Role of Campus Green in Climate Change Mitigation

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ABSTRACT

This research was conducted to assess the role of ornamental trees in mitigating climate change within the Rivers State University campus. Stratified random sampling technique was used to collect data on tree height and DBH using D-tape and clinometer. The allometric method was used to calculate the carbon the above and below ground biomass estimated from tree height and DBH. *Terminalia superba, Casuarina equisetifolia* and *Gmelina arborea* had the highest mean height of 48.24m, 40.54m and 33.66, while *Monoon longifolium* and *Terminalia irvorensis* had the least height of 29.93m and 21.49 respectively. *Terminalia superba, Casuarina equisetifolia* and *Gmelina arborea* had the highest mean diameters of 145.83cm, 90.66cm and 78.43m, while *Monoon longifolium* and *Terminalia irvorensis* recorded DBH of 58.47cm and 43.42cm. The above ground biomass was 155164.98, 50557.65 and 31283.69 tons for *Terminalia superba, Casuarina equisetifolia* and *Gmelina arborea,* while *Monoon longifolium* and *Terminalia irvorensis* recorded 15047.95 and 6150.91 tons. *Terminalia superba, Casuarina equisetifolia* and *Gmelina arborea* recorded the highest below ground biomass of 186197.96, 60669.18 and 37540.43 tons respectively and sequestered the highest carbon 206427.60, 67260.63 and 41619.05 tons respectively. This research has provided evidence on the potential of ornamental trees in mitigating climate change in the Rivers State University campus. Hence, urban planners and policy makers should incorporate trees such as T*erminalia superba, Casuarina equisetifolia* and *Gmelina arborea* in campus landscaping programs to serve dual purpose of aesthetics, climate amelioration and mitigation.

Keywords: Carbon Sequestration; Ornamental Trees; Climate Mitigation; Campus Landscaping

INTRODUCTION

Climate change is a term used to describe the long-term shifts in temperatures and weather patterns arising from natural causes such as changes in the sun's activity or large volcanic eruptions. However, since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas (United Nations, 2020). Burning of fossil fuels which is amongst the drivers of climate change generates greenhouse gas emissions (Zhou, *et al*, 2017), which causes climate change and poses many risks to life forms on Earth (Bialecki and Stanek, 2017). Carbon dioxide (CO_2) has been described as one of the major greenhouse gases whose concentrations are rising and are of environmental concern (WMO, 2022). IPCC, (2022) described carbon dioxide as one of the most pressing global challenges of the 21st century.

Carbon sequestration, a process of capturing and storing atmospheric carbon dioxide is one method of reducing global climate change by reducing the amount of carbon dioxide in the atmosphere (IPCC, 2022). Trees play a crucial role in carbon sequestration (Nowak *et al.*, 2013). Beyond the capacity to regulate carbon, trees also influence local microclimates, reduce urban heat island effects, enhance air quality, and improve ecological resilience (Escobedo *et al*., 2011). Trees draw carbon dioxide from the atmosphere using its vegetative parts through the photosynthetic process. Trees are natural carbon capture and storage machines, absorbing carbon dioxide (CO_2) in the atmosphere through photosynthesis then locking it up for centuries. The utilization of available atmospheric CO_2 in photosynthetic process provides a natural sink for the excess carbon dioxide generated by anthropogenic activities (Chavan and Rasal, 2012).

University campuses, often characterized by diverse tree species and significant green cover, represent important

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microcosms for studying the role of vegetation in climate change mitigation (Jim & Chen, 2009). These institutional landscapes not only provide shade, aesthetic value, and recreational benefits, but also serve as living laboratories for assessing the ecosystem services of trees. In urban areas where rapid development and deforestation have contributed to the loss of natural vegetation, the conservation and management of campus green spaces become even more relevant (Roy *et al*., 2012).

The integration of campus trees into urban planning frameworks is particularly critical. As cities expand, the deliberate inclusion of green infrastructure can help balance urban growth with environmental sustainability. Trees in universities, when strategically managed, provide data and models that urban planners can adopt in broader city contexts, linking academic research to practical climate action policies (Pataki *et al*., 2011). Thus, assessing the contribution of trees to carbon sequestration within university campuses becomes necessary as it does not only highlight environmental value but also underscores its relevance in shaping sustainable urban futures.

MATERIALS AND METHOD

The study was conducted in the Rivers State University Campus, Rivers State University is in NkpoluOroworukwo, Port Harcourt, the capital city of Rivers State and a major oil-producing hub in the Niger Delta. It is situated in a highly urbanized and industrial environment with latitude 4.51ºN and longitude 7.01ºE at an altitude of 223 above sea level (Uko and Tamunobereton-Ari, 1991). The average rainfall of the area ranges between 200mm and 2600mm per annum. The area is marked with two distinct seasons: the wet and dry seasons. The wet season begins in March and ends in November while the dry season begins in December and ends in February.

The systematic sampling technique was used in this study. The campus was divided into four sampling locations, selected ornamental tree species were randomly picked within each sampling location for the study. The study locations were, Location A (school farm, Vice Chancellor's lodge, convocation arena, straight to old administration block). Location B (Law Faculty, Post Graduate School, Faculty of Management Science, Medical College, straight to Estate and Works). Location C (Hostel's F, G, and H, Faculty of Engineering, Nimi Briggs hospital, NDDC hostel, Amphitheater. Location D (Road A, E and Old Site). Five ornamental tree species (*Terminalia irvorensis, Gmelina arborea, Casuarina equisetifolia, Terminalia superba,* and *Monoon longifolium),* were selected for the study with twenty replications each. A total of hundred trees were studied.

Tree diameter at breast height (1.3m above ground level) were taken in centimetres using 800-647-5368 diameter/Linear tape by Forestry Suppliers Inc. On trees with buttress, bulge, canker or branch whorl, diameter measurements were taken above the deformity where it occurs at 1.3m above ground level. Tree terminal height measurements were taken in meters using digital clinometer by Haglof Sweden. The GPS coordinates of each tree location was taken using the GPS test App.

Non-destructive approach using the allometric equation by Brown (1997) was used for above ground biomass (AGB) and below ground biomass (BGB) estimation. BGB was estimated from AGB as developed by PonceHernandez *et al.,* (2004) for non-destructive below-ground biomass value of vegetation as 20% of the AGB. Biomass data was used to quantify carbon stock which was used to estimate the amount of carbon sequestrated with field measurements of height and diameter at breast height. The algorithm functions of Clark *et al*., (1986) was used to determine the above-ground green weight of the trees expressed as:

$AGW = 0.25D^2H$: For trees with $D \leq 28$cm

$AGW = 0.15\ D^2H$: For trees with $D \geq 28$cm

Where AGW=Above-ground green weight(ton)

D=Stem diameter(cm), H =Total height of tree (m)

The root system weight was estimated at 20% of the above-ground weight. Therefore, the total green weight of the tree was determined by multiplying the above ground weight by 1.2

The above-ground biomass of each standing tree was determined using the functions of Chavan and Rasal (2010) which states that the average tree is 72.5% dry matter and 27.5% moisture. The function therefore was expressed as:

DW= AGW x 0.725 = $0.25D^2H$ x 0.725 for trees with D≤28cm

DW=AGW x $0.15D^2H$=0.15 D^2H x 0.725 for trees with D≥28cm

Where DW=Dry weight(ton), D=Stem diameter(cm), H =Total height of tree (m)

The content of carbon in woody biomass is generally 50% of the dry weight (Paladinic, *et al.,* 2009; Afzal and Akhtar, 2013; Eneji, *et al*., 2014). Therefore, the weight of carbon in sampled trees was determined by multiplying the dry weights by the factor of 0.5.

The weight of carbon dioxide in the sampled trees was determined by multiplying the weight of carbon in the trees by 3.67. The atomic weight of carbon is 12, the atomic weight of oxygen is 16. The weight of carbon dioxide in a tree is determined by the ratio of CO_2 to C (44/12 = 3.67).

Data collected were subjected to descriptive statistical analysis. The one-way analysis of variance was used to test the significant differences of carbon sequestered by different tree species using IBM SPSS statistics 27. Means were separated using the Duncan Multiple Range Test (DMRT) at a probability of 0.05%.

RESULTS

Results on tree height and diameter at breast height of ornamental trees within the Rivers State University Campus are presented in Fig 1. The result showed that *Terminalia superba* had the highest mean height (48.24m) followed by *Casuarina equisetifolia* (40.54m) while *Monoon longifolium* and *Terminalia irvorensis* recorded the least mean height of 28.93m and 21.49m respectively at P≤0.05 using DMRT. Significant differences in mean DBH sizes were observed. *Terminalia superba* recorded the highest mean DBH (145.82cm) followed by *Casuarina Equisetifolia* (90.66cm). The least DBH were observed in *Monoon Longifolium* and *Terminalia ivorensis* (58.47cm and 43.42cm) respectively.

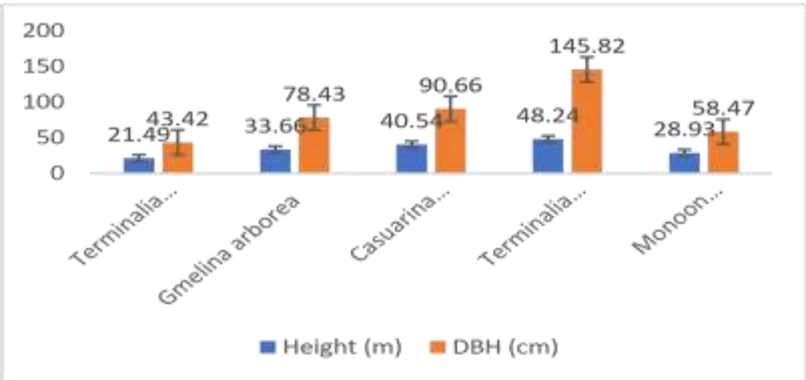

Fig 1. Mean Height and DBH of ornamental trees in Rivers State University

Results on Table 1 shows *Terminalia Superba* had the highest mean above ground biomass (155164.98 tons) followed *Casuarina equisetifolia* (50557.65 tons), while *Monoon longifolium* and *Terminalia ivorensis* recorded the least AGB (15047.95 tons and 6150.91 tons) respectively at P≤0.05 using DMRT. *Terminalia Superba* also recorded the highest mean BGB (186197.97 tons) and was significantly different from the other species at P≤0.05 using DMRT. *Terminalia ivorensis* (7381.10 tons) recorded the least BGB.

Table 1. Mean Above and Below Ground Biomass

Species	Mean AGB (tons) ±SD	Mean BGB (tons) ±SD
Terminalia ivorensis	6150.91 ^{e} ± 1206.86541	7381.100 ^{e} ± 1448.21541
Gmelina arborea	31283.69 ^{c} ±4696.64331	37540.43 ^{c} ± 5635.94810

Casuarina equisetifolia	50557.65 [b] ± 9724.05140	60669.18 [b] ± 11668.86685
Terminalia superba	155164.98[a] ± 25301.92700	186197.97 [a] ± 30362.30853
Monoon longifolium	15047.95 [d] ± 3297.82679	18057.53 [d] ± 3957.37651

Within rows means with different superscript are significantly different at P≤0.05 using DMRT

Terminalia superba sequesters the highest CO_2 (206427.60 tons) in the Rivers State University Campus followed by *Casuarina equisetifolia* and *Gmelina arborea* (67260.63 tons and 41619.05 tons) respectively. *Monoon longifolium* (20019.42 tons) and *Terminalia ivorensis* (8183.02 tons) recorded the least CO_2 sequestered at P≤0.05 using DMRT (Fig 2).

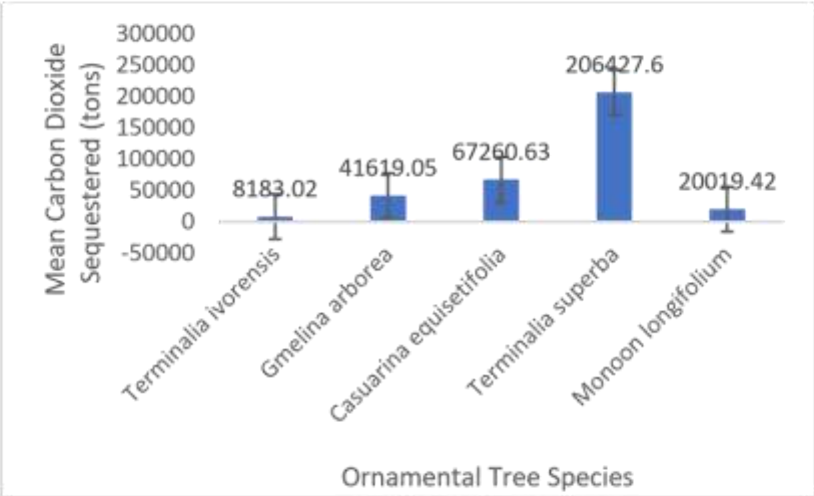

Fig 2. Mean Carbon dioxide Sequestered

DISCUSSION

Results from this study revealed that *Terminalia superba* recorded the highest mean height and diameter at breast height (DBH) among the studied species. This finding agrees with the reports of Hawthorne and AbuJuam (1993) and Orwa *et al*. (2009), who described *Terminalia superba* as a fast-growing species with high height and diameter increment when compared with *Khaya anthotheca* and *Cedrela odorata*. The superior growth performance of *Terminalia superba* can be attributed to its rapid photosynthetic efficiency, high nutrient uptake capacity, and strong genetic adaptation to tropical environments (Oliver and Larson, 1990). In addition, its straight bole architecture and efficient canopy structure enhance light interception, promoting higher biomass accumulation.

Terminalia superba also recorded the highest mean biomass and carbon sequestered in this study. This observation aligns with Samuel and Simon (2020), who reported that mixed stands containing *Terminalia superba* demonstrated superior growth performance, basal area development, volume yield, and carbon storage capacity compared to other species combinations. The high biomass productivity of *Terminalia superba* reflects its fast growth rate, large stem volume, and efficient carbon allocation to above-ground tissues, which enhances carbon capture and storage.

Furthermore, *Terminalia superba*, *Casuarina equisetifolia*, and *Gmelina arborea* recorded the highest aboveground and below-ground biomass and carbon sequestered. This finding supports Aladesanmi and Jonathan (2020), who stated that biomass accumulation is a key determinant of carbon sequestration potential in forest ecosystems. Similarly, Eneji *et al*. (2014) reported that tree species with broad crowns, dense foliage, and extensive leaf area index tend to sequester more carbon due to increased photosynthetic surface area and greater organic matter accumulation. The high carbon sequestration potential observed for *Gmelina arborea* in the Rivers State University campus also agrees with Morenike *et al*. (2022), who reported high carbon storage capacity of *Gmelina arborea* across selected university campuses in Ondo State.

Ezekiel (2021) further reported that *Gmelina arborea* exhibited the highest carbon sequestration potential (25.41 kg of carbon and 93.03 kg CO_2 equivalent) when compared with *Acacia auriculiformis*, *Terminalia mentalis*, *Eucalyptus camaldulensis*, *Delonix regia*, and *Azadirachta indica*. Conversely, *Terminalia ivorensis* recorded the least mean height, DBH, and carbon sequestration in this study, which is consistent with the findings of Eneji *et al*. (2014). The relatively low biomass accumulation of *Terminalia ivorensis* may be associated with slower growth rate, lower canopy density, and limited adaptability to prevailing site conditions.

The observed positive relationship between tree height, DBH, biomass, and carbon sequestration confirms that larger tree dimensions generally translate into higher carbon storage capacity, as supported by Ulolo *et al.* (2025). However, Eneji *et al.* (2014) reported a weak and statistically insignificant relationship between tree height and CO_2 sequestration ($R^2 = 0.266$), suggesting that height alone may not adequately predict carbon storage. This highlights the importance of considering multiple structural parameters such as DBH, crown size, wood density, and rooting depth when estimating biomass and carbon stocks.

According to Brady and Weil, (2016); Lal, (2004) Environmental factors also play a significant role in influencing growth performance and biomass accumulation. Soil fertility, moisture availability, texture, and organic matter content directly affect nutrient uptake, root development, and overall productivity, thereby influencing tree growth and carbon sequestration capacity. Pretzsch, (2009) reported that canopy cover regulates light interception, microclimate stability, and evapotranspiration rates, which in turn affect photosynthetic efficiency and biomass production. Allen *et al.,* 2010; IPCC, (2019) reported that variations in microclimatic conditions such as temperature, rainfall distribution, and site exposure may further influence physiological processes including transpiration, respiration, and carbon assimilation, this may also have contributed to interspecies differences observed in this study.

Overall, the findings demonstrate that species-specific physiological traits, growth strategies, and environmental interactions may have jointly determined biomass accumulation and carbon sequestration potential. This emphasizes the importance of selecting fast-growing, high-biomass species such as *Terminalia superba* and *Gmelina arborea* for afforestation, urban greening, and climate change mitigation programs in tropical environments.

CONCLUSION

The findings of this study demonstrate significant variability in carbon sequestration potential among the examined tree species within Rivers State University. *Terminalia superba* exhibited the highest mean carbon sequestration followed by *Casuarina equisetifolia*, and *Gmelina arborea* highlighting their importance as effective carbon sinks. In contrast, *Monoon longifolium* and *Terminalia ivorensis* stored considerably lower amounts of carbon. These results underscore the ecological value of fast-growing and large-canopy species in enhancing carbon capture, which is critical for mitigating climate change in urban ecosystems. Consequently, species selection for afforestation and campus greening initiatives should prioritize high-performing taxa such as *Terminalia superba*, *Casuarina equisetifolia* and *Gmelina arborea* to maximize long-term carbon storage and contribute to climate action strategies.

It is evident from this study that the Rivers State University campus provides a vital green space where trees contribute to environmental sustainability by sequestering carbon, reducing air pollutants, and moderating local climate conditions. The university's tree population thus represents a valuable natural asset that not only supports biodiversity and ecosystem balance but also offers insights into the broader role of green infrastructure in urban planning within the Niger Delta region.

This study provides critical insights for urban planners seeking to integrate climate change mitigation strategies into city development. The markedly higher carbon sequestration capacity of species such as *Terminalia superba*, *Gmelina arborea*, and *Casuarina equisetifolia* indicates their potential as cornerstone species in urban forestry and green infrastructure projects. Incorporating such high-performing trees into city landscapes, parks, and roadside planting schemes can significantly enhance urban carbon sinks, thereby offsetting emissions from transportation, industry, and domestic activities.

Moreover, the species-specific differences observed in this study highlight the need for deliberate tree selection in urban planning rather than random planting. For instance, prioritizing species with larger canopy size and faster growth rates can maximize long-term carbon capture and provide co-benefits such as shading, air purification, and improved urban aesthetics. On the other hand, species with lower sequestration potential, such as *Terminalia ivorensis* and *Monoon longifolium*, may still be valuable for biodiversity conservation, microclimate regulation, or cultural purposes, but should be integrated with high-carbon-storing species for optimal ecosystem services. By aligning tree-planting initiatives with carbon sequestration data, urban planners can design greener, climate-resilient cities that contribute directly to national and global carbon reduction targets.

REFERENCE

1. Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (2010). Crop evapotranspiration: Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper No. 56. Food and Agriculture Organization of the United Nations.
2. Afzal, M., & Akhtar, A. M. (2013). Factors affecting carbon sequestration in trees. Journal of Agricultural Research, 51(1), 61-69.
3. Aladesanmi, D. A. & Jonathan C. O. (2020). Tree species diversity, volume yield, biomass and carbon sequestration in urban forests in two Nigerian cities. Springer Science+Business Media, LLC, part of Springer Nature (23) 23 957-970. DOI: 10.1007/s11252-020-00994
4. Białecki, R. & Stanek, W., (2017). Cumulative Green-House Gases (GHG) Emissions as Total Measure of Global Warming Potential. Thermodynamics for Sustainable Management of Natural Resources; Springer: Berlin, Germany. 473–488.
5. Brady, N. C., & Weil, R. R. (2016). The nature and properties of soils (15th ed.). Pearson Education.
6. Brown, S., 1997. Estimating biomass and biomass change of tropical forests. (ForestResources Assessment Publication. Forestry Papers 134). FAO, Rome.
7. Chavan, B. L., & Rasal, G. B. (2010). Sequestered Standing Carbon Stock in Selective Tree Species Grown in University Campus at Aurangabad, Maharashtra, India. International Journal of Engineering Science and Technology. 2, 3003-3007.
8. Chavan, B., & Rasal, G. (2012). Total Sequestered Carbon Stock of Mangifera indica. Journal of Environment and Earth Science, 2.
9. Clark, A. (Alexander) III, Saucier, J. R., & McNab, W. H. (1986). Total-tree weight, stem weight, and volume tables for hardwood species in the Southeast. Georgia Forestry Commission, Research Division.
10. Eneji, I. S., Ofoegbu Obinna., and Emmanuel T. Azua (2014). Sequestration and Carbon Storage Potential of Tropical Forest Reserve and Tree Species Located Within Benue State of Nigeria. Journal of Geoscience and Environment Protection. 2, 157-166.
11. Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). "Urban forests and pollution mitigation: Analyzing ecosystem services and disservices. Environmental Pollution, 159(8-9), 2078-2087. DOI: 10.1016/j.envpol.2011.01.010
12. Ezekiel, M. E; Meilby, H.; & Treue, T. (2014). Volume and Aboveground Biomass Models for Dry Miombo Woodland in Tanzania. International Journal of Forestry Research, 2014, Article ID 531256, 11 pp. https://doi.org/10.1155/2014/531256
13. Hawthorne, W.D & Abu-Juam, M (1993). Forest Protection in Ghana. Glnd, Cambridge IUCN. 203
14. IPCC. (2019). Climate change and land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Intergovernmental Panel on Climate Change.
15. IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D. C.
16. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (Eds.)]. Cambridge University Press. https://doi.org/10.1017/9781009325844
17. Jim, C. Y., & Chen, W. Y. (2009). Ecosystem services and valuation of urban forests in China. Cities, 26(4), 187-194. https://doi.org/10.1016/j.cities.2009.03.00

18. Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. Science, 304(5677), 1623–1627. https://doi.org/10.1126/science.1097396
19. Morenike O. O., Ezekiel, A., & Ayorinde, A. (2022). Tree Species Diversity and Carbon Sequestration Potentials of the Trees in the Three Ondo State Owned University Campuses, Southwest, Nigeria. Proceedings of the 8th Biennial Conference of the Forests & Forest Products Society, Held at the Forestry Research Institute of Nigeria, Ibadan, Nigeria. 263-269
20. Nowak, D.J., Crane, D.E., Stevens, J.C., Hoehn, R.E., Walton, J.T., & Bond, J., (2008). A ground-based method of assessing urban forest structure and ecosystem services. Arboriculture and Urban Forestry. 34(6):347358.
21. Oliver, C.D. & Larson, B.C. (1990). Forest stand Dynamics (P.467) New York: McGraw-Hill
22. Orwa, C., Mutua, A., Kindy, R., Jamnadass R., & Anthony, S. (2009). Agroforestry Database: A Tree Reference and Selection Guide Version 4.0
23. Paladinić, E., Vuletić, D., Martinic, I., Marjanović, H., Indir, K., Benko, M., & Novotny, V. (2009). Forest Biomass and Sequestrated Carbon Estimation According to Main Tree Components on the Forest Stand Scale. Periodicum Biologorum, 111, 459-466.
24. Pataki, D. E., Carreiro, M. M., Cherrier, J., Grulke, N. E., Jennings, V., Pincetl, S., … Zipperer, W. C. (2011). Coupling biogeochemical cycles in urban environments: ecosystem services, green solutions, and misconceptions. Frontiers in Ecology and the Environment, 9(1), 27-36. https://doi.org/10.1890/090220
25. Ponce-Hernandez, R., Koohafkan, P., & Antoine, J. (2004). Assessing Carbon Stocks and Modelling Win-win Scenarios of Carbon Sequestration Through Land-use Changes. Food and Agricultural Organization of the United Nations (FAO), Rome, Italy. ISBN 92-5-105168-5.
26. Pretzsch, H. (2009). Forest dynamics, growth and yield: From measurement to model. Springer-Verlag.
27. Roy, A., Byrne, J., & Pickering, C. (2012). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. Landscape and Urban Planning, 125, 234-244. https://doi.org/10.1016/j.landurbplan.2012.12.013
28. Samuel N. & Simon A. (2020). Growth perfprmance, Undergrowth diversity and Carbon Sequestration Potentials of Tree Species Stand Combinations, Ghana. Open Journal of Forestry. 10(1)
29. Uko, E. D., & Tamunobereton-Ari, I. V. (2013). Variability of climatic parameters in Port Harcourt, Nigeria. Journal of Emerging Trends in Engineering and Applied Sciences, 4(5), 727-730.
30. Ulolo, M. B., Simbi-Wellington, W. S., & Nnadi, P. C. (2025). Carbon sequestration potential of selected ornamental trees in Isaac Boro Park, Port Harcourt. International Journal of Agriculture and Environmental Research (IJAER), 11(1), 142–152. Available at: https://ijaer.in/carbon-sequestration-potential-of-selected-ornamental-trees-in-isaac-boropark-port-harcourt
31. United Nations. (2020). What is climate change? United Nations Climate Action. Retrieved from https://www.un.org/en/climatechange/what-is-climate-change
32. World Meteorological organization (WMO, 2022). Greenhouse gas Bulletin-No. 17. Accessed at https://library.wmo.int/index.php?lvl=notice_display&id=21975
33. Zhou, T.; Roorda, M.J.; MacLean, H.L.; Luk, J. (2017). Life cycle GHG emissions and lifetime costs of mediumduty diesel and battery electric trucks in Toronto, Canada. Transp. Res. Part D Transp. Environ. 55, 91– 98.