SOIL ORGANIC CARBON CONTENT UNDER DIFFERENT LAND USES IN THE MT. ELGON ECOSYSTEM, KENYA

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Elizabeth Adobi Okwuosa
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SOIL ORGANIC CARBON CONTENT UNDER DIFFERENT LAND USES IN THE MT. ELGON ECOSYSTEM, KENYA

Elizabeth A. Okwuosa*[,1], Michael M. Makokha[1], Peter Keter[1], Adano W. Roba[2], J.B. Okeyo-Owuor[2], Polycarp Mwima[3], Wilson Yabann[2] & Annah Agasha[4]

[1]Kenya Agricultural Research Institute, P.O Box 30148, Nairobi- Kenya, [2]Victoria Institute for Research on Environment and Development (VIRED) International, P.O Box 6423, Kisumu- Kenya, [3]The Environmental Conservation Trust of Uganda, P.O Box 8996, Kampala- Uganda, [4]Nature Harness Initiatives, P.O Box 25286, Kampala- Uganda
* Corresponding author

ABSTRACT

This study compared total soil organic carbon in soils from a mature primary undisturbed 30-year old forest with that from 5-year old secondary forest plantation and 20-year old coffee plantation in Cheptais forest of the Mt. Elgon ecosystem. Insights into its potential for soil carbon sequestration are essential in developing carbon offset products from the ecosystem. Data was collected from plot sizes of 50m by 50m (2500 m^2) set up at the different landscapes depicting different land use type. Soil profiles were excavated to a depth of 40 cm at representative points within each plot. Three separate soil samples were taken from 0- 10 cm, 10-20 cm and 20-30 cm starting with the lower depth. Total organic carbon was estimated using chemical combustion method. The undisturbed forest had higer levels of SOC compared to the coffee cropped land. With the opportunities presented by Reducing Emission from Deforestation and Degradation (REDD) and Payment for Environmental Services (PES) the productive landscapes should indentify strategies that improve the SOC and package for possible consideration in the carbon market and other carbon offset programs for ecosystem management in the region.

Introduction

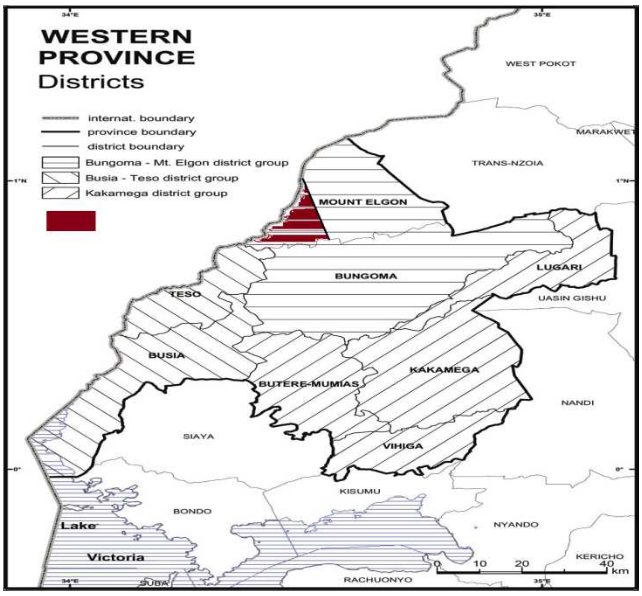
Soils as a carbon sink are proposed in recent years as a strategy to mitigating the effects of elevated carbon dioxide (CO_2) concentration (Lal, *et al*., 1999; Lal. 2002, 2005). In order to determine the potential of soil to absorb carbon, estimation of soil organic carbon (SOC) content under different land use and management practices needs to be assessed through estimation of C stocks in exiting land uses (IPCC, 1997). Soil organic carbon (SOC) shows variability according to land use and soil depth which generally diminishes with depth. Land management practice regulates carbon sinks. Land use, erosion and reafforestration are significant in controlling the soil carbon cycle. Some of the common activities that affect soils are shifts in land use or shifts in cultivation. The shifts in land use is manifested through the influence in the amount of plant residue input and therefore soil organic matter.

Different tree species and the set up of the tree species (forest structure) have a different impact on soil carbon dynamics (Paul *et al*. 2002, Glenday 2006, Russell, *et al*., 2007). Studies conducted by Glenday, (2006) in the Kakamega forest a tropical forest in Kenya estimated C stocks in an undisturbed indigenous forest at 356 t C ha^{-1} compared to 94 and 108 t C ha^{-1} in a 10-year Eucalyptus saligna and 30-year *Cupressus lusitanica* plantations. Kamau, *et al*., (2008) reported that in Kenya biomass C in tea plantations ranged from 43 to 72 t C ha^{-1} which compared with C stored in tree plantations of 30 years of age. With conversion of land use from such forests, the estimated carbon stock will be released.

Given its vast area Mt. Elgon ecosystem is a potential carbon sink capable of contributing to terrestrial carbon stock in the East African region. Insights into its potential for soil carbon sequestration are essential in developing carbon offset products from the ecosystem. This study aims at quantifying the amount of soil organic carbon under dominant land use types in the hilly Mt Elgon ecosystem. The results obtained will provide a valuable baseline for evaluating changes in SOC associated with conversion on productive landscapes. The information will provide a basis for developing carbon offset programs for ecosystem management in the region.

Materials and Methods

Study Area



The Mt Elgon ecosystem (Figure 1) lies between latitude 2.50 S and 1.50 N, and longitude 320 and 350 E, and is bisected by the border between Kenya and Uganda. Figure 1 shows the location in Kenya where the ecosystem spans an area of 107,82 ha (Forest Department, 2000) and falls within the Trans Nzoia and Elgon districts and has altitude of up to 4250 m above sea level in the Kenya part of the mountain. The ecosystem is made up of protected areas which include indigenous and plantation forests. The mountain comprises of the national park and a reserve which are under the jurisdiction of the Kenya forest service and the Kenya wildlife service respectively. Settlements are located at the slopes of the mountain with a small community of indigenous tribe living within the forest reserves.

The landscape consists of low hills with steep slopes (23% on average). The most common soils are relatively young, poorly developed, sandy loams (Cotler *et al*., 2002). Using the FAO system, the soils found in the area can be grouped in to Luvisol, Cambisol, Rigosols, and Fluvisols.

Soil Sampling and Data Analysis

Soil sampling sites were selected to represent each of the dominant land use types within the ecosystem. Plot sizes of 50m by 50m (2500 m^2) were set up in each land use type. Soil profiles were excavated to a depth of 40 cm at representative points within each plot. Three separate soil samples were taken from 0- 10 cm, 10-20 cm and 20-30 cm starting with the lower depth.

Soil samples were air dried, sieved through a 0.5 mm sieve and were analysed for total organic carbon by chemical combustion method as outlined in Okalebo, *et al.*, (2002), and Soil reaction (pH) determined with a pH electrode at soil /water ratio of 1:1 (Hesse, 1971). Soil bulk density (BD) measurements were determined by the core ring method driving cores into the soil by hammering until sufficiently filled (Blacke and Hartge, 1986). The soil carbon stock was calculated using the following equation:

$$C\ (t / ha) = [(\text{soil bulk density}, (g / cm3) \times \text{soil depth (cm)} \times OC\ g/kg)] \times 100$$

Data was analyzed using Genstat using the one way analysis of variance (ANOVA). Statistical significance was calculated using turkeys test at P< 0.05 level.

Result and Discussions

Soil Bulk Density

Figure 2 shows that the conversion from forest to coffee increased soil bulk density (BD). Undistrubed soils had a low bulk density that can be attributed to less disturbance through tillage or commercial harvesting. On the other hand, the coffee plantations had a high BD indicating compaction.

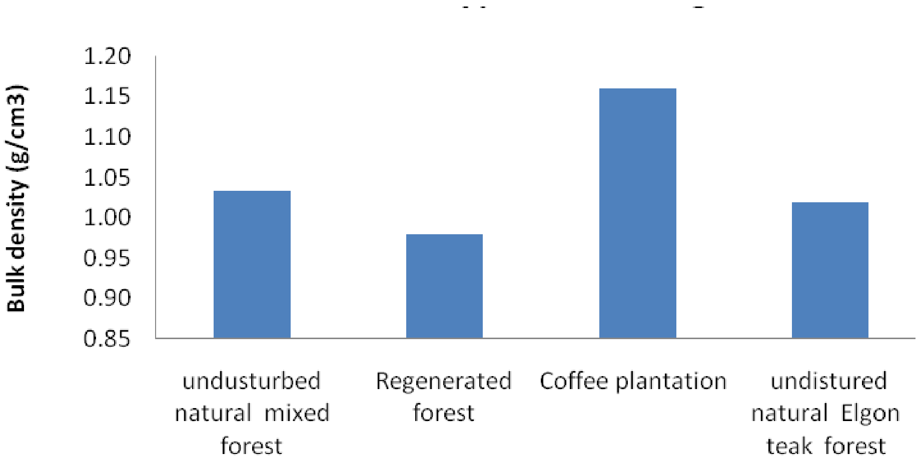


Figure 2: Soil Bulk Density at 0-15 Soil Depth for Four Land Use Types in Mt. Elgon

Soil Organic Carbon Content

The impact of cultivation was pronounced for the top 10 cm for coffee plantations and regenerating plantation. The undisturbed forest had higer levels of SOC compared to the coffee cropped land and regenerating forest which was been under cultivation for 10 years before regenarating in the last 5 years. The low SOC can be attributed to breakdown of soil aggregates and a high high rate of C mineralization (Lal 1999). The amount of SOC in deeper profiles varies across land used with high C amounts in 20-30 cm depth for coffee plantation. There maybe redistribution due to tillage or deep rooting.

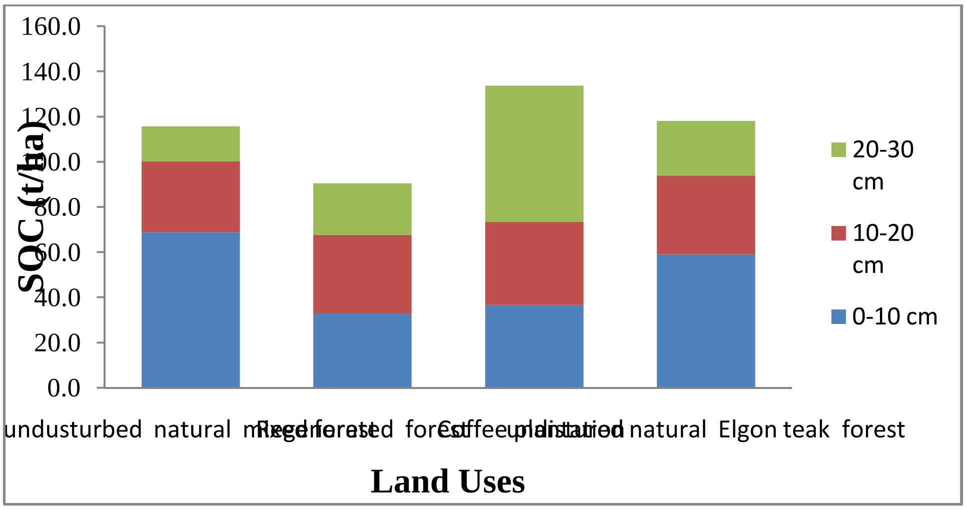


Figure 3: Soil Organic Carbon in different depths under various land uses in Cheptais forest, Mt. Elgon, Kenya

Conversion to cropland reduce SOC in 0-10 cm and increased in 20-30 cm depth. Cultivation increased SOC due to increased translocation of SOC. Whole soil profiles need to be assesed in order to get accurate assesment of cuttent soc pool. Because of their natural regeneration and higher plant diversity, secondary and regenerated forests have higher carbon stocks similar to natural forests due to higher biomass returns.

Conclusions

This study has demonstrated that soil organic carbon differs with the different land use management in the area. SOC acts as a good indicator of the effects of land use change from forest to intensively managed systems such coffee plantation and other agricultural uses. With the opportunities presented by Reducing Emission from Deforestation and Degradation (REDD) and Payment for Environmental Services (PES) the productive landscapes should indentify strategies that improve the SOC and package for possible consideration in the carbon market. It is imperative that conversion of lands to different possible use causes alteration of the SOC stocks. In order to mitigate the impacts of climate change, there should be concerted efforts to assess the changes in SOC from all productive landscapes to identify any synergism or antagonism of land use arrangement in different productive landscapes.

Acknowledgements

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