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Carbon Sequestration Potentials of Woody Plant Species in Makurdi Zoological Garden Benue State Nigeria

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Authors' contributions

This work was done in collaboration among the authors. Author AMP designed the study, did literature searches, carried out the field studies, performed statistical analysis and managed the analyses of the study. Authors CCI and CUA supervised the study, author UJA wrote the first draft of the manuscript while all the authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of this study is to estimate the total carbon sequested by some Woody plant Species in Makurdi zoological garden and its contribution to climate change.
Study Design: Random sample plots of 100 m × 100 m were located in the field using a Garmin GPS and simple allometric procedures using standard carbon inventory principles and techniques that are based on data collection and analysis of carbon accumulating in the above-ground biomass, below-ground biomass, and soil carbon using verifiable modern methods were adopted.
Place and Duration of Study: Field experiment was carried out at the Makurdi zoological garden, Benue State, Nigeria between September and October 2018.
Methodology: The non-destructive method was used with the view to determine the above ground biomass (AGB), below ground biomass (BGB), Estimate the above ground carbon (AGC), below ground carbon (BGC), Total Carbon Content (TCC) and also to estimate the Above ground $C0_2$ and

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below ground $C0_2$ and the total $C0_2$ Sequestered in the study area.
Results: A total number of 27 species of trees belonging to 16 different families were found in randomly selected sample plots. The diameter at breast height (DBH) was measured at 1.3 m from ground level with a good measuring tape while heights of plants were measured using haga altimeter. The result showed that a total of 3331.05 ton/ha of $C0_2$ was estimated to have been sequestered using the non-destructive field measurement.
Conclusion: Total average standing biomass of various tree species was calculated to be 907.6395 tons/ha whereas the total average carbon sequestered was 302.6918 tons/ha. Carbon sequestration capacity of trees increased as the age of trees increases. Therefore it can be concluded that the older trees have higher carbon content than younger trees hence, they are reservoirs of carbon.

Keywords: Carbon sequestration; above ground biomass; below ground biomass; carbon content; above ground carbon; below ground carbon.

1. INTRODUCTION

Carbon sequestration is a mechanism for the removal of carbon from the atmosphere by storing it in the biosphere [1]. Carbon sequestration in terrestrial ecosystem is referred as the absorption of CO_2 from the atmosphere by photosynthesis. Photosynthesis in plants converts carbon dioxide (CO_2) to biomass, thereby reducing the carbon in the atmosphere and stores it in plant tissues above and below ground [2]. The biomass produced is mainly stored as aboveground biomass (AGB), below ground biomass (BGB), dead wood, and litter and soil organic matter in the forest ecosystem [3]. Forest ecosystems are very important in the global carbon cycle as they sequester close to 80% and 40% of all above- and below-ground terrestrial organic carbon, respectively [4], and are directly influenced by deforestation and forest degradation [5]. According to the IPCC Special Report on CO_2 Capture and Storage, CO_2 sequestration could provide an emission reduction of CO_2 until 2100 of up to 55% which is known for its potential influence as a greenhouse gas to Climate pattern of the world [6]. Carbon sequestration in growing forests is known to be a cost-effective option for mitigation of global warming and global climatic change. Estimates of carbon stocks and stock changes in tree biomass (above and belowground) are necessary to study climate change under United Nations Framework Convention on Climate Change [7]. The increasing carbon emission is of major concern for the entire world as addressed in Kyoto protocol [1,8]. Terrestrial vegetation and soil represents important sources and sinks of atmospheric carbon [8]. The quantification of CS potential of various ecosystems is a challenge [9]. Forests sequester and store large amounts of atmospheric carbon and thus play a key role in the mitigation of climate change [10]. Inventory measurements in both managed and unmanaged forests in temperate and tropical regions indicates that forests accounted for a substantial net sink of 550 Gt CO_2 from 1750 to 2011 [11,12,13]. Hence, estimating and monitoring carbon sequestered in forests is necessary for sustainable management in order to leverage the mitigation potential of forests [10]. Thus, assessing the amount of carbon stored in the forest ecosystem periodically is a means of determining the CO_2 emitted into the atmosphere due to deforestation and degradation [6]. Why carbon cycle drew much attention is because carbon dioxide being the chief among the greenhouse gases has the potentials to influence the global climate pattern [14], and it also has a relatively long residence time in the atmosphere. About 60% of the observed global climate change is attributable to this increasing carbon dioxide concentration in the atmosphere [15].

Nature has provided us with natural carbon “sinks” or “sponges” like the terrestrial ecosystem and the oceans. Forest’s ecosystem is one of the most important carbon sinks of the terrestrial ecosystem. Forest’s vegetation takes up the carbon dioxide in the process of photosynthesis. In this natural process, it removes the carbon dioxide from the atmosphere and stores the carbon in the plant tissues, forest litter and soils [6]. Thus, forest ecosystem plays a very important role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere. This process is more prolific in a relatively new forest where the growths of the trees are still rapid. It is estimated that about 86% of the terrestrial above-ground carbon and 73% of the earth’s soil carbon are stored in the forests. The tropical forests are said to play a major role in the global carbon cycle, storing up to about 46% of the world's terrestrial carbon pool and about 11.55% of the world's soil carbon pool, acting as a carbon reservoir and functioning as a constant sink of atmospheric carbon [16,17,18,19]. According to a study conducted by [16], it was suggested that half of the so called "matured forests" could also sequester carbon and the rate of sequestering carbon could be further increased if human pressures are reduced or removed from these forests. In a tropical forest ecosystem, the living biomass of trees, the understory vegetation and the deadwood, which includes the standing deadwood and the fallen deadwood like fallen stems and fallen branches, woody debris and soil organic matters constitute the main carbon pool. Among the above mentioned carbon pools, the above-ground biomass of the tree is mainly the largest carbon pool and it is directly affected by deforestation and forest degradation [5]. The change in the forest areas and the changes in forest biomass due to management and regrowth greatly influence the transfer of carbon between the terrestrial forest ecosystem and the atmosphere [20]. Hence, estimating the forest carbon stocks is mainly important to assess the magnitude of carbon exchange between the forest ecosystem and the atmosphere. Assessment of the amount of carbon sequestered by a forest will give us an estimate of the amount of carbon emitted into the atmosphere when this particular forest area is deforested or degraded. Furthermore, it will help us to quantify the carbon stocks which in turn will enable us to understand the current status of carbon stocks and also derive the near-future changes in the carbon stocks [5,20].

2 MATERIALS AND METHODS

2.1 Study Area

Makurdi Zoological garden is located in Makurdi Local Government Area of Benue State. Makurdi is the state capital of Benue State and lies on the south bank of the Benue River. It Coordinates is 7°43'50''N 8°32'10E. The study area is shown in Fig. 1.

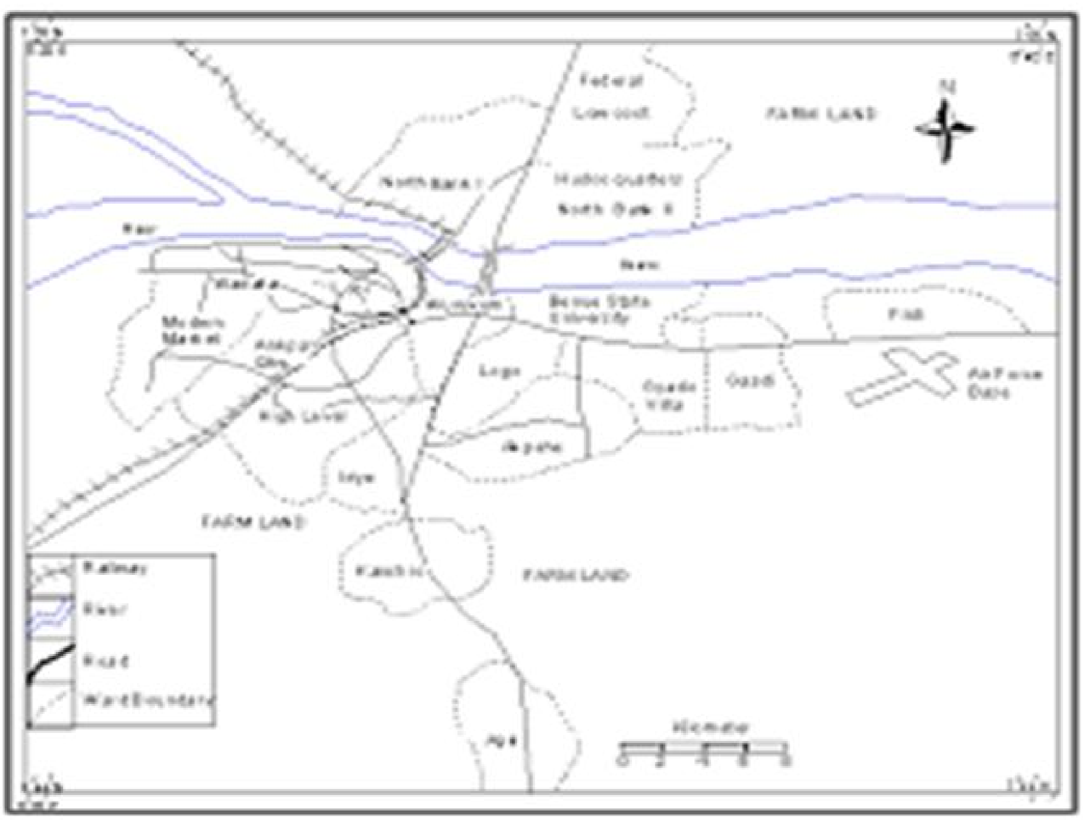

Fig. 1. Map of Makurdi showing the study area
Source: Google Map

2.2 Field Data

2.2.1 Sampling design

As recommended by [21] and [22], to be in line with recommended practice, 10 Random sample plots of 100 m × 100 m were located in the field using a Garmin GPS. According to MacDicken (1997), the use of GPS receivers enables efficient and accurate placement of the plots. In each of the plots, all trees with DBH (i.e. diameter at 1.3 m) exceeding 5 cm were measured with a 50 m girt measuring tape and their heights measured with haga altimeter.

2.2.2 Soil sampling

Soil samples were randomly collected at the center of each plot at depths of 0–15 and 15–30 cm, respectively, since the highest proportion of the total root is within first 30 cm of the soil surface. About two- thirds of the carbon in terrestrial ecosystems comes from soil organic carbon. As a result, the soil samples were carefully collected since it forms the major component of the result, thereby preventing the top-layer soil from falling to the lower samples according to best practices.

2.3 Data Preparation

2.3.1 Estimation of biomass

2.3.1.1 Above ground biomass

The pan tropical biomass allometric equation proposed by Chave et al.;[23] for tropical moist forest was used for the estimation of tree aboveground biomass:

$$AGB = \exp(-2.977 + \ln(\rho D^2 H)) = 0.0509 \times \rho D^2 H \qquad (1)$$

Where TAGB is tree aboveground biomass, D is diameter at breast height, H is total height and ρ is wood density (wood specific gravity) and estimated as 0.88.

2.3.1.2 Below ground biomass.

Below Ground Biomass is estimated from Above Ground Biomass. According to Ponce-Hernandez; [24], a non-destructive approach depends on belowground biomass values for vegetation as 20% of the aboveground biomass.

Below ground biomass = 20% × above ground biomass

That is:

$$BGB = 20\% \times Agb \qquad (2)$$

2.3.2 Estimation of carbon stock

2.3.2.1 Aboveground carbon stock

To estimate the Above Ground Carbon (AGC), the aboveground biomass (AGB) was multiplied by 50%

$$AGC = \text{total } AGB \times 0.50$$

2.3.2.2 Below ground carbon stock

To estimate Below Ground Carbon (BGC), the Below Ground Biomass (BGB) was multiplied by 50%

$$BGC = \text{total } AGB \times 0.50$$

2.3.2.3 Soil carbon stock

The Total Organic Carbon (TOC) of soil matter was determined by collecting soil samples from the sub-plot within the main sample plots using the Walkley–Black method. A total of 20 samples at 0–15 and 15–30 cm were collected for TOC (%Carbon). Soil carbon stock was computed by multiplying the concentration of total carbon (C) by bulk density and the corresponding depth at which the sampling was done:

$$\text{Soil carbon (Mg/ha)} = \text{bulk density (g/cm}^3) \times \text{soil depth interval (cm)} \times \%\text{carbon} \qquad (3)$$

Soil carbon at 0-15 cm = TOC × Depth × Bulk Density,
Soil carbon at 15-30 cm = TOC × Depth × Bulk Density:

2.3.3 Estimation of carbon dioxide

2.3.3.1 Above ground biomass carbon dioxide

To estimate the amount of Carbon dioxide (CO_2) sequestered in the above ground biomass, the aboveground carbon was multiplied by 3.67 which is the ratio of the molecular weights between CO_2 and carbon.

$$CO_2 = \text{aboveground carbon stock} \times 3{:}67$$

2.3.3.2 Below ground biomass carbon dioxide

To estimate the amount of Carbon dioxide (CO_2) sequestered in the belowground biomass, the belowground carbon was multiplied by 3.67 which is the ratio of the molecular weights between CO_2 and carbon.

CO_2 = belowground carbon stock × 3:67

2.3.3.3 Total carbon stock estimation

The total carbon stock was estimated as the total stock of carbon in the ecosystem, including above ground and below ground stock. The constituents of the below ground stock are the carbon content in roots and all Below Ground Biomass and the carbon in the soil. The total below ground carbon stock is the addition total below ground carbon stock Below Ground Biomass and soil carbon. The sum total of all the biomass obtained from the three pools considered which Above Ground Biomass, Below Ground Biomass is and Soil Organic Carbon was calculated and the carbon stock was obtained using Equation (4).

Total Carbon Stock = Total biomass × % Carbon, (4)

Total carbon stock can be calculated from Carbon stock in standing tree as follows:

Total carbon stock = AG carbon stock + BG carbon stock = AG carbon stock + carbon belowground biomass + carbon stock in soil.

2.3.3.4 Carbon dioxide (CO_2) sequestered

The total carbon stock can be converted to CO_2 by multiplying carbon stock by 3.67 which is the ratio of the molecular weights between CO_2 and carbon.

CO_2 = Total carbon stock × 3.67.

2.4 Data Analysis

After the data collection was completed from the field and laboratory, the analysis of data was done by organizing and recording on the excel data sheet. The data that was gained from the field such as DBH, height of each species and soil were analyzed using Statistical Package for Social Science (SPSS) software version 20.

3. RESULTS AND DISCUSSION

3.1 The Forest Structure

A total of 27 plant species from 16 families were identified (Table 1). A total of 689 trees were sampled in the study area. Among the species sampled, *Daniella oliveri* was the dominant species (339) followed by *Azadirachta indica* (95), *Elaeis guineensis* (39) and *Vitex doniana* (34). Other species recorded are *Acacia seyal* (1) and *Parkia biglobosa* (1).This information is also represented in Table 1.

3.2 DBH Distribution of Makurdi Zoological Garden

The DBH class 51-70 was dominant, followed by 31-50 cm, 71-90 cm and 10-30 cm respectively. As mentioned in Table 1, the mean maximum DBH value in the studied area was recorded for *Parkia biglobosa* with the mean DBH value of 88cm followed by *Pterocarpus erinaceus* and *Daniella oliveri* with the mean DBH value of 74 cm and 62.3 cm respectively. The least mean DBH was recorded for *Lophira lanceolata* with the mean value of 15 cm followed by *Hannoa undulate* with the mean value of 16.3.

3.3 Height Distribution of Makurdi Zoological Garden

Height distribution was based on class rang. Class range of 0 – 10 has an approximate height distribution of 90, while class rang of 11 – 15 has an approximate value of 170 and class range of 16 -20 has an approximate value of 470 (Table 2). The numbers of trees between 16-20m height have the highest number of individual tree species followed by 11-15m, and 5-10 respectively. As a result, the higher class with the height range of 16-20 m consists of the greatest number of individual tree species. About 63.6% of the total trees found in the studied area fall between the height ranges of 16-20 cm. 23.5% of trees were found between the height ranges of 11-15 m while 12.9% of trees were found between the ranges of 5-10 m.

3.4 Estimation of Biomass

3.4.1 Above Ground Biomass (AGB)

The result shows that the maximum above ground biomass sequestered by the plant species was 1037.3 ton/ha, the minimum above ground biomass sequestered by plant species was 0.181 ton/ha and the total above ground biomass (TAGB) for the studied area was 1512.7 ton (Table 3).

3.4.2 Below Ground Biomass (BGB)

The maximum below ground biomass sequestered by plant species was 207.5 ton/ha,

Table 1. Species collected from Makurdi zoological garden with their mean DBH, mean height, number of plots in which they occur and number of trees

S/N	Species scientific name	Family	No. of plots species occur	Total no. of trees	Mean DBH (cm)	Mean height (m)
1	*Anacardum ocindentel*	Anacardiaceae	1	2	37	10
2	*Ficus sur*	Moraceae	6	17	38.7	10.7
3	Daniella oliveri	Caesalpinioideae	10	339	62.3	17.6
4	Gmelina aborea	Verbanaceae	4	21	32.8	13.8
5	Azadirachta indica	Meliaceae	8	95	50.5	15.6
6	*Ficus exasperate*	Moraceae	5	20	37.2	11
7	*Acacia seyal*	Fabaceae	1	1	57	10
8	*Pterocarpus erinaceus*	Fabaceae	3	26	74	12.7
9	*Vattelleria paradoxa*	*Sapotaceae*	*4*	*10*	31.8	*10*
10	*prosopis Africana*	Mimosoideae	2	7	35.6	11
11	*Vitex doniana*	Verbanaceae	4	34	32	10.5
12	*Lannea shimperi*	Anacardiaceae	1	2	43	19.5
13	*Elaeis guineensis*	Arecaceae	6	39	42.4	10.2
14	*Bridelia ferruginea*	Euphorbiaceae	1	3	21	7
15	*Psedocedrella kotschyi*	Meliaceae	2	6	37.2	10
16	*Lannea acida*	Anacardiaceae	5	23	47.2	14.4
17	*Acacia nilotica*	Mimosoideae	5	15	45.2	13.2
18	*Mytragyna inermis*	Rubiaceae	1	3	40	10
19	*Terminalia avicenniodes*	Combretaceae	2	7	34.6	8
20	*Magnifera indica*	Anacardiaceae	3	29	45.3	16
21	*Hannoa undulate*	Simaroubaceae	3	6	16.3	6
22	*Sterculia setigera*	Sterculiaceae	1	2	40	12
23	*Albizia zygia*	Mimosoideae	2	6	47.2	10.5
24	*Delonix rigia*	Fabaceae	1	2	58	8
25	*Scheflera actinophylla*	Araliaceae	1	12	28	9
26	*Parkia biglobosa*	Mimosoideae	1	1	88	12
27	*Lophira lanceolata*	Onchnaceae	1	3	15	6

the minimum below ground biomass sequestered by plant species was 0.036ton/ha while the total below ground biomass (TBGB) for the studied area was 302.579 ton (Table 3).

Table 2. Class range and approximate height distribution

Class range	Height distribution
0 - 10	90
11 - 15	170
16 - 20	470

3.5 Estimation of Carbon Stocks

3.5.1 Above ground carbon stock

The maximum and the minimum above ground carbon stock potentials of each plant species sampled in Makurdi zoological garden was 518.65 ton/ha and 0.0905 ton/ha while the total above ground carbon (TAGC) in the studied area was 756.4 ton (Table 4).

3.5.2 Below ground carbon stock

The maximum and the minimum value of the below ground carbon sequestered in the area was 103.73 tons/ha and 0.0181 tons/ha respectively while the total below ground carbon (TBGC) for the studied area was 151.294 ton (Table 4).

3.6 Carbon Dioxide (CO_2) Estimation

3.6.1 Above ground CO_2

The maximum and minimum above ground carbon dioxide sequestered in the study area was 1903.45 tons/ha and 0.332 tons/ha respectively while the total above ground CO_2 sequestered was 2775.8 tons/ha (Table 5).

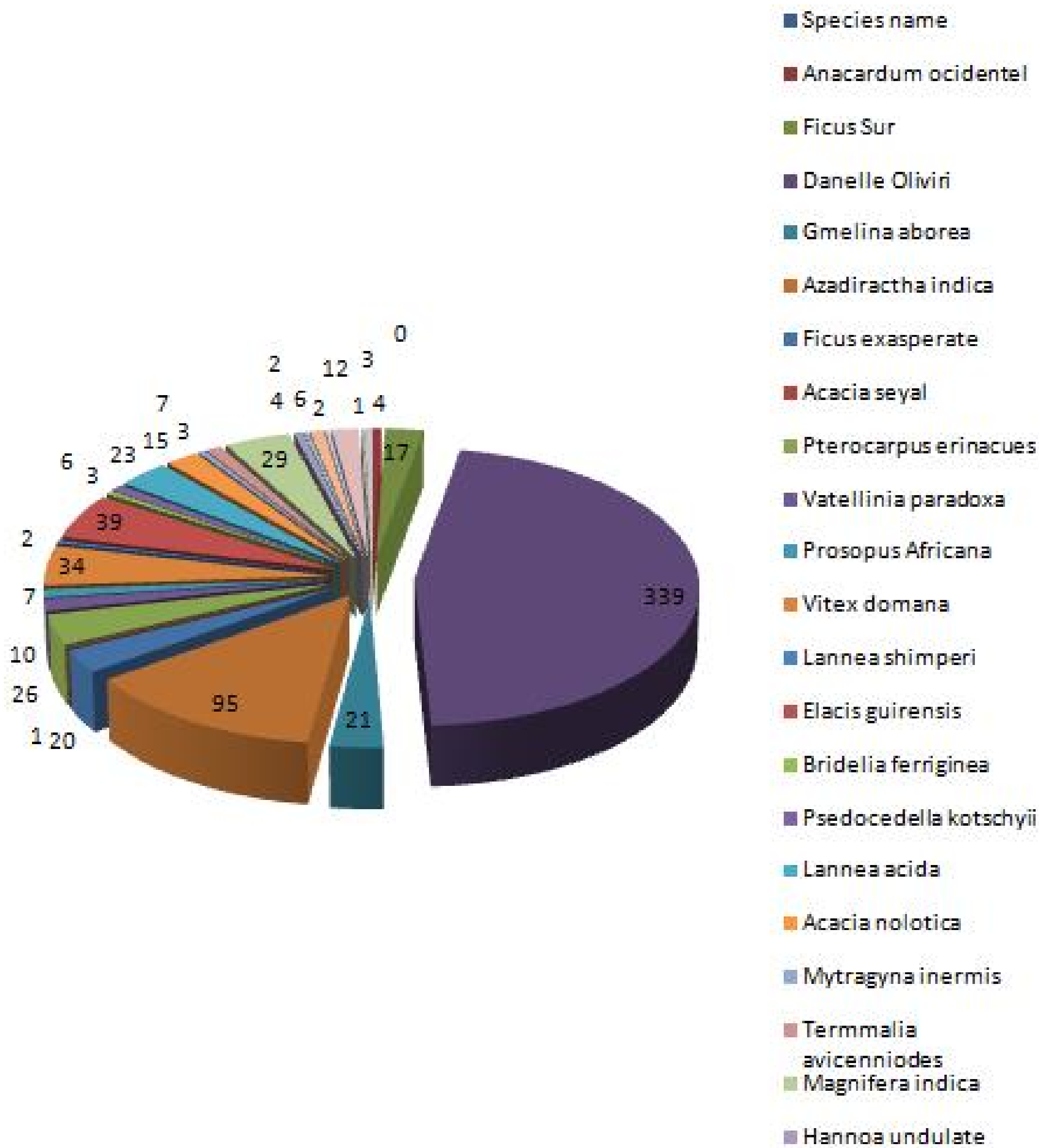

Fig. 2. Trees species distributions in the study area

3.6.2 Below ground CO_2

The maximum and minimum below ground carbon dioxide sequestered in the study area was 380.7 tons/ha and 0.0666 tons/ha respectively while the total below ground CO_2 sequestered was 555.25 ton/ha (Table 5). Also, the total CO_2 sequestered in the study area = total above ground CO_2 + total below ground CO_2. Total CO_2 = 2775.8 +555.25 = 3331.05 ton/ha

To estimate the AGB and BGB in the study area, determine the total caron stock and evaluate the total carbon dioxide sequestered, a total of 731 tree species from sixteen different families were measured on field. The average DBH of all tree species measured ranged from 15 cm to 88 cm. *Daniellia oliveri* has the highest number of trees of 331 having an average DBH of 62.3 cm while *Parkia biglobosa* has the least number of trees of one with DBH of 88 cm. The pantropical biomass allometric equation proposed by [23] for tropical

Table 3. Estimated above and below ground biomass of species

S/N.	Scientific name	Total AGB Ton/ha	Total BGB Ton/ha
1	*Anacardum ocindentel*	1.2264	0.2453
2	*Ficus sur*	12.203	2.441
3	*Daniella oliveri*	1037.3	207.5
4	*Gmelina aborea*	13.965	2.793
5	*Azadirachta indica*	169.29	33.858
6	*Ficus exasperate*	13.636	2.727
7	*Acacia seyal*	1.4553	0.2911
8	*Pterocarpus erinaceus*	80.99	16.198
9	*Vattelleria paradoxa*	4.529	0.906
10	*prosopis Africana*	4.37	0.874
11	*Vitex doniana*	16.375	3.275
12	*Lannea shimperi*	3.229	0.6459
13	*Elaeis guineensis*	32.033	6.4066
14	*Bridelia ferruginea*	0.4148	0.0829
15	*Psedocedrella kotschyi*	3.719	0.744
16	*Lannea acida*	33.05	6.6101
17	*Acacia nilotica*	18.12	3.624
18	*Mytragyna inermis*	2.15	0.43
19	*Terminalia avicenniodes*	3.003	0.601
20	*Magnifera indica*	42.65	8.53
21	*Hannoa undulate*	0.428	0.0857
22	*Sterculia setigera*	1.72	0.344
23	*Albizia zygia*	6.287	1.257
24	*Delonix rigia*	2.411	0.4822
25	*Scheflera actinophylla*	3.793	0.759
26	*Parkia biglobosa*	4.162	0.832
27	*Lophira lanceolata*	0.181	0.0363
Total		**1,512.7**	**302.579**

moist forests was used for the estimation of tree aboveground biomass which has been tested and shown to accurately predict TAGB in several sites. Tree aboveground biomass per plot was estimated by the summation of the TAGB of all individual trees in the plot. The total AGB for the studied area (1512.7 $tonha^{-1}$) was higher when compared with [25] assertion that the global AGB in tropical dry and wet forest range between 30-275 $tonha^{-1}$ and 213-1173$tonha^{-1}$ respectively and that recorded in Ile- Ife (54.52 tonha-^{1}) and reported by [26] but was smaller when compared with other studies. [14] estimated above ground biomass to be an average 215 mg $tonha^{-1}$ and 192 mg $tonha^{-1}$ for undisturbed tropical forest of Asia and the world respectively and also with study carried out by [27] that the total AGB of Oluwa forest of Ondo state was 162,826.343 $tonha^{-1}$ that is, 162 mg $tonha^{-1}$. The total above ground carbon stock estimated was 756.4$tonha^{-1}$ of carbon while the total below ground carbon stock was 151.294 $tonha^{-1}$ of carbon are lower when compared with the value found in other system in Africa. E.g. 152 mg t c/ha for cocoa agroforestry in South Cameroon [28]; 66-88 mg t c/ha for rubber plantation in Cameroon [29] but however higher than the value of carbon stock recorded in Ile- Ife (28.18) reported by [26]. A total of 3331.04 ton ha^{-1} of CO_2 was estimated to have been sequestered in the area.

Generally one must exercise caution in comparing the study results because of differences in the forest types, site types, management systems, monitoring, the methodology and model equation used in different studies [30,23,31,32] Reported that fast growing species accumulate more carbon in the first stages of their life span, while the high specific gravity of slower-growing species accumulates more carbon in the long term. Above ground biomass and consequently carbon stock has been reported to be influenced in any particular region by factors such as climate, solar radiation, and disturbance, age of forest, species composition, and soil characteristics [33,34] Has also pointed out that the rate of carbon storage in forest biomass depends on tree growth rate: the more biomass is added through photosynthesis the more carbon is stored. It is clear from this study that species composition, disturbance and age of the vegetation are the main factors influencing carbon stock especially in the above ground biomass.

Table 4. Estimated above and below ground carbon stock of species

S/N	Scientific name	Total AGC Ton/ha	Total BGC Ton/ha
1	*Anacardum ocindentel*	0.6132	0.1227
2	*Ficus sur*	6.1015	1.2203
3	*Daniella oliveri*	518.65	103.73
4	*Gmelina aborea*	6.9825	1.3965
5	*Azadirachta indica*	84.645	16.3965
6	*Ficus exasperate*	6.818	1.3636
7	*Acacia seyal*	0.7277	0.1455
8	*Pterocarpus erinaceus*	40.495	8.099
9	*Vattelleria paradoxa*	2.265	0.453
10	*Prosopis Africana*	2.185	0.437
11	*Vitex doniana*	8.188	1.6375
12	*Lannea shimperi*	1.6145	0.3229
13	*Elaeis guineensis*	16.017	3.2033
14	*Bridelia ferruginea*	0.207	0.0415
15	*Psedocedrella kotschyi*	1.8595	0.372
16	*Lannea acida*	16.53	3.305
17	*Acacia nilotica*	9.06	1.812
18	*Mytragyna inermis*	1.075	0.215
19	*Terminalia avicenniodes*	1.502	0.3003
20	*Magnifera indica*	21.33	4.265
21	*Hannoa undulate*	0.214	0.043
22	*Sterculia setigera*	0.86	0.172
23	*Albizia zygia*	3.144	0.629
24	*Delonix rigia*	1.2055	0.2411
25	*Scheflera actinophylla*	1.897	0.379
26	*Parkia biglobosa*	2.081	0.416
27	*Lophira lanceolata*	0.0905	0.0181
Total		**756.4**	**151.29**

Table 5. Estimated carbon dioxide sequestered by plant species

S/N	Scientific name	Total AG CO_2 Ton/ha	Total BG CO_2 Ton/ha
1	*Anacardum ocindentel*	2.25	0.45
2	*Ficus sur*	22.4	4.48
3	*Daniella oliveri*	1903.45	380.7
4	*Gmelina aborea*	25.6257	5.125
5	*Azadirachta indica*	310.65	62.129
6	*Ficus exasperate*	25.022	5.005
7	*Acacia seyal*	2.6705	0.534
8	*Pterocarpus erinaceus*	148.62	29.723
9	*Vattelleria paradoxa*	8.3107	1.662
10	*prosopis Africana*	8.0189	1.604
11	*Vitex doniana*	30.05	6.009
12	*Lannea shimperi*	5.925	1.185
13	*Elaeis guineensis*	58.78	11.76
14	*Bridelia ferruginea*	0.7612	0.1522
15	*Psedocedrella kotschyi*	6.824	1.365
16	*Lannea acida*	60.65	12.13
17	*Acacia nilotica*	33.25	6.65
18	*Mytragyna inermis*	3.95	0.789
19	*Terminalia avicenniodes*	5.511	1.102

S/N	Scientific name	Total AG CO_2 Ton/ha	Total BG CO_2 Ton/ha
20	*Magnifera indica*	78.3	15.652
21	*Hannoa undulate*	0.785	0.157
22	*Sterculia setigera*	3.156	0.6312
23	*Albizia zygia*	11.5366	2.307
24	*Delonix rigia*	4.424	0.885
25	*Scheflera actinophylla*	6.96	1.392
26	*Parkia biglobosa*	7.64	1.528
27	*Lophira lanceolata*	0.332	0.0666
	Total	**2775.8**	**555.23**

4. CONCLUSIONS

Total average standing biomass of various tree species was calculated to be 907.6395 tons/ha whereas the total average carbon sequestered was 302.6918 tons/ha. Carbon sequestration capacity of trees increased as the age of trees increases. Therefore it can be concluded that the older trees have higher carbon content than younger trees hence, they are reservoirs of carbon. In order to protect the world from global warming and climate change, achieving the objectives of carbon sequestration is mandatory. The result of this study will facilitate further planning and decision making regarding plantation in the environment because there is a need for better management and conservation of the biodiversity in the environment.

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COMPETING INTERESTS

The authors have declared that no competing interest exists.

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