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ASSESSMENT OF CARBON SEQUESTRATION POTENTIAL OF TREES IN ADEOYO GENERAL HOSPITAL PREMISES, IBADAN, OYO STATE

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ABSTRACT

This study assessed the carbon sequestration of trees around healthcare facilities at Adeoyo General Hospital, Adeoyo, Ibadan. Total enumeration of all the trees in the study areas was carried out. Data were collected on dbh (cm) and total height (m) and these parameters were used to compute basal area (m^2), volume (m^3) and Carbon sequestered (ton). The parameters measured from the study area tree include: diameter at breast height (DBH), total height (H), basal area (B.A), Total volume (V). Trees species of 10cm Dbh and above were measured and enumerated. The carbon sequestration of 64 trees belonging to 13 species, 8 families was estimated using allometric equations. The results showed the growth characteristics of various tree species. *Azadirachta indica* dominated constituting 42.2% of the total population. *Terminalia catappa and Gliricidia sepium* are also significant. Mean diameter, height, basal area, and volume suggest a diverse forest with a wide range of tree sizes. The total carbon sequestered by these trees was 194425.2tCwith the average carbon sequestered of the trees as 3037.8947tC. The highest average of 8880.9tC sequestration was observed in *Delonix regia* and the lowest (44.1tC) in *Ficus capensis. Delonix regia* showed the highest DBH and more carbon sequestration potential, whereas *Newbouldia laevis* showed the minimum in both DBH and carbon sequestration potential.

Keywords: Forest carbon sequestration, Soil organic carbon, Climate change, Assessment, Adeoyo General Hospital, Organic carbon

INTRODUCTION

Climate change is a global concern and forests play a vital role in its regulation as they are a viable option for offsetting terrestrial Carbon dioxide emissions (Raj *et al.,* 2018). Forests are relevant to climate change issues due to its function as a reservoir of carbon. Forests account for 48% of the total storage capacity of carbon by global terrestrial ecosystems (Watson *et al*., 2000; IPCC, 2001). The carbon storage of forest ecosystems in the entire terrestrial ecosystem accounts for about 46.6%. It is of great significance to reduce the concentration of greenhouse gases in the atmosphere (Phillips and Simon, 2014). Unfortunately, natural forests alone are not enough to offset all the terrestrial emissions and there is a need is to find an alternate viable option to bridge this gap (Chakravarty *et al.,* 2012). Planted forest are a viable alternative as they play important role in global carbon (C) cycling since these are one of the largest Carbon pools which act as a potential Carbon sink and also as one of the major sources of CO_2 (Kumar *et al.,* 2017).

Studies have shown that the productivity of the plantations is higher (3.2 Mg ha/1 yr/1) than the productivity of natural forests (1.1 Mg ha/1yr/1) (Chauhan *et al.,* 2020). This is because plantation forestry has an added advantage over the natural forest in terms of better silvicultural practices (Baishaya *et al.,* 2009). Thus, the past decades have witnessed increased interest in tree plantations in both agricultural- and non-agricultural-dominated landscapes.

Trees, the major components of forest, absorb large amounts of atmospheric carbon dioxide (CO) through photosynthesis, and forests return almost equal amount to the atmosphere byauto- and heterotrophic respirations (Folega *et al*., 2010).

The main carbon pool in tropical forest ecosystems consists of the living biomass of trees, under vegetation, dead mass of litter, wood debris and soil organic matter (Kumar and Sharma, 2015). The major environmental concern today is the increase of carbon dioxide in the atmosphere and its potential effect on climate, considered as global warming. However, a small fraction of carbon remaining in forests continuously accumulates in vegetation, detritus, and soil. Thus, forest ecosystems have been viewed as important global carbon sinks (Lorenz and Lal, 2009).

Global warming and climate change are two major environmental problems that humans face today (Heath and Gifford, 2006). Carbon sequestration is considered the most effective way to reduce atmospheric carbon (Houghton, 2012). Assessing carbon sequestration potential of plantation becomes necessary due to increased interest in them. Reducing atmospheric carbon emission and concentration through forest management has recently become an important issue in many countries. Several studies show that specific forest management strategies can improve carbon sequestration capacity and soil carbon storage (Abderrahmane, 2021).

The ability of forests to store large amounts of carbon depends heavily on the tree species growing in them and their stand structure (Chambers *et al*, 2001; Boisvenue and Running, 2006). Structural attributes of forest stand are important in understanding and managing forests ecosystems because they have direct value as a product or in providing ecosystem service of carbon storage (Franklin *et al*.,2002). Trees planted within health care facilities in urban areas serve diverse purpose including economical, ecological and environmental benefits, therefore this study was carried out to assess carbon sequestration potential of trees in Adeoyo General Hospital, Ring Road, Ibadan, Oyo state

MATERIALS AND METHODS

Study area

Adeoyo Hospital, formerly known as Adeoyo Maternity Hospital (established in 1928) is a large general hospital in the city of Ibadan, Oyo State, Nigeria. The hospital was established in 1928. It was formerly used as a College Hospital by the University of Ibadan between 1948 and 1954 after which it was upgraded with an additional fifty beds, laboratory, X-ray annex, medical lecture rooms, and mortuary. The hospital provides maternal and child healthcare services to people in Ibadan and its environ.

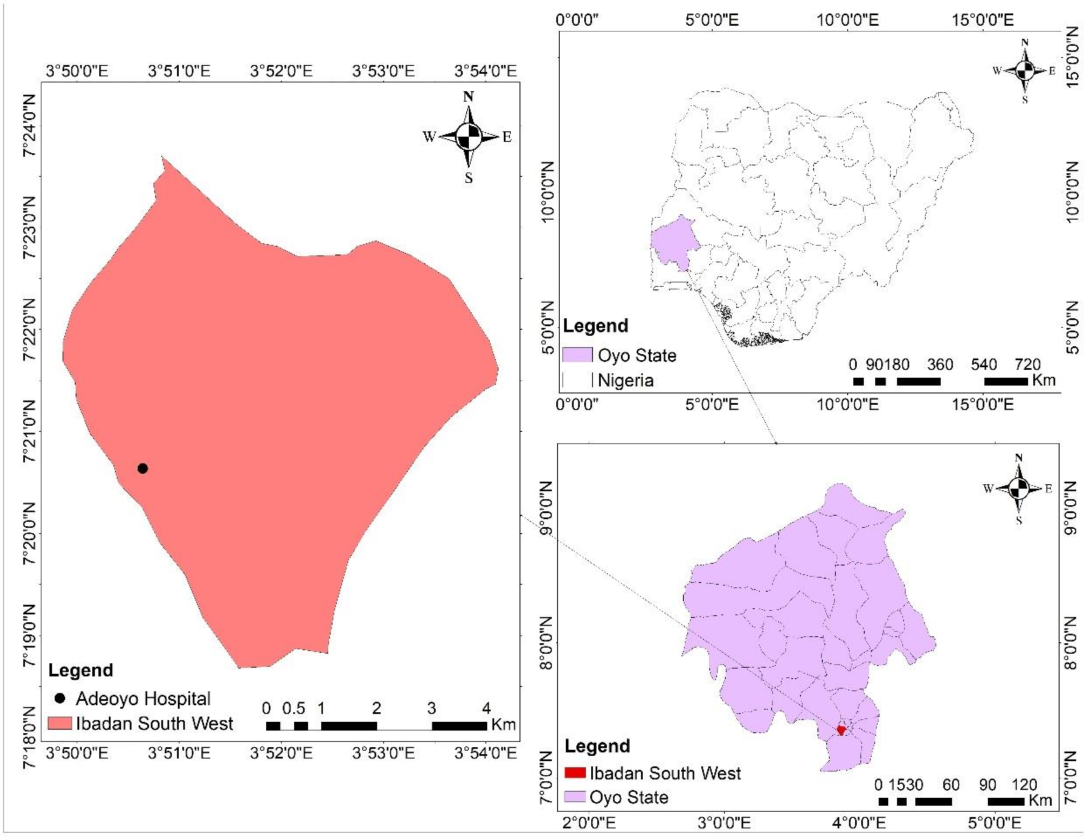

Figure 1: Map of study area
Source: Field survey, 2023

Sampling technique and data collection

Total enumerations of all the trees in the study area was carried out. Data on growth variables measured were; Diameter at breast height (Dbh) in cm, Total height (Tht) in m. This was used to compute biomass and carbon stock.

Estimation of biomass and carbon sequester

The allometric equations for biomass estimation were developed by establishing a relationship between the various physical parameters of the trees such as the diameter at breast height which was measured at 1.3 m above the ground level and height of the tree trunk was measured using Haga altimeter.

The standing biomass of each tree was estimated using allometric functions of Terakumpisut *et al*, (2007) developed for tropical environment The functions were expressed as follows:

$W_s = 0.0509\ (D^2H)^{0.919}\ldots$ (1)

$W_b = 0.00893\ (D^2H)^{0.977}\ldots$ (2)

$W_l = 0.0140\ (D^2H)^{0.669}\ldots$ (3)

Where;

Ws = stem biomass (tons/individual tree)
Wb = branch biomass (tons/individual tree)
W_l = leaf biomass (tons/individual tree)
D = diameter at breast height (cm)
H = height (m)

The stem, branch and leaf biomass together constitute the standing biomass of individual tree.

The carbon sequestered in the standing biomass of individual trees was estimated by multiplying the estimate of the standing biomass by 0.5 conversion factor which implies that 50% of standing biomass is carbon (Genene *et al*, 2013, Cannell and Milne,1995; Dixon *et al*, 1994, Iversion *et al*, 1994)

Basal area (BA) of individual trees was estimated using the formula according to Husch *et al* (2003)

$BA = \frac{\pi D^2}{4}\ldots$ (4)

Where BA=Basal area (m^3), D= Diameter at breast height (cm) and π=3.142

Volume

The volume over bark of individual trees was estimated using Newton equation developed for stem volume estimated (Husch *et al* 2003).

$V = \pi H \frac{\{db^2+4dm^3+dt^2\}}{24}\ldots$ (5)

Where:

V= volume over bark (m^3), H= Stem height (m), Db= Diameter at base, Dm= Diameter at middle Dt=Diameter at the top and π=3.142

RESULTS AND DISCUSSION

Growth characteristics of trees in Adeoyo General Hospital

Forests store carbon by photosynthesis and carbon sequestered in forest biomass. In general, planted forests are a cost-effective means of sequestering Carbon (Sedjo *et al.*, 1995; Adams *et al.*, 1999).The analysis of the growth characteristics of trees in Table 1 reveals a diverse composition of species with varying growth traits such as DBH (Diameter at Breast Height), height, basal area, and volume. *Azadirachta indica* had the highest relative frequency (42.2%) and the largest volume of wood (644.6 m³), suggesting its significant contribution to carbon sequestration on the premises. Additionally, *Delonix regia* though less frequent (6.3%), exhibits a high average DBH of 198.3cm and volume (240.3 m³), marking it as another major contributor to the hospital's carbon storage capacity. Species such as *Bridelia ferruginea* and *Newbouldia laevis* have much lower frequencies (1.6, table 1) and carbon storage potentials (148.8tC and 29.7tC respectively), with minimal volumes of 0.7 m³ and 0.1 m³, respectively. This indicates that while the hospital has a mix of species, the contribution to carbon sequestration is uneven, with a few large, fast-growing species such as *Delonix regia* accounting for the majority of the biomass and carbon storage. The species is widely recognized for its rapid growth and large biomass, attributes that make it a major player in carbon sequestration, especially in urban areas (Gupta *et al*., 2018).

The total number of trees enumerated and the other growth variables of trees in the study area are shown in table 2. The minimum diameter was found to be 15m and the maximum was 286.2cm. The smallest tree in height was 4.2m while the tallest was 19.8m. Carbon sequestered ranged from 29.74tC to 194425.2tC. However, the findings of Villiers *et. al* (2014) revealed that in a University in New Zealand annual CO_2 emissions were 4,086 tonnes in 2011. They further stated that more than 70 per cent of this amount relates to overseas travel. Therefore, CO_2 sequestration in trees promises to mitigate only about 6 per cent of total emissions over the next ten years. This suggests that other initiatives will be needed if the university is serious about reducing its greenhouse gas emissions impact.

Table 1: Growth characteristics of trees in Adeoyo General Hospital

Species	Freq.	Rel Freq	av dbh	av. Ht	B.A	Vol
Albizia zygia	2	3.1	45.1	7.8	0.3	2.5
Antiaris africana	2	3.1	44.6	19.8	0.3	6.6
Azadirachta indica	27	42.2	151.4	12.0	51.8	644.6
Bridellia ferrugenea	1	1.6	30.1	10.2	0.1	0.7
Delonix regia	4	6.3	198.3	15.3	13.8	240.3
Ficus capensis	1	1.6	24.3	4.2	0.0	0.2
Ficus exasperate	2	3.1	42.1	10.4	0.3	2.9
Gliricidia sepium	7	10.9	125.4	9.4	10.5	109.4
Holarrhena floribunda	1	1.6	128.7	10.9	1.3	14.2
Leucena leucocephala	3	4.7	60.9	8.4	1.0	8.6
Newbouldia laevis	1	1.6	15.0	7.2	0.0	0.1
Terminalia catappa	12	18.8	128.8	10.1	17.5	198.1
Terminalia randii	1	1.6	73.6	4.8	0.4	2.0
Total	64	100				

Table 2: Summary of the parameter of trees in Adeoyo General Hospital

	DBH (cm)	Ht (m)	B.A (m2)	Vol. (m3)	Stand biomass (t/C)	Seq carbon (t/C)
N	64	64	64	64	64	64
Min	15	4.2	0.02	0.13	59.49	29.74
Max	286.2	19.8	6.43	127.39	36548.19	18274.1
Sum	8021.7	711	97.36	1230.2	388850.5	194425.2
Mean	125.34	11.11	1.52	19.22	6075.79	3037.89
Std. error	7.6	0.4	0.2	2.6	754.1	377.1

Carbon sequestration of trees in Adeoyo General Hospital

Similarly, *Delonix regia* also exhibits a substantial role in carbon sequestration, despite having a population of just 4 individuals. Its high DBH (198.3 cm) contributes to a stand biomass of 71,047.32 t/C and sequestered carbon of 35,523.66 t/C, averaging 8,880.9 t/C per tree (table 3). A similar experience by Luyssaert *et al.,* (2008); Lutz *et al*., (2018) revealed that large-diameter trees constitute about half of the mature forest biomass worldwide and are key to the ability of forests to accumulate substantial amounts of carbon needed to mitigate climate change. This indicates that species with larger diameters, even though with few stands, play significant roles in carbon storage—a pattern that is well-established in urban forestry research.

Table 3: Carbon sequestration of trees in Adeoyo General Hospital

Species	Freq	Av. DBH (cm)	Av. Ht (m)	B.A (m^2)	Vol (m^3)	Stand biomass (tC)	Av. Std biomass (tC)	Seq carbon (tC)	Av. Seq carbon (tC)
Albizia zygia	2	45.1	7.8	0.3	2.5	984.0937	492.0	492.0469	246.0
Antiaris Africana	2	44.6	19.8	0.3	6.6	2422.175	1211.1	1211.088	605.5
Azadirachta indica	27	151.4	12.0	51.8	644.6	204908.3	7589.2	102454.2	3794.6
Bridellia ferrugenea	1	30.1	10.2	0.1	0.7	297.6951	297.7	148.8475	148.8

Delonix regia	4	198.3	15.3	13.8	240.3	71047.32	17761.8	35523.66	8880.9
Ficus capensis	1	24.3	4.2	0.0	0.2	88.13891	88.1	44.06945	44.1
Ficus exasperate	2	42.1	10.4	0.3	2.9	1137.197	568.6	568.5987	284.3
Gliricidia sepium	7	125.4	9.4	10.5	109.4	35242.72	5034.7	17621.36	2517.3
Holarrhena floribunda	1	128.7	10.9	1.3	14.2	4714.101	4714.1	2357.05	2357.1
Leucena leucocephala	3	60.9	8.4	1.0	8.6	3145.787	1048.6	1572.894	524.3
Newbouldia laevis	1	15.0	7.2	0.0	0.1	59.48706	59.5	29.74353	29.7
Terminalia catappa	12	128.8	10.1	17.5	198.1	64026.15	5335.5	32013.07	2667.8
Terminalia randii	1	73.6	4.8	0.4	2.0	777.2625	777.3	388.6313	388.6

(DBH- Diameter at breast height, Ht- Height, St- Stand biomass, Seq- Sequestered)

Family composition in Adeoyo General Hospital

The data on family composition as presented in Table 4 indicates that Meliaceae was the dominant family with 42.2% of the total tree population, followed by the Fabaceae with 25%. The dominance of these two families aligns with Murtala *et al*. (2020) who reported these families (Meliaceae and Fabaceae) as two of the most prominent families in the diversity assessment of trees in two cities of North-western Nigeria. Agbelade *et al* (2016) also reported Fabaceae being dominant in a similar finding conducted in Ibadan. Trees in the Meliaceae family, such as *Azadirachta indica*, are especially valued for their robustness and high carbon storage potential, which is evident from their significant representation in the Adeoyo General Hospital. This agree with the work of Chauhan and Joshi (2024) whose studies have shown that higher frequencies of families like Meliaceae and Fabaceae can enhance the overall carbon sequestration capacity of green spaces due to the species' fast growth and adaptability to urban conditions. In contrast, families like *Apocynaceae, Bignoniaceae, and Euphorbiaceae* were underrepresented, each accounting for only 1.6% of the total tree population. The poor representation of these families may suggest that they are either less well-suited to the urban environment of the hospital grounds or less frequently planted due to slower growth rates or preference by the hospital management.

Table 4: Family composition in Adeoyo General Hospital

Family	Freq.	Rel. Freq (%)
Apocynaceae	1	1.6
Bignoniaceae	1	1.6
Combretaceae	13	20.3
Euphorbiaceae	1	1.6
Fabaceae	16	25.0
Meliaceae	27	42.2
Moraceae	5	7.8
Total	64	100

Diameter structure of tree species in Adeoyo General Hospital

The diameter structure of tree species in the study area as presented in fig.2 revealed that,20 (31%) of tree species in the area were within class of 161-200 cm, this was followed by class of 41-80cm with 14 tress (22%), while diameter class of tree above 200 cm was 3 (5%) trees. This result was similar to what was recorded during an urban study conducted in the Federal College of Education Osiele (Akomodesegbe, 2024)

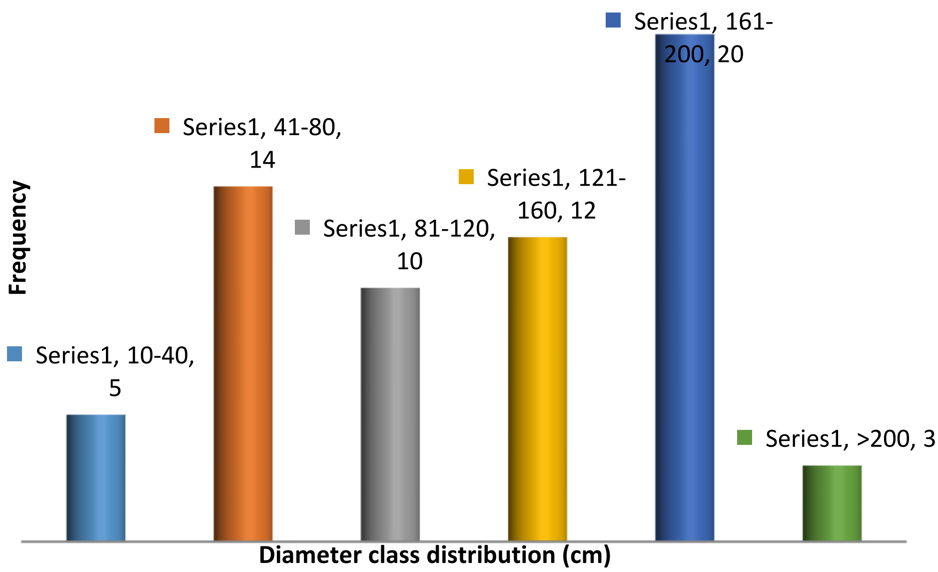

Figure 2: Diameter Class Distribution of trees in Adeoyo General Hospital

Distribution of Tree species Height in Adeoyo General Hospital

The height class distribution revealed that 5 trees (8%) fall under 0-5 m, with 30 trees (47%) within 6-10 m class which is the highest frequency in the study area. There are 24 (37%) trees which heights are between 11-15m while 16-20 m (5 trees, 8%) has the joint lowest frequency (Figure 3). This is also similar to the findings of Akomodesegbe (2024) who recorded dominant heights for trees in the class distributions of 6-10 m and 11-15 m with 54 % and 45 % respectively.

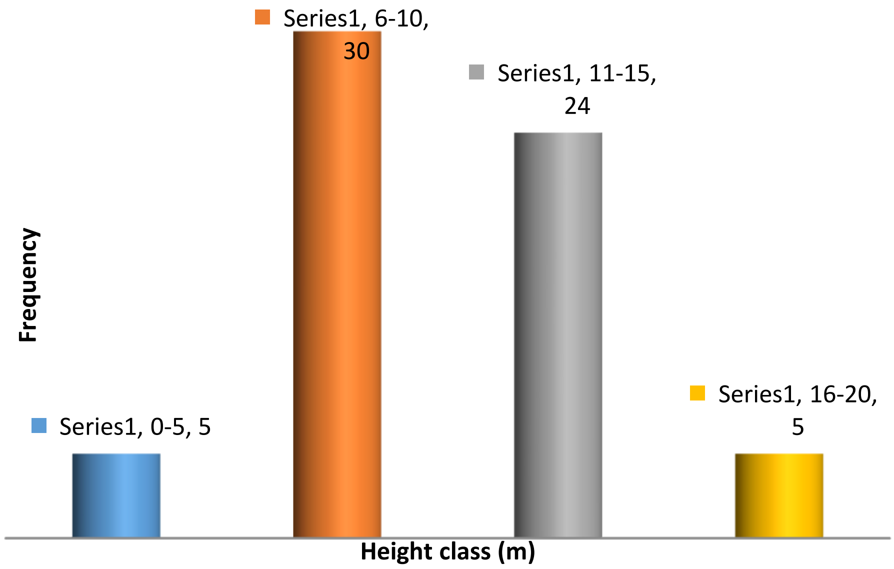

Figure 3: Height Class Distribution of trees in Adeoyo General Hospital

CONCLUSION

Adeoyo General Hospital exhibits a diverse range of tree species with varying growth characteristics and carbon sequestration potentials. *Azadirachta indica* and *Delonix regia* sequestered the largest share of the carbon among the tree species as evident from the results. This study recommends that more trees should be introduced in healthcare facilities in Ibadan so as to harness their potential to sequester carbon while also helping in greening the urban space. Also further studies on carbon sequestration potential of trees in other hospitals should be carried which could also incorporate below ground biomass to obtain a comprehensive information on the full potentials of the tree species within healthcare facilities.

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