e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:03/Issue:09/September-2021 Impact Factor- 6.752 www.irjmets.com

A REVIEW OF RECENT ADVANCEMENT IN USING GEO-SPATIAL METHODS TO ESTIMATE ABOVE GROUND BIOMASS PRODUCTION AND CARBON SEQUESTRATION IN SUB-SAHARA AFRICA

Kamal Murtala Farouq[*1]

[*1]Faculty Of Agricultural Sciences, Vivekananda Global University; Jaipur (Rajasthan) India.

ABSTRACT

Terrestrial carbon stock and above ground biomass production can be estimated easily by integrating remote sensing and geographical information system which is cost effective and timely wise across wide region. However, this research has mostly done in developed countries but incorporation of this approach in Sub-Sahara Africa is limited base on the literature reviewed and as such the quantitative data on Above Ground Biomass, carbon sequestration is still a problem. The Review emphasizes the need for more research to fill in the gaps and overcome the limits of these new carbon management approaches, looks at standard methodologies and shows where they fall short. It's also explained carbon credit, geo-engineering merits and demerits towards its significant to global warming which was also a suggestion for this review, it's also examines a variety of remote sensing-related strategies utilized in carbon stock evaluation, Finally secondary data from Elsiveir; MDPI; Springer; Google Scholar has been used for the review.

Keywords: Carbon Sequestration; Biomass; Geo-Engineering, Geo-Spatial; Sub-Saharan Africa.

I. INTRODUCTION

Sub-Saharan Africa comprises southern countries [1]. While Sudan is excluded by the United Nations geo-scheme, although members of the Arab League are also regarded geographically part of sub-Saharan Africa [2]. However; Late professor Herbert Ekwe-Ekwe has challenged the term "sub-Saharan as a racist word since the geographical conference believe the phrase "inferiority's linguistic condo" to be a sub specific prefix, which they claim to be a linguistic remnant of European colonialism [2]

However, Carbon sequestration is the process by which plants absorb CO2 from the environment and store in its biomass [3], it has been stated clearly by [4] Unbalanced utilization of fertilizers, cessation of traditional methods such as fossil-fuel burning, cultivation residue, excessive tillage and pudding for rice farming are the causes of climate change. It is highlighted that short rotation forestry and agroforestry have the ability to promote climatic and economic advantages, and they are regarded as the best "no regrets" strategies for helping communities adapt and become resilient to climate change consequences.[5]

However, current global greenhouse gas (GHG) emissions are expected to be 10 Pg (Pg = Petagram, 1 Pg=1015 68 69 g) carbon (C) Per year with India ranked to be third prior to China and USA [6]. According to the Integrated Biosphere Simulator model (IBIS), in the A2 (740 ppm CO2) scenario, 39% of forest grids in India would see plant type change, while 34% will not. By the end of the century, the B2 scenario (575 ppm CO2) will have been realized. In many cases, States with a lot of trees, are expected to undergo transformation [7].

It is has been noticed that Trees, seas, soil, and living organic substances all play a role in carbon sequestration [8]. Furthermore; Forest biomass stores the majority of carbon sequestered on land [9]. The total quantity of aboveground living organic matter in trees represented as oven-dry tonnes per unit area is a measure of forest biomass [10]. Estimating biomass is a difficult undertaking, particularly in developing nations. However, "despite their significance to society and extreme susceptibility to climate change", sub-Saharan African regions, particularly dry regions, have received less attention in recent decades. More than two billion people rely on their ecosystem services, which include major agricultural production and fodder for wildlife and domestic cattle [11].

Monitoring carbon has been recognized by The Paris Agreement, which was signed by 197 countries and approved by 189 countries [12]. Forests can help overcome global climate change by acting as both carbon sources and sinks [13]. Carbon credit can be obtain as a results of land use planning project which converts it to forest and helps in greenhouse gas reduction [14].

Natural resource management and biomass evaluation have recently been subjected to geospatial technology processes [15]. Remote sensing can collect biomass data from a vast area [16]. Numerous researches have explored and tested various techniques and sensors so far example as radar and many more. Finally secondary from Elsiveir; IEEE; Springer; Google Scholar; SAGE; Web science, Taylor and Francis, has been used for the review.

1.1 IMPACT OF CARBON CREDIT

A carbon credit is one metric tonne of carbon released by the combustion of fossil fuels, as specified by the Kyoto Protocol. Companies are given a set amount of "credits" that they can utilize over time. If a corporation is given 10 credits and only uses 10 of them, it can sell the remaining credits on the market. Carbon credits help underdeveloped countries achieve sustainable development while also lowering the expenses of industrialized countries reaching their emission reduction goals.

Table 1: Global warming potential: 25,000 times that of Co2 (19)

Country	Change in Green house 2»s Emissions (1992-2008)
India	+ 124%
China	+ 167%
United States	+ 17%
Russian Federation	-23%
Japan	+9%
Worldwide Total	+42%

1.2 Advantage and Disadvantage of Geo-Engineering towards Global Warming

In February 2009, 313 silver iodide sticks were launched into the skies over Beijing by a regional meteorological department in northeastern China. The initiative, which was intended to address the country's worst drought in over four decades, resulted in heavy snowfall and the shutdown of 12 motorways [17]. Scientists and policymakers have looked at new strategies to lower greenhouse gas (GHG) concentrations in the atmosphere and reduce their impact on the climate as climate change [18]. Geoengineering is a wide concept that covers a variety of technologies that may be divided into two categories: Management of CDR and solar radiation [19]. CDR technologies attempt to remove carbon dioxide from the atmosphere, thus producing "negative emissions," in order to reduce greenhouse gas concentrations in the atmosphere and minimize global warming. SRM methods attempt to reflect incoming sunlight away from the Earth using clouds or other reflective materials, minimizing atmospheric warming. Many climate experts see both forms of geoengineering as a possible diversion of resources away from emissions-reduction efforts [20].

Table 2: Carbon dioxide removal technology [21].

Geoengineering technology	Technical Readness	Cost Magnitude (in U.S dollars)	Time scale	Secondary Effects
Large-scale reforestation or afforestation focuses on conserving forests and jungles,as well as large –scale planting of non-forested areas	High	\$100 billion (for 1 gigationof carbon {GTC^a]	Decades	Increase fertilization and irrigation risk water pollution, nutrein runoff, and depletion of fresh water, microclimate alterations; unequal land –use burden on well- forested areas, likely developing countreis
Bioenergy with	Medium	Trillion (for	About a decade	Emit Co$_2$ via

carbon capture and storage captures Co_2 released from bioenergy applications(e.g., biofuels, biomass burning) and store in geological formations underground		100Gtc)		bioenergy processes and Co_2 capture; land-rightsconflict from higher demand for agricultural land ad fertilization; microseismicity; disposal of captured CO_2 is a concern
Direct air capture pulls CO_2 out of the air via chemical or electrochemical means	Medium	Trillion (for 100Gtc)	About a decade	Scaling up process requires large amounts of energy and water; threats of toxicity of chemicals; disposal of captured CO_2 is a concern
Ocean iron fertilization adds iron into the ocean to increase phytoplankton, which store CO_2 from the atmosphere	Low /medium	10 billion (for 100GtC)	1-5 years	Surface cooling and/or sea surface temperature increase; ozone depletion; potentially produce other GHGs, such as nitrogen oxide (NOx); ecosystem distruption with ocean acidification, algal blooms, and ocean oxygen depletion; causing loss if ocean life

II. GEOPOLITICAL RISKS OF GEOENGINEERING

Importantly, the development and execution of geoengineering is an issue of geopolitics as well as scientific and engineering progress. International geopolitical factors, as well as state-level internal political dynamics, have a considerable impact on how countries respond to climate change, including how they perceive geoengineering [22]. According to experts, these responses might potentially lead to international tensions, conflict, and eventually war [23].

III. TRADITIONAL METHOD OF ESTIMATING CARBON SEQUESTRATION

There are two approaches for assessing carbon sequestration from plants: destructive and non-destructive. The Allometric equation, remote sensing, and GIS are examples of non-destructive approaches. However, combining RS and GIS is the best method for estimating carbon sequestration. Meanwhile, the destructive method produces correct results, but it is time-consuming, cost, deforestation and causes calamities such as global warming [24].

3.1 ALLOMETRIC EQUATION

The "Allometric equation is a statistical model for estimating the biomass of trees based on their biometrical features (e.g., height, DBH, or crown size), which are straightforward to quantify" [25]. Model selection [26] determines the amount of accuracy. Therefore No any number of trees has been authorized to destruct in allometric equation construction[27].14 and 15 trees has been utilized by Russell [28] and Deans et al.[29], "while Brown et al. [30] and Khalid et al. [31], utilized just 8 and 10 trees to make Allometric" equation, study shown that Allometric equations with a small sample size (10) are biased [32]. Furthermore, for diverse plant species, several Allometric equations have been constructed. The GlobeAllomeTree database, for example, comprises over "706 equations from Europe, 2843 equations from North America, and 1058 equations from Africa " [33].

IV. GEO-SPATIAL APPROACH FOR ESTIMATING ABOVE GROUND BIOMASS

Above ground biomass and structure of vegetation are collected using remote sensing on a broad scale [34]. But spectral similarities make some plants indistinguishable therefore High spectral resolution (e.g., hyperspectral) should be considered since it aids in the resolution of such inconsistencies and improves the quality of the maps produced [35].

Table 3: Remote sensing optical commonly used for Above ground biomass estimation [8].

Sensor	Type	Band	Spatial resolution(m)	Temporal resolution	Swath (km)	Cost
AVHRR	Multispectral	**5 bands (RedIR, AND 3 Thermal IR)**	**1100**	**12hr**	**2500**	**Free**
MODIS	Multispectral	**36 bands (from blue to Thermal IR)**	**250,500 and 1000**	**1-2 days**	**2330**	**Free**
SPOT VEG	Multispectral	**4 Band s(blue, red and SWIR)**	**100**	**1 day**	**2250**	**Free**
TM	Multispectral	**7 bands (3 VIS, 3IR and Thermal IR)**	**30 and 120**	**16 days**	**185**	**Free**
ETM+	Multispectral	**9 bands (3VIS, 3IR and 2 Thermal IR and 1PAN)**	**15, 30and 60**	**26 days**	**60**	**Free**
SPOT	Multispectral	**4 BANDS (2vis, 1 NIR and 1 PAN)**	**5,10 and 20**	**16 days**	**60**	**Commercial**
Landsat 8 OLI	Multispectral	**11 bands (1 Ultra, 3 VIS, 3 IR, 1 Cirrus, 2 Thermal IR, AND 1**	**15, 30 and 100**	**5-24 days**	**185**	**Free**

		PAN)				
LISS-111(IRS)	Multispectral	**5 bands (2 VIS, 2 IR, and 1 PAN)**	**53,23 and 50**	**5-10 days**	**142**	**Commercial**
Sentinel-2	Multispectral	**13 bands (4 VIS,6 NIR 3 SWIR)**	**10, 20 and 60**	**3 days**	**290**	**Free**
IKONOS	Multispectral	**5 bands (3 VIS, 1 , IR and 1 PAN)**	**1 and 4**	**3 days**	**11**	**Commercial**
World View2	Multispectral	**9 bands (6 VIS,2 IR, 1 PAN**	**1.84 and 0.46**	**3 days**	**16**	**commercial**
Quickbrd	Multispectral	**5 band (4 bands and 1 pan)**	**0.61 and 2.44**	**Airborne**	**16**	**commercial**
HyMap	Hyperspectral	**126 bands**	**2-10**	**Airborne**	**2.3and 4.6**	**commercial**
AVIRIS	Hyperspectral	**224 bands (from VIS to MIR)**	**2.5 to 20**		**1.9 and 11**	**commercial**

4.1 REMOTE SENSING-BASED METHODS

Varied methodologies and sensors have been adopted and tested in multiple researches to investigate the possibility of remote sensor -based technologies to give information of biomass in various situations. A number of approaches have been performed to measure AGB using optical, RADAR, and LiDAR data [36]. AGB research utilizing geospatial technology may be classified into multiple categories based on the amount of methodological complexity, with varying levels of depth and accuracy. However, vegetation indices (VIs), can enhance biomass forecast accuracy [37]. The "advanced machine learning algorithms methods and/or other state-of-the-art processing techniques can reveal important information about the spatial and temporal biomass patterns by determining relationships between field measurements and RS data, especially over large areas" [38]. Combining remote sensing and geostatistics in biomass estimation is the fit model compared to stepwise linear regression model [39].

It is important to note that biophysical predictors such as diameter at breast height, total height, crown diameter are use to estimate biomass [40]. .

V. REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM INTEGRATION APPROACH (RS-GIS)

Spatial data analysis and map production can be utilized using remote sensing – geographical information system integration, this help to get accurate and efficient results RS data are utilized [41]. Geospatial modeling is a promising tool for studying the current status of carbon sequestration and its future dynamics; it has the potential to solve ecological assessment difficulties. Furthermore, as previously indicated, integrating RS data into GIS models allows for the inclusion of supplementary and field data (soil, climate, topography, etc.) in the analysis, boosDifferent GIS-based AGB estimate techniques, for example, incorporate additional data models including "digital terrain models (DTM), rainfall models, canopy height models, forest and regression scattering models" [42]. Landsat data has been effectively improved using remote sensing approach [43]. The results suggest that combining RS and spatial analysis capabilities in a GIS may boost total classification accuracy from 50.12% to 74.38 percent [44]. Furthermore, the use of multiple sensors and GIS-based models is becoming more widespread, with 12.3 percent and 12.8 percent of the examined research, respectively.

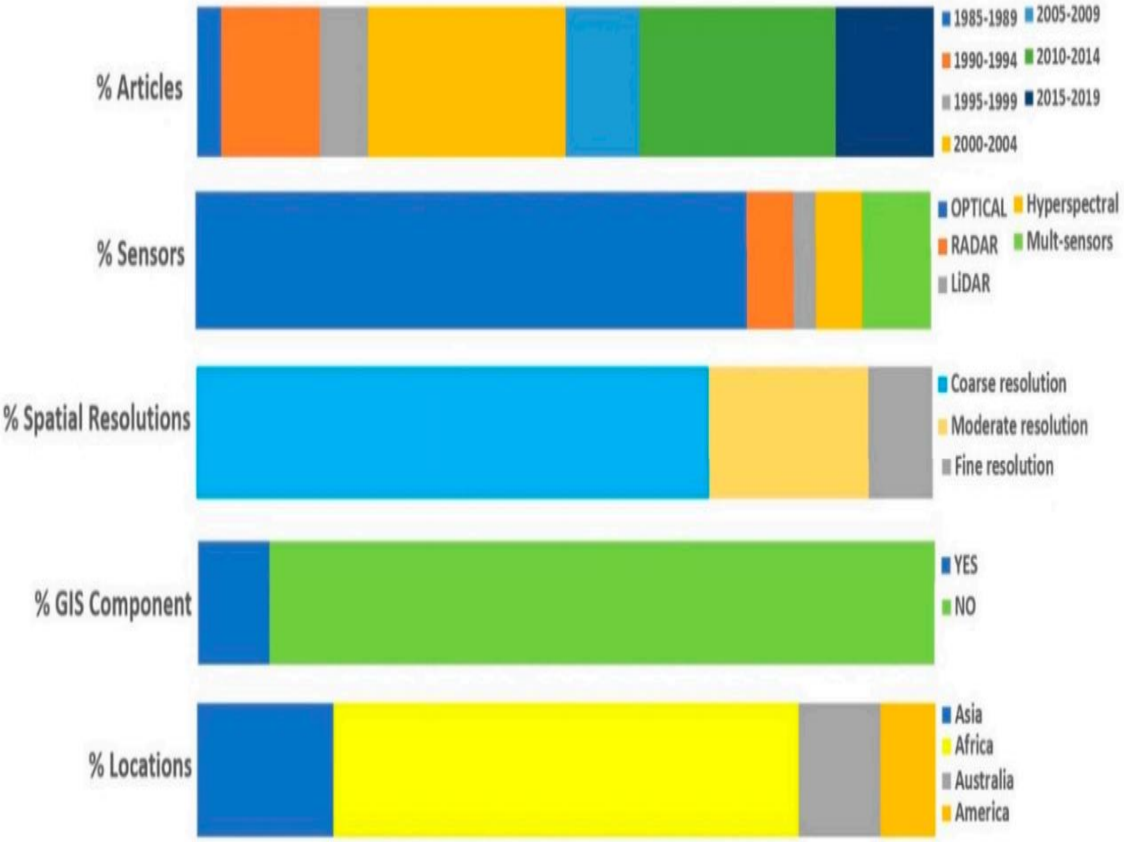

Figure1: Geo-spatial technology for estimating AGB in arid and semi-arid last (two-decades)

VI. GEOSPATIAL METHODS: VALUES, GAPS, LIMITATIONS, AND ACCURACY

Remote sensing has proven to be efficient in terms of time and money saving, but it cannot achieve its goal without more field and data measurements [13]. However, when using remote sensing in the research the amount of fieldwork required is directly reduced. This should not lead to the abandoning of traditional AGB estimation approaches, but rather to the application of geospatial technology advantages to accelerate and improve current procedures s through process integration and modeling [45]. Geospatial technology can be a modern replacement to earlier AGB prediction approaches and will continue to be developed but have limits and drawbacks in terms of cost, availability of the technology more especially in sub Saharan Africa and technical know-how.

LIMITATIONS OF GEO-SPATIAL METHODS FOR ESTIMATING ABOVE GROUND BIOMASS

Costs and management of the machines such as (drones and computers) are obstacles to this approach, access to learn this technology is too expensive and the expertise to this technology should update themselves regularly because RS and GIS are recent advancement.

VII. CONCLUSION

Geospatial technology is a modern replacement to earlier AGB prediction method and will be continue to develop and limit ecosystem destruction. Moreover, the types of equipment and platforms that are used to assess carbon inventories remotely and regularly across wide areas differ significantly. Yet, these issues might be overcome and addressed via a choice of sensor alternatives as well as other novel ways, reducing the restrictions that come with size, cost, and related mistakes and uncertainties. Furthermore, the most accurate RS data is high-resolution RS data, but access to learn this technology is too expensive and the expertise to the technology should update themselves regularly because the technology is newly introduced. Land sat as a moderate –resolution proven to give accuracy in calculating AGB and carbon stock. Based on the overall reviewed field measurement, RS-GIS give best possible.

AKNOWLEDGEMENT

I am grateful to Vivekananda Global University, Jaipur; Rajasthan; Particularly Dr.V. Kumar.

VIII. REFERENCES

[1] "definition @ web.archive.org," Internet archive wayback machine, 2021. https://web.archive.org/web/20100420040243/http://esa.un.org/unpp/definition.html.

[2] "What exactly does ' Sub sahara Africa'mean," Pambazuca News, 2012.

[3] A. Dao, B. André, S. Traoré, and F. Bognounou, "Using allometric models to estimate aboveground biomass and predict carbon stocks of mango (Mangifera indica L .) parklands in the Sudanian zone of Burkina Faso," Environ. Challenges, vol. 3, no. December 2020, p. 100051, 2021, doi: 10.1016/j.envc.2021.100051.

[4] V. Kumar, "A monthly open access e-," no. June, 2015, doi: 10.13140/RG.2.1.5171.6881.

[5] C. Paper, A. Mani, and T. Czech, "Potential of Short Rotation Forestry and Agroforestry for Climate Change Mitigation and Sustainability," Agrofor. Clim. Resil. Rural Livelihood, no. January 2017, 2016.

[6] A. J. N. Jitendra Ahirwal, Amitabha Nath, Bipal Brshma, Sourabh Deb, Uttam Kmar Sahoo, "Patterns and driving factors of biomass carbon and soil organic carbon stock in the Indian Himalayan region," 2021.

[7] M. Manjunatha, V. kumar, and A. V Santhoshkumar, "Modeling Potential Climate Change Impacts With Special Reference To Indian Forests," Int. J. Usuf. Mngt, vol. 16, no. 2, pp. 40–60, 2015.

[8] S. I. 1 and T. K. 2 and N. S. , Basam Dahy 1, "A Review of Terrestrial Carbon Assessment Methods Using Geo-Spatial Technologies with Emphasis on Arid Lands," 2020.

[9] V. Kumar, "Carbon benefits from forest activities," Van Sangyan A monthly open access e-magazine, India, 2016.

[10] S. Brown, "Estimating Biomass and Biomass Change of Tropical Forests," 1997.

[11] B. T. Bestelmeyer et al., "Desertification , land use , and the transformation of global drylands In a nutshell :," no. Safriel 2007, pp. 28–36, 2015, doi: 10.1890/140162.

[12] U. N. the K. Protoco, "Status of Ratification|UNFCCC," 2021. .

[13] D. O. Wondrade N1, 2, * and and T. H1, "Estimating above Ground Biomass and Carbon Stock in the Lake Hawassa Watershed, Ethiopia by Integrating Remote Sensing and Allometric Equations," 2015.

[14] A. G. Soibam Lanabir Singh, Uttam Kumar Sahoo*, Alice Kenye, "Assessment of Growth, Carbon Stock and Sequestration Potential of Oil Palm Plantations in Mizoram, Northeast India," J. Environ. Prot., 2018.

[15] A. Lidar, W. Wannasiri, M. Nagai, K. Honda, and P. Santitamnont, "Extraction of Mangrove Biophysical Parameters Using," pp. 1787–1808, 2013, doi: 10.3390/rs5041787.

[16] D. Lu, "The potential and challenge of remote sensing-based biomass estimation," Int. J. Remote Sens., 2006.

[17] R. Staff, "China's Artificially Induced Snow Closes 12 Highways," 2009.

[18] J. R. Fleming, "The Checkered History of Weather and Climate Control, New York," 2010.

[19] and L. C. Ken Caldeira, Govindasamy Bala, "The Science of Geoengineering," 2013.

[20] Royal Society, "A Review of Climate Geoengineering Proposals," Climatic Change," 2011.

[21] M. Grisé, E. Yonekura, J. S. Blake, D. Desmet, A. N. Garg, and B. Lee, "CLIMATE," no. C.

[22] L. H. n Geoffrey D. Dabelko and B. Schuyler Null, Meaghan Parker, and Russell Sticklor, eds., "'Climate Gambit: Engineering Climate Security Risks?,'" 2013.

[23] Joshua B. Horton and Jesse L. Reynolds, ""The International Politics of Climate Engineering:," 2016.

[24] S. U. Sandhi I. Maulana, Yohannes Wibisono, "DEVELOPMENT OF LOCAL ALLOMETRIC EQUATION TO

ESTIMATE TOTAL ABOVEGROUND BIOMASS IN PAPUA TROPICAL FOREST," Indones. J. For. Res., 2016.

[25] M. Picard, N.; Saint-André, L.; Henry, "Manual for Building Tree Volume and Biomass Allometric Equations," ; FAO, 2012.

[26] H. M. (1) et al., "Allometric models for estimating biomass, carbon and nutrient stock in the Sal zone of Bangladesh," i For. Biogeosceinces For., 2018.

[27] J. Qi, T. Fung, and A. D. Ziegler, "Forest Ecology and Management Review of allometric equations for major land covers in SE Asia : Uncertainty and implications for above- and below-ground carbon estimates," For. Ecol. Manage., vol. 360, pp. 323–340, 2016, doi: 10.1016/j.foreco.2015.09.016.

[28] C. T. P. pdf. E. Russell, "Nutrient Cycling and Productivity of Native and Plantation Forests at Jari Florestal," 1986.

[29] J. D. Deans, J. Moran, and J. Grace, "Biomass relationships for tree species in regenerating semi-deciduous tropical moist forest in Cameroon," vol. 127, no. 96, 1996.

[30] I. F. Browrpb, L. A. Martinelli, W. W. Thomasd, M. Z. Moreira, C. A. C. Ferreira, and R. A. Victoria, "Uncertainty in the biomass of Amazonian forests : An example from RondGnia , Brazil," vol. 75, no. 94, pp. 175–189, 1995.

[31] J. M. Khalid, H.; Zin, Z.Z.; Anderson, "Quantification of oil palm biomass and nutrient value in a mature plantation," J. Oil Palm Res, pp. 23–32., 1999.

[32] O. R. & R. D. L. Duncanson1, 2, "Small Sample Sizes Yield Biased Allometric Equations in Temperate Forests," 2015.

[33] G. W. Sileshi, "Forest Ecology and Management A critical review of forest biomass estimation models , common mistakes and corrective measures," For. Ecol. Manage., vol. 329, pp. 237–254, 2014, doi: 10.1016/j.foreco.2014.06.026.

[34] E. O. Makinde, A. A. Womiloju, and M. O. Ogundeko, "The geospatial modelling of carbon sequestration in Oluwa Forest , Ondo State , Nigeria," Eur. J. Remote Sens., vol. 50, no. 1, pp. 397–413, 2017, doi: 10.1080/22797254.2017.1341819.

[35] P. S. Thenkabail, N. Stucky, B. W. Griscom, and M. S. Ashton, "International Journal of Remote Biomass estimations and carbon stock calculations in the oil palm plantations of African derived savannas using IKONOS data," no. November 2013, pp. 37–41, 2010, doi: 10.1080/01431160412331291279.

[36] N. Clerici, K. Rubiano, A. Abd-elrahman, J. Manuel, P. Hoestettler, and F. J. Escobedo, "Estimating Aboveground Biomass and Carbon Stocks in Periurban Andean Secondary Forests Using Very High Resolution Imagery," 2016, doi: 10.3390/f7070138.

[37] S. Pandit, S. Tsuyuki, and T. Dube, "Estimating Above-Ground Biomass in Sub-Tropical Buffer Zone Community Forests , Nepal , Using Sentinel 2 Data," 2018, doi: 10.3390/rs10040601.

[38] L. Kumar, "Remote Sensing of Above-Ground Biomass," pp. 1–8, 2017, doi: 10.3390/rs9090935.

[39] P. Taylor, O. Mutanga, and D. Rugege, "International Journal of Remote Integrating remote sensing and spatial statistics to model herbaceous biomass distribution in a tropical savanna," no. November 2014, pp. 37–41, doi: 10.1080/01431160600639735.

[40] K. L. Chong, K. D. Kanniah, C. Pohl, K. P. Tan, and F. Group, "Geo-spatial Information Science A review of remote sensing applications for oil palm studies," Geo-spatial Inf. Sci., vol. 5020, no. June, pp. 1–17, 2017, doi: 10.1080/10095020.2017.1337317.

[41] S. Deng, Y. Shi, Y. Jin, and L. Wang, "A GIS-based approach for quantifying and mapping carbon sink and stock values of forest ecosystem : A case study," Energy Procedia, vol. 5, pp. 1535–1545, 2011, doi: 10.1016/j.egypro.2011.03.263.

[42] C. L. Maynard, R. L. Lawrence, G. A. Nielsen, and G. Decker, "GIScience & Remote Sensing Modeling Vegetation Amount Using Bandwise Regression and Ecological Site Descriptions as an Alternative to Vegetation Indices," no. January 2015, pp. 37–41, doi: 10.2747/1548-1603.44.1.68.

[43] C. Kamusoko and M. Aniya, "International Journal of Remote Hybrid classification of Landsat data and

GIS for land use / cover change analysis of the Bindura district ," no. October 2014, pp. 37–41, doi: 10.1080/01431160802244268.

[44] S. W. Myint, P. Gober, A. Brazel, S. Grossman-clarke, and Q. Weng, "Remote Sensing of Environment Per-pixel vs . object-based classification of urban land cover extraction using high spatial resolution imagery," Remote Sens. Environ., vol. 115, no. 5, pp. 1145–1161, 2011, doi: 10.1016/j.rse.2010.12.017.

[45] B. TSITSI, "Remote sensing of aboveground forest biomass," Trop. Ecol, pp. 125–132., 2016.