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David Suru Aweh,
Yahaya Olotu,
Rasheed Ibrahim,
Linda Ngozi Izah,
Arohunmolase Adeboye John

ASSESSMENT OF DEFORESTATION IMPACTS ON CARBON SEQUESTRATION IN EDO STATE SOUTH SOUTHERN NIGERIA

The stocking and sequestering of increasing atmospheric carbon dioxide (CO_2) and the reduction of greenhouse gas (GHG) emissions that result from improving the carbon sink are two important ways that forested land contributes to the fight against global warming. The purpose of the study is to estimate the rate of carbon sequestration (CS) in Edo State, Nigeria, as well as the volume of deforestation and its impact on CS. To gauge the changes in carbon stock, stock-difference and gain-loss methods were employed. The gain-loss method predicts gains and losses based on off-take and growth rates, while the stock-difference approach uses actual measurements of carbon stocks over a given period of time. These two methods presuppose that changes in carbon stock and CO_2 flows to or from the atmosphere are equal. To quantify the decline of the forest, geographical studies and satellite imagery were used. Comparing the area covered by forest in the same region at two distinct eras allowed researchers to determine the annual rate of change. The outcome showed that tree cover loss (TCL, kg/ha) was decreased in 18 local government regions (LGAs). As a result, throughout the baseline consideration period of 2010 to 2022, Etasko East (EE) and Estako West (ES), Ovia South East (OSW), and Ovia North have had the least loss in tree cover. The increased demand on human survival brought on by the expanding population may provide an explanation for this observation and discovery. As a result of this development, forests underwent transformation and were used to produce food, build cities and homes, and generate energy. The region with the highest rates of tree cover loss and deforestation was associated with the highest CS, which was calculated at 2700 tC/ha at OSW, and the lowest CS value point at 22.2 tC/ha at Oredo Edo (OE). As a result, OSW showed that dense forests had higher biomass carbon storage than grazing land and open forests. In conclusion, the study showed that Edo State has a significant potential for raising the level of carbon sequestration in order for the state to generate a profit from the sale of carbon stock and enhance climate change mitigation efforts.

Keywords: *deforestation, carbon sequestration, tree cover loss, forested land, climate change mitigation, Edo State.*

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1. Introduction

As more national and international organizations, as well as all privately and publicly owned businesses allowed to use these resources, advocate sustainable practices, it is crucial to monitor natural resource stocks around the world [1]. However, in reality, it is frequently challenging to implement laws pertaining to the sustainable use of natural resources at all levels of government as well as by international non-governmental organizations (NGOs) looking to gauge progress and identify offenders. The effective collection of systematic data at appropriate scales, separated into reasonable temporal segments, for a period of sufficient duration, is the first crucial step in any fair-minded environmental assessment strategy. Only then can the phenomenon in question be evaluated effectively and objectively. Due to lax rules, insufficient enforcement resources, and corruption in the face of expanding international markets, Nigeria has battled illegal logging and deforestation for a long time [2, 3].

The primary means of support for many people and a key factor in the economic development of many nations are the forest ecosystems [1]. They are vital natural resources that provide a variety of ecosystem services, like regulating the balance of atmospheric carbon and, thus, preventing climate change [4]. The global carbon cycle benefits greatly from the presence of forests. Depending on the particular management regime and activities, they might operate as generators or sinks of carbon [5]. Forests are important natural carbon sinks that help to store atmospheric carbon in biomass and soil. It is among the most effective strategies for limiting the accumulation of greenhouse gases in the atmosphere. The global cycle of carbon via the environment is significantly influenced by microbes and plants. People receive ecosystem services, which are advantages from ecological processes that are essential to their existence and quality of life. Some of these ecological services include providing food, storing carbon, cycling nutrients, filtering air and water, and reducing floods [1].

Carbon stocking is the capture and storage of carbon that would somehow be produced and kept in the atmosphere or terrestrial systems [2]. Terrestrial systems, especially plants, represent an important carbon store, estimated globally at 638 Gt, of which 44 % is present in plant biomass [2]. Carbon stock varies across forest types. While an average of 303 tons of carbon ha^{-1} is retained in tropical forests, 66 tons of carbon ha^{-1} and 44-ton ha^{-1} are retained in temperate and boreal forests, respectively [6]. Through the process of photosynthesis, growing trees and other flora take in CO_2 from the atmosphere. Plants generate carbohydrates from CO_2 and water using the energy of sunlight. However, in addition to absorbing CO_2 through photosynthesis, forests also release CO_2 as a result of plant respiration and cellular decomposition. Whether an ecosystem is acting as a source or sink of carbon depends on the net balance of CO_2 uptake and release. The largest levels of carbon stock are found in young forests, and as forests mature, they tend to become less abundant. Carbon stock refers to the amount of carbon that is absorbed by growing vegetation and stored in wood, other biomass, and soil organic matter [7]. More carbon is stored and sequestered by forests than any other terrestrial ecosystem, making them an essential natural «brake» on climate change. The stored carbon in forests is released as CO_2 when they are destroyed or cleared. The second-leading contributor to global warming is deforestation and forest degradation. A substantial global carbon sink is destroyed when tropical forests are cleared, which contributes about 20 % of anthropogenic carbon emissions [8].

Deforestation currently accounts for approximately 18 % of global carbon emissions and is the third largest source of emissions [9]. Reducing emissions from deforestation and degradation is now recognized as a critical component of climate change mitigation [5]. A good understanding of the carbon dynamics of forests is therefore important, particularly about how carbon stocks vary in relation to environmental conditions and human land-use activities. Average values of biomass carbon densities for the major forest biomes are used as inputs to climate-carbon models, estimating regional and national carbon accounts, and informing policy debates. Modified natural forests and plantation forests have drawn the most interest in carbon accounting. Because of the argument that primary forests, especially very old forests, are unimportant in addressing the climate change issue because their carbon exchange is at equilibrium, carbon offset investments prioritize planting young trees because of their quick growth, which provides a higher sink capacity than old trees, and/or coverage, and as a result, the significance of modified forests is rising [10].

According to [11], deforestation has dominated land use changes globally and has had a negative influence on the environment by generating biodiversity loss, climate change, and land degradation [12]. Carbon inputs and outputs must balance out to produce carbon reserves. As a result, it typically exhibits a positive correlation with the quantity of both above- and below-ground plant litter [13]. As a result of intricate interactions between the biotic and abiotic environments as well as the dynamics of carbon input, carbon is converted and stabilized in the soil. As a result of these intricate and poorly understood relationships, carbon stock is regarded as an ecological property [7].

Therefore *the study aimed* at assessing the significant effects of forest deforestation on carbon stocking in Edo State with a view to providing sustainable solutions to the menace of deforestation and setting up holistic afforestation strategies to construct a substantial window for carbon stocking.

2. Materials and Methods

2.1. Study area. The state of Edo is located in southern Nigeria between latitudes 05°44′ and 07°34′ N and longitudes 05°04′ E. It is bordered on the west by Ondo State, the south by Delta State, the east by Kogi and Anambra States, and the north by Kogi State. About 19.794 square kilometers make up the state, which is known as the beating heart of the country. The Edo, Esan, Owan, and Afemai people live in Edo State. The state's capital and main city, Benin Metropolis, serves as Nigeria's center for the production of rubber. There are a lot of Edo speakers in Benin City. There are 18 LGAs in the state: Akoko-Edo, Egor, Esan Central, Esan North-East, Esan South-East, Esan West, Etsako-Central, Etsako East, Etsako West, Igueben, Ikpoba-Okha, Oredo, Orhionmwon, Ovia North-East, Ovia South-West, Owan East, Owan West, and Uhunmwon. In these local government areas, there are farmers, traders, and civil servants. The primary forest and tree cover losses in Edo State, Nigeria, are depicted in Fig. 1, 2.

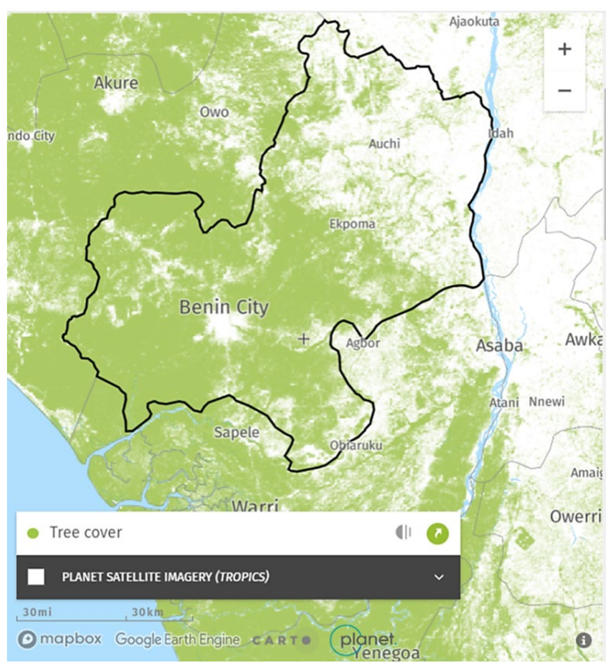

Fig. 1. Map showing Tree Cover Area in Edo State [14]

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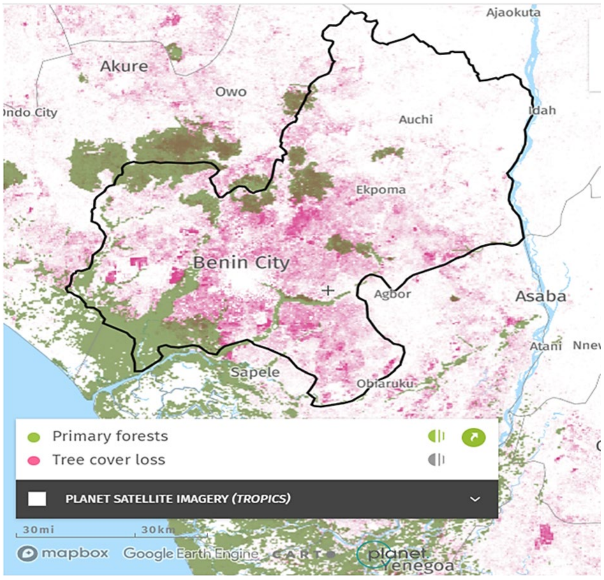

Fig. 2. Map showing primary forests and tree cover loss in Edo State [14]

2.2. Data collection

2.2.1. Deforestation. Numerous techniques are used to measure national deforestation. The degree of deforestation, bio-geographic factors (such as the seasonality of forests, relief, and cloud cover), and cost all influence the monitoring techniques chosen. The rate of deforestation in the 18 local government areas was estimated using real-time areas' tree cover loss per hectare, primary forest content per hectare, tree cover loss percentage, and primary forest content percentage. Additionally, relevant tree loss and deforestation figures from 2010 to 2021 were gathered from the Department of Forestry, Ministry of Environment, Edo State, Nigeria. Satellite imagery and geographical studies were used to assess the decline of forests. By comparing the area covered by forest in the same location at two distinct dates, the annual rate of change was estimated.

Using the compound interest rule as a starting point, [15] computed the annual rate of forest change as follows:

$$q=\left(\frac{A_2}{A_1}\right)^{1/(t_2-t_1)}-1, \qquad (1)$$

where A_1 and A_2 are forest covers at time t_1 and t_2 respectively.

2.2.2. Carbon sequestration. The stock-difference and gain-loss approaches measure carbon stock change differently but equally well [16]. In the stock-difference approach, carbon stocks were physically measured over a specific time interval, as shown in Fig. 3.

The gain-loss method estimates gain and losses based on off-take and growth rates. These two approaches assume CO_2 flows to or from the atmosphere equal carbon stock changes and estimated as also shown in the equations in the Fig. 3 as described in [17]. Field carbon stock was measured using LI-7825 CO_2 Isotope Analyzer which measures four (4) most abundant CO_2 gas isotopologues in air and reports $\delta^{13}C$, $\delta^{17}O$, and $\delta^{18}O$ with high precision and accuracy.

Inventory-based methods and country-specific conversion equations and models were used to determine carbon stocks in forest land and change over time. Standard-sized sampling areas (forest plots) were located on a sampling grid across forest land. The plots were permanent and monitored over time. Measurements of living trees, dead wood, and other plot-specific data were taken. These forest plot data were converted to carbon by applying explicitly developed methodologies. These methods vary between natural and planted forests. Allometric equations and modelling techniques were used to calculate natural and planted forests as indicated in equation (1).

Airborne scanning laser (LiDAR) data were used in conjunction with field measurements to improve the precision of the carbon stock and stock change estimates for planted forests. These techniques enable the conversion of plot data to carbon units per forest area.

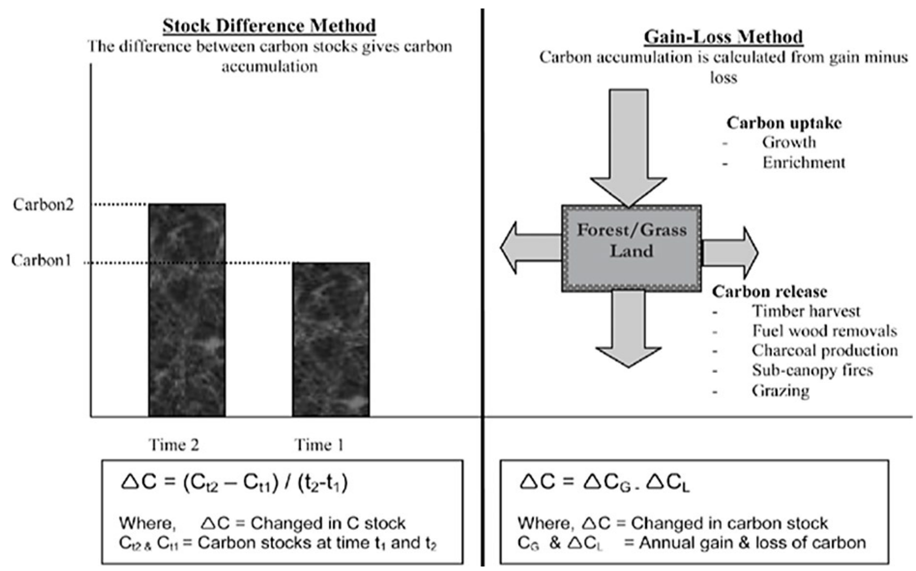

Fig. 3. Estimating Carbon Stock Changes [17]

2.2.3. Data analysis. The deforestation trends from 2010 to 2020 were analyzed using statistical tool of MAKESEN 1.0 software. To obtain the total carbon stock for the different forests in the 18 LGAs, the total carbon stock contained in the forests from 2010 to 2020 and the tree cover loss per hectare, primary forest content remaining per hectare, percentage of tree cover loss, and percentage of primary forest content remaining in the same period were determined using statistical metrics such as Duncan and ANOVA tests.

The results of the ANOVA and Duncan tests were used to evaluate this research's goals and determine if there is a significant difference between the total carbon stocks and the rate of deforestation. Spatial window was used to represent the outputs.

3. Results and Discussion

3.1. Trend of tree cover losses. The potential focus of the study is to evaluate and characterize the effects of deforestation on carbon stock in the eighteen (18) local government areas (LGAs) of Edo State, Nigeria. The data were acquired database on real-time values of tree cover loss per hectare, primary forest content remaining per hectare, percentage of tree cover loss, and percentage of primary forest content remaining for the eighteen local government areas in Edo State. The estimated tree cover loss in tons per hectare is presented in Table 1 and Fig. 4.

Table 1

Tree cover loss trend from 2010–2022

N/S	LGAs	Long	Lat	*Z* (ton/h)
1	Akoko Edo	6.1103°E	7.3533°N	2.65
2	Egor	5.5722°E	6.3671°N	0.78
3	Esan Central	6.2164°E	6.6888°N	2.89
4	Esan North East	6.3439°E	6.7297°N	3.36
5	Esan West	6.1315°E	6.6899°N	0.62
6	Estsako Central	6.4503°E	7.0057°N	2.11
7	Estsako East	6.4503°E	7.2627°N	1.71
8	Estsako West	6.2801°E	7.0080°N	1.56
9	Igueben	6.2389°E	6.5888°N	2.43
10	Ikpoba Okha	5.6879°E	6.1649°N	–1.64
11	Oredo-Edo	5.5407°E	6.2298°N	0.62
12	Orhionmwo	5.9833°E	6.1194°N	0.47
13	Ovia North	5.6037°E	6.5047°N	2.02
14	Ovia South West	5.3103°E	6.4653°N	0.55
15	Owan East	6.0256°E	7.0969°N	1.25
16	Owan West	5.8565°E	6.9279°N	–0.16
17	Esan south East	6.4930°E	6.6214°N	–2.02
18	Uhunmwonde	5.9833°E	6.4579°N	2.18

The result shown in Fig. 4 depicts the decline in tree cover (Kg/ha) across the 18 LGAs in Edo State. All of Edo State's local government areas, with the exception of three (3) LGAs, showed consistent increases in the reserve forest's loss of forest cover. For instance, between 2010 and 2022, there would be reductions of 1.64 ha, 0.16 ha, and 2.02 ha at Ikpoba Okha, Owan West, and Esan South East, respectively. As a result, Esan North East had the highest average yearly total loss of tree cover, followed by Esan Central and Akoko Edo with 3.36 ha, 2.89 ha, and 2.65 ha, respectively (Table 1 and Fig. 4). This observation and finding may be explained by the rising pressure on human survival brought on by the growing population. Due to this development, forests were transformed and used for energy production, urban and housing development, and food production. This result is consistent with several studies [3]. Also the finding showed similarity to the study of authors of [18] which indicated that depletions of the forest to the tune of 5,715.8 ha (50.2 % of the original forest cover), whereas agricultural land had increased by 5,146.9 ha (732.4 %), thus the degradation of the forest, shrub land increased by 1,548.3 ha (239 %). According to the overall deforestation trends in Edo State from 2010 to 2020 based on tree cover loss and primary forest content, there were 10.5 hectares of land with no tree cover in 2010 and 12 hectares in 2011.

A loss of tree cover of nearly 9.5 hectares occurred in 2012, and from 2013 to 2014, it increased by 10 to 27 hectares. Between 2015 and 2017, the state's tree cover decreased by an increasing amount, from 11 hectares to 39.5 hectares of land. The finding is supported by studies of [6, 9]. Hence, increase in tree cover losses could also be attributed to persistent fire outbreak in Edo State. Authors of [19] reported that annual area of fire-induced tree cover loss was highest in 2018 (1371 km^2), second highest in 2008 (1035 km^2) and third highest in 2015 (748 km^2). The result in Fig. 5 presents the total tree cover loss in each local government area in Edo State.

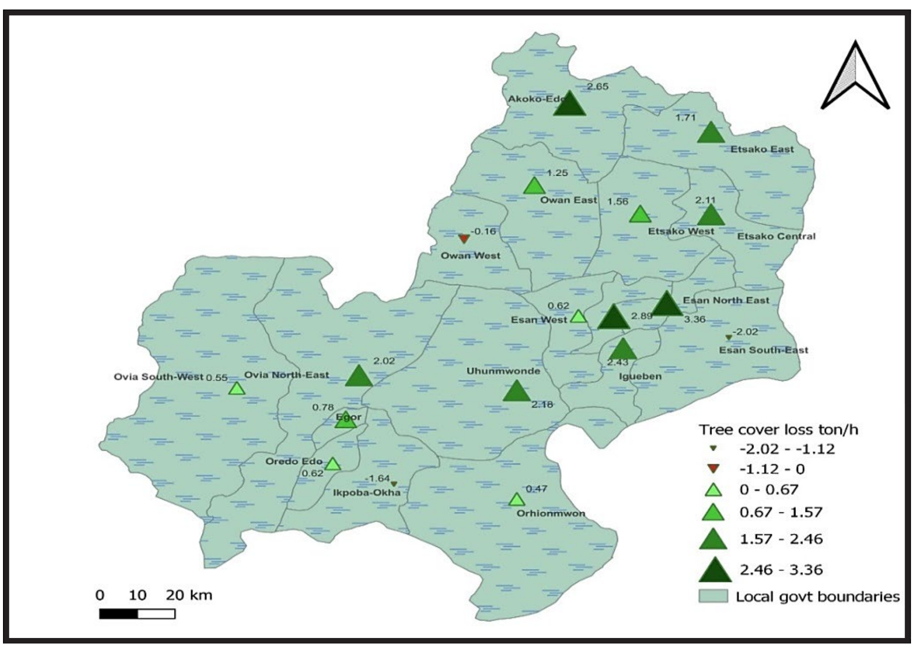

Fig. 4. Trend in tree cover loss from 2010 to 2022

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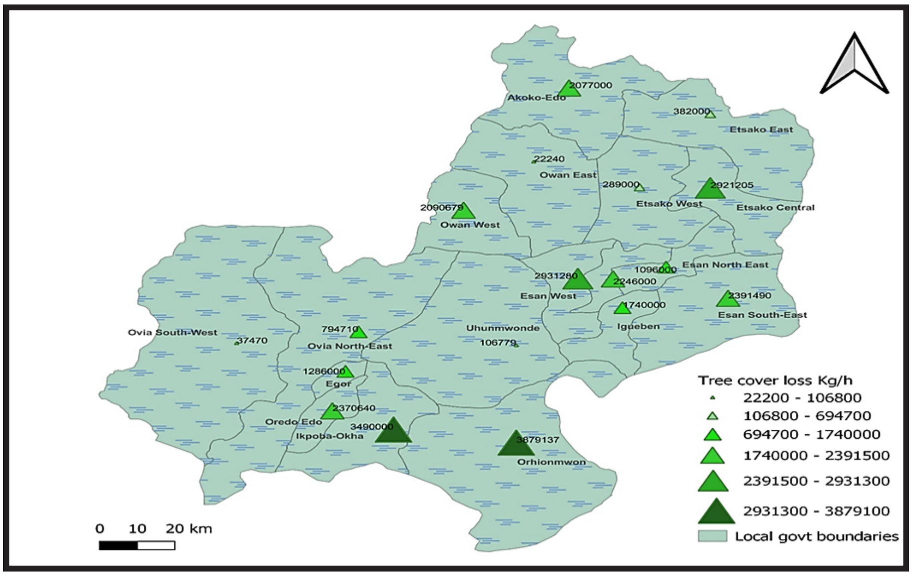

Fig. 5. Total tree cover loss from 2010 to 2022

3.2. Evaluation of carbon sequestration. Carbon sequestration was estimated in the study forest landscape for the years 2010 to 2022. The result in Fig. 6 showed increasing rate of carbon sequestration in all the local government areas (LGAs). The highest CS between 1400–2800 tons/ha were obtained in regions like Ovia-Southwest, Owan East, Etasko West, and Uhunmwonde, whereas the lowest carbon sequestration rate between 735–768 tons were estimated in Orhionmwo and Ikpoba-Okha.

The overall average annual carbon sequestration rate of 3.65 $tC \cdot ha^{-1}yr^{-1}$ was estimated. The most recent discovery may be related to REDD+ (Reducing Emissions from Deforestation and Degradation) activities. Also, the result showed strong similiarity with the finding of REDD+ investigated in central Himalayan region which estimated carbon sequestration rate at 2.4 to 5.6 $tC \cdot ha^{-1}yr^{-1}$ as reported [19]. Numerous farmers have started participating in tree planting and complete afforestation for the past five years or so. This is strongly encouraged by the rising carbon price on a global scale, which results in reduced carbon emissions through carbon stocking. Additionally, the development of climate smart agriculture (CSA) and innovative agricultural techniques that decrease the amount of total forest cover and forest clearance. Fig. 7 presents the relationship between the tree cover loss (ton-ha) and carbon stocking (tC/ha) over the eighteen local government areas (LGAs) in Edo State.

Highest carbon sequestration (CS) of 2700 tons/ha and lowest tree cover loss (TCL) of 22.2 ton-ha in Ovia South West (OSW) from 2010 to 2020. According to the study, deforestation has an impact on the carbon reserves of forests and plants. Dense forests exhibited higher biomass carbon reserves as compared to grazing land and open forests. Because each land cover type has a different number of stems, density, and size of trees, there may be a significant variance in carbon between forest types. The loss of forest cover brought on by populations encroaching on areas to obtain wood for fuel, building materials, more arable land, and animal feed, however, resulted in a drop in the overall carbon stock between 2010 and 2020.

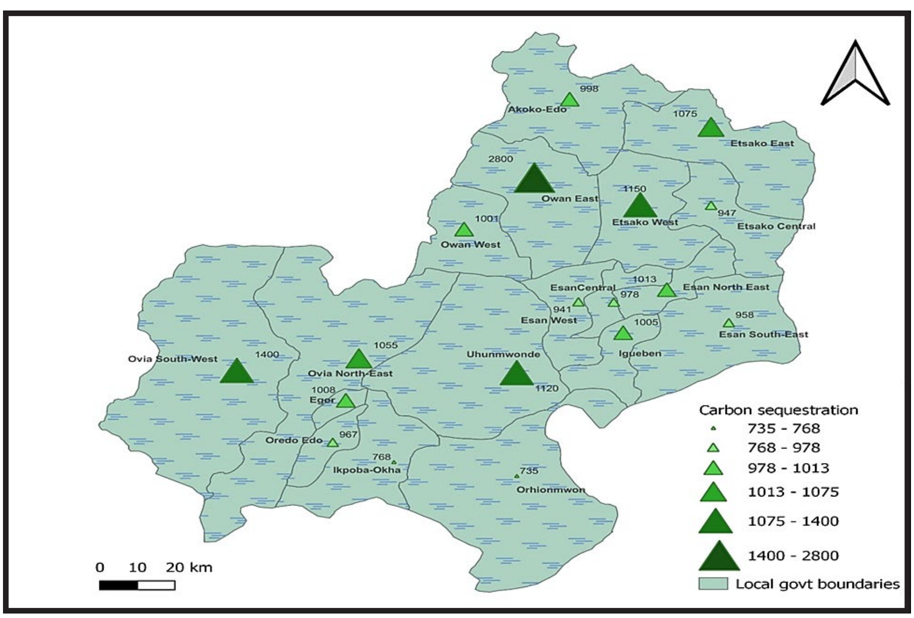

Fig. 6. Carbon sequestration from 2010 to 2022

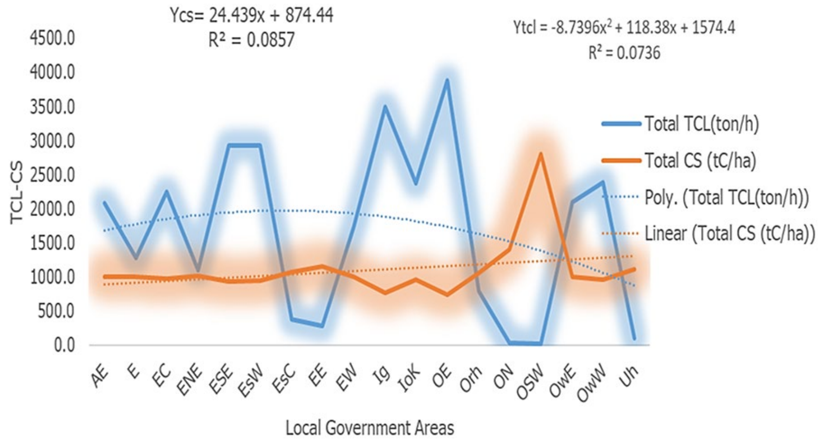

Fig. 7. TCL and CS trend calibration

Forestland consists of a variety of long-lived native tree species and a substantial amount of understory flora. So total carbon stocks are significantly impacted by the conversion of forest to grassland and cultivated land. The study is consistent with the studies of [20, 21].

The study is limited to Edo State, Nigeria. However, a recent analysis performed by the International Energy Agency reports that the need for CO_2 storage is positioned to increase from 40 million metric tons per year today to more than 5,000 million metric tons by the middle of the century [20]. Therefore, this study is significant to understand the relationship between forest deforestation and carbon sequestration in Edo State. Increasing CO_2 storage suggests that complete afforestation with minimum deforestation should be encouraged. This will be essential to reducing global warming and, by consequence, mitigating the effects of climate change. In addition to climate change mitigation measures, complete afforestation is another economic index as the global carbon price continues to soar. It is important to conduct future research on this study to determine a drought-resistant tree or forest plantation with a large canopy coverage area and early maturity.

4. Conclusions

The sustainability of both the environment and people depends in large part on forests. By preserving and sustaining biodiversity, they stop the extinction of species and uphold ecological balance. As a source of income, people also rely on forest products. The water cycle, carbon sequestration, and absorption of direct solar radiation by forests all have an impact on climate. Therefore, stopping the loss of forests is essential. The current study assessed the effects of deforestation on carbon stocking in all of Edo State's local government areas (LGAs). The result showed that tree cover loss (TCL, kg/ha) decreased in 18 local government areas (LGAs). As a result, throughout the baseline consideration period of 2010 to 2022, Etasko East (EE) and Estako West (ES), Ovia South East (OSW), and Ovia North have had the least loss in tree cover. For instance, between 2010 and 2022, there would be reductions of 1.64 ha, 0.16 ha, and 2.02 ha at Ikpoba Okha, Owan West, and Esan South East. As a result, Esan North East had the highest average yearly total loss of tree cover, followed by Esan Central and Akoko Edo with 3.36 ha, 2.89 ha, and 2.65 ha. In addition, there is a considerable correlation between the carbon stock (CS) and the rate of tree loss cover (TCL). Highest carbon sequestration (CS) of 2700 tons/ha and lowest tree cover loss (TCL) of 22.2 ton-ha in Ovia South West (OSW) from 2010 to 2020. According to the study, deforestation has an impact on the carbon reserves of forests and plants. Therefore, the outcome of this study can be used to create further positive interventions to encourage forest regeneration in Edo State and thereby improve carbon sequestration. Also, it is revealed that Edo State has a good chance of making internal money from the sale of carbon stock by stepping up and maintaining the current afforestation techniques.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has no associated data.

References

1. Kumar, R., Nandy, S., Agarwal, R., Kushwaha, S. P. S. (2014). Forest cover dynamics analysis and prediction modeling using logistic regression model. *Ecological Indicators, 45,* 444–455. doi: https://doi.org/10.1016/j.ecolind.2014.05.003
2. Global Forest Resource Assessment (2005). *FAO Forestry Paper 147.* Rome: Food and Agriculture Organization of the United Nations.
3. Newell, J. P., Simeone, J. (2014). Russia's forests in a global economy: how consumption drives environmental change. *Eurasian Geography and Economics, 55 (1),* 37–70. doi: https://doi.org/10.1080/15387216.2014.926254
4. Herzog, H., Golomb, D. (2004). Carbon Capture and Storage from Fossil Fuel Use. *Encyclopedia of Energy,* 277–287. doi: https://doi.org/10.1016/b0-12-176480-x/00422-8
5. Righelato, R., Spracklen, D. V. (2007). Carbon Mitigation by Biofuels or by Saving and Restoring Forests? *Science, 317 (5840),* 902–902. doi: https://doi.org/10.1126/science.1141361

6. Thurner, M., Beer, C., Santoro, M., Carvalhais, N., Wutzler, T., Schepaschenko, D., Shvidenko, A. et al. (2013). Carbon stock and density of northern boreal and temperate forests. *Global Ecology and Biogeography, 23 (3),* 297–310. doi: https://doi.org/10.1111/geb.12125
7. Schmidt, M. W. I., Torn, M. S., Abiven, S., Dittmar, T., Guggenberger, G., Janssens, I. A. et al. (2011). Persistence of soil organic matter as an ecosystem property. *Nature, 478 (7367),* 49–56. doi: https://doi.org/10.1038/nature10386
8. *Climate Change 2007: Synthesis Report. Summary for policy makers* (2007). An assessment of the Intergovernmental Panel on Climate Change. IPCC. Cambridge University Press.
9. Gibbs, H. K., Brown, S., Niles, J. O., Foley, J. A. (2007). Monitoring and estimating tropical forest carbon stocks: making REDD a reality. *Environmental Research Letters, 2 (4),* 045023. doi: https://doi.org/10.1088/1748-9326/2/4/045023
10. Phillips, O. L., Lewis, S. L., Baker, T. R., Chao, K.-J., Higuchi, N. (2008). The changing Amazon forest. *Philosophical Transactions of the Royal Society B: Biological Sciences, 363 (1498),* 1819–1827. doi: https://doi.org/10.1098/rstb.2007.0033
11. Smith, P., House, J. I., Bustamante, M., Sobocká, J., Harper, R., Pan, G. et al. (2015). Global change pressures on soils from land use and management. *Global Change Biology, 22 (3),* 1008–1028. doi: https://doi.org/10.1111/gcb.13068
12. Lal, R. (2001). World cropland soils as a source or sink for atmospheric Carbon. *Advances in Agronomy, 71,* 145–191. doi: https://doi.org/10.1016/s0065-2113(01)71014-0
13. Powlson, D. S., Gregory, P. J., Whalley, W. R., Quinton, J. N., Hopkins, D. W., Whitmore, A. P. et al. (2011). Soil management in relation to sustainable agriculture and ecosystem services. *Food Policy, 36,* S72–S87. doi: https://doi.org/10.1016/j.foodpol.2010.11.025
14. *Carbon, Emissions, Reducing Emissions from Deforestation & Forest Degradation (REDD+), Conflict and Governance, Forest/Forestry, Land Use, Sustainable Landscapes* (2022). Global Forest Watch.
15. Puyravaud, J.-P. (2003). Standardizing the calculation of the annual rate of deforestation. *Forest Ecology and Management, 177 (1-3),* 593–596. doi: https://doi.org/10.1016/s0378-1127(02)00335-3
16. Brown, S., Braatz, B. (2008). *Methods for Estimating CO_2 Emissions from Deforestation and Forest Degradation.* GOFCGOLD Reducing Greenhouse Gas Emissions from Deforestation and Degradation in Developing Countries: A Sourcebook of Methods and Procedures for Monitoring, Measuring and Reporting. GOFC-GOLD Report version COP 13-2. Alberta: GOFC-GOLD.
17. Murdiyarso, D., Skutsch, M., Guariguata, K., Luttrell, C., Verweij, P., Stella, O. (2008). *Measuring and Monitoring Forest Degradation for REDD: Implications of Country Circumstances.* Bogor: CIFOR. doi: https://doi.org/10.17528/cifor/002596
18. Adeyemi, A. A., Adeleke, S. O. (2020). Assessment of land-cover changes and carbon sequestration potentials of tree species in j4 section of Omo Forest Reserve, Ogun State, Nigeria. *Ife Journal of Science, 22 (1),* 137–152. doi: https://doi.org/10.4314/ijs.v22i1.14
19. Dwomoh, F. K., Auch, R. F., Brown, J. F., Tollerud, H. J. (2023). Trends in tree cover change over three decades related to interannual climate variability and wildfire in California. *Environmental Research Letters, 18 (2),* 024007. doi: https://doi.org/0.1088/1748-9326/acad15
20. Solomon, N., Hishe, H., Annang, T., Pabi, O., Asante, I., Birhane, E. (2018). Forest Cover Change, Key Drivers and Community Perception in Wujig Mahgo Waren Forest of Northern Ethiopia. *Land, 7 (1),* 32. doi: https://doi.org/10.3390/land7010032
21. Chen, X., Hutley, L. B., Eamus, D. (2003). Carbon balance of a tropical savanna of northern Australia. *Oecologia, 137 (3),* 405–416. doi: https://doi.org/10.1007/s00442-003-1358-5

David Suru Aweh, *Department of Surveying and Geoinformatics, Auchi Polytechnic, Auchi, Nigeria, ORCID: https://orcid.org/0009-0006-7166-7832*

✉***Yahaya Olotu,*** *PhD, Department of Agricultural and Bio-Environmental Engineering, Auchi Polytechnic, Auchi, Nigeria, e-mail: realyahaya@yahoo.com, ORCID: https://orcid.org/0000-0002-5622-6506*

Rasheed Ibrahim, *Department of Agricultural and Bio-Environmental Engineering, Auchi Polytechnic, Auchi, Nigeria, ORCID: https://orcid.org/0000-0003-3261-1837*

Linda Ngozi Izah, *Department of Surveying and Geoinformatics, Auchi Polytechnic, Auchi, Nigeria, ORCID: https://orcid.org/0009-0007-7836-8955*

Arohunmolase Adeboye John, *Department of Mineral and Petroleum Engineering, Auchi Polytechnic, Auchi, Nigeria, ORCID: https://orcid.org/0009-0006-2097-4162*

✉*Corresponding author*