ تن در هکتار نسبت به عمق دوم ۳۰-۱۵ که ۱۸/۷۴ تن در هکتار بود بیشتر و معنی‌دار بود. این موضوع نشان می‌دهد که این ذخایر هرچه عمق زمین بیشتر می‌شود کاهش پیدا می‌کند. می‌توان نتیجه گرفت که انواع استفاده از زمین بر کیفیت خاک اثر می‌گذارد و مدیریت آنها می‌تواند به مدیریت پایدار زمین برای کاهش اثرات منفی تغییرات آب و هوایی کمک کند.

کلمات کلیدی: ذخایر کربن خاک، تغییرات کاربری و پوشش زمین، تغییرات اقلیمی