Research Application Summary

Impact of landuse change on soil carbon stocks and livelihoods of communities on Mt. Elgon region, Uganda

Tumwebaze, S.B.[1], Tenywa, M.M.[2], Buyinza, M.[3] & Nantumbwe, C.M.[4]
[1]Faculty of Forestry & Nature Conservation, Makerere University, P.O. Box 7062, Kampala, Uganda
[2]Faculty of Agriculture, Department of Soil Science, P. O. Box 7062 Kampala, Uganda.
[3]Département of Community Forestry, Faculty of Forestry & Nature Conservation, Makerere University, P. O. Box 7062, Kampala, Uganda
[4]Faculty of Arts, Department Geography, Makerere University P. O. Box 7062, Kampala, Uganda
Corresponding author: tumwebaze@forest.mak.ac.ug, balaba2@yahoo.com

Abstract

There is inadequate knowledge on the form of soil organic carbon (SOC) pools and fluxes that are affected by land use change. Hence, there is a need to understand how soil organic carbon is affected by land use change and how these impacts affect rural livelihood. This knowledge gap makes it difficult to predict the effects of land use change and limits the management of ecosystems. This study will be conducted on and around Mt. Elgon area in Uganda to obtain information from the community about their perception on landuse/cover change and its impact on the their livelihood and soil organic carbon. Knowledge on community copping strategies in improving and maintaining soil carbon levels will also be investigated.

Key words: Ecosystems, land use changes, Mt. Elgon, soil organic carbon, terrestrial ecosystems, Uganda

Résumé

Il y a une maigre connaissance sur la forme d'accumulation du carbone organique du sol (SOC) et des flux qui sont affectés par le changement d'utilisation de terre. Par conséquent, il y a un besoin de comprendre comment le carbone organique du sol est affecté par le changement d'utilisation de terre et comment ces impacts affectent la vie rurale. Cet intervalle de connaissance le rend difficile pour prévoir les effets du changement d'utilisation de terre et limite la gestion des écosystèmes. Cette étude sera menée dans et autour de la Région du Mont Elgon en Ouganda pour obtenir l'information fournie par la communauté au sujet de leur perception sur le changement d'utilisation de terre /couverture de terre et son impact sur leur subsistance et sur le carbone organique du sol. La connaissance des stratégies utilisées par la communauté dans l'amélioration et le maintien des niveaux de carbone du sol sera également recherchée.

Mots clés: Écosystèmes, changements d'utilisation de terre, Mt.Elgon, carbone organique du sol, écosystèmes terrestres, Ouganda

Background

Most of the studies on land use change on Mt. Elgon have focused on the causes and soil properties (Nantumbwe, 2005), soil erosion (Bamutaze, 2004), landslides (Kitutu, 2002), and forest plant communities and natural vegetation types (Mark, 2000). Limited studies have been conducted on the effects of land use changes on soil organic carbon (SOC) and livelihood. Increase in population pressure leads to conversion of natural forest to agricultural land hence decreased amount of SOC (Suzanna, 2007). The African continent has a large and growing role in the global carbon cycle, with potentially important climate change implications. However, there is limited information and understanding of the global carbon cycle in Africa (Christopher, 2007).

Change in land uses from forest to agriculture has led to the reduction of soil organic matter levels (Nantumbwe, 2005) thereby changing diversity on Mt. Elgon slopes. This has caused economic losses and food insecurity, leading to broader social costs to the local community living on the slopes of Mt. Elgon. There is limited understanding of the impacts of land use change on soil carbon stocks and fluxes in Uganda. There is also inadequate information on the awareness of the communities about the effects of change in landuse/cover on their livelihood. This information is required to determine the impacts on the global carbon cycle and the sustainability of agricultural systems that are replacing native forest. This study will evaluate the trend and spatial pattern of land use change along the altitudinal gradient, and assess its related impacts on soil organic carbon stocks and fluxes in the Mt. Elgon area. The copping strategies of the communities in improving and maintaining soil carbon levels will also be investiaged.

Literature Summary

Land use/cover changes are important elements of the global environmental change. Land use patterns result in land cover changes that cumulatively affect the global biosphere and climate (William *et.al.*, 1995). Intensification of land use in the fragile mountain environments due to increase in human and livestock populations has profound effects on the system leading to land degradation (Jennifer *et al.*, 2000). About 77.3% of all land use change is due to removal of forests and conversion of grasslands for arable land use (Lal, 1995). Long-term experimental studies have shown that SOC is highly sensitive to changes in land use, with changes from native ecosystems such as forest or grassland to agricultural systems almost always resulting in a loss of SOC (Jenkinson, 1977). Land use/cover changes are evident on the slopes of Mt. Elgon (Nantumbwe, 2005). They are induced by land degradation resulting from increasing population pressure (Kikula, 1990).

Land use/cover change is a global phenomenon and the most affected resources are water, soil, and vegetation cover, which are closely linked to geomorphology, climate, fauna, and humanity. The linkages among the different elements of the environment are highly complex and not clearly understood (AAG, 1996). Land-use/ land-cover change are significant to a range of themes and issues central to the study of global environmental change. Effective maintenance of the soil requires an understanding of how land-use practices affect more subtle indicators of soil quality and erosion control. Reduction in vegetation cover by ploughing, grazing or burning tends to reduce SOM due to reduced inputs of organic matter and enhanced activity of soil microbes (Young, 1997).

Change in land use impacts on soil organic carbon (SOC) pools and fluxes due to the change in microbial diversity and numbers. Studies that consider soil carbon losses or gains due to land use change have been limited to a single soil type (AAG, 1996). Furthermore, most SOC studies have not comprehensively analyzed the relevant ecological factors, which are essential to understanding the effects of land use on SOC pools and dynamics (AAG, 1996). This study will be conducted on Mt. Elgon, which is endowed with a number of natural resources such as fertile volcanic soils, fresh water, wild life and a number of natural vegetation species in the forest. Over decades there have been a number of pressures on the natural resources due to increased human demand associated with development and increased population (Nantumbwe, 2005). The consequences of this increased demand are land use change from the natural forest to agricultural land. Understanding the effects of land use changes is important in the planning for sustainable management of natural resources and decision-making. Mapping and monitoring land use change on Mt. Elgon slopes will help to improve land use management practices for the preservation of forests in Uganda as well as sustainably utilizing the agricultural land.

Study Description

The study will be conducted in the Mt. Elgon area of Uganda and the surrounding communities. To evaluate the temporal land use changes on Mt. Elgon slopes a reconnaissance study will be conducted to obtain preliminary information about the study area. Information from topographic maps of 1:50,000 of 1960 (Sheets Mbale and Kapchorwa), Scale 1:50,000, Series Y732, and different satellite images will be obtained. Interpretation of these digital land sat TM satellite images will be done to get an over view of the land uses in the area. The land use change map will be obtained from the satellite images.

The land use change map obtained from the satellite images, will be used to stratify the area into three land use types (forested, agriculture and grazing) for soil sampling. To classify the soils on Mt. Elgon, soil profiles will be dug on all the sites using a back hoe, soil samples will be taken from each soil depth 0-15cm and 15-30 cm, respectively. To assess the amount of SOC, 100 soil samples will be randomly collected from plots of $2m^2$ by $2m^2$ at two soil depths for three different land use types. The soil samples will be analyzed for total carbon by the dry combustion method. Soil bulk density measurements will be made by the core method for every 15cm layer to a depth of 30cm layer. The differences in soil organic carbon between the landuse systems will be analysed using Analysis of variance (ANOVA), with the aid of Genstat statistical package. The GEFSOC modeling system (2006) will be used to estimate current SOC stocks at regional scale for 2009-2030 (Paustian *et al.*, 2007). The system was developed based upon available existing data on area such as: land use and land management; climate; soils; potential natural vegetation and geographic location.

Participatory approaches and household interviews will be used to obtain community information about the soil conservation measures in place, awareness about the effects of land use/ cover change to their livelihood and environment. Information about the mitigation and adaption measures for soil conservation will also be investigated. To account for gender differences, women and children will form separated discussion groups from men. The data obtained will be analysed using chi-square test for testing association between demographic factors and opinions towards adoption and maintenance of soil carbon levels.

Acknowledgement

The study is funded by the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM).

References

Association of American Geographers (AAG),1996. Active learning modules on the human dimensions of global change. Human driving forces and their impacts on land use/land cover. www.aag.org/HDGA/www/LUCC/tittlepge.html, September, 2009.

Bamutaze, Y. 2002. The impact of land use on run off and soil loss in Wanale micro-catchments, Mt.Elgon Slopes. MA Thesis. Unpublished. Makerere University.

Christopher, S. and Lal, R. 2007. Nitrogen limitation on carbon sequestration in North America crop and soils. *Crit. Rev. Plant Sciences* 26:45–64.

Houghton, R.A. 1994. The worldwide extent of land-use change. BioScience. *Global Impact of Land-Cover Change* 44(5):305-313.

International Centre for Research in Agro forestry (ICRAF), 2003. Combining strengths in the Amazon initiative. World Agro Forestry Centre: Agro forestry in action a new consortium for sustainable development. United Nations Avenue, Gigiri. http://www.worldagroforestrycentre.org.

Jenkinson, D.S. and Rayner, J.H. 1977. The turnover of soil organic matter in some of the Rothamsted classical experiments. *Soil Sci.* 123:298-305.

Kikula, I.S., Mung' ongo, C.G. and Jengo, R.D. 1990. Perspectives of land degradation and conservation in Tanzania. Unpublished.

Kitutu, 2002. Effects of landuse change on the stability of slopes in the Mount Elgon area, Mbale, eastern Uganda, A study of landslides in the Manjia county area. Unpublished.

Lal, R. 1995. Global soil erosion by water and carbon dynamics. In: Lal, R., Kimble, J.M., Levin, E. and Stewart, B.A. (Eds.) Soils and global change. CRC/Lewis Publishers, Boca Raton, FL. pp. 131-142.

Mark, S.R. and Martha, R.J.C. 2000. Effects of grazing and cultivation on forest plant communities in Mount Elgon National Park, Uganda. University of Aberdeen, Department of Forestry, Aberdeen, U.K. and Leicester University, Department of Biology, Leicester, U.K.

Nantumbwe, C.M. 2005. Temporal land use and soil property interrelationships in Wanale and Manafwa catchments of Mt. Elgon. Makerere University, Kampala, Uganda.

Osher, L.J, Matson. P. and Amundson, R. 2003. Effect of land use change on soil carbon in Hawaii. *Biogeochemistry* 65:213–232.

Paustian, A., Easter, K., Killian, K., Williams, S., Feng, T., Al-Adamat, R., Batjes, N.H., Bhattacharyya, M.B.,Cerri, C.C., Cerri, C.E.P., Coleman, K., Falloon, P., Gicheru, P., Kamoni, P., Milne, E., Pal, D.K., Powlson, D.S., Sessay, M. and Wokabi, S. 2007. The GEFSOC soil carbon modeling system: A tool for conducting regional-scale soil carbon inventories and assessing the impacts of land use change on soil carbon. Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523 1499, USA.

Schlesinger, W. 1998. Response of vegetation to rising carbon dioxide. U.S. Global Change Research Program, Seminar Series, Rayburn House Office Building, Washington, 8 December 1998.

Suzanna, E. 2007. Aggressive colonizer earthworms drastically increase carbon dioxide. University of Puerto Rico. http://graduados.uprrp.edu/inventio/vol2/earthworms.htm

Van Oost, K., Govers, G., Quine, T. A. and Heckrath, G. 2004. Technical comment on “managing soil carbon”. Science 305 No. 5690. pp. 1567.

Vladimir, S., Brechje, M., Arwyn, J., Esio, R. and Montanarella, 2008. Climate change-soil can make a difference! Slide presentation at the conference: Climate change-can soil make a difference? Brussels, Thursday 12th June 2008.

William, B.M. 1995. Consequences: Past and present land use and land cover in the USA. Volume 1, Number 1. 1995.

Yoneyama, T., Nakanishi, Y., Morita, A. and Liyanage, B.C. 2001. 13C Values of organic carbon in crop-land and forest soils in Japan. *Soil. Sci. Plant Nutr.* 47:17–26.

Young, A. 1997. Agroforestry for soil management. ICRAF CAB International UK.