WebLog Journal of Environmental Sciences

Research Article
Published: 17 Sep, 2025

Allometric Model for Predicting above Ground Carbon Stock of *Gardénia* Stands in Central Africa: A Case Study of Cameroon

Dr. Awé Djongmo Victor[1]* and Prof. Noiha Noumi Valery[2]

[1]Department of Plant Production, Higher Institute of Agriculture, Wood, Water Resources and Environment of Belabo, University of Bertoua, P.O. Box 60, Belabo, Cameroon

[2]Department of Life Science, Higher Teacher Training College of Bertoua, University of Bertoua, Cameroon

WebLog Open Access Publications
Article ID : wjets.2025.i1701
Author : Dr. Awé Djongmo Victor, Ph.D.

OPEN ACCESS

***Correspondence:**
Dr. Awé Djongmo Victor, Department of Plant Production, Higher Institute of Agriculture, Wood, Water Resources and Environment of Belabo, University of Bertoua, P.O. Box 60, Belabo, Cameroon,
E-mail: awevictor920@gmail.com

Received Date: *07 Sep 2025*
Accepted Date: *15 Sep 2025*
Published Date: *17 Sep 2025*

Citation:
Victor AD, Valery NN. Allometric Model for Predicting above Ground Carbon Stock of Gardénia Stands in Central Africa: A Case Study of Cameroon. WebLog J Environ Sci. wjets.2025.i1701. https://doi.org/10.5281/zenodo.17282538

***Copyright**© 2025 Dr. Awé Djongmo Victor. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.*

Abstract

Allometric equations estimating carbon stock of *Gardenia aqualla* and *Gardenia ternifolia* stands in Cameroon have been developed. The sample consists of 35 individuals of *Gardenia aqualla* and 35 individuals of *Gardenia ternifolia*. These individuals were cut, measured and weighed entirely and the data acquired was used to build predictive models of biomass as a function of diameter at breast height. Adjusted coefficients of determination, residual standard error, root mean square error and Akaike's information criterion were used to choose the best models. Linear, power, exponential and logarithmic functions were fitted for aboveground biomass using diameter at breast height as the independent variable. The best fit model for estimation of total aboveground biomass (TAGB) was in the form of a power function TAGB = $0.289D^{1.168}$ (*Gardenia aqualla*) and TAGB= $0.279D^{1.052}$ (*Gardenia termifolia*). This study indicated that, *Gardenia aqualla* showed higher AGC (59.98 Mg $C.ha^{-1}$) compared to *Gardenia ternifolia* (50.95 Mg $C.ha^{-1}$). *Gardenia aqualla* (220.12 Mg $CO_2.ha^{-1}$) sequestered CO_2 more than *Gardenia ternifolia* (186.98 Mg $CO_2.ha^{-1}$). These developed equations will be useful tools to assess the potential for carbon sequestration in *Gardenia aqualla* and *Gardenia ternifolia* stands and represent key information for scaling up biomass estimates for the REDD + context. This study showed that the *Gardenia* genera plays a role as a carbon sink.

Keywords: Aboveground Biomass, Allometric Model, Cameroon, Carbon Sink, Gardenia

Introduction

Forests play a specific and important role in the global carbon-cycle, absorbing carbon dioxide during photosynthesis and storing it above and belowground [1]. The Reduction of Emissions from Deforestation and Forest Degradation (REDD+) projects are a political-effective option for the mitigation and adaptation to climate change. One of REDD+'s goals is to estimate the carbon reserves stored in the forests [1-4]. The existence of local allometric models to estimate biomass in different land uses is a fundamental part of the carbon inventories, and these are a basic requirement to develop forest projects for greenhouse gases (GHG) mitigation [1-4]. Forest biomass have been studied with different purposes, among which is the nutrient cycle, for energy purposes, in forest growth assessment for forest management purposes, environmental impact mitigation [1].Obtaining economic incentives for forest preservation and the reduction of such gases [1]. Since forest cover is the main carbon sink [1]. These ecosystems are considered as a climate change mitigation strategy at global level [1]. Allometric models make easy to estimate volume and AGB from measuring easily measurable individual tree parameters such as diameter at breast height (Dbh) and total tree height (ht) in forest inventories [1].

Gardenia aqualla Stapfand Hutch. and *Gardenia ternifolia* Schumach and Thonn. are species belonging to the Rubiaceae families. The latter contains about 200 genera and is among the most numerous families of flowering plants. *Gardenia aqualla* Stapf and Hutch., and *Gardenia ternifolia* Schumach and Thonn. It is present from Senegal to Sudan via Mali, the Republic of Guinea, Guinea-Bissau, Ghana, Togo, Côte d'Ivoire, Benin, Niger, Nigeria and Cameroon [5, 6]. It grows in the Sahelo-Sudanese and Guinean savannas on compact, sandy clay soils with temporarily flooded ferruginous crusts [5, 6].

The estimation of carbon sink or sequestration relies on biomass content and growth data.

Biomass content can be measured by direct or indirect methods [7, 8]. Direct methods consist of felling trees, cutting them into sections, and weighing them to obtain the actual biomass. Indirect methods are based on developed equations to estimate tree biomass. The carbon absorbed in plants can be estimated by using diameter at breast height (Dbh) and height as predictors. There are many equations for estimating biomass, and previous researchers have reported that the allometric equation for a forest must be selected appropriately in order to accurately estimate forest biomass because these equations differ significantly between forest types [9-12].

Although the importance of *Gardenia aqualla* Stapf and Hutch., and *Gardenia ternifolia* Schumach and Thonn are widely documented, information on the potential for carbon storage is scarce or nonexistent in Cameroon. Little or no effort has been made to develop allometric equations to estimate the biomass of *Gardenia genera*. Allowing the prediction of the above-ground biomass of multispecies formations. Thus, knowledge of biomass would make it possible to improve the management of the species in savannah ecosystems, which can contribute to the resilience of rural populations to climate change. Stands of *Gardenia aqualla* Stapf and Hutch., and *Gardenia ternifolia* Schumach and Thonn can be used in carbon sequestration programs such as the REDD + Mechanism. In order to accomplish this, better information is needed on its carbon stock, and therefore, there is a strong need to develop allometric models that will be used to predict the available aboveground and belowground biomass. This study emphasized the estimation of AGB and carbon stock of *Gardenia aqualla* Stapf and Hutch and *Gardenia ternifolia* Schumach and Thonn planted in the Sudano-Sahelian savannah of North, Cameroon. The specific objective of this study was to develop allometric models to estimate the AGB of *Gardenia aqualla* Stapf and Hutch and *Gardenia ternifolia* Schumach and Thonn trees. The models were then used to determine the amount of carbon stored and sequestered by these two *Gardenia* variants in the savannah ecosystems setting.

Material and Methods

Study Area

The study took place in Central Africa, more precisely in Cameroon, in the North region of Cameroon, Benue department. This region is located between 9° 18'N to 8° 10'N latitude and 13° 23'E to 12° 16'E longitude [13] (Figure 1). The relief is a vast pedi-plain between the Mandara Mountains (1442 m) to the north and the Adamawa Plateau to the south. The climate is Sudano-Sahelian with two seasons: a dry season lasting six months (November-May) and a rainy season lasting six months (June-October) [14]. The average monthly temperature varied from 26°C in August to 40°C in March. The soil is of the ferruginous type characterized by acidity (pH = 5.5 - 6) and low cation exchange capacity [15]. The vegetation is a shrubby Sudanian savannah with a clear and degraded savannah appearance around the villages [16] (Figure 1).

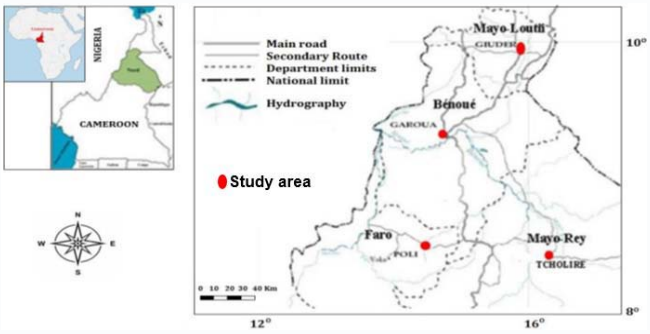

Figure 1: Geographic location of the study area in the North Cameroon Region.

Data Collection

Sampling method was conducted from September 2019 to September 2020. *Gardenia aqualla* and *Gardenia ternifolia*, were selected. Five sampling plots of 50 m x 50 m each were established randomly in each of the two stands [17]. The direct method was employed to determine the biomass of each tree. 35 trees of *Gardenia aqualla* and 35 trees of *Gardenia ternifolia* were harvested from the sampling plots within the two stands. Trees were felled close to ground level. The trees were selected to ensure a representative distribution of diameter classes within the sampling plots.

To conduct this study, the direct method based on the felling of *Gardenia aqualla* and *Gardenia ternifolia* trees were used. Individuals were selected on the basis of their availability and the absence of human exploitation (traces of pruning or limping) or disease. Before the trees were felled, the diameters of the individuals with bark were determined using a tape and the height was determined using a clinometer. The 35 trees of *Gardenia aqualla* and 35 trees of *Gardenia ternifolia* individuals were then cut 10 cm from the ground using a chainsaw and divided into compartments: the leaves; branches and trunks. The trunks and large branches were cut into small pieces, and bagged and weighed with a scale in the field. A sample from each compartment was taken and driedin an oven for 48 hours at a temperature of 70°C forthe leaves and 105°C for the trunk, branch discs.

The water contents of the samples of leaves, branches and trunks will be calculated according to the following formula:

WC (%) = ((WM-DM) / MS) * 100

Where: WC is the water content of the samples in percentage, WM and DM are respectively the wet mass (Kg) and the dry mass (Kg) of the sample.

From the water content of the samples, the total dry masses of the fractions were calculated as follows:

TDM = 100 * TWM / (100 + WC)

Where: TDM is the total dry mass

TWM is the total wet mass (Kg).

The total dry masses are called biomass and expressed in Kilograms (Kg).

Data Analysis

Biomass equations using Dbh as the independent variable were developed and were regressed against the total AGB of the combined tree components (leaves, branches and trunk). Total AGB allometric model of individual trees were derived from 35 trees for *Gardenia aqualla*and 35 for *Gardenia ternifolia*. Four forms of the model, namely linear (Eq. 1), power (Eq. 2), exponential (Eq. 3), and logarithmic (Eq. 4), were fitted for total AGB. The following models were considered for estimating AGB (*B*, kg dry weight) from DBH (*D*), where *a*and *b* are coefficients [11, 18, 19]:

$B = aD + b$ Eq. (1)

$B = aD^b$ Eq. (2)

$B = ae^{bD}$ Eq. (3)

$B = a\ln(D) - b$ Eq. (4)

Four criteria were used to measure the robustness and precision of the models in the estimation of above-ground biomass. They are in order of importance: i) Adjusted coefficient of determination (adjusted R^2) where STS: Sum of Total Squares and SRS: Sum of Residual Squares. ii) AIC or Akaike Information Criterion obtained by the following formula: AIC = - 2ln (L) + 2p where L "Likelihood" or Probability at which the predicted model is correct to the unknown true and p: Total number of parameters of the model. iii) RSE or Residual standard error: RSE = ln (AGB obs) - ln (AGB pred) where RSE: Residual standard error; AGB obs: Measured above-ground biomass; AGB pred: Predicted above-ground biomass. iv) RMSE or Root mean squared error:

$$RMSE = \frac{\sqrt{\sum(\ln(\text{AGBobs}) - \ln(\text{AGBpréd}))^2}}{\sqrt{n-k}}$$

Where:

n: total number of observations used in the model;

AGB obs: Measured above-ground biomass;

AGB pred: Predicted above-ground biomass;

K: number of parameters included in the model.

The selection of the best allometrics developed for the prediction of the above ground biomass (AGB) of *Gardenia aqualla* and *Gardenia ternifolia* was made on the basis of several statistical parameters. Thus, the lower the residual standard error (RSE), Akaike information criterion (AIC), mean square error (RMSE) and the strong adjusted R^2, the better the model will be [20-22].

The allometric equations were subjected to a series of statistical tests in order to meet all the validation conditions [19]. Thus, each model is subject, at the probability threshold of 5%, respectively to:

Normality test (Shapiro-Wilk test) to check the normality of the residuals;

Test of the zero mean (One Sample Test) to check the nullity of the residuals;

Heteroscedasticity test (Studentized Breusch-Pagan) to check the heterogeneity of the residues; Autocorrelation test (Durbin-Watson test) for the independence of the residues.

The statistical analyzes were carried out with Excel 2020 and R i386 3.1.2 software.

Estimation of Carbon Stock

The carbon (C) stocks were obtained by converting AGB to stored carbon fractions (CF) by multiplying by 0.47 [23] expressed in biomass per hectare. The amount of (CO_2)- equivalent sequestered was calculated by multiplying by the ratio of CO_2 to C, which is 3.667 to obtain the amount of CO_2 sequestered by the two stands.

Results

Measurable Parameters Dendrometric and Pearson's Correlation between Diameters, Height with Total Aboveground Biomass

The analysis of Table 1 shows that the populations of *Gardenia aqualla* and *Gardenia ternifolia* inventoried in the Sudano-Sahelian savannah of North, Cameroon are morphologically different. Indeed, the standard deviation observed in *Gardenia aqualla* is much more terms of the height (H) from the ground compared to *Gardenia ternifolia*. And much greater variability is noted with the diameter at breast height (Dbh) in *Gardenia aqualla* compared to *Gardenia ternifolia*. Thus, the high standard deviations show that there is a large difference between the sampled individuals, reflecting a large intra-site variability.

A correlation matrix made it possible to see the relationship which exists between the calculated dry biomass and the various dendrometric parameters measured: height (H) and diameters at breast height (Dbh). The results of the correlation showed that the dendrometric parameter of Dbh more measured than height. This parameter for each species was tested on four (04) models of equations (polynomial, linear, power, exponential andlogarithmic) fora possible prediction of the biomass (Table 2).

Preliminary Tests for the Selection of Equations

Table 3 presents the results of the various statistical tests of the four allometric equations. It emerges from this table that only equation 2 (Power) answers the various statistical tests mentioned above with a p-value for each test greater than 0.05. For Eq. 2 (Power), the residuals are normal, their mean is zero, their variance is constant and independent. We denote for each of the other three equations 1; 3 and 4 (Linear, Exponential and Logarithm) that the residuals are abnormal and that their mean is not zero. These results give a first indication for the most acceptable equation selection sequence.

Modelling Allometric Equations Tests

Table 4 shows the analysis of variance confirms that all the regression coefficients of the models tested are statistically significant ($p < 0.001$). These coefficients differ between the aboveground biomass of the two species for the same model, with RSE, AIC and

Table 1: Distribution of diameter and height.

Variables	*Gardenia aqualla*			*Gardenia ternifolia*		
	Minimum	Maximum	Mean (sd)	Minimum	maximum	Mean (sd)
Dbh (cm)	4.96	48.87	26.91 ± 2.92	4.75	48.04	26.39 ± 2.18
H (m)	2.95	12.54	7.74 ± 0.98	3.54	11.85	7.69 ± 0.94

Dbh: Diameter at Breast height, H: Height, sd: standard deviation

Table 2: Relationship between dry biomass and dendrometric parameters.

Species	Dbh (cm)	Height (m)
Gardenia aqualla	0.96***	0.28ns
Gardenia ternifolia	0.90***	0.35ns

Dbh: Diameter at Breast height, H: Height

Table 3: Results of the various statistical tests of the four allometric equations.

Species	Form	Shapiro-Wilk	One Sample	Breusch-Pagan	Durbin-Watson
Gardenia aqualla	Linear	0.005	0.0134	0.886	0.634
	Power	0.694	0.789	0.782	0.559
	Exponential	0.014	0.0208	0.955	0.668
	Logarithm	0.012	0.008	0.984	0.691
Gardenia ternifolia	Linear	0.045	0.014	0.996	0.702
	Power	0.649	0.701	0.711	0.517
	Exponential	0.027	0.020	0.995	0.611
	Logarithm	0.022	0.006	0.974	0.631

Table 4: Allometric equations developed from the different models for *Gardenia aqualla* (n = 35) and *Gardenia ternifolia* (n = 35).

Species	Form	Regression coefficient		AdjustedR^2	RSE	RMSE	AIC	*P*-value
		a	b					
Gardenia aqualla	Linear	1.852	-23.862	0.96	1.88	1.59	21.08	<0.001
	Power	0.289	1.168	0.98	1.72	1.39	17.60	<0.001
	Exponential	11.022	0.203	0.90	2.85	2.66	24.8	<0.001
	Logarithm	22.952	57.025	0.88	4.14	4.01	25.90	<0.001
Gardenia ternifolia	Linear	33.327	24.818	0.95	1.78	1.47	22.80	<0.001
	Power	0.279	1.052	0.97	1.64	1.29	19.54	<0.001
	Exponential	12.085	0.287	0.93	2.63	2.43	26.71	<0.001
	Logarithm	21.026	79.531	0.87	4.10	3.97	27.12	<0.001

Coefficient of regression model (a and b), Height (H), Biomass (B), adjusted coefficient of determination (adj. R^2), residual standard error (RSE), Root mean squared error (RMSE) and Akaike information criteria (AIC)

Table 5: Selection of the Best Models for *Gardenia aqualla* (n = 35) and *Gardenia ternifolia* (n = 35).

Species	Model	AdjustedR^2	RSE	RMSE	AIC
Gardenia aqualla	$B = 0.289D^{1.168}$	0.98	1.72	1.39	17.6
Gardenia ternifolia	$B= 0.279D^{1.052}$	0.97	1.64	1.29	19.54

Biomass (B), Diameter at breast height (D), Height (H), Biomass (B), adjusted coefficient of determination (adj. R^2), residual standard error (RSE), Root mean squared error (RMSE) and Akaike information criteria (AIC)

Table 6: Total Aboveground Biomass (AGB), C-stock content of Aboveground Biomass (AGC), and CO_2Sequestered (VCO_2eq) and Density in *Gardenia aqualla* and *Gardenia ternifolia stands.*

Species	Density (stems/ha)	AGB ($Mg.ha^{-1}$)	AGC ($MgC.ha^{-1}$)	$VCO_{2}eq$ ($MgCO_2.ha^{-1}$)
Gardenia aqualla	185 ± 12.65b	127.63 ± 8.73b	59.98± 3.32b	220.12± 14.68b
Gardenia ternifolia	154 ± 10.21a	108.41± 5.93a	50.95± 2.94a	186.98± 12.85a

The values assigned the same letter are not statistically different (p> 0.05; Duncan test)

RMSE ranging from 1.64 - 4.14 kg; 17.60 - 27.12 kg and 1.29 - 4.01 kg, respectively. The equation 2 (Eq. 2) has residual standard error (RSE), Akaike information criterion (AIC), mean square error (RMSE) weaker and the strong adjusted R^2 compared to the other three equations (Table 4 et 5). This means that the power model is the most explanatory of the aboveground biomass of *Gardenia aqualla* and *Gardenia ternifolia* in the Sudano-Sahelian savannas of North Cameroon. The other three equations each have a high residual standard error (RSE), Akaike information criterion (AIC), high mean square error (RMSE) and low adjusted R^2. Which disqualifies them from selection. These best equations are shown in Table 5 and Figure 2 show their adjustments.

Aboveground Biomass and Carbon Stock Estimation

The power functions $B = 0.289D^{1.168}$ and $B= 0.279D^{1.052}$ were used to estimate AGB of each tree in all five plots (Table 1) of *Gardenia aqualla* and *Gardenia ternifolia*, respectively. Total AGB were expressed in megagram (Mg) and converted into Mg per hectare ($Mg.\ ha^{-1}$) (Table 6). The estimates showed that AGB of *Gardenia aqualla* was higher (127.63 $Mg.\ ha^{-1}$) than that of *Gardenia ternifolia* (108.41 $Mg.\ ha^{-1}$) (Table 6). *Gardenia aqualla* showed higher AGC (59.98 $MgC.ha^{-1}$) compared to *Gardenia ternifolia* (50.95 $MgC.ha^{-1}$). *Gardenia aqualla* (220.12 $MgCO_2.ha^{-1}$) sequestered CO_2 more than *Gardenia ternifolia*(186.98 $MgCO_2.ha^{-1}$) (Table 6).

Discussion

This study made it possible to develop allometric equations for estimating the above-ground biomass of the species *Gardenia aqualla* and *Gardenia ternifolia*. The DBH of felled *Gardenia aqualla* and *Gardenia ternifolia* ranged from 4.96 - 48.87 cm and 4.75 - 48.04 cm, respectively. And also with a strong coefficient of determination (R^2) varying between 0.95-0.96; 0.97-0.98; 0.90-0.93 and 0.87-0.88 respectively for the linear (Eq. 1), power (Eq. 2), exponential (Eq. 3) equations, and logarithmic (Eq. 4). The sample size was 35 individuals

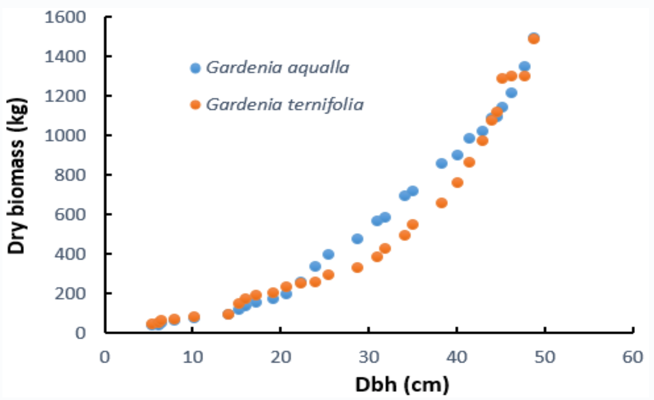

Figure 2: *Gardenia aqualla* and *Gardenia ternifolia* for allometric equations obtain.

of *Gardenia aqualla* and 35 individuals of *Gardenia ternifolia*. In fact, the size of the sample in the development of allometric models varies in the literature and takes into account the resources and time allocated to the study [20].

Allometric models have been developed with a number of trees greater than 100 [7, 18]. However, other models focused on a number of trees less than 20 [3, 19, 24, 25] and others higher or equal to 20 [4, 26, 27, 28]. Others integrate very few large diameter trees, from 1 to 79 cm in diameter [29]. In contrast, [27] used trees with diameters of less than 17.509 cm and 41.5 cm, respectively, to determine the allometric equations. Indeed, the size of the sample in the literature can in fact be variable for the development of allometric models. However, it takes into account the resources and time allocated to the study [30].

The four allometric equations each have a coefficient of determination close to 1, but three of them including linear, exponential, and logarithmic equations do not pass all of the preliminary statistical tests. A model may have a high coefficient of determination and be subsequently rejected by the assessment of certain validation criteria, in particular the various statistical tests, the residual standard error (RSE), the Akaike information criterion (AIC), the mean square error (RMSE) [20]. Among the four equations developed for *Gardenia aqualla* and *Gardenia ternifolia*, the power equation ($B = 0.289D^{1.168}$ and $B = 0.279D^{1.052}$) presents respectively the weakest AIC (17.6 and 19.54), a weak RSE (1.72 and 1.64), a low RMSE (1.39 and 1.29) and mostly responds to all preliminary tests (p-value> 0.05). Thus, within the framework of this study, it emerged that whatever the criterion retained for the validation of the equations thus developed, the power model, with the equation $B = 0.289D^{1.168}$ (*Gardenia aqualla*) and $B = 0.279D^{1.052}$) (*Gardenia ternifolia*), is best indicated.

The power functions $B = 0.289D^{1.168}$ and $B= 0.279D^{1.052}$ were used to estimate AGB of each tree in all five plots (Table 1) of *Gardenia aqualla* and *Gardenia ternifolia*, respectively. The estimates showed that AGB of *Gardenia aqualla* was higher (127.63 Mg. ha^{-1}) than that of *Gardenia ternifolia* (108.41 Mg. ha^{-1}). The biomass and carbon content of the *Gardenia aqualla* and *Gardenia ternifolia* stands was very low compared to the average of 202 Mg ha^{-1} in tropical Africa [31]. The low carbon content of the two stands can be attributed to the low tree density, only 185 and 154 individuals/ha compared to 426 individuals/ha in African lowland forest [32]. Although Biomass are not based on the number of trees, but rather related to diameter at breast height [33, 34], emphasize the influence of soil type on the spatial variability of biomass stocks, and therefore of their carbon in tropical areas. *Gardenia aqualla* showed higher AGC (59.98 MgC. ha^{-1}) compared to *Gardenia ternifolia* (50.95 MgC.ha^{-1}). Our results are not contained in the intervals 12-33 MgC.ha^{-1}given by [17] in an agroecosystem to cashew tree, 11-26 MgC.ha^{-1} obtained by [35] in an agrosystem to Eucalyptus but contained in the intervals 10-60 MgC.ha^{-1} obtained by [36] and 11-63 MgC.ha^{-1} obtained by [37] in an agroecosystem to coconut. The CO_2 equivalent range 220.12 $MgCO_2.ha^{-1}$ (*Gardenia aqualla*) and 186.98 $MgCO_2.ha^{-1}$ (*Gardenia ternifolia)*. The ecological values of *Gardnia aqualla* and *Gardenia ternifolia* stands are very encouraging. It is necessary that the services in charge of rural development sensitize the populations for a better management of this species in the perspective of the reduction of greenhouse gases. This result does not similar by the results found by [17] in cashew plantations (146.88 $MgCO_2$/ha) and savannah (48.28 $MgCO_2$/ha) in the North Region Cameroon. From these savanna ecosystems studied value can offset the CO_2 emissions resulting from human activities.

Conclusion

The study tested four mathematical models; linear (Eq. 1), power (Eq. 2), exponential (Eq. 3), and logarithmic (Eq. 4); in the development of the allometric equation two species, *Gardenia aqualla* and *Gardenia ternifolia.* The results of various statistical validation tests made it possible to select the power model was determined as the most appropriate model for estimating total AGB of *Gardenia aqualla* and *Gardenia ternifolia* in the Sudano-Sahelian savannah of North, Cameroon. Application of the developed model yielded total aboveground biomass of *Gardenia ternifolia* and *Gardenia aqualla* of 108.41 Mg.ha^{-1} and 127.63 Mg.ha^{-1}, respectively. *Gardenia aqualla* showed higher AGC (59.98 MgC.ha^{-1}) compared to *Gardenia ternifolia* (50.95 MgC.ha^{-1}). *Gardenia aqualla* were shown to be capable of sequestering 220.12 $MgCO_2.ha^{-1}$ compared to *Gardenia ternifolia*, which were shown to be capable of sequestering only 186.98 $MgCO_2.ha^{-1}$. This makes of the *Gardenia aqualla* and *Gardenia ternifolia* contributory lungs to mitigate the mitigations of climatic disturbances. Finally, these results are also an important economic, ecological and dynamic informative value to serve as a basis for guiding any program of action aimed at the conservation and sustainable management of this species.

Acknowledgements

Authors thank all the referred whose contributions have been very significant for the improvement of this study.

References

1. Segura MA, Luis MA, Hernán JA. Allometric models to estimate aboveground biomass of small trees in wet tropical forests of colombian pacific area. Rev. Árvore. 2018; 42(2): 1806-9088. https://doi.org/10.1590/1806-90882018000200009

2. Henry M, Besnard A, Asante WA, Eshun J, Adu-Bredu SA, Valentini R, Bernoux M, Saint-Andre′ L. Wood density, phytomass variations within and among trees and allometric equations in a tropical rainforest of Africa. For EcolManag. 2010; 260: 1375-1388. https://doi.org/10.1016/j.foreco.2010.07.040

3. Tchindebe A, Ibrahima A, Tchobsala, Mohamadou LMA. Allometric Equations for predicting biomass of *Danielliaoliveri* (Rolfe) hutch and dalz. Stands in the Sudano-Guinea Savannahs of Ngaoundere, Cameroon. Ecology and Evolutionary Biology. 2019; 4(2): 15-22.

4. Tchindebe A, Tchobsala, Amadou MLM, Ahmadou H, Adamou I. Species-Specific Allometric Equations for Predicting Biomass of *Faidherbiaalbida* (Del.) A. Chev. In the Sudano-sahelian Savannahs of Far-North, Cameroon. Journal of Agriculture and Ecology Research International. 2020; 21(6): 33-44.

5. Arbonnier M. Arbres arbustes et lianes des zones sèches d'Afrique de l'Ouest. CIRAD-MNHN. 2002; 573.

6. Arbonnier M. Trees, Shrubs and Vines of West Africa (4th edition). Éditions Quae, Hors Collection, 02689NUM. 2019; 779.

7. Chave J, Andalo C, Brown S, Cairns MA, Chambers JQ, Eamus D et al. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia. 2005; 145: 87-99.

8. Chave J, Rejou MM, Burquez A, Chidumayo E, Colgan MS, Delitti WBC et al. Improved allometric models to estimate the aboveground biomass of tropical trees. Glob Change Biol. 2014; 20: 3177-3190. https://doi.org/10.1111/gcb.12629

9. Ekoungoulou R, Liu X, Loumeto J, Ifo SA. Above-and belowground biomass allometrics for carbon stocks estimation in secondary forest of Congo. J. Environ. Sci. Toxicol. Food Technol. 2014; 8: 9–20. DOI:10.9790/2402-08420920

10. Nam VT, van Kuijk M, Anten NPR. Allometric equations for aboveground and belowground biomass estimations in an evergreen forest in Vietnam. PLoS One. 2016; 11(6): e0156827. doi: 10.1371/journal.pone.0156827

11. Adam SN, Jusob I. Allometric model for predicting Aboveground biomass and Carbon stock of *Acacia plantations in Sarawak,* Malaysia. BioRessources. 2018; 13(4): 7381-7394.

12. Talla R, Sagna MB, Diallo MD, Diallo A, Ndiaye D, Sarr O and Guisse A. Development of Allometric Models for Estimating the Biomass of *Sclerocaryabirrea* (A.Rich) Hoscht and *Bosciasenegalensis* (Pers.) Lam. ex Poir. Open Journal of Ecology. 2020; 10: 571-584. DOI: 10.4236/oje.2020.108035

13. AwéDV, Noiha NV, Zapfack L. Carbon Storage and emission factor of Savanna ecosystems in Sudano-Sahelian zone of Cameroon. Journal of Botany Research. 2020; 2(1): 60-67. DOI: 10.36959/771/562

14. Awé DV, Noiha NV, Zapfack L, Ali AD, Madou C. Carbon stocks in dead wood biomass of Savannah ecosystems in Northern Region Cameroon. Journal of Botany Research. 2019; 2(1): 60-70. DOI:10.36959/771/562

15. Awé DV, Noiha NV, Zapfack L, Vroh BTA, Nyeck B. Vegetation structure, root biomass distribution and soil carbon stock of Savannah agrosystems in Sudano-Sahelian Zone of Cameroon. Journal of Botany Research. 2019; 2(1): 71-80.

16. Awé DV, Noiha NV, Madou C, Zapfack L. Floristic composition, diversity and structure of *Khayasenegalensis* stands in Benue Department, Cameroon. J. Trop. Resour. Sustain.Sci. 2020; 8: 60-68. DOI:10.47253/jtrss.v8i1.165

17. Noiha NV, Zapfack L, Awé DV, Witanou N, Nyeck B, Ngossomo JD, Hamadou MR, Chimi CD, Tabue MRB. Floristic structure and sequestration potential of cashew agroecosystems in Africa: A case study from Cameroon. Journal of Sustainable Forestry. 2017; 36(3): 277-288. https://doi.org/10.1080/10549811.2017.1296776

18. Brown S, Gilespie AJR, Lugo AE. Biomass estimation methods for tropical forest with application to forest inventory data. Forest Sciences. 1997; 35(4): 881–902. https://doi.org/10.1093/forestscience/35.4.881

19. Manzo OL, Moussa M, Issoufou H, Bil A, Abdoulaye D, Morou B, Youssifi S, Ali MRP. Equations allométriques pour l'estimation de la biomasse aérienne de *Faidherbiaalbida* (Del.) Achev dans les agrosystèmes d'Aguié, Niger. Int. J. Biol. Chem. Sci. 2015; 9(4) : 1863-1874. DOI:10.4314/ijbcs.v9i4.12

20. Picard N, Saint-André L, Henry M. Manual for building tree volume and biomass allometric equations: from field measurement to prediction. Rome: Food and Agricultural Organization of the United Nations and Montpellier, Centre de Coopération Internationale en Recherche Agronomique pour le Développement. 2012; 215.

21. Picard N, Rutishauser E, Ploton P, Ngomanda A, Henry M. Should tree biomass allometry be restricted to power models? For EcolManag. 2015; 353: 156-163. https://doi.org/10.1016/j.foreco.2015.05.035

22. Ouédraogo K, DimobeK,Thiombiano A. Allometric models for estimating aboveground biomass and carbon stock for *Diospyrosmespiliformis* in West Africa. *Silva Fennica*. 2020; 54(1): 2242-4075.

23. IPCC (Intergovernmental Panel on Climate Change). Guidelines for national greenhouse gas inventories., Agriculture, Forestry and other land use (AFLOLU). Institute for Global Environmental strategies, Hayama, Japan. 2006; 4: 54.

24. Larwanou M, Yemshaw Y, and Saadou M. Prediction Models for Estimating Foliar and Fruit Dry Biomasses of Five Savannah Tree Species in the West African Sahel. International Journal of Biological and Chemical Sciences. 2010; 4: 2245-2256. DOI:10.4314/ijbcs.v4i6.64943

25. Ebuy J, Lokombe D, Ponette JP, Sonwa D, and Picard N. Biomass Equation for Predicting Tree Aboveground Biomass at Yangambi, RDC. Journal of Tropical Forest Science. 2011; 23: 125-132.

26. Guendehou GHS, Lehtonen A, Moudachirou M, Mäkipää R, Sinsin B. Stem biomass and volume models of selected tropical tree species in West Africa. South Forests. 2012; 74(2): 77–88. DOI:10.2989/20702620.2012.701432

27. Mbow C, Verstraete MM, Sambou B, Diaw AT, Neufeldt H. Allometric models for aboveground biomass in dry savanna trees of the Sudan and Sudan Guinean ecosystems of Southern Senegal. J For Res. 2013; 19: 340-347. https://doi.org/10.1007/s10310-013-0414-1

28. Thiam S, Sambou B, Mbow C, Guisse A. Élaboration de modèles allométriques d'*Acacia Sénégal* L. Willd pour l'analyse du carbone ligneux en milieu sahélien : cas de la zone sylvopastorale au Sénégal. Afrique Science. 2014 ; 10(3): 304-315.

29. Djomo AN, Chimi CD. Tree allometric equations for estimation of above, below and total biomass in a tropical moist forest: Case study with application to remote sensing. For. Ecol. Manag. 2017; 391: 184-193. https://doi.org/10.1016/j.foreco.2017.02.022

30. Balima LH, Nacoulma BMI, Ekue MRM, Kouame NF, Thiombiano A. Use patterns, use values and management of *Afzeliaafricana* Sm. in Burkina Faso: implication for domestication and sustainable conservation. J. Ethnobiol. Ethnomed. 2018; 14(23): 1-14.

31. Lewis SL, Lopez-Gonzalez G, Sonke B, Affum-Baffoe K, Baker TR, Ojo LO. Increasing carbon storage in intact African tropical forests. Nature. 2009; 457: 1003–1006.

32. Lewis SL, Sonké B, Sunderland T, Begne SK, Lopez-Gonzalez G, Heijden GMFVD et al. Aboveground biomass and structure of 260 African tropical forests. Philosophical Transactions of the Royal Society of London B: Biological Sciences. 2013; 368: 20120295.

33. Aabeyir R, Adu-Bredu S, Agyare WA, Weir MJC. Allometric models for estimating aboveground biomass in the tropical woodlands of Ghana, West Africa. Forest Ecosystems. 2020; 7: 41. Available: https://doi.org/10.1186/s40663-020-00250-3

34. Gourlet-Fleury S, Rossi V, Rejou-Mechain M, Freycon V, Fayolle A, Saint-Andre L et al. Environmental filtering of dense wooded species controls above-ground biomass stored in African moist forests. Journal of Ecology. 2011; 99: 981-990. https://doi.org/10.1111/j.1365-2745.2011.01829.x

35. Noiha NV, Awé DV, Nyeck B, Tabue MRB, and Zapfack L. Vegetation structure, carbon sequestration potential and species conservation in four agroforestry systems in Cameroon (Tropical Africa). *Acta Botanica Brasilica*; 2018. DOI: 10.1590/0102-33062017abb0279

36. Valentini. Evaluation de la séquestration de carbone dans des plantations

agroforestières et des jachères issues d'une agriculture migratoire dans les territoires autochtones de Talamanca au Costa. Mémoire présenté pour l'obtention du grade de Maître es sciences (M.Sc). Faculté des Sciences de l'Agriculture et de l'alimentation, Université Laval Québec. 2007; 140.

37. Ngossomo JD. Diversité floristique et des stocks de carbone des plantations à cacaoyère dans la région du Centre-Cameroun : Cas de Mbandjiock. Mémoire de master II, université de Ngaoundéré (Cameroun). 2016; 45.