Asian Journal of Environment & Ecology

Volume 23, Issue 8, Page 119-127, 2024; Article no.AJEE.120436
ISSN: 2456-690X

Development of Local Volume Table for *Pinus caribbaea* var. *hondurensis* (Senecl) in Area J4, Omo Forest Reserve, Nigeria

Ige Peter Oluwagbemiga [a*] and Silas Abigail Emunu [b]

[a] Department of Social and Environmental Forestry, University of Ibadan, Nigeria.
[b] Department of Forestry and Wildlife Management, Federal University Wukari, Taraba State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ajee/2024/v23i8588

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/120436

Original Research Article

Received: 25/05/2024
Accepted: 20/07/2024
Published: 07/08/2024

ABSTRACT

Volume estimation is a crucial part of every forest or plantation because it provides the quantity of timber or wood available at a given period and predicts future or expected growth of the forest. Unfortunately, local volume table are not readily available for some–economically important tree species in Nigeria. Hence, it is of paramount importance that local volume tables for economic tree species such as *Pinus caribbaea* in Area J4, Omo Forest reserve, Ogun state, Nigeria.

Aim: The aim of this study is to develop a local volume table for *Pinus caribbaea* in Area J4, Omo Forest Reserve, Ogun State, Nigeria.

Study Design: Simple random sampling was used for this study. Ten Temporary Sample Plots (TSP) of equal size 25m x 25m were randomly located in the selected plantation (*P. caribbaea*: established in 1997). All the trees with diameter at breast height (dbh) ≥ 10cm in each TSP were enumerated.

**Corresponding author: E-mail: igepetero@gmail.com, po.ige@ui.edu.ng;*

Cite as: *Oluwagbemiga, Ige Peter, and Silas Abigail Emunu. 2024. "Development of Local Volume Table for Pinus Caribbaea Var. Hondurensis (Senecl) in Area J4, Omo Forest Reserve, Nigeria". Asian Journal of Environment & Ecology 23 (8):119-27. https://doi.org/10.9734/ajee/2024/v23i8588.*

Place and Duration of Study: The study was carried out in the *Pinus caribbaea* plantation in Area J4, Omo forest reserve, Ogun State from November 9th to 20th, 2023.
Methodology: The total tree height, merchantable height, diameters at the top, middle, base, and dbh were measured and used to estimate stand volume. A volume table was developed using five selected models, and the best model was selected using least Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and Root Mean Square Error (RMSE). Data were analyzed using descriptive statistics and regression at $\alpha_{0.05}$ with R statistical software.
Results: The results obtained in *P. caribbaea* plantation revealed that the dbh and height were 27.93±6.95 cm and 28.72±3.47 m, respectively, while individual tree volume was 0.83±0.57m³. The combined variable model ($V_i = -9.857e - 02 + 3.851e - 05D_i{}^2H_i + \varepsilon_i$) was selected as the best model to develop local volume table for *P. caribbaea* (AIC = -54.73, BIC = -45.49 and RMSE = 0.20). The statistical metrics implied a suitable selected model which can be use for future predictions with minimal error.
Conclusion: The developed volume table for estimating the quantity of wood or timber available in the *Pinus caribaea* plantation at a given time. The volume model and local volume table developed are to be applied only to the *Pinus caribaea* plantation in the study area for continuous estimation and valuation of the species.

Keywords: Volume table; volume models; non-destructive sampling; Pinus caribbaea; Omo Forest Reserve; forest volume estimation.

1. INTRODUCTION

Forest inventory is a crucial tool in forest management, providing essential data for planning, monitoring, evaluation, research, growth and yield predictions, and timber sales. The current level of the growing stock can be assessed through forest inventories and the future growth can be projected using growth and yield models [1]. Volume estimation plays a vital role in forestry as it quantifies the available timber or wood at a given time and predicts future growth. Accurate wood volume estimates are central to forest management and the trade of forest resources. [2]. For inventory and management purposes, the forest managers or researchers must be able to determine the volume of standing trees quickly and efficiently, even after the trees have been harvested. A volume table is a tabular statement that shows the volume in relation to diameter of trees in a specific area. Globally, volume tables play a significant role in calculating the volume of standing trees [3,4].

Pinus caribbaea is a durable and easily workable softwood widely used for construction, engineering, and decorative purposes. In tropical countries, the demand for long-fiber wood in the building and paper industries has made *P. caribbaea* a suitable species for extensive reforestation reforestation programs that not only restore forest losses but also aims to increase forest cover and mitigate desertification. This Caribbean pine has been successfully used in reforestation programs worldwide. Research has shown that volume tables have been developed for *P. caribeae* in Bulolo-Wau Forest plantations New Guinea [5] and volume equations and tables have been developed for other species [e.g. 6,7]. However, no volume table has been developed for *P. caribaea* in Area J4, Omo Forest reserve. The main objective of this study is to develop a local volume table for *Pinus caribbaea* in area J4, Omo Forest Reserve, Ogun State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted on the *Pinus carribaea* plantation at Area J4, Ijebu- Ode, Ogun State, Nigeria. The location spans latitudes 6°35' to 7°05' N and longitudes 4°19' to 4°40' E in the South-west of Nigeria (Fig. 1) and covering an area of 130,500 hectares [8]. It is approximately 135 km North-East of Lagos, 120 km East of Abeokuta and 80 km East of Ijebu-Ode [9]. The reserve shares its northern boundary with the Ago Owu and Shasha Forest Reserve in Osun state and its Eastern boundary with Oluwa Forest Reserve in Ondo State [10]. The mean annual rainfall ranges from 1600 to 2000 mm with peaks in June and September, and the driest months being November and February [11,12].

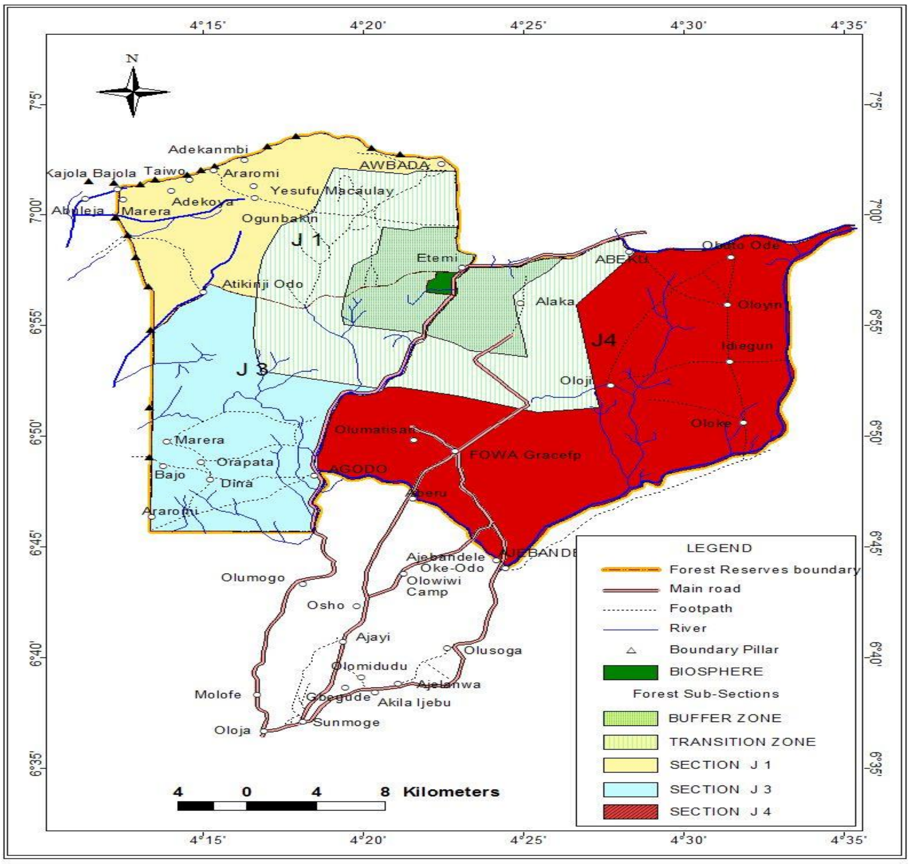

Fig. 1. Omo Forest Reserve showing the study area
Source: [13]

2.2 Species Description

Pinus caribaea var. *Hondurensis* (Senecl) Barr.et Golf. is widely grown in the African tropics and subtropics [14]. In its natural habitat in central America and the Caribbean Basin, *Pinus caribaea* thrives best at low altitudes (up to approximately 700 m above mean sea level) on fertile, well-drained soils with mean annual rainfall (MAR) of 1200 mm per year and mean annual temperatures ranging from 20°Cto 27°C [15]. In Africa, *Pinus caribaea* is known for its adaptability to a wide range of climates and elevations [16,17]. The hard wood of *Pinus caribaea* is suitable for floors and various types of construction.

2.3 Sampling Procedure

Simple random sampling was employed in this study. *P. caribbea* plantation stand established in 1997 was purposively selected due to its availability and relatively low disturbance/ harvesting. Developing a volume table for this age series is crucial as the trees are mature enough to meet management objectives (timber production). Consequently, the management of the forest reserve will utilize the table for valuation purposes during allocation processes. Ten Temporary Sample Plots (TSP) each measuring 25 m x 25 m were randomly located in each of the plantation.

2.4 Method of Data Collection

All trees in each Temporary Sample Plot (TSP) were enumerated. The total tree height, merchantable height, diameter at the top (Dt), middle (Dm), base (Db), and diameter at breast height (dbh) over bark at 1.3 m above the ground of all trees in the sample plot were measured using a diameter tape and height was measured using a Spiegel relaskop.

2.5 Data Analysis

2.5.1 Volume estimation

The volume of all trees in the sample plots was calculated using Newton’s formula.

Table 1. Selected Local Volume Equations

S/N	Model Name	Formula	Reference
1	Combined variable	$V_i = b_0 + b_1 {D_i}^2 H_i + \varepsilon_i$	[18]
2	Constant form factor	$V_i = b_1 {D_i}^2 H_i + \varepsilon_i$	[18]
3	Logarithmic	$V_i = e^{b1} {D_i}^{b2} {H_i}^{b3} e^{\varepsilon_i}$	[18]
4	Gen. combined variable	$V_i = b_0 + b_1 {D_i}^2 + b_2 H_i + b_3 {D_i}^2 H_i + \varepsilon_i$	[18]
5	Generalized logarithmic	$V_i = b_0 + b_1 {D_i}^{b2} {H_i}^{b3} e^{\varepsilon_i}$	[18]

Note: V_i- Individual tree stem volume, Di- Individual tree diameter at breast height, Hi- Individual tree total height, b0, b1, b2 and b3- Regression parameters, e- Exponential function, ε_i- Error term. Gen-Generalized

$$V = \pi \frac{H}{24}\left({D_b}^2 + 4{D_m}^2 + {D_t}^2\right) \quad \text{Eq. 1}$$

Where,

V = volume (m^3)
D_b = the diameter at the base (m^2)
D_m = the diameter at the middle (m^2)
D_t = the diameter at the top (m^2)
H = total tree height (m)

2.5.2 Development of Local Volume Tables

For developing the local volume Table 1, a non-destructive method was used. Five (5) volume equations, including the the constant form factor, combined variable, logarithmic, generalized combined variable and generalized logarithmic were used (Table 1).

2.5.3 Model evaluation

The Akaike information criterion (AIC), Bayesian information criterion (BIC) and Root Mean Square Error (RMSE) were used as evaluation indices. Models with the least AIC, BIC and RMSE were selected as the best.

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

$$BIC = ln\left(\frac{RSS}{n-k}\right) + \frac{k}{n}ln(n) \quad \text{Eq. 3}$$

$$RMSE = \sqrt{\frac{\sum(y_i - \hat{y}_i)^2}{n}} \quad \text{Eq. 4}$$

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

3. RESULTS AND DISCUSSION

Table 2 summarizes the descriptive statistics of the different tree growth variables obtained and calculated for *Pinus caribbaea* plantation in Area J4, Omo Forest reserve. According to the result, diameter at breast height (dbh, cm) has a mean of 27.93±6.95 cm, with minimum and maximum values of 16.2 and 52.0 cm, respectively. For total height (H, m), the mean value is 28.72±3.47 m, with minimum and maximum heights of 10.6 and 33.2 m, respectively. The Basal Area (BA, m^2) has a mean of 0.065±0.033 m^2, with minimum and maximum values of 0.021 and 0.212, respectively. The mean volume is 0.832±0.571 m^3, with minimum and maximum volumes of 0.088 and 3.284 m^3, respectively.

The relationship between dbh and stem height (Fig. 2) shows a positive linear relationship, typical of tropical plantation forests [3]. Additionally, all the selected trees in this study exhibit similar tapering from bottom to the top, confirming the biological validity of the data set as indicated by [3].

Table 2. Descriptive statistics for Growth Variable of *Pinus caribaea* plantation in Area J4, Omo Forest Reserve

Growth variable	Mean	Min	Max	Standard deviation
Dbh (cm)	27.93	16.2	52.0	6.95
H (m)	28.72	10.6	33.2	3.47
BA (m^2)	0.065	0.021	0.212	0.033
V (m^3)	0.832	0.088	3.284	0.571

Dbh=diameter at breast height, H=total tree height, BA=basal area, V= volume

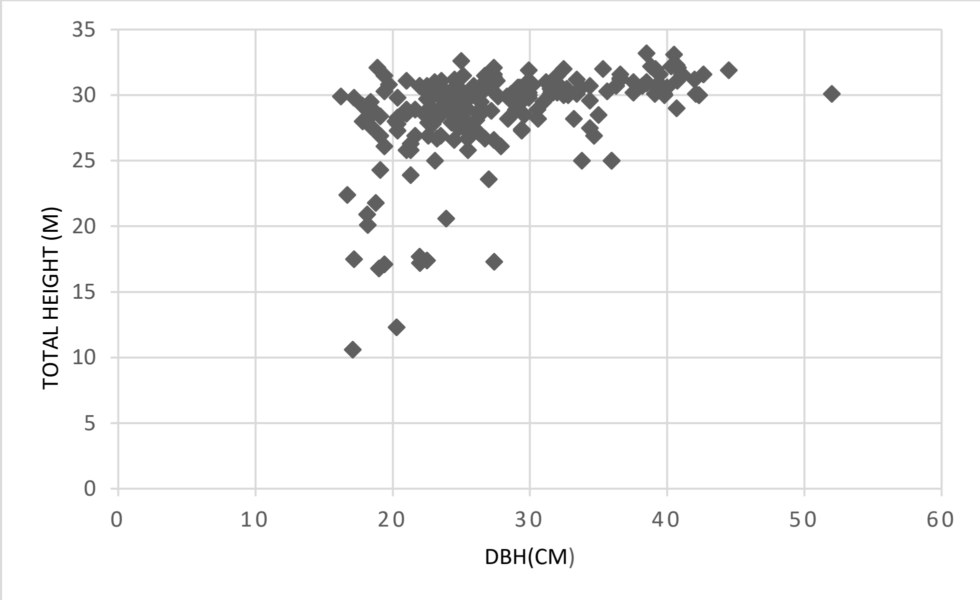

Fig. 2. Relationship between total tree height and diameter at breast height for *Pinus caribaea*

Table 3. Summary of Volume Models for Pinus caribaea in Area J4, Omo Forest Reserve

S/N	Models	Regression parameters	Fit indices
1	Combined variable	b_0= -9.857e-02 b_1= 3.851e-05	AIC= -54.73395 BIC= -45.48974 RMSE= 0.2016
2	Constant form factor	b_1= 3.540e-05	AIC= -47.70249 BIC=-41.53968 RMSE= 0.2067
3	Logarithmic	b_0= -11.8963 b_1= 1.4826	AIC= -48.07534 BIC= -38.83112 RMSE= 0.2058
4	Generalized combined variable	b_0= 3.352e-01 b_1= -4.859e-04 b_2= -1.547e-02 b_3=5.542e-05	AIC= -54.09115 BIC= -38.68413 RMSE= 0.2008
5	Generalized logarithmic	b_0= 3.352e-01 b_1= -4.859e-04 b_2= -1.547e-02 b_3= 5.542e-05	AIC= -54.09115 BIC= -38.68413 RMSE= 0.2008

AIC= Akaike information criterion, BIC= Bayesian information criterion, RMSE= Root Mean square error, b_0, b_1, b_2, b_3 are regression parameters

The Table 3 summarizes the five volume models used for *Pinus caribbaea* plantation in the study area. According to the results, the Combined variable model has the best fit with the least values for two of the fitting indices *i.e.,* AIC (-54.73395), BIC (-45.48974) and RMSE (0.2016). The next best fit is the Generalized Combined Variable (GCV) with AIC (-54.09115), BIC (-38.68413) and RMSE (0.2008), followed by the Logarithmic Model with AIC (-48.07534), BIC (-38.83112) and RMSE (0.2058). The Constant Form Factor model has the least favourable fit with AIC (-47.70249), BIC (-41.53968) and RMSE (0.2067). The Combined Variable Model was chosen as the best fit and used to construct the volume table for *Pinus caribbaea.* All the models used in this study were based on two variables (dbh and total height). As noted by [6], models based on two variables (dbh and total tree height) generally have the least standard error (10.3) and the highest Adjusted R^2 (0.982) making them the best choice.

3.1 Volume Table

After fitting the selected volume models on the *Pinus caribbaea* data set and subjecting them to the required selection indices such as Akaike information criterion (AIC), Bayesian information criterion (BIC) and Root Mean square error (RMSE), the Combined variable model, with the least AIC (-54.73395), BIC (-45.48974) and RMSE (0.2016) was selected as the best fit and used to construct the volume table. The measured and estimated volumes were compared using correlation graph (Fig. 3).

The models used in this study were similar to the models used by [18] to estimate the volume of *Tectona grandis* stands in Nnamdi Azikiwe University, Awka, Nigeria. The result from this study differs from those of [5] who used the Logarithmic volume model to develop the volume table for *Pinus caribaea* in Bulolo Wau forest plantations of Papua New Guinea. The Logarithmic model was found suitable based on the data and has an Adjusted R^2 of 0.957 indicating that the volume estimation of *Pinus caribaea* using the derived volume equation will be 95.70% accurate. The disagreement might result from differences in site quality, stand age or other factors. To confirm the validity of using these equations, residual analysis was conducted as pointed out by [19], revealing a strong positive correlation (Fig. 3) between the volumes obtained from Newton's equation and the selected volume model. The volume tables developed by [20] for *Gmelina arborea* and *Nauclea diderichii* [21] are in agreement with what was obtained in this study. The developed volume table is presented in Table 4 using the selected model:

$$V_i = -9.857e-02 + 3.851e-05 {D_i}^2 H_i + \varepsilon_i$$

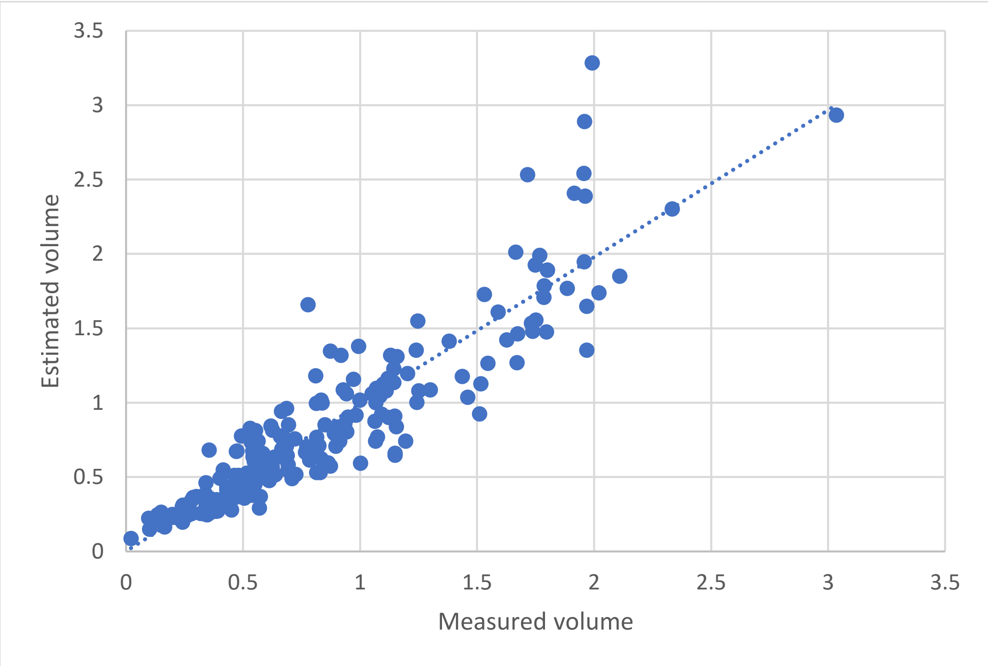

Fig. 3. Correlation between Measured and Estimated volume for *P. caribaea*

Table 4. Volume table for *Pinus caribaea* based on Combined Variable Model (Estimated 1997)

Dbh(cm)	H(m)	V (m^3)	Dbh(cm)	H(m)	V (m^3)	Dbh(cm)	H(m)	V (m^3)
18.4	29.5	0.286049	27.4	17.3	0.401604	39.8	30	1.731471
33.2	28.2	1.098443	20.3	12.3	0.096626	41.1	31.6	1.957057
24.3	27.9	0.53587	32.8	30	1.144348	32	31.5	1.143609
39.1	30.1	1.673552	28.4	28.2	0.77734	40.7	29	1.751381
22.5	29.7	0.480452	40.8	32.1	1.95921	32.1	30.5	1.111703
27.9	26.1	0.683818	29.3	29.4	0.873407	23.1	25	0.415163
23.5	26.9	0.473516	23.3	28.3	0.493089	32.7	30.5	1.15737
27.6	31.1	0.81376	25.7	29.9	0.661951	16.7	22.4	0.142007

Dbh(cm)	H(m)	V (m^3)	Dbh(cm)	H(m)	V (m^3)	Dbh(cm)	H(m)	V (m^3)
25.6	30.2	0.663615	26.2	28.7	0.660109	27	23.6	0.563971
22	17.2	0.222018	25.5	28.9	0.625119	30.6	28.2	0.9183
31	29.5	0.993169	29.4	27.4	0.81348	25.5	25.8	0.547491
29.4	27.3	0.810152	25.5	27.2	0.582549	17.1	10.6	0.020794
17.2	17.5	0.100804	42.1	30.1	1.955921	40	30.6	1.78688
25.7	30	0.664494	23.9	20.6	0.354574	38.5	30.9	1.665247
40.3	32.2	1.915337	24.5	26.6	0.516306	25.9	30.7	0.6945
40.7	32.3	1.961893	44.5	31.9	2.334106	39.4	30.9	1.748675
22.9	28.2S	0.47093	26.3	27.1	0.623292	32.3	30.6	1.130849
22.5	17.4	0.240655	18.2	20.1	0.157827	28.9	30.2	0.872781
26.2	29.9	0.691831	22.5	30.7	0.499948	25	32.6	0.686071
40.5	33.1	1.992226	27.2	28.8	0.721978	52	30.1	3.035774
25.4	27.9	0.594609	31.7	30.2	1.070119	35	28.5	1.24591
25.4	28.9	0.619454	24.8	30.6	0.626197	22	17.7	0.231337
19.4	17.1	0.149271	18.9	32.1	0.343003	34.4	30.7	1.300466
19	16.8	0.134985	24	28.9	0.542483	22.9	27.8	0.462852
36.3	30.7	1.459278	24.9	28.6	0.5843	24.5	30.1	0.59721
29.1	30.6	0.899316	29	28.9	0.837412	42.3	30	1.968597
20.4	29.8	0.379014	33.8	25	1.001314	42.3	30	1.968597
30.6	28.9	0.943542	36	25	1.149154	21.6	26.9	0.384748
35.3	32	1.437012	21.3	26.3	0.360933	22.6	26.9	0.430536
27.4	31.4	0.80926	26.7	26.7	0.634436	29.6	28.5	0.863046
21.6	28.9	0.420683	26.4	28.6	0.669052	39.8	30.1	1.737572
26.4	30.7	0.725416	29.6	30.1	0.917032	28.3	29.9	0.823614
29.3	30.6	0.91308	42.6	31.6	2.10984	39.3	30.5	1.715518
26.4	29.5	0.693208	21	31.1	0.429599	34.7	26.9	1.14877
27.5	30.1	0.778038	38.8	32.2	1.768209	25.5	26.7	0.570028
23.9	30.3	0.567948	29.9	31.9	0.999694	23.2	26.7	0.454858
26.6	28.9	0.688901	29.3	29.9	0.889937	22.6	27.9	0.450205
22.6	28.9	0.469875	29.9	30	0.93428	26.1	28.1	0.638588
22.6	30.1	0.493478	31.7	30.6	1.085598	23.9	30	0.561349
23.2	30.3	0.529477	23.1	31	0.538459	31.5	30.1	1.051598
31.5	30.5	1.066882	22	30.7	0.473642	27.7	29.9	0.784925
22.3	28.6	0.449138	22	30.7	0.473642	26.4	30.1	0.709312
29	28.8	0.834173	24.7	28.6	0.573375	37.6	31	1.589191
21	25.8	0.339589	31.6	30.5	1.074294	31.2	31	1.063532
39.1	32	1.785413	32	30.2	1.092344	29.3	30.1	0.89655
18.1	20.9	0.16511	31.6	30.3	1.066603	17.2	29.8	0.240935
24.8	30.5	0.623828	29.8	30.6	0.947902	33.4	31.2	1.241789
30.2	30.8	0.983208	22.9	29.9	0.505261	39.5	31.6	1.800123
33.7	30.6	1.239734	28.6	29.6	0.833819	39.5	31.6	1.800123
21	28.9	0.392236	32.5	30	1.121716	24.5	30.6	0.608768

4. CONCLUSION

This developed volume table is a valuable tool for estimating the quantity of wood or timber available in the *Pinus caribaea* plantation at any given time. This tool is not only essential for forest managers aiming to monetize their plantations but also for making informed decisions regarding forest management and planning. The volume model and the local volume table are specifically designed for application within the *Pinus caribaea* plantation in the study area, ensuring accuracy and relevance to the local condition.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

ACKNOWLEDGEMENT

The authors wish to appreciate the management of Omo forest reserve for the privilege to carry out this research on their plantation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Methol RJ. Comparisons of approaches to modeling tree taper, stand structure and stand dynamics in forest plantations. Ph. D thesis. University of Canterbury, Newzealand; 2001.
2. Davis LS, Johnson KN, Bettinger P, Howard TE. Forest management: To sustain ecological, economic, and social values. 4th ed. Waveland Press, Inc., Long Grove, IL; 2001.
3. Husch, Bertram, Beers, Thomas W, Kershaw, John A. Forest mensuration. John Willey and Sons Inc. Hoboken New Jersey, Canada; 2003.
4. Jayaraman K. A statistical manual for forestry research**.** Forestry research support programme for Asia and the Pacific (FORSPA). Food and Agriculture Organization, Bangkok, Thailand; 2000.
5. Mondo Karmar, Peter Damba, Arinaso Pilisi, Elizabeth Malabuo, Alois Jenkiau. Volume table for pinus caribaea in Bulolo Wau forest plantations of Papua New Guinea. HS7-2013-098; 2013.
6. Yousefpour M, Fadaie Khoshkebijary F, Fallah A, Naghavi F. Volume equation and volume table of pinus pinaster Ait. International Research Journal of Applied and Basic Sciences. 2012;3(5):1072-1076, 20 ISSN 2251-838X ©2012
7. Shrestha HL, Kafle MR, Khanal K, Mandal RA, Khanal K. Developing local volume tables for three important tree species in Nawalparasi and Kapilvastu districts; 2018.
   DOI: 10.3126/banko.v27i3.20552
8. Ojo LO. The fate of a tropical rainforest in Nigeria: Abeku sector of Omo Forest Reserve, Global Nest. 2004;6(2):116 – 130.
9. Ola-Adams BA. Biodiversity inventory of Omo biosphere reserve, Nigeria: Country report on biosphere reserves for biodiversity conservation and sustainable development in Anglophone Africa (BRAAF) project. United Nations Educational Scientific and Cultural Organization (UNESCO); 1999.
10. Karimu SA. The role of surrounding communities on the management of Omo Forest reserve. Consultant report for FORMECU. June, 1999;47pp
11. Isichei AO. Omo biosphere reserve: Current status, utilization of biological resources and sustainable management. South-South Cooperation on Environmentally Sound Socio-Economic Development in the Humid Tropics, Working Paper 11, UNESCO, Paris. 1995;48pp.
12. Chima UD, Ola-Adams BA, Adedire MO, Oyelowo OJ. Impacts of land use changes on soil quality of a biosphere reserve in Southwestern Nigeria. J. of Research in Forestry, Wildlife andEnvr. 2014;1(1):120 – 131.
13. Oladoye AO, Bello OS, Basiru AO, Ige PO, Ezenwenyi JU. Above ground biomass and carbon stock of *Nauclea diderrichii* (De Wild. & T. Durand) Merill plantation in Omo Forest Reserve, Nigeria. Journal of Forestry Research and Management. 2018;15(2):95-111. ISSN 0189-8418
14. Louppe D, Oteng-Amoako AA, Brink M. Plant resources of tropical africa. Backhuys publishers, Leiden, Netherlands; 2008.
15. Dupuy B, Mille G. Timber plantations in the humid tropics of Africa. FAO Forestry Paper. 1993;98. Rome, Italy
16. Francis JK. Pinus caribaea Morelet. Caribbean pine. Pinaceae.Pine family. SO-ITF-SM-53. USDA Forest Service, Southern Forest Experiment Station, Institute of Tropical Forestry, New Orleans, LA, USA; 1992.
17. Oteng-Amoako AA, Brink M. Pinus caribaea Morelet. Record from plant resources of tropical Africa. Wageningen, Netherlands; 2008.
    Online available: http://www.prota4u.org/search.asp. Last visited on 20th July 2014
18. Chukwu O, Emebo AA. Nonlinear yield models for young *Tectona grandis L*. f. stands in Nnamdi Azikiwe University Awka, Southeastern Nigeria. Tropical Plant Research. 2020;7(3):678–683.
19. Huang S, Yang Y, Wang Y. A critical look at procedures for validating growth and

yield models. In: Amaro, A., D. Reed and P. Soares (Eds.). Modeling Forest Systems. CAB International, Vancouver, Canada. 2003;156-172.
20. Payal D Thumbar, Behera LK, Patel SM, Mehta AA, Dholariya CA, Amlani MH. Volume table preparation for timber yielding tree species *Gmelina arborea* Roxb. The Pharma Innovation Journal 2023;SP-12(7):1257-1260.
21. Ige PO, Silas AE. Development of local volume table for *Nauclea diderrichii* (De Wild. & Th. Dur.) In Area J4, Omo Forest Reserve, Ogun State, Nigeria. FUOYE Journal of Pure and Applied Sciences. 2023;8(3):1–9.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/120436