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ASSESSING SOIL ORGANIC CARBON STOCKS UNDER DIFFERENT LAND USES IN UGANDA

SEKAJUGO JOHN

BU/GSI4/MCC/12

SUPERVISORS

1. **ISABIRYE MOSES, PhD (ASSOC. PROFESSOR)**

2. **OCHWOH VICTOR AKANGAH, PhD (ASSOC. PROFESSOR)**

A DISSERTATION SUBMITTED TO THE DEPARTMENT OF NATURAL ECONOMICS, FACULTY OF NATURAL RESOURCE AND ENVIRONMENTAL SCIENCES, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN CLIMATE CHANGE AND DISASTER MANAGEMENT OF BUSITEMA UNIVERSITY

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Declaration

I, Sekajugo John, declare that this dissertation is original and is a result of my own efforts. It has not, to the best of my knowledge, been submitted to any higher institution of learning for award of a degree or any other academic purpose.

Signature...................................... Date 16/09/2017

SEKAJUGO JOHN

BU/GSI4/MCC/12

Approval

This is to confirm that this Dissertation is original and has entirely been the efforts of Sekajugo John. He has therefore submitted it in partial fulfillment for the award of the Degree of Master of Science in Climate Change and Disaster Management of Busitema University with our approval.

Signature ………………………………… Date 16/09/2017

Isabirye Moses, PhD (Assoc. Professor)

Signature………………………………… Date 16/09/2017

Ochwoh Victor Akangah, PhD (Assoc. Professor)

Dedication

To my beloved daughter Princess M.N.Leticia, my dear wife Areto Dorcus, my dear parents and the entire family of Birungi Joseph.

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List of acronyms

AIDS	Acquired Immune Deficiency Syndrome
C	Carbon
CCAFS	Climate Change Adaptation and Food Security
CDM	Clean Development Mechanism
^{0}C	Degrees centigrade
Cm	Centimeter
Co_2	Carbon dioxide
Co_2-e	Carbon dioxide equivalent
CSA	Climate Smart Agriculture
DEM	Digital Elevation Model
E.g	For example
FAO	Food and Agriculture Organization for United Nations
FREL	Forest Reference Emission Level
G	Grams
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Green House Gas
GIS	Geographical Information System
Gt	Giga tons
Ha	Hectare
HIV	Human Immune Virus

IPCC	Intergovernmental Panel on Climate Change
Kg	Kilogram
M	Meter
ME	Model Efficiency
MWE	Ministry of Water and Environment
MM	Millimeter
NFMS	National Forest Monitoring System
NPV	Net Present Value
%	Percentage
REDD	Reducing Emission from Deforestation and forest Degradation
SLM	Sustainable Land Management
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
SRMSE	Scaled Root Mean Square Error
SRTM	Shuttle Radar Topography Mission
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCC	United Nations Framework Convention for Climate Change

Abstract

Currently, there is alot of debate, on the total potential of agricultural soils to store additional carbon, the rate at which soils can accumulate carbon, the permanence of this sink, and how best to monitor changes in soil organic carbon stocks. The general lack of research in this area is currently preventing a more quantitative assessment of the carbon sequestration potential of soils across land uses, yet soil information is relevant for the transfer of soil technologies, estimation of amounts and distribution of carbon stocks, provision of data to support model simulations of soil carbon change, and provision of relevant information for the establishment of the national soil monitoring system. This study assessed soil organic carbon stocks and the determinants across land cover tyes (Cropland, Forestland, Grassland and Wetland).

Soil organic carbon stocks were calculated using models suggested by IPCC (2006) and outlined in the REDD+ methodological module (2009). The determinants of soil organic carbon stocks were assessed through a regression analysis using a mixed-effect generalized linear regression model.

Croplands contained, on average 17.95, 29.74, 34.84 and 37.01Tc/ha for 0-15, 15-30, 30-45 and 45-60cm depths, respectively; forestlands had 127.78, 167.12, 148.47 and 124.49Tc/ha for 0-15, 15-30, 30-45 and 45-60cm respectively; grasslands had 55.30, 70.35, 81.83 and 73.17Tc/ha for 0-15, 15-30, 30-45 and 45-60cm respectively; while wetlands had 6.36, 10.78, 14.59 and 15.47Tc/ha for the same respectice soil layers. SOC stocks were found to vary significantly across land uses. Regression analysis revealed that SOC stocks are significantly influenced by type of land use, bulk density of the soil, altitude, silt and clay contents of the soil. With in the same land use class such as cropland, different crop cominations store different carbon in the soil. Therefore, there is need to assess soil organic carbon stocks at landscape and plot level so as to identify appropriate plant, tree and crop species with abilities to enhance soil organic carbon storage and develop carbon sequestration finance programs that focus on livelihood and income improvement so that there is an incentive for farmers to invest in climate smart agriculture.

CHAPTER ONE: INTRODUCTION

1.1 Background

Recently, research perspectives about Soil Organic Carbon (SOC) have changed. In the past, SOC concentration was primarily measured to evaluate ''soil quality'' (Pe´ rie´ and Munson 2000; Pe´ rie´ and Rock 2007). Presently, Carbon (C) storage is studied in the context of greenhouse gas balance assessment and how soil C dynamics exert influence on the global C cycle (Ouimet *et al.*, 2007). The potential of using SOC both as an indicator of soil quality and a broader indicator of ecosystem response to environmental changes has reinforced the importance of having appropriate techniques to accurately quantify and predict landcover based SOC stocks. Information about soil organic carbon storage is very important for national monitoring of soil health and fertility change over time. This research assessed soil organic carbon stocks for different land uses based on laboratory analytical results of different soil parameters. It was mainly intended to assess the potential of soils to contribute to carbon sequestration in Uganda on its path to a climate-resilient and low-carbon development for agriculturalsustainability.

When agricultural land is no longer used for cultivation and allowed to revert to natural vegetation or replanted to perennial vegetation, soil organic carbon can accumulate by processes that essentially reverse some of the effects responsible for soil organic carbon losses from when the land was converted from perennial vegetation (Post and Kwon, 1999). There is a large amount of variation in rates and the length of time that carbon may accumulate in soil that are related to the productivity of the recovering vegetation, physical and biological conditions in the soil, and the past history of soil organic carbon inputs and physical disturbance.

1.1.1. Climate change mitigation and adaptation in Uganda

Uganda, is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and recognizes the importance of fulfilling the commitments under the respective article of the Convention on Climate Change, particularly the Principle of "common but differentiated responsibilities and respective capacities" (MWA, 2015). As a result, Uganda submitted its Intended Nationally Determined Contribution in compliance with Decision 1/CP.19 (Further advancing the Durban Platform: and in particular Paragraph 1 (b & c)) and as elaborated in Decision 1/CP.20 (Lima Call for Climate Action and in particular paragraph 11) premised on

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