ABOVE-GROUND BOLE CARBON STOCK ESTIMATION USING FOREST INVENTORY AND REMOTE SENSING OF THE SECONDARY FOREST ECOSYSTEM IN IBADAN, NIGERIA

BY

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ABSTRACT

Secondary forest ecosystem contributes to global climate change mitigation through carbon sequestration. Above-Ground Bole Biomass (AGBB) is the major component for monitoring and estimating Carbon Stocks (CS) and fluxes in tropical forests. Integrating Remote Sensing (RS) with Forest Inventory (FI) techniques had also been reported to provide accurate estimation of Above Ground Bole Carbon Stock (AGBCS). However, information on AGBCS for the International Institute of Tropical Agriculture (IITA), which hosts relics of the undisturbed secondary forest ecosystem in south-western Nigeria, has not been documented. Therefore, AGBCS of the secondary forest ecosystem was estimated using remote sensing and forest inventory techniques.

Forest inventory and remote sensing data were used for this study. One hundred and forty plots of 50m x 50m were laid in IITA secondary forest using systematic sampling technique at 10% sampling intensity. Trees in each plot were enumerated and identified to species level. The Total Height (TH) and Diameter at Breast Height (DBH) of trees ≥10 cm were measured to determine Tree Volume (TV). Sixty wood core samples were randomly collected from dominant trees species at breast height for Wood Density (WD) estimation. The TV and WD were used to determine AGBB, which were converted to CS using standard forest inventory method. Pleiades satellite imagery was acquired using RS technique and spectral data for each sample plot extracted. The spectral indices used for AGBB estimation were: Normalised Difference Vegetation Index (NDVI), Difference Vegetation Index (DVI), Infrared Percentage Vegetation Index (IPVI), Optimised Soil Adjusted Vegetation Index (OSAVI) and Renormalised Difference Vegetation Index (RDVI). The RS data were integrated with FI data to develop regression equations for the prediction of AGBB from where the total CS estimate was obtained. Data were analysed using descriptive statistics and linear regression analysis at $\alpha_{0.05}$.

A total of 9,985 individual trees comprising 121 tree species and 30 families were recorded. The highest and least frequency of species recorded were *Funtumia elastica* (61/ha) and *Cordia alliodora* (1/ha) respectively. The TH and DBH ranged from 4.70 to 39.30 m and 10.76 to 74.50 cm, respectively, while TV ranged from 129.57 to 167,186 m^3/ha. The WD of tree species ranged from 0.23 to 0.89 kg/cm^3. The AGBB and CS ranged from 101.06 to 881,834.92 kg/ha and 50.53 to 440,917.46 kg/ha, respectively. The DVI had the highest AGBB value which ranged from 187 to 15,577 kg/ha, followed by IPVI, RDVI and OSAVI which ranged from 7,561 to 12,324 kg/ha, 64.0591 to 133.178 kg/ha, 0.0134 to 0.5621 kg/ha, respectively, while NDVI had the least values which ranged from -0.01 to 0.48 kg/ha. The best AGBB estimation model was AGBB = $exp(3,496.61 + 0.99 \times (RDVI)^{1/2})$; (Coefficient of Determination = 0.93, Bayesian Information = 2129.34). The total carbon stock ranged from 11,035 to 18,774 kg/ha.

Model with renormalised difference vegetation index was most suitable among other indices for estimating above-ground bole carbon stock when integrated with forest inventory data. Therefore, effective integration of different sensor data will be an important research topic for improving above-ground bole biomass estimation performance.

Keywords: Carbon stock prediction; Secondary forest biomass; Vegetation spectral indices; Remote sensing

Word Count: 500

DEDICATION

This research work is dedicated to almighty God for his guidance, strength, divine favour, divine grace and love endowed on me towards the successful completion of this Ph.D. research thesis.

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CERTIFICATION

I hereby certify that this research thesis was carried out by EHIMWENMA VICTOR AGHIMIEN at the Department of Forest Resources Management, Forest Biometric and Remote Sensing Unit, Faculty of Agriculture and Forestry, University of Ibadan, Ibadan, Oyo State, Nigeria

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LIST OF ACRONYMS USED IN THE THESIS

AGBC	Above-ground Bole Carbon
AGB	Above-ground Biomass
BA	Basal Area
BGB	Below-ground Biomass
C	Carbon
CO_2	Carbon Dioxide
CAVIS	Clouds, Aerosols, Water Vapour, Ice and Snow
CM	Centimetre
D	Diameter
DBH	Diameter at Breast Height
DVI	Difference Vegetation Index
EVI	Enhanced Vegetation Index
FAO	Food and Agriculture Organisation
G	Grams
GEMI	Global Environmental Monitoring Index
GHGs	Greenhouse Gases
GIS	Geographical Information Systems
GPS	Global Positioning System
Gt	Giga-tonnes (10^{-9})
H	Total Height
ha	Hectare
IITA	International Institute of Tropical Agriculture
IPCC	Intergovernmental Panel on Climate Change
IR	Infra-Red
KG	Kilogram
L	Length
M	Metre
MM	Millimetre
NDVI	Normalized Difference Vegetation Index
NIR	Near-Infra-Red
^oC	Degree Census
RB	Reading at the Base
REDD	Reducing Emissions from Deforestation and Forest Degradation
RS	Remote Sensing
RT	Reading at the Top
IPVI	Infrared Percentage Vegetation Index
OSAVI	Optimized Soil-Adjusted Vegetation Index
UNFCCC	United Nations Framework Convention on Climate Change
UTM	Universal Transverse Mercator
TSP	Temporary Sample Plot
VNIR	Visible, Near-Infra-Red
WSG	Wood Specific Gravity
WD	Wood Density
Π	Pi
AGBB	Above-Ground Bole Biomass
P	Pleiades

AOI	Automated Optical Inspection
SFE	Secondary Forest Ecosystem
DN	Digital Number
LULC	Land –Use and Land-Cover
NPV	Non-photosynthetic Vegetation
K-NN	K-Nearest Neighbor
ANN	Artificial Neural Network
SVM	Support Vector Machine
PLS	Partial Least Squares
WWF	World Wide Fund
SFE	Secondary Forest Ecosystem
DAIS	Digital Airborne Imagery Spectrometer
AVHRR	Advance Very High Resolution Radiometer
U	Wind Speed
T_a	Air Temperature
FPAR	Fractional Photo-synthetically Active Radiation
SMA	Spectral Mixture Analysis
TCT	Tasseled Cap Transform
ALS	Airborne Laser Scanning
WIFS	Wide Field Sensor
r_{an}	Aerodynamic Resistance
C/N	Carbon-Nitrogen
GLCM	Gray Level Co-occurrence Matrix
DPI	Dots per inch
PPI	Pixels per inch

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