



Research Article

Structural Analysis of Shrub - Tree Species in Yobe State,
North Eastern Nigeria

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ABSTRACT

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The study examined the structural characteristics of shrub-tree species in Nangere, Yobe State, Northeastern Nigeria. Ten sampling point of quadrant size 200 by 100 meters were considered and five quadrants were randomly selected for the sampling using table of random number. Plant physical parameters such as the height, crown cover, diameter breast height (DBH), the volume of the tree and girth of the tree were measured on the field. The data obtained from the field were subjected to statistical analysis using correlation coefficient. The volume of tree is considered to be dependent variable height; girth, crown cover and diameter at breast (DBH) were considered to be independent variables. From the result, the height of the trees ranges from 3.25 m to 17.71 m, the girth 0.39 m to 8.00 m, the crown cover 1.20 m to 30.20 m, DBH 0.32 m to 7.20 m and the volume of the trees ranges from 2.06 m³ to 215.03 m³. The result of the analyses revealed that there is a strong and positive correlation between the height of the trees and volume of the trees, the girth and volume of the trees, the crown cover and volume of the trees as well as the DBH and volume of the trees. The joint contributions of the four parameters (height, girth, crown cover and DBH of the trees) on the volume of the trees in the study area shows that R² obtained for quadrant one, three, four and five are 0.99, 0.64, 1 and 1.00 respectively implying that the combined contribution of the parameters to the volume of trees in the study area was very high.

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INTRODUCTION

The identification and analysis of species assemblages is the primary goal of plant community ecology (Dibaba, Soromessa, & Warkineh, 2022; Omijeh, 2020). In an effort to give a structural description of vegetation, Dansereau (1951) developed the structural approach to vegetation studies that leads to numerous researches on vegetation's structure changes with time. Aweto (1981) found that plant density increased with fallow age, ranging from fewer than 60 trees per hectare at the start of the fallow to more than 2500 trees per hectare after 10 years. Aweto (2001) also noted that tree height and diameter rose as the rate of fallow vegetation increased. Hall and Okali (1979), who quantitatively defined the life form structure of an 8 years fallow community, are among the few quantitative research on change in plant life form that have also been explored in the forest fallow overtime in the west African sub-region. Aweto (1981) quantified the life-form composition of successional communities, aged 1 to 10 years, and compared it to the Raunkiar (1937) life form categorization system-based life form structure of a mature forest community.

Asase and Adeniyi (2021) used 25 m x 25 m plots delineated over a 1 km transect in the Ghanaian grove to assess plant diversity and tree community structure in response to an elevation gradient. Overall findings, from the Apra Hills Sacred Grove in West Effutu Awutu Senya district in the Central Region of Ghana, indicated that while tree species diversity increased with elevation, plant species richness declined. However, there was no statistically significant correlation between elevation and tree species richness, tree density, or basal area. In Kuje Area Council of the Federal Capital Territory in North-central Nigeria, Edicha and Abdullahi (2016) investigated the relationship between the volume of woods and vegetation characteristics such as height, volume, canopy,

and girth and discovered a positive relationship between vegetation height and girth. Shamaki and Isah (2016), on the other hand, examined the height-diameter relationships of *Eucalyptus camaldulensis* in the Afaka Forest Reserve in Kaduna, Northwest Nigeria, and came to the conclusion that as a tree gets bigger in size; its height tends to decline. Bukar & Abba (2022) used the point-centered-quarter (PCQ) approach to analyze the diversity of vegetation (shrubs and trees) for the preservation, utilization, and conservation of tree species in Northern Yobe, Nigeria. Importance Value Indices (IVI) revealed that the Sodom apple (*Calotropis procera*) was the dominant tree species (IVI). This study further indicated an extremely low Simpson's index of diversity (-0.0082) and a species richness of 0.41.

Few researches have been done to explore the structural analysis of trees and shrub species in Nangere Local Government Area (LGA) of Yobe State, North-Eastern Nigeria. Additionally, the issue has not been adequately investigated despite the area is currently facing desertification, which has an impact on the development and composition of trees (Amadii et al., 2013; Elijah & Ikusemoran, 2017; Eze, 2018; Hassan et al., 2019; Zemba et al., 2018). In light of the aforementioned, the purpose of this study was to examine the volume of trees and the vegetation structure in the study area. Consequently, the objective of this study is to characterize the allometric properties of the tree species in order to establish a correlational analysis of the development of the vegetation in the study area.

The Study Area

Nangere LGA, which has a land area of about 980 sq. km, is situated between latitudes 10°51'34E and 11°11' 37E of the Greenwich meridian and longitudes 11°29'40N and 12°4'35N of the Equator (Oruonye, 2009). Nangere LGA is one of the 17 LGAs of Yobe State, Nigeria. The town of Sabon Garin

Nangere serves as its administrative center. It is located in Nigeria's Sudano-Sahelian region, where desertification threatens the local

environment and way of life (UNESCO, 2000; UNDP, 2009; Orounye, 2009).

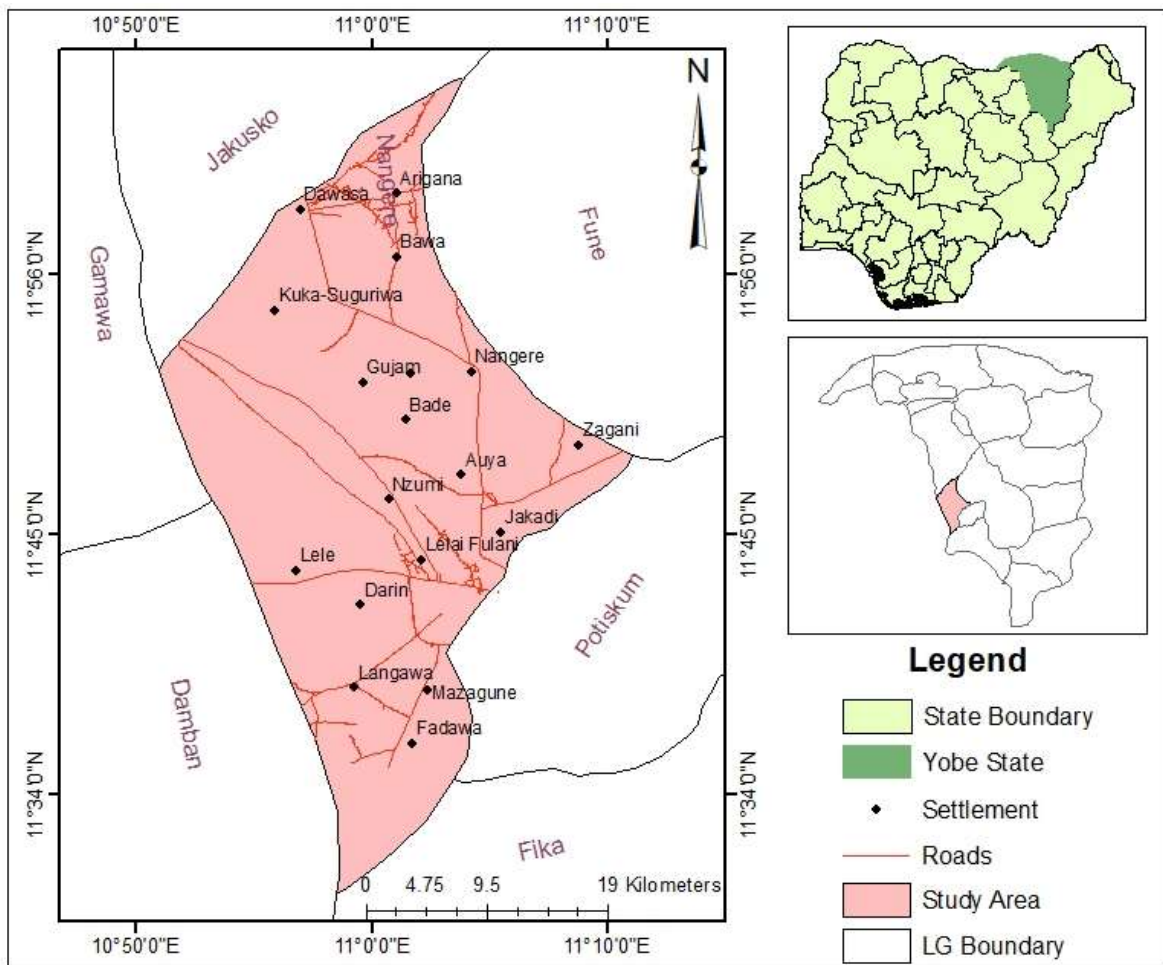


Figure 1: Map of Yobe State, showing the study area
Source: Administrative map of Yobe State (2018)

MATERIALS AND METHODS

In an effort to identify the research area's boundaries and learn more about the basic characteristics of the vegetation there, a three days' reconnaissance survey was conducted .in

June 2018 which made it possible for the study to acquire first-hand information about the vegetation and human activity in the study area. The list of materials and equipment used during the field survey is contained in Table 1 below.

Table 1: List of Material and Equipment that were used in the Field

S/No	Name	Uses
1.	Tape (100m)	This was used for measuring linear measurements in the field as well as tree girth, crown cover and DBH.
2.	Global Positioning System (GPS)	It was used to take the location of the quadrants.
3.	Digital Camera	It was used to take pictures of sample vegetation
4.	Pegs	It was used to demarcate areas of interest in the field
5.	Hammer	It was used to drive the pegs into the ground during demarcation
6.	Line	It was used to construct quadrants, that enable differentiating between samples found within or outside the quadrants
7.	Masking Tape	It was used for labeling and numbering of trees for sampling
8.	Hand held abney	It was used to determine the height of trees in the field
9.	Markers	It was used in writing important numbers on the masking tape

Source: Field Survey (2018)

Because the studied area is experiencing desertification (Eze, 2018; Gana et al., 2021), the vegetation is concentrated in selected areas of Yobe State's Nangere Local Government Area. As a result, eventual vegetation detection, leads to quadrant sampling technique application, with a sample size of 200m by 100m. This is due to the fact that the quadrant size was adequate for analyzing the vegetation, and any larger size would have resulted in some areas being devoid of vegetation. The total area with vegetation was divided into ten quadrants of size 200m by 100m, with five of the ten quadrants chosen at random from a table of random numbers. The plant species were

enumerated in each quadrant, and the height, girth, crown cover, DBH, and volume were measured (see Table 2). The trees were numbered, and the trees for sampling were chosen using a table of random numbers. Previous research that produced desirable results for practical applications used similar sampling approaches (Szajdak, Gaca and Karg, 2005). The chosen quadrant size has been tested with some success in several locations of the tropics (Adejuwon and Adesina, 1988). A handheld GPS (Garmin eTrek Touch 35) was used to obtain the geographic positions of the four corners of all specified quadrants.

Table 2: Data Required for the Study and Sources

S/No	DATA REQUIRED	SOURCES OF DATA
	Structure and Composition of trees	Field Sampling
i	Tree height (metre)	Field survey (primary data)
ii	Tree Girth (metre)	Field survey (primary data)
iii	Tree crown cover (metre)	Field survey (primary data)
iv	Tree species Diversity	Field survey (primary data)
v	Tree Diameter at Breast Height-DBH (metre)	Field survey (primary data)
vi	Tree species dominance	Field survey (primary data)
vii	Tree volume (m ³)	Field survey (primary data)

Source: Field Survey (2018)

To assess the species density, all tree species, excluding plants and creeping species, were recognized and counted in each quadrant. The plants found in the field were identified locally in Hausa, and in certain cases, plant parts such as leaves were collected and stapled for transport to the herbarium for identification and scientific listing. In this study, a tree was operationally defined as any woody plant with an erect habit and a height of at least 1.5m as specified in Raunkiers classification of plant life form (Ellenberg and Mueller-Dombois, 1966). A measuring tape was used to measure the girths, crown covers, and DBH of the trees. Over-bark circumference measurement is the easiest method for determining tree diameter; the measurement is taken at breast height (1.3m) from the base of the tree and then converted to tree diameter by dividing the circumference by $22/7 = 3.14 (\pi)$. It is quick, cheap, and directly related to tree volume or biomass. On the trees, readings from a hand-held abney were taken. These were taken from distances ranging from 10 to 50 meters in order to determine the height of the trees. In the laboratory, the values were utilized to compute tree heights using the equation, thus:

$$r_p = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{(N \sum x^2) - (\sum x)^2 (N \sum y^2) - (\sum y)^2}}$$

Where:

r_p = Correlation

N = Number of pairs of scores

$\sum xy$ = Sum of products of paired scores

$\sum x$ = Sum of x scores

$\sum y$ = Sum of y Scores

$\sum x^2$ = Sum of Squared of x scores

$\sum y^2$ = Sum of Squared of y scores

Height = $(D \times \tan \Theta) + Ob$ where;

D = horizontal distance

Θ = angle of elevation

Ob = observer's height (SOP, 2011).

Method of Data Analysis

Volume of trees

The volume of tree will be determined by using the formula $V = \pi r^2 h$

Where:

V = volume

π is a constant and stand for $22/7 = 3.14$

h = height of the tree

r^2 = Stands for radius of the Tree and it is derived from dividing the girth by two. The radius will be calculated using the formula for calculating area of a circle since the girth of a tree is similar to a circumference.

$C = 2\pi r$

$r = C/2\pi$

Pearson Product Moment Correlation (PPMC)

The Pearson's product moment correlation was used for analyzing the relationship between the height and volume, girth and volume, crown cover and volume and the DBH and volume of the trees.

Multiple Regression Analysis (MRA)

Multiple regression analysis was employed to test the combined relationship between volume of trees and the parameters of the vegetation species (i.e. tree height, girth, crown cover, and DBH) using the formula: $Y = a + bX_1 + cX_2 + dX_3 + eX_4$.

Where:

Y= Volume of tree

X₁= Tree Height

X₂= Tree Girth

X₃= Tree Crown cover

X₄= Tree DBH

RESULTS AND DISCUSSION

Tree Parameters in Quadrant One

The tree parameters Height, Girth, Crown cover and DBH in quadrant one were examined and the values obtained are presented in table 3. Furthermore, correlation analysis was also performed on the parameters to determine the strength of association and direction among the parameters.

From Table 3, *Tamarindus indica*, *Piliostigma reticulatum*, *Cassia arereh* and *Indigofera echinata* has the highest heights with 7.34m, 6.01 m, 5.65 m, and 5.19 m respectively while *Cassia arereh* has the least height of 3.25 m. Again with respect to girth, *Tamarindus indica* and *Cassia arereh* has the largest girths with 1.56 m and 1.10 m respectively while *Datarium microcarpum* and *Indigofera echinata* 0.42 and 0.50 respectively. In terms of Crown cover, *Cassia arereh* has the widest crown cover which covers 7.10m followed by *Tamarindus indica* which covers an area of 6.72m while *Indigofera echinata*, *Datarium microcarpum* and *Cassia arereh* has the lowest values of 1.20m, 2.30m and 2.30m respectively and in terms of DBH of trees in the quadrant, *Tamarindus indica* and *Cassia arereh* has the highest values of 1.45m and 0.91m respectively while *Datarium microcarpum* and *Indigofera*

echinata has the smallest DBH with 0.32 and 0.39 respectively. However, the total height of trees sampled in quadrant one is 101.08 m, total girth of trees 16.34 m, crown cover 80.59m and the total DBH of trees sampled in quadrant one is 13.59 m.

The result shows that the relationship that exists between the volume of the tree and the height $r = 0.92$, volume and girth $r = 0.98$, volume and crown cover $r = 0.86$ and that of volume and Diameter at Breast Height (DBH) $r = 0.97$. The relationship between the dependent variable (volume) and the independent variables (height, girth, crown cover and DBH) shows how much of explanation is provided by the independent variables to the dependent variable given as the correlation coefficient r . The result above means that there is a very strong and positive correlation between the volume of the tree and the height, girth, crown cover and DBH of the tree in the study area. These findings are consistent with those from Koirala et al. (2021), where there was a positive and significant association between DBH and *Castanosopsis indica* height at Midhills, Nepal, with a R square value of 0.71. Consequently, as the height, girth, crown cover and DBH of the tree increases, the volume of the tree also increases. However, the coefficient of explanation of the four parameters (Height, Girth, Crown Cover and DBH) are 84.6%, 96%, 74% and 94.1% respectively indicating that the parameters accounted for the percentages respectively while the remaining percentages for each parameter to make 100% is explained by other factors. DBH was also employed by Buba (2013) as a predictor variable and was positively connected with tree height and crown length, however the correlation coefficients of determination (r^2) of 0.447 and 0.399, respectively, were low in comparison to the results previously described.

Table 3: Tree Parameters in Quadrant One

S/No	Species	Height (m)	Girth (m)	Crown Cover (m)	DBH (m)	Volume (m ³)
1	<i>Cassia arereh</i>	5.65	1.10	7.10	0.91	9.76
2	<i>Tamarindu sindica</i>	7.34	1.56	6.72	1.45	17.98
3	<i>Datarium microcarpum</i>	3.34	0.42	2.30	0.32	2.20
4	<i>Indigofera echinata</i>	5.19	0.50	1.20	0.39	4.07
5	<i>Piliostigma reticulatum</i>	6.01	0.79	4.35	0.63	7.45
6	<i>Cassia arereh</i>	3.42	0.51	2.60	0.42	2.74
7	<i>Cassia arereh</i>	3.42	0.52	2.80	0.40	2.79
8	<i>Cassia arereh</i>	3.33	0.52	2.80	0.43	2.72
9	<i>Cassia arereh</i>	3.30	0.51	2.70	0.42	2.64
10	<i>Cassia arereh</i>	3.34	0.63	3.00	0.50	3.30
11	<i>Cassia arereh</i>	3.33	0.51	2.62	0.44	2.67
12	<i>Cassia arereh</i>	3.27	0.52	2.60	0.41	2.67
13	<i>Cassia arereh</i>	3.39	0.60	3.20	0.53	3.19
14	<i>Cassia arereh</i>	3.25	0.51	2.54	0.42	2.60
15	<i>Cassia arereh</i>	3.34	0.53	2.60	0.42	2.78
16	<i>Cassia arereh</i>	3.45	0.52	3.22	0.45	2.82
17	<i>Cassia arereh</i>	3.36	0.64	2.63	0.50	3.38
18	<i>Cassia arereh</i>	3.49	0.51	2.60	0.46	2.79
19	<i>Cassia arereh</i>	3.36	0.52	2.64	0.42	2.74
20	<i>Cassia arereh</i>	3.34	0.51	2.47	0.46	2.67
21	<i>Cassia arereh</i>	3.33	0.60	2.51	0.53	3.14
22	<i>Cassia arereh</i>	3.31	0.56	2.40	0.51	2.91
23	<i>Cassia arereh</i>	3.27	0.55	3.20	0.51	2.82
24	<i>Cassia arereh</i>	3.31	0.57	2.52	0.52	2.96
25	<i>Cassia arereh</i>	3.25	0.51	2.51	0.48	2.60
26	<i>Cassia arereh</i>	3.33	0.60	2.30	0.53	3.14
27	<i>Cassia arereh</i>	3.34	0.52	2.46	0.49	2.73
	Total	101.08	16.34	80.59	13.95	104.26

Source: Field Survey (2018)

In furtherance of this study, the multiple regression analysis was also carried out to examine the joint contribution of the independent variables (height, girth, crown cover and DBH) on the dependent variable (volume) and the result shows that the R square is 0.99 which means the joint contribution of the four parameters on the volume of the trees is 99% and there is a significant relationship between the height, girth, crown cover and DBH of the trees and the volume of the trees in the quadrant. The result obtained corroborated the findings of Edicha and Abdullahi (2016) argued that the characteristics of tree species especially the height, the girth and the aerial

cover have a significant relationship with the volume of the tree. Furthermore, in view of the finding, it is observed that 92.6% of the trees sampled in this quadrant have girths of less than 1 meter. In a similar study, Edicha and Abdullahi (2016) observed tree height, tree girth, and canopy cover in estimating volume of wood in Kuje area of Abuja, Nigeria. They also observed that most of the girth of the trees in Kuje area are relatively small, which is related to the fact that the girth has little time to develop into maturity due to frequent fuel wood exploitation.

Tree Parameters in Quadrant Two

The tree parameters (height, girth, crown cover and DBH) in quadrant two were examined and the data are presented in Table 4. From the table 4, *Combretum hypopilium* and *Prosopis africana* have the highest heights with 10.66 and 7.18 respectively while *Datarium microcarpum* has the least height of 3.36 m. Again with respect to girth, *Prosopis africana* and *Combretum hypopilium* has the largest girths with 1.52 m and 1.35 m respectively while *Datarium microcarpum* has the lowest with 0.42m. In terms of Crown cover,

Combretum hypopilium and *Prosopis africana* has the widest crown cover which covers 5.31 m and 3.50 m respectively while *Datarium microcarpum* has the lowest value of 2.32 m and in terms of DBH of trees in the quadrant, *Prosopis africana* and *Combretum hypopilium* has the highest values of 1.80 m and 1.58 respectively while *Datarium microcarpum* has the smallest DBH with 0.34 m. However, the total height of trees sampled in quadrant two is 24.56 m, total girth of trees 3.76 m, crown cover 13.47 m and the total DBH of trees sampled in quadrant one is 4.08 m.

Table 4: Tree Parameters in Quadrant Two

S/No	Species	Height (m)	Girth (m)	Crown Cover (m)	DBH (m)	Volume (m ³)
1	<i>Combretum hypopilium</i>	10.66	1.35	5.31	1.58	22.59
2.	<i>Prosopis africana</i>	7.18	1.52	3.50	1.80	17.13
3.	<i>Datarium microcarpum</i>	3.36	0.42	2.32	0.34	2.22
4.	<i>Datarium microcarpum</i>	3.36	0.47	2.34	0.36	2.48
	Total	24.56	3.76	13.47	4.08	44.42

Source: Field Survey (2018).

The result shows that the relationship that exists between the volume of the tree and the height $r = 0.98$, volume and girth $r = 0.94$, volume and crown cover $r = 0.94$ and that of volume and Diameter at Breast Height (DBH) $r = 0.95$. This means that there is a very strong and positive correlation between the volume of the tree and the height, girth, crown cover and DBH of the tree in the study area. The results reported here are consistent with those of Amer et al. (2023), whose findings showed no correlation for *P. dactylifera* ($R^2 = 0.03-0.06$) in Jericho but a moderate to high relationship for *F. nitida* and *D. regia* between tree height, crown diameter, and crown volume. Consequently, as the height, girth, crown cover and DBH of the tree increases, the volume of the tree also increases. However, the coefficient of explanation of the four parameters (Height, Girth, Crown Cover and DBH) are 96%, 88.4%, 88.4% and 90.3% respectively indicating that the parameters accounted for the percentages above while the

remaining percentages for each parameter to make 100% is explained by other factors. This finding is connected to a study done by Sumida et al. (2013) in the Nagoya University Experimental Forest at Inabu, Aichi Prefecture, Japan, which found that diameter growth rates at various heights also tended to increase slightly from breast height upwards as the stem below the crown (except for the butt swell).

Tree Parameters in Quadrant Three

The tree parameters Height, Girth, Crown cover and DBH in quadrant three were examined and the values obtained are presented in Table 5. Furthermore, correlation analysis was also performed on the parameters to determine the strength of association and direction among the parameters. From Table 5, *Tamarindus indica*, has the highest height with 5.89m while *Combretum hypopilium* has the least height of 4.21m. In terms of girth, *Diospyros mespiliformis* has the largest girth with 2.05m while *Tamarindus indica* and *Acacia nilotica*

1.22m each. In terms of Crown cover, *Balanites aegyptiaca* has the widest crown cover which covers 5.21m while *Tamarindus indica* has the lowest value of 1.46m and in terms of DBH of trees in quadrant three, *Diospyros mespiliformis* has the largest with 1.88m while *Tamarindus*

indica and *Acacia nilotica* has the smallest DBH with 1.10m each. However, the total height of trees sampled in quadrant three is 65.36m, total girth of trees 20.03m, crown cover 41.46m and the total DBH of trees sampled in quadrant one is 19.13m.

Table 5: Tree Parameters in Quadrant Three

S/No	Species	Height (m)	Girth (m)	Crown Cover (m)	DBH (m)	Volume (m ³)
1.	<i>Combretum hypopilium</i>	4.21	1.91	4.33	1.85	6.01
2.	<i>Tamarindus indica</i>	5.79	1.22	1.46	1.10	11.09
3	<i>Balanites aegyptiaca</i>	5.37	1.90	5.21	1.75	16.02
4	<i>Tamarindus indica</i>	5.89	1.40	3.33	1.65	12.92
5	<i>Tamarindus indica</i>	5.36	1.35	3.46	1.44	11.36
6	<i>Acacia seibrana</i>	5.09	1.60	4.00	1.45	12.79
7	<i>Acacia seibrana</i>	4.74	1.52	3.82	1.40	11.31
8	<i>Acacia seibrana</i>	4.85	1.61	3.32	1.50	12.16
9	<i>Diospyros mespiliformis</i>	4.47	2.05	2.55	1.88	14.39
10	<i>Diospyros mespiliformis</i>	4.99	1.60	2.63	1.55	12.53
11	<i>Cassia singueana</i>	5.39	1.42	2.80	1.31	12.02
12	<i>Acacia nilotica</i>	4.50	1.22	2.25	1.10	8.62
13	<i>Balanites aegyptiaca</i>	4.71	1.23	2.30	1.15	9.01
	Total	65.36	20.03	41.46	19.13	150.23

Source: Field Survey (2018)

The result shows that the relationship that exist between the volume of the tree and the height $r = 0.49$, volume and girth $r = 0.34$, volume and crown cover $r = 0.23$ and that of volume and DBH $r = 0.32$. This means that there is a positive correlation between the height and volume whereas there is a weak and negative correlation between the volume of the tree and the girth, crown cover and DBH of the tree in the study area. Consequently, as the height, girth, crown cover and DBH of the tree increases, the volume of the tree also increases. However, the coefficient of explanation of the four parameters (Height, Girth, Crown Cover and DBH) are 24%, 11.6%, 5.3% and 10.2% respectively indicating that the parameters accounted for the percentages above while the

remaining percentages for each parameter to make 100% is explained by other factors.

In furtherance of this study, the multiple regression analysis was carried out to see the combined contribution of the independent variables (height, girth, crown cover and DBH) on the dependent variable (volume) and the result shows that the R square is 0.64 which means the joint contribution of the four parameters on the volume of the trees is 64%. Thus, these findings corroborate Buba's (2013) findings that *Vitellaria paradoxa* had correlations with DBH, tree height, crown length, crown height, and crown ratio.

Tree Parameters in Quadrant Four

The tree parameters, Height, Girth, Crown cover and DBH, in quadrant four were examined and the values obtained are presented

in Table 6. Furthermore, correlation analysis was also performed on the parameters to

determine the strength of association and direction among the parameters.

Table 6: Tree Parameters in Quadrant Four

S/No	Species	Height (m)	Girth (m)	Crown Cover (m)	DBH (m)	Volume (m ³)
1	<i>Cassia arereh</i>	3.45	1.24	7.19	0.93	6.72
2	<i>Datarium microcarpum</i>	3.39	0.44	2.35	0.34	2.34
3	<i>Datarium microcarpum</i>	3.36	0.39	2.2	0.32	2.06
Total		10.2	2.07	11.74	1.59	11.12

Source: Field Survey (2018)

From the Table 6, *Cassia arereh* has the highest height with 3.45m while *Datarium microcarpum* has the least height of 3.36m. In terms of girth, *Cassia arereh* has the largest girth with 1.24m while *Datarium microcarpum* has the smallest girth with 0.39m. In terms of Crown cover, *Cassia arereh* has the widest crown cover which covers 7.19m while *Datarium microcarpum* has the lowest values of 2.20m and in terms of DBH of trees in quadrant four, *Cassia arereh* has the largest with 0.93m while *Datarium microcarpum* has the smallest DBH with 0.32m. However, the total height of trees sampled in quadrant three is 10.20m, total girth of trees 2.07m, crown cover 11.74m and the total DBH of trees sampled in quadrant one is 11.12m.

The result shows that the relationship that exist between the volume of the tree and the height $r = 0.96$, volume and girth $r = 1.00$, volume and crown cover $r = 1.00$ and that of volume and Diameter at Breast Height (DBH) $r = 1.00$. This means that there is a very strong and positive correlation between the volume of the tree and the height, girth, crown cover and DBH of the tree in the study area. Consequently, as the height, girth, crown cover and DBH of the tree increases, the volume of the tree also increases. However, the coefficients of explanation of the

four parameters (Height, Girth, Crown Cover and DBH) are 92.2%, 100%, 100% and 100% respectively. In furtherance of this study, the multiple regression analysis was carried out to see the combined contribution of the independent variables (height, girth, crown cover and DBH) on the dependent variable (volume) and the result shows that the R square is 1 which means the joint contribution of the four parameters on the volume of the trees is 100%. The findings also concurred with (Buba, 2013), who found that DBH was positively linked with tree height and crown length of *Vitellaria paradoxa* C.F. Gaertn in the Nigerian Guinea Savanna. The study, however, does not support Adedoyin, et al.'s (2022) findings from 2022, which found a greater correlation between crown diameter and DBH ($r = 0.79$) than between crown diameter and tree height ($r = 0.38$).

Tree Parameters in Quadrant Five

The tree parameters Height, Girth, Crown cover and DBH in quadrant five were examined and the values obtained are presented in Table 7. Furthermore, correlation analysis was also performed on the parameters to determine the strength of association and direction among the parameters.

Table 7: Tree Parameters in Quadrant Five

S/No	Species	Height (m)	Girth (m)	Crown Cover (m)	DBH (m)	Volume (m ³)
1	<i>Adansonia digitata</i>	17.12	8	19.82	7.2	215.03
2	<i>Parkia biglobosa</i>	17.71	5.19	30.2	4.6	144.31
3	<i>Azadirachata indica</i>	10.02	1.25	10.25	0.96	19.66
	Total	44.85	14.44	60.27	12.76	379

Source: Field Survey (2018)

From the Table 7, *Parkia biglobosa* has the highest height with 17.71m while *Azadirachata indica* has the least height of 10.02m. In terms of girth, *Adansonia digitata* has the largest girth with 8.00m while *Azadirachata indica* has the smallest girth with 1.25m. In terms of Crown cover, *Parkia biglobosa* has the widest crown cover which covers 30.20m while *Azadirachata indica* has the lowest value of 10.25m and in terms of DBH of trees in quadrant five, *Adansonia digitata* has the largest with 7.20m while *Azadirachata indica* has the smallest DBH with 0.96m. However, the total height of trees sampled in quadrant three is 44.85m, total girth of trees 14.44m, crown cover 60.27m and the total DBH of trees sampled in quadrant one is 12.76m.

The result shows that the relationship that exist between the volume of the tree and the height $r = 0.91$, volume and girth $r = 1.00$, volume and crown cover $r = 0.61$ and that of volume and DBH $r = 1.00$. This means that there is a very strong and positive correlation between the volume of the tree and the height, girth and DBH whereas there is a strong correlation between volume and crown cover of the tree in the study area. Consequently, as the height, girth, crown cover and DBH of the tree increases, the volume of the tree also increases. However, the coefficient of explanation of the four parameters (Height, Girth, Crown Cover and DBH) are 82.8%, 100%, 37.2% and 100% respectively indicating that the parameters accounted for the percentages above while the remaining percentages for each parameter to

make 100% is explained by other factors. The trees in the quadrant are bigger in size and produce more volume compared to trees in the other quadrants. In a similar study by Shamaki and Isah (2016) on the modeling height-diameter relationship for *Eucalyptus camaldulensis* in Afaka forest reserve Nigeria; their result suggested that trees that are bigger in size also produce more volume compared to those with smaller diameters. However, the result of this study shows that as the trees grow bigger, the height of the trees also increases as compared to the result of Shamaki and Isah (2016) whose result shows that height growth of trees in Afaka forest reserve tends to decline as the trees grow bigger in size which is as a result of lesser competition at the upper level of the stand distribution. In furtherance of this study, the multiple regression analysis was carried out to see the combined contribution of the independent variables (height, girth, crown cover and DBH) on the dependent variable (volume) and the result shows that the R square is 1 which means the joint contribution of the four parameters on the volume of the trees is 100%. This finding is congruent with that of Sönmez (2009), who found a statistically significant ($P > 0.05$) and strong ($R^2 > 0.80$) association between diameter at breast height and crown diameter variables in *Picea orientalis*.

CONCLUSION

Four vegetation parameters (height, girth, crown cover and DBH) were analyzed and the volume of trees determined. The height of the trees

ranges from 3.25 m to 17.71 m, the girth 0.39 m to 8.00 m, the crown cover 1.20 m to 30.20 m, DBH 0.32 m to 7.20 m and the volume of the trees ranges from 2.06 m³ to 215.03 m³. The result of the analyses revealed that there is a strong and positive correlation between the height of the trees and volume of the trees, the girth and volume of the trees, the crown cover and volume of the trees as well as the DBH and volume of the trees. The joint contributions of the four parameters (height, girth, crown cover

and DBH of the trees) on the volume of the trees in the study area shows that R² obtained for quadrant one, three, four and five are 0.99, 0.64, 1 and 1.00 respectively implying that the combined contribution of the parameters to the volume of trees in the study area is very high. This could be because the vegetation in the area is located in government reserves, where anthropogenic activities such as indiscriminate tree cutting are strongly prohibited.

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