FAO
FORESTRY
PAPER

168

Soil carbon monitoring using surveys and modelling

General description and application in the United Republic of Tanzania

Cover photos: ©FAO/Simon Maina

Soil carbon monitoring using surveys and modelling

General description and application in the United Republic of Tanzania

FAO
FORESTRY
PAPER
168

by
Raisa Mäkipää,
Jari Liski,
Sabin Guendehou,
Rogers Malimbwi
and
Abel Kaaya

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2012

ISBN 978-92-5-107271-4

Contents

Foreword

Rising levels of greenhouse gas concentrations in the atmosphere are predicted to alter the global climate pattern significantly, resulting in severe adverse effects on people's livelihoods, especially in Africa. An increase in the frequency of extreme weather events, such as tropical storms, droughts and persistently higher temperatures, has a direct impact on people's well-being, as these events reduce access to clean water and facilitate the spread of disease.

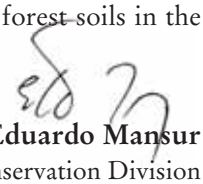
Forests play a major role in climate change. Nearly 20 percent of total anthropogenic greenhouse gas emissions result from changes within forests and changes from forest to other land uses in tropical countries. Therefore, limiting deforestation and forest degradation in the tropics is widely seen as an efficient means to mitigate climate change.

Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD) – a mechanism developed under the United Nations Framework Convention on Climate Change – is an effort to create a financial value for the carbon stored in forests, and thus provide incentives for developing countries to decrease deforestation and reduce carbon emissions from forested lands. To benefit from the REDD mechanism, countries need to be capable of reporting their forest carbon stocks and changes in these stocks over time.

One of the most important forest carbon stocks is forest soil. At the global level, the estimates of forest soil carbon stock vary from equal to twice that of forest vegetation. Because forest soils constitute such a large pool of carbon, releases from this pool, caused by deforestation, may significantly increase the concentration of greenhouse gases in the atmosphere.

Changes in soil carbon stocks over time can be estimated through repeated measurements or dynamic models. In both cases it is advisable to assess first the current stock through a carefully designed soil inventory. This study presents how to design such an inventory and discusses alternative approaches, including their advantages and drawbacks, to monitoring changes in soil carbon stock. In addition, it provides an example of a practical soil survey application, namely the soil carbon stock inventory of the National Forestry Resources Monitoring and Assessment project of the United Republic of Tanzania.

FAO's National Forest Monitoring and Assessment programme has developed multi-purpose and multi-source monitoring systems that have traditionally helped countries to assess their natural resources and manage them in a sustainable manner. Now, as illustrated in this paper, they also support designing and implementing REDD-compatible monitoring of forest carbon stocks and their changes. We hope that the example provided in the paper will help and encourage other countries to improve their capacity to assess and monitor their soil carbon stocks. This would help us all to understand better the role and potential of forest soils in the mitigation of climate change.



Eduardo Mansur
Director, Forest Assessment, Management and Conservation Division
FAO Forestry Department

Acknowledgements

The first draft of this publication was prepared by the authors, who worked under the coordination of FAO Forestry Officers Anssi Pekkarinen and Mikko Leppänen. The draft was then peer-reviewed by staff of the FAO Forestry Department and external reviewers, and a revised version was prepared by the authors, taking into account the inputs provided.

FAO sincerely thanks the authors for their dedication and the reviewers for their constructive feedback. Thanks are also extended to the personnel of the National Forestry Resources Monitoring and Assessment (NAFORMA) project of the United Republic of Tanzania and especially to its National Coordinator, Nurudin Chamuya, and its Chief Technical Advisor, Soren Dalsgaard, for their support during this process. Design and layout were done by Roberto Cenciarelli; Roberta Mitchell, Rebecca Obstler and Esther Phillips gave their support in the final editing and publishing of this work.

Acronyms

CDM	Clean Development Mechanism
COP	Conference of the Parties (to the UNFCCC)
GHG	Greenhouse gas
GPG	Good practice guidance
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land-use change and forestry
NAFORMA	National Forestry Resources Monitoring and Assessment
QA	Quality assurance
QC	Quality control
REDD	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

The Intergovernmental Panel on Climate Change (IPCC) good practice guidance (GPG) defines five carbon pools that need to be monitored and reported as part of greenhouse gas (GHG) inventories, namely: above-ground biomass, below-ground biomass, litter, dead wood and soil carbon. Litter and soil are important carbon stocks. According to global assessments, soils contain two to three times as much carbon as the biomass or the atmosphere. As a result of the large carbon stock and active exchange of carbon dioxide with the atmosphere, soil can act as a major source of GHGs contributing to global climate change if carbon is released from soil to the atmosphere. Deforestation, forest degradation or changes in land management practices can cause releases of carbon from soil to the atmosphere. For these reasons, reliable estimates of soil organic carbon stock and stock changes are needed for REDD+ (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) and GHG reporting under the United Nations Framework Convention on Climate Change (UNFCCC).

There are two principal approaches for estimating the stock and the stock changes of soil organic carbon, namely repeated soil surveys and modelling. A soil survey provides both an estimate of the stock of soil organic carbon when conducted for the first time and an estimate of the stock change when repeated. Dynamic soil carbon models provide an alternative for obtaining soil organic carbon estimates. Application and testing of soil carbon models typically require information about the amount and quality of litter input to the soil, the amount of carbon in different soils and the changes in the amount of soil carbon over time. Both approaches can form part of a national GHG inventory, and may be linked to national biomass inventories.

The objective of this report is to describe the application of survey- and modelling-based methods for monitoring soil organic carbon stock and its changes on a national scale. Examples of applying the methods are demonstrated in the United Republic of Tanzania, which represents a developing country in the tropics. The report presents i) a design of the first inventory of soil organic carbon, including discussion on factors that affect the reliability of carbon stock estimates; and ii) a design of a modelling-based approach, including links to national forest inventory data and discussion on alternative soil organic carbon models.