CARBON SEQUESTRATION POTENTIAL IN COMMUNITY MANAGED FORESTS IN MAHOTTARI DISTRICT OF CENTRAL NEPAL

A THESIS SUBMITTED TO THE
CENTRAL DEPARTMENT OF BOTANY
INSTITUTE OF SCIENCE AND TECHNOLOGY
TRIBHUVAN UNIVERSITY
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FOR THE AWARD OF
DOCTOR OF PHILOSOPHY
IN BOTANY

BY
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JANUARY, 2015

LETTER OF RECOMMENDATION

This is to recommend that Ram Asheshwar Mandal has carried out research entitled **"Carbon Sequestration Potential in Community Managed Forests in Mahottari District of Central Nepal"** for the award of Doctor of Philosophy (Ph.D.) in Botany under our supervision. To our knowledge, this work has not been submitted for any other degree.

He has fulfilled all the requirements laid down by the Institute of Science and Technology (IOST), Tribhuvan University, Kirtipur for the submission of the thesis for the award of Ph.D. degree.

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LETTER OF APPROVAL

On the recommendation of Prof. Dr Siddhi Bir Karmacharya and Ishwar Chandra Dutta of supervisor and co-supervisor of this Ph. D. thesis submitted by Ram Asheshwar Mandal**,** entitled **"Carbon Sequestration Potential in Community Managed Forests in Mahottari District of Central Nepal"** is forwarded by Central Department Research Committee (CDRC) to the Dean, IOST, T.U.

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DECLARATION

Thesis entitled **"Carbon Sequestration Potential in Community Managed Forests in Mahottari District of Central Nepal"** which is being submitted to the Central Department of Botany, Institute of Science and Technology (IOST), Tribhuvan University, Nepal for the award of the degree of Doctor of Philosophy (Ph.D.), is a research work carried out by me under the supervision of Prof. Dr Siddhi Bir Karmacharya, Department of Botany, Trichandra College, Tribhuvan University and co supervised by Prof. Dr Ishwar Chandra Dutta, Chairman of Tribhuwan University Service Commission, Kathmandu, Nepal.

This research is original and has not been submitted earlier in part or full in this or any other form to any university or institute, here or elsewhere, for the award of any degree.

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Ram Asheshwar Mandal

January, 2015

Letter of Approval

(Next File to Print in Letter Head)

DEDICATION

This thesis is dedicated to my parents for their love and affection

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Ram Asheshwar Mandal

ABSTRACT

Forest carbon sequestration plays a significant role in mitigation and adaptation to the impacts of the climate change. The carbon sequestration is accounted as carbon credit for reducing emission from deforestation and forest degradation (REDD+) programme. On the other hand, increasing concentration of CO_2 emission contributes to green house gases (GHGs), which are mainly responsible for global warming and consequence is impacts of climate change. These, both need intensive scientific records to assess them, the former needs the records of carbon stock change while the latter one needs the record of sources of GHGs emission particularly the CO_2 and CH_4 emission. Such researches are very limited in Nepal. Thus, this study is objectively carried out to assess the specieswise Importance value index (IVI) and carbon stock; to assess the carbon stock in community managed forests; to identify the carbon sequestration potential and confrontation for carbon trade; to evaluate the carbon stocks for sustainable management of forests; to appraise the plant biodiversity status and its relationship with the forest carbon stock; to identify drivers of deforestation and forest degradation and its effects on carbon stocks in community managed forests and to quantify the CO_2 and CH_4 emission from domestic fuel and livestock keeping of household living near to forest and distant from the forests.

For this study, two types of data specifically biophysical and socio-economic data were collected. The biophysical data were collected from community managed forests like three from each collaborative and community forests as well as public plantations and community planted forests of Mahottari district. In addition, socio-economic data collection was focused on drivers of deforestation and forest degradation, which were collected from workshop with key informants. Meanwhile, Sahodawa and Maisthan villages were selected for assessing the CO_2 and CH_4 emission from fuel consumption and cattle keeping respectively, which are sources of climate change process drivers. The maps of forest areas were prepared and stratified using GPS coordinates. Latter, altogether 96, 80, 28 and 24 permanent sample plots were distributed randomly on the maps of collaborative forests, community forests, public plantations and community planted forests respectively. The randomized block design (RBD) was set so the data were collected using stratified random sampling from collaborative and community forests. Meanwhile, the complete random design (CRD) was set to gather data applying simple random sampling from public and community planted forests. Similarly, altogether 138 households were sampled randomly after well-being ranking such as rich, medium and poor, then the quantity of fuel consumption was recorded in the morning and evening for seven days during summer and winter seasons setting RBD. Next, the record of cattle keeping was noted in order to determine the CH_4 and CO_2 emissions. At the same time list of drivers of deforestation and forest degradation were also gathered. The biophysical data were analyzed using the biomass equation of Chave *et al.* The species wise IVI was also calculated and their ranking was evaluated

to know the effect of carbon on IVI. Same biophysical data were used to find out the relationship between biodiversity and forest carbon. Moreover, soil carbon was calculated applying Walkley and Black Method. Meanwhile, the carbon stocks of community forests and collaborative forests were checked applying Biolley's "Check Method" - Method du-Control and Biolley's sustainable principle. Additionally, the relationships were evaluated between carbon stocks and species richness and between carbon stocks and Simpson's evenness. The socio-economic data were analyzed using descriptive analysis.

It showed that, IVI of *Shorea robusta* was the highest about 68.59 in Tuteshwarnath CFM while this value of *Gmelina arborea* was the lowest 0.4 in Gadhanta- Bardibash CFM. Meanwhile, the carbon stock of *Shorea robusta* was the highest 50.43±0.43 t ha^{-1} and this of *Desmodium oojeinense* was the lowest 0.01 t ha^{-1} in Gadhanta-Bardibash CFM. In addition, there was effect of carbon stock in species ranking. It was found that the estimated carbon stock was the highest 274.67 t ha^{-1} in Gadhanta-Bardibash CFM while it was the lowest in 30.34 t ha^{-1} in Bisbitty public plantation. The estimated current annual carbon increment (CACI) was found to be highest 2.85 t ha^{-1} at third year in Chyandanda community forest. However, annual carbon loss (ACL) was recorded as leakage -1.68 t ha^{-1} from Banke- Maraha CFM. The net value of carbon sequestration potential was US$ 5967.62. Therefore, these community managed forests can be avenue for carbon trade under the REDD+ programme. Neither community forests nor collaborative forest showed sustainability performance based on Biolley's "Check Method" - Method du-Control and Biolley's sustainable principle. Here, the issues of sustainable forest management and biodiversity should be balanced equally. The estimated R^2 values indicated that there is very weak relationship between species richness and carbon stock, however, the hump- shaped relationship was exist between them. The over exploitation, grazing and forest fire were major drivers of deforestation and forest degradation, which are affecting the carbon stock. Total quantities of CO_2 emission were 4792.25 t and 9235.68 t in Maisthan and Sahodawa villages respectively from firewood consumption. The CH_4 emissions were 160.58 and 157.66 t yr^{-1} in Maisthan and in Sahodawa villages respectively from the livestock keeping, which together may emit 7367.59 t CO_2 equivalents but managing the CH_4 emission through biogas can offer US$ 47568.35 certified emission reduction. Therefore, it can be concluded that community managed forests are potential for carbon trade. On the other it is essential to determine the drivers of deforestation and forest degradation to address them for REDD+ programme in Nepal as well as to determine the sources of CO_2 and CH_4 clearly to reduce them as measures of climate change adaptation and mitigation.

Keywords: Carbon sequestration, CO_2 and CH_4 emission, REDD+, biodiversity, community forests, collaborative forests, public plantation, community planted forest.

TABLE OF CONTENTS

Page No.

LIST OF TABLES

Page No.

LIST OF FIGURES

Page No.

LIST OF ACRONYMS AND ABBREVIATION

ACL	Annual Carbon Loss
ACOFUN	Association of Collaborative Forest Users, Nepal
ANSAB	Asia Network for Sustainable Agriculture and Bioresources
BISEP-ST	Biodiversity Sector Programme for Siwalik and Tarai
CACI	Current Annual Carbon Increment
CER	Certified emission reduction
CFM	Collaborative Forest Management
CFs	Community Forests
CFUGs	Community Forest Users Groups
COP	Conference of Parties
CPF	Community planted forests
DBH	Diamter at Breast Height
DFCC	District Forest Coordination Committee
DFOs	District Forest Officers
DFRS	Department of Forest Research and Survey
DNPWC	Department of National Park and Wildlife Conservation
DoF	Department of Forests
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization of United Nations
FCPF	Forest Carbon Partnership Facility
FECOFUN	Federation of Community Forest Users, Nepal
FRA	Forest Resource Assessment
GHGs	Green House Gases
GIS	Geographical Information System
GO	Governmental Organization
GPS	Geographical Positioning System
HDI	Human Development Index
HR	Human Resource
HSD	Honesty Significant Difference
ICIMOD	International Center for Integrated Mountain Development
IEE	Initial Environmental Examination
INGO	International Non-governmental Organization
IoF	Institute of Forestry

LHG	Litter, Herbs and Grass
LRMP	Land Resource Mapping Project
MACI	Mean Annual Carbon Increment
MEA	Millennium Ecosystem Assessment
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoFSC	Ministry of Forests and Soil Conservation
MRV	Monitoring, Reporting and Verification
NEFIN	Nepal Federation of Indigenous Nationalities
NFA	Nepal Foresters' Association
NFI	National Forest Inventory
NGOs	Non-governmental Organizations
NORAD	Norwegian Agency for Development Cooperation
NRM	Natural Resource Management
NRs	Nepali Rupees
NSCFP	Nepal Swiss Community Forestry Project
NTFPs	Non-Timber Forest Products
PP	Public plantation
REDD	Reducing Emissions from Deforestation and Forest Degradation
REL	Reference Emission Level
RL	Reference Level
R-PP	Readiness Preparation Proposal
RS	Remote Sensing
RWG	REDD Working Group
SDC	Swiss Development Cooperation
SES	Social and Environmntal Standard
SESA	Strategic Environmental and Social Assessment
TAL	Tarai Arc Landscape
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations REDD
USAID	United States Assistance for International Development
VDC	Village Development Committee
WB	The World Bank
WWF	World Wildlife Fund