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Above-ground bole biomass and carbon stock of recreational trees at Agodi Gardens, Oyo State, Nigeria

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ABSTRACT

This study used allometric equations to evaluate the biomass and carbon stock of recreational trees at Agodi Gardens in Ibadan Metropolis. Stratified sampling technique was used to delineate 15 plots (25m x 25m). Six allometric equations were selected to estimate Aboveground Biomass (AB) of the tree species. Models selected were assessed based on highest adjusted coefficient of determination ($AdjR^2$), significant F-ratio ($P<0.05$) and least Root Means Square Error (RSME). A total of 220 trees belonging to 18 species were encountered. The dominant Diameter at Breast Height (DBH) and Height (Ht) were 62.8cm and 39.1m, respectively for *Alstonia bonnei* and *Elaeis guineensis.* The mean AB/ha was 2.8006$Kgha^{-1}$ and the highest carbon stock of 3.332147 x 10^{-4} was recorded for *Khaya ivorensis.* Equation $C= 2.6 \times 10^{-7}+\ln(AB) + \ln DBH^2+\ln Ht$ ($AdjR^2$=99%), gave the best fit to estimate carbon stock in the study area. The study found a significant relationship between AB, DBH and Ht, with a high correlation between DBH and Ht (P-value=0.00). Hence, as the DBH increases, the Ht increases with an increase in AB. Most trees had low slenderness coefficients (<70). The developed allometric model improved the prediction of aboveground stem biomass and carbon stock, making it useful for future research.

Contribution/Originality: Carbon stock of recreational centre of Agodi Gardens has not been estimated before now despite the location's prime position in the urban city of Ibadan, Nigeria. Hence, this study is novel in providing baseline information to enlighten both the tourist and government on its potential to ameliorate climate change effects.

1. INTRODUCTION

Tree biomass is a function of tree volume, architecture and wood density (dry weight per unit volume of fresh wood). Wood density varies according to species of individual tree [1, 2], tree age [3], life-history strategy [4] and environmental factors such as relief/terrain, slope, aspect [5] among others. Tree biomass could be quantified by two different means; destructive harvest (direct method) and use of allometric equations (indirect method) [6]. Allometric models, often time, used measurable variables such as Diameter at Breast Height (DBH), total tree height, and wood density to estimate/predict tree biomass [7, 8]. The estimation and forecasting of ecosystem productivity, carbon budgets, nutrient allocation, and fuel buildup all depend on information regarding aboveground biomass (AGB) [9-11]. Therefore, it is critical to be able to estimate biomass accurately when determining the contribution of forests to sequestering carbon [12]. This is especially true when determining their role in the global carbon (C) cycle. In addition, biomass is regarded as a valuable indication of structural and functional characteristics of forest ecosystems under a variety of environmental situations [9]. Understanding recreational gardens' potential as carbon sinks and guiding urban planning and management plans require a thorough assessment of their AGB and carbon stock. Policymakers and urban planners may optimize the environmental benefits that these green spaces offer by increasing their capability to sequester carbon by assessing their carbon storage capacity.

It takes a variety of approaches and procedures to evaluate the above-ground biomass and carbon stock in recreational gardens. The application of allometric equations, which establish a link between readily quantifiable factors like tree diameter or height and biomass or carbon stock, is one widely utilized strategy. These equations, which can be tailored to different plant species or vegetation types, are derived through field data.

Studies have looked into the possibility of recreational trees storing carbon. For instance, a study by Nowak, et al. [13]. indicated that urban trees in the US yearly store about 23.2 million metric tons of carbon. According to McPherson, et al. [14] research, California's urban trees sequester about 1.9 million metric tons of carbon dioxide annually. These data demonstrate how recreational trees significantly contribute to carbon sequestration. A study conducted by Nowak, et al. [13] estimated the capacity of American urban forests, which include parks and gardens, to store carbon. They discovered that urban forests contain over 643 million metric tons of carbon, demonstrating the important role that these green areas play in carbon sequestration. Trees' potential to slow down climate change, carbon sequestration and storing carbon dioxide (CO_2) studies have attracted a lot of attention lately. The potential for recreational trees to sequester carbon has generally been underestimated, despite the fact that forests are frequently acknowledged as significant carbon sinks. This introduction attempts to summarize the present studies in this area and provide light on the significance of recreational trees in carbon sequestration.

2. METHODOLOGY

This study was conducted at Agodi Garden (Figure 1), a recreational center situated in the city of Ibadan. The Garden is situated in the northwest of the Premier Hotels and the north-east of the Oyo State Secretariat [15]. It was founded in 1967 as a major recreation centre and formerly known as Agodi Zoological Garden which was managed solely by the Western Region until the creation of Oyo State Government in 1976. Agodi garden is located on latitude 7.405556°N & 7.406538°N and longitude 3.903056°E & 3.903607°N at altitude 193m above sea level.

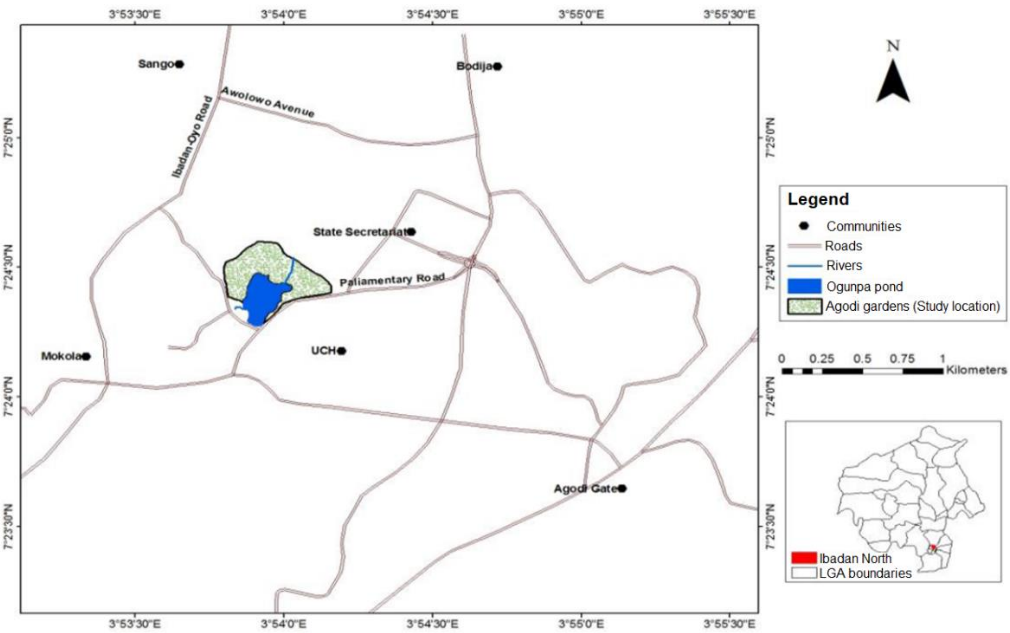

Figure 1. Agodi garden.

2.1. Vegetation and Climate

Previously, the garden comprised of 32 plant species with *Tectona grandis*, *Khaya senegalensis*, *Azadirachta indica*, *Gmelina arborea* and *Eucallyptus toreliana* having high densities, but due to several rehabilitations, many of these species have been destroyed to accommodate the beautification and attractive landscaping of the garden. A river named the Dandaru flows through the Garden. The equatorial climate of Oyo state, where the garden is located, features dry and wet seasons as well as a high level of relative humidity. The wet season begins in April and lasts until October, whereas the dry season occurred from November to March. Almost all of the year, the daily average temperature is between 25 and 35 degrees Celsius.

2.2. Sampling Procedure and Data Collection

Stratified sampling method was used in which each land use (zoo section, recreational section, built-up section and conservation section) was the stratum. In each stratum, Temporary sample plots (TSP) of size 25m x 25m was laid proportionate to size (using 30% sampling intensity). In each TSP, all standing live trees with diameters at breast height (dbh) ≥ 10cm were identified to species level and enumerated. The dbh; Diameters at the base (Db), middle (Dm) and top (Dt); and the total height (THt) of all trees in each TSP were measured using Spiegel relascope and girthing tape. Wood density of each species found on the TSP was obtained from literatures (i.e. Reyes, et al. [16] and African Wood Density Data Base website).

2.3. Data Analysis

Biodiversity indices and tree species classification.

Shannon-weiner tree species diversity index [17].

$$H = -\sum_{i=1}^{S} Pi \ln Pi \quad (1)$$

Where:

H = Shannon-Weiner tree species diversity index.

S = Total number of species in the community.

Pi = Proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N).

ln = Natural logarithm.

Margalef's index of species richness (M).

$$M = \frac{(S-1)}{\ln N} \quad (2)$$

Where

S = Total number of species in the community.

N = Total number of all individual trees.

Ln = Natural logarithm.

2.4. Species Evenness (E)

To determine the Species evenness (E), in each community Shannon's equitability equation was used following Kent and Coker [18].

$$E_H = \frac{H'}{H_{Max}} = \frac{\sum_{i=1}^{S} P_i \ln(P_i)}{\ln(S)} \quad (3)$$

Where H' = Shannon diversity index, S = the total number of species in the community, pi = proportion S (species in the family) made up of the ith species and ln = natural logarithm, $H_{max=}$Shannon diversity index maximum.

2.5. Important Value Index

Important Value Index was computed following the equation used by Ige and Komolafe [19] which is expressed as the sum $RD and RD_0$ divided by 2. This simply expresses the share of each species in the tree community.

$$IVI = (RD + RDo)/2 \quad (4)$$

Where IVI = Important value index, RD = Relative density and RD_0 = Relative dominance.

2.6. Relative Density (RD)

As computed by Ige and Komolafe [19].

$$RD = \frac{n_i}{N} \times 100 \quad (5)$$

Where: RD (%) = species relative density; ni = number of individuals of species i; N = total number of all tree species in the entire community.

2.7. Relative Dominance (RDO)

As it was computed using the equation used by Akindele [20].

$$RD_O = \frac{\sum Ba_i \times 100}{\sum Ba_n} \quad (6)$$

Where: Bai = basal area of individual tree belonging to species i and Ban = stand basal area.

2.8. Tree Growth Characteristics

2.8.1. Stem Volume

$$V = \pi H \left[\frac{Db^2 + 4Dm^2 + Dt^2}{24} \right] \quad (7)$$

Where V= volume over bark (m^3), H= Total Tree Height (m), Db=Diameter at the base, Dm= Diameter at the middle, Dt= Diameter at the top and π = 3.142 (constant).

2.8.2. Basal Area

The Basal Area for individual tree species within each plot was estimated by using:

$$Basal\ Area = (\pi DBH^2)/4 \quad (8)$$

Where: BA is the Basal Area (m^2), π is 3.142 (constant), DBH is Diameter at Breast Height (m).

2.8.3. Slenderness Coefficient

$$TSC = THt/DBH \quad (9)$$

Tree Slenderness Coefficient (TSC) values were classified into three categories according to Ige [21]:

TSC values > 99…………… High slenderness coefficient (Prone to wind throw).

70 < TSC values < 99……… Moderate slenderness coefficient (Can withstand wind throw).

TSC values < 70…………… Low slenderness coefficient (Can withstand wind throw).

2.9. Biomass and Carbon Stock Estimation

2.9.1. Aboveground Biomass (AB)

The AB was estimated using the following formula:

$$AGB = \delta\ x\ V \quad (10)$$

Where, AB = Aboveground Biomass.

δ = Wood density.

V = Stem Volume of individual trees.

2.9.2. Carbon Stock Estimation

The amount of carbon stock by each tree species was estimated using the Pearson, et al. [22] formula:

$$Tree\ Carbon\ Stock\ =\ 0.5\ \times\ AB \quad (11)$$

To determine the equivalent amount of carbon-dioxide, Carbon stock is multiplied by 3.67.

$$CO_2\ =\ Carbon\ stock\ \times\ 3.67 \quad (12)$$

2.9.3. Carbon Stock Models

Most abundant tree species (≥ 5 stands per species) were selected and carbon stock models were developed for each of the species. Below are the six models selected for the study:

$$C\ =\ \beta_o\ +\ \beta_1 ln(AB)\ +\ \beta_2 ln(DBH)]\ +\ \beta_3 ln(Ht)] \quad (13)$$

$$C\ = \beta_o\ +\ ln(AB)\ +\ ln(DBH^2)\ +\ ln(Ht) \quad (14)$$

$$C\ =\ \beta_o +\ \beta_1[exp^{(AB\ +\ DBH)}] \quad (15)$$

$$C\ =\ \beta_o + \beta_1 ln\ (DBH^2)\ +\ \beta_2 lnHt^2 + \beta_3\ (AB\ +\ DBH) \quad (16)$$

$$C\ = \beta_o + \beta_1(AB)\ + \beta_2(DBH^2)\ +\ \beta_3 ln\ (Ht\ +\ DBH) \quad (17)$$

$$C\ =\ \beta_o + \beta_1 ln\ (AB)\ +\ \beta_2 ln(DBH)\ +\ \beta_3 ln\ (Ht\ +\ DBH) \quad (18)$$

2.9.4. Model Evaluation and Selection

Alkaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Root Mean Square Error (RMSE) and Adj.R^2 were used as the evaluation indices. Model with the least AIC, BIC, RMSE and highest Adj. R^2 were selected as the best.

$$\text{AIC}=\ln\left(\frac{\text{RSS}}{\text{n-k}}\right)+\frac{2}{\text{n}}\text{K} \quad (19)$$

$$\text{BIC}=\ln\left(\frac{\text{RSS}}{\text{n-k}}\right)+\frac{\text{k}}{\text{n}}\ln(\text{n}) \quad (20)$$

$$\text{RMSE}=\sqrt{\frac{\Sigma(y_i-\hat{y}_i)^2}{n}} \quad (21)$$

$$\text{Adj. } R^2=1-\left[\frac{(1-R^2)(n-1)}{n-k-1}\right] \quad (22)$$

Where:

ln = Natural logarithm.

RSS= Residual sum of squares.

n = Total number of observations.

K = Number of independent variables.

y_i = Observed values of y.

$\hat{y}_i$ = Predicted values of y.

R^2 = Sampled R-squared.

3. RESULT AND DISCUSSIONS

3.1. Biodiversity Indices and Tree Species Classification

The total number of trees (dbh ≥10cm) measured were 220 stems/ha (Table 1) where the dominance is less than 1 (i.e. shows lower dominance), higher value of Shannon index of 2.181 indicates less diversity, Evenness ratio of 0.4919 indicates that few species dominate the garden, while the low Margalef's index of 3.152 indicates low diversity of the species in the garden. Table 2 shows the frequency of trees within the identified 12 families, while the most abundant families are Meliaceae which comprises of 74 species, followed by Lamiaceae and Malvaceae with 35 species each while Leguminosae-mimosoideae, Anacardiaceae and Moraceae families have 1 species each. However, Meliaceae had the highest number of individual species of 74, followed by Lamiaceae and Malvacea with 35 each and Leguminosae-mimosoideae, Anacardiaceae and Moraceae have 1 stems ha^{-1} (33.64%, 15.91% and 0.45% respectively) as shown in Table 2. Table 3 shows the relative density, relative dominance and important value index. *Khaya senegalensis* of Meliaceae family has the highest number of stem per hectare (64 stems/ha) and relative density of 29.13, this makes the species the most abundant tree species in the study area. *Triplochiton scleroxylon* of Malvaceae family follows with 34 stems/ha with a relative density of 15.48 while *Nauclea diderichii* 1 stem ha^{-1} had relative density of 0.46 and 0.9 and relative dominance of 0.75. However, *Khaya senegalensis* has the highest important value index of 16.45, followed by *Anthocephalus cadamba* with IVI of 12.03 and *Nauclea diderichii* with least IVI of 0.60.

The carbon sequestration potential of the majority of forests in a typical developing tropical country, such as Nigeria, has been significantly reduced over the years [23]. Deforestation and degradation activities in these forest estates, exacerbated the situation. For example, FAO [24] highlighted that Nigeria experienced the highest net losses in forest area between 2010 and 2015 (410 K ha yr−1). Consequently, many of these forest areas that once acted as carbon sinks have now become notable sources of carbon emissions [25, 26]. This coefficient serves to assess the stability of the tree against wind throw. In contrast to Aghimien, et al. [27] findings, which reported a 98.8% prevalence of low TSC in the study area, this study reveals that 22.2 % of trees per hectare has low TSC, 5.6% of trees exhibit high TSC, while 72.2% demonstrate a moderate TSC. This suggests a lower susceptibility to wind throw. The divergence in TSC outcomes between this study and that of Ige and Komolafe [19] may be attributed to differences in encountered tree species, form, and growth patterns over the years in their study.

Table 1. Biodiversity indices.

Indices	Values
Taxa_S	18
Individuals	220
Dominance_D	0.1535
Shannon_H	2.181
Evenness_e^H/S	0.4919
Margalef	3.152

Table 2. Family composition of tree species in the study area.

Family	Frequency	Percentage (%)
Leguminosae-mimosoideae	1	0.45
Anacardiaceae	1	0.45
Apocynaceae	2	0.91
Arecaceae	4	1.82
Combretaceae	15	6.82
Lamiaceae	35	15.91
Lythraceae	4	1.82
Malvaceae	35	15.91
Meliaceae	74	33.64
Moraceae	1	0.45
Myrtaceae	19	8.64
Rubaceae	29	13.18
Total	220	100.00

Table 3. Family important value index.

Species	F/ha	RD	RD_o	IVI
Albizzia lebbek	1.0	0.46	2.26	1.36
Anthocephalus cadamba	28.0	12.75	11.32	12.03
Alstonia bonnie	2.0	0.91	13.58	7.25
Azadirachta indica	10.0	4.55	3.77	4.16
Elaeis guineensis	1.0	0.46	4.15	2.30

Species	F/ha	RD	RD_o	IVI
Eucalyptus toreliana	19.0	8.65	4.15	6.40
Ficus capensis	1.0	0.46	6.79	3.62
Gmelina arborea	10.0	4.55	2.64	3.60
Khaya senegalensis	64.0	29.13	3.77	16.45
Lagerstroemia speciosa	4.0	1.82	5.66	3.74
Mangifera indica	1.0	0.46	3.02	1.74
Mansonia altissima	1.0	0.46	9.81	5.13
Nauclea diderichii	1.0	0.46	0.75	0.60
Roystonea regia	3.0	1.37	2.26	1.81
Tectona grandis	25.0	11.38	5.28	8.33
Terminalia catappa	13.0	5.92	6.04	5.98
Terminalia ivorensis	2.0	0.91	8.30	4.61
Triplochiton scleroxylon	34.0	15.48	6.42	10.95
Total	220	100.00	100.00	100.00

3.2. Tree Growth Characteristics

Table 4 showed the statistical analysis of the tree growth variables for this study. Alstonia bonnie has the highest dbh of mean value of 62.8cm while Nauclea diderichii has the mean value of 16.3 cm. Elaeis guineensis has the highest tree height of 39m and Nauclea diderichii with least average value of 10.5m. The highest mean basal area/ha and mean volume/ha are 0.36m2 and 5.7m3, respectively while the lowest mean values of the basal area and volume per hectare are 0.06m2 and 0.3m3, respectively. The measure of TSC (%) in the study area indicates that relatively large numbers of trees are of good vigor with Elaeis guineensis having the highest (107) and few trees which that are prone to wind throw.

Table 4. Statistical summary of the tree growth characteristics.

Species	DBH (cm)	BA (m^2/ha)	Volume (m^3/ha)	Height (m)	TSC (%)
Albizzia lebbek	28.5	0.06	0.33	11.2	39
Anthocephalus cadamba	54.71	0.3	5.71	21.7	42
Alstonia bonnie	62.8	0.36	5.18	23.3	39
Azadirachta indica	33.01	0.1	1.85	30.0	97
Elaeis guineensis	37.2	0.11	2.63	39.7	107
Eucalyptus toreliana	34.88	0.11	2.48	36.4	85
Ficus capensis	47.6	0.18	1.3	10.9	23
Gmelina arborea	27.66	0.07	0.44	19.9	77
Khaya senegalensis	43.25	0.1	1.64	23.6	80
Lagerstroemia speciosa	43.25	0.15	2.74	31.9	74
Mangifera indica	32.6	0.08	0.78	19.9	61
Mansonia altissima	58	0.26	4.95	29.8	51
Nauclea diderichii	15.3	0.02	0.09	10.5	69
Roystonea regia	27.77	0.06	0.78	24.3	91
Tectona grandis	36.13	0.14	2.74	20.5	65
Terminalia catappa	44.44	0.16	2.59	25.2	60
Terminalia ivorensis	49.85	0.22	3.99	33.0	69
Triplochiton scleroxylon	42	0.17	3.77	31.3	85
Total	-	2.65	43.99	-	-

3.3. Carbon Stock Estimation

Table 5 shows the estimated AGB in which Khaya senegalensis with 0.6643±4.94 x10-20 kg/ha has the highest value. Table 6 shows aggregate of CO2 sequestered by the obtained sample plots of 5.3ha of the land size which is 0.001246 tons per hectare. Hence, the carbon sequestration potential of the garden is 0.0066038 tons. However, Khaya senegalensis has the highest carbon sequestration potential with 0.0003322tons followed by Eucalyptus torelliana with 0.00029 tons, while Albizzia lebbek with 0.0000001 tons has the lowest carbon stock potential.

Table 5. Estimated above-ground bole biomass.

Species	Family	AGB (kg/Ha)	Standard deviation
Albizzia lebbek	Leguminosae-mimosoideae	0.2 x10^{-3}	0.00
Anthocephalus cadamba	Rubaceae	0.25	3.25x10^{-20}
Alstonia bonnie	Apocynaceae	0.02	1.14 x10^{-05}
Azadirachta indica	Meliaceae	0.20	1.15 x10^{-05}
Elaeis guineensis	Arecaceae	0.01	0.00
Eucalyptus toreliana	Myrtaceae	0.58	7.89 x10^{-20}
Ficus capensis	Moraceae	3.4 x10^{-4}	0.00
Gmelina arborea	Lamiaceae	0.09	7.86 x10^{-06}
Khaya senegalensis	Meliaceae	0.66	4.94 x10^{-20}
Lagerstroemia speciose	Lythraceae	0.07	1.47 x10^{-05}
Mangifera indica	Anacardiaceae	0.01	0.00
Mansonia altissima	Malvaceae	0.01	0.00
Nauclea diderichii	Rubiaceae	0.01	0
Roystonea regia	Arecaceae	0.06	1.57 x10^{-05}
Tectona grandis	Lamiaceae	0.28	1.32 x10^{-05}
Terminalia catappa	Combretaceae	0.17	1.34 x10^{-05}
Terminalia ivorensis	Combretaceae	0.03	6.55 x10^{-06}
Triplochiton scleroxylon	Malvaceae	0.03	2.92 x10^{-20}
Total (Kg/ha)		2.8006	0.00
Total AGB in the study area (5.3ha)		14.84318	0.00

Table 6. Quantity of carbon dioxiode (CO_2) sequestered by the tree species in the study area.

Species	AGB (kg/ha)	CO_2(Kg/ha)	CO_2 (ton/ha)
Albizzia lebbek	0.2 x10^{-03}	0.1 x10^{-3}	1.0x10^{-07}
Anthocephalus cadamba	0.25	0.13	1.3 x10^{-4}
Alstonia bonnie	0.02	0.01	9.2 x10^{-06}
Azadirachta indica	0.20	0.10	9.9 x10^{-05}
Elaeis guineensis	0.01	0.01	5.5 x10^{-06}
Eucalyptus toreliana	0.58	0.29	2.9 x10^{-4}
Ficus capensis	3.4 x10^{-3}	1.7 x10^{-3}	1.7 x10^{-06}
Gmelina arborea	0.09	0.04	4.3 x10^{-05}
Khaya senegalensis	0.66	0.33	3.3 x10^{-4}
Lagerstroemia speciosa	0.07	0.04	3.6 x10^{-05}
Mangifera indica	0.01	0.01	5.5 x10^{-06}
Mansonia altisima	0.01	0.01	5.4 x10^{-06}
Nauclea diderichii	0.01	3.6 x10^{-3}	3.6 x10^{-06}
Roystonea regia	0.06	0.03	3.2 x10^{-05}
Tectona grandis	0.28	0.14	1.4 x10^{-4}
Terminalia catappa	0.17	0.08	8.3 x10^{-05}
Terminalia ivorensis	0.03	0.02	1.7 x10^{-05}
Triplochiton scleroxylon	0.03	0.02	1.7 x10^{-05}
Total	2.80	1.25	1.2 x10^{-3}

3.4. Carbon Stock Model

In the six regression models selected (Table 7), using four performance criteria, the best model selected for this study after the fitting is model 2 with the least RMSE, AIC and BIC of 1.48x10^{-7}, -3.66.78 and -3.63.96, respectively and highest R^2 of 0.99. Thus, the model can be used to predict the carbon stock of the garden. Among other unselected models, the model is presented below:

$$Model\ 1: C = 3.66x10^{-4} + 3.68x10^{-5}\ [ln(AB)] - 2.18x10^{-6}\ [ln(DBH)] - 5.6x10^{-5}\ [ln(Ht)]$$

$$Model\ 2: C = 2.6x10^{-7} + ln(AB) + lnDBH^2 + lnHt \text{ (Selected model)}$$

$$Model\ 3: C = 8.63x10^{-5} - 4.064e^{-32}\ [exp^{(AB + DBH)}]$$

$$Model\ 4: C = 4.22x10^{-8} + 4.99x10^{-4}\ (DBH^2) - 1.95x10^{-10}\ [ln(Ht^2 - 2.45x10^{-8})(AB + DBH)]$$

$$Model\ 5: C = 4.22x10^{-8} - 1.95\ x10^{-10}\ (AB) - 2.46x10^{-8}\ (DBH^2) + 4.99x10^{-4}\ [ln(Ht + DBH)]$$

$$Model6: C = 6.56\ x10^{-4} + 3.81x10^{-5}\ (lnAB) - 4.09x10^{-5}\ [ln(DBH)] - 7.38x10^{-5}\ [ln(Ht + DBH)]$$

Table 7. Carbon stock model.

Model type	Model parameters				Performance criteria					
	β_0	β_1	β_2	β_3	RMSE	AIC	BIC	$AdjR^2$	P-value	F-test
Mod_1	3.66x10^{-4}	3.68x10^{-5}	-2.18x10^{-6}	-5.6x10^{-5}	6.91x10^{-5}	-206.95	-204.12	0.61	0.03*	4.69
Mod_2	2.6x10^{-7}	4.99x10^{-4}	-4.27x10^{-8}	-2.79x10^{-8}	1.48x10^{-7}	-3.66.78	-3.63.96	0.99	0.00*	1.68x10^{6}
Mod_3	8.63x10^{-5}	-4.064e^{-32}	-	-	9.76e^{-51}	-199.38	-197.68	-35885.99	0.00*	0.58
Mod_4	4.22x10^{-8}	4.99x10^{-4}	-1.95x10^{-10}	-2.45x10^{-8}	1.56 x10^{-7}	-364.91	-361.52	-6.13	0.00*	1.13x10^{6}
Mod_5	4.22x10^{-8}	-1.95 x10^{-10}	-2.46x10^{-8}	4.99x10^{-4}	1.56 x10^{-7}	-364.91	-361.52	-18417.67	0.00*	1.13x10^{6}
Mod_6	6.56 x10^{-4}	3.81 x10^{-5}	-4.09x10^{-5}	-7.38x10^{-5}	6.76x10^{-5}	-203.69	-203.43	-8.56 x10^{13}	0.04*	4.69

Note: *Significance at 5% probability level.

4. CONCLUSION AND RECOMMENDATION

The allometric models that were developed for the recreational trees at Agodi Garden plantation would give researchers a solid foundation for in improving predictions of aboveground stem biomass and carbon stock. The study found that while calculation of biomass can be done using any model with a variety of independent variables, model with just dbh provides the most accurate estimate. According to the findings of the study, the dbh and total height sizes have a considerable impact on the aboveground stem carbon stock of the plantation as well. The carbon stock modeled for this study, 2.6x10-7 + ln (AB) + $\ln DBH^2$ + lnHt, should be henceforth put into use for the proper management plan on whether to plant more trees or retain the existing green.

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