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Original Article

Comparative analyses of tree stem volume estimation of west bank and block a forests ecosystem of International Institute of Tropical Agriculture, Ibadan, Oyo State, Nigeria

Ariyo Oluyinka Christopher[1]*, Usman Mohammed Bello[2], Ariyo Mary Oluyemisi[3]

[1]Department of Entrepreneurship and Innovative Agriculture, Federal College of Forestry Mechanization, Afaka, Forestry Research Institute of Nigeria, Kaduna State, Nigeria, [2]Federal College of Forestry Mechanization, Afaka, Forestry Research Institute of Nigeria, Kaduna State, Nigeria, [3]Department of Horticultural Technology, Federal College of Forestry Mechanization, Afaka, Forestry Research Institute of Nigeria, Kaduna State, Nigeria

ABSTRACT

A comparative analysis of trees volume estimates in two distinct forests is important for planning tree harvesting and proper forest management. The study was carried out in the west bank and block A forest of International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, to estimate and compare the volume of trees in the two forests using diameter at breast height (DBH) measurement. Data were collected from 60 plots laid along six transects; A (270°W), B (90°E), C (180°S), D, E (0°N), and F (180°W)}. Complete enumeration, identification, and measurement of all the trees with DBH≥10 cm in all the plots were carried out. The data were analyzed using descriptive statistics, basal area analysis, and volume equation of tree developed by FORMECU. The results showed 581 per 0.3 ha woody plants from 65 species and 28 families in west bank forest and 389 per 0.3 ha of wood plants from 68 species and 27 families in block A forest. Trees dominated the two forests (75.38% and 69.12%) but are more, well stocked in west bank forest than block A forest and are merchantable. The most abundant family in the two forests are *Fabaceae* subfamilies of *Caesalpinioideae*, *Mimisoideae,* and *Papilinoideae*. *Newbouldia laevis* (57) and *Trichilia monadelpha* (44) are the most abundant trees in west bank forest while *N. laevis* (33) and *Lecaniodiscus cupanioides* (28) are most abundant in block A forest. *Milicia excelsa* had the highest basal area and volume of 40.34 m^2/ha and 2.10 m^3/ha in west bank forest while *Daniellia ogea* had the highest basal of 14.03 m^2/ha and volume 1.87 m^3/ha in block A forest. Some species of woody plants were encountered once in the two forests. The study concludes that adequate and continuous protection of the two forests to prevent the extinction of monospecific tree species and continuous forest inventory is required for proper monitoring of trees volume in the two forests.

Keywords: Comparative analyses, transects, basal area, trees, species, volume

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INTRODUCTION

Sustainable management of forest resources requires a large amount of supporting information. Especially when managing a forest for the production of commercially valuable materials, estimation of the present growth of variables which are not possible to measure easily (such as timber volume) and to estimate the growth values in future is essential. The most important variable to take into consideration regarding to forestry is tree diameter at breast height (DBH). Not only is it used to estimate the volume of the tree but also as a way to describe the stand structure and to select an inventory sample. DBH (D) and total tree height have often been used as standard predictors of biomass (both above- and below-ground biomass) and volume.[1-4] This is because these variables are highly correlated with biomass and volume. The principal goal of the forest survey was to estimate the total volume and area of the forest resource. Standard volume tables (equations) are often used to estimate tree volume as a function of tree diameter and height for both routine forest measurement and for forest research purposes. Developing forest inventory estimates

Address for correspondence: Ariyo Oluyinka Christopher, Department of Entrepreneurship and Innovative Agriculture, Federal College of Forestry Mechanization, Afaka, Forestry Research Institute of Nigeria, Kaduna State, Nigeria. E-mail: ask4ariyo@yahoo.com

often involves predicting tree volumes from only DBH and/or merchantable height.

Estimation of growing stock provides information that guides forest managers in timber valuation as well as in allocation of forest areas for harvest.[5] For timber production, an estimate of growing stock is often expressed in terms of timber volume, which can be estimated from easily measurable tree dimensions. Tree volume is one of many parameters that are measured to document the size of individual trees. Volume is the common widely used measure of wood quantity in forest mensuration.[6] The ability to estimate the volume of trees and stands and to predict what the forest will produce, on different sites, in response to particular types of silvicultural treatment, is central to all rational planning processes connected with forestry. The most common procedure is to use volume equations based on relationships between volume and variables such as diameter and height.[5]

The west bank forest covers about 150 ha while block A covers an area of about 50 ha. The two forest came to been as a result of the decision by International Institute of Tropical Agriculture (IITA) to preserve the remaining land as an informal forest and nature reserve after the clearing of land for research plots, housing and other facilities were largely completed in 1987. Today, the forest and nature reserve at IITA cover nearly 350 ha. Both the west bank and block A forests have grown to secondary stage of regeneration and are in their mid-succession stage.[7,8] They are repository of useful timber and non-timber forest products (NTFPs) which are useful for food, medicine, cooking, and wrapping or preservation of food items.[9-11] The west bank forest has been under active protection for many years while block A forest serves as buffer zone for villagers living around the perimeter fence of IITA, the forest serves as a source of livelihood to the women living in the adjoining villages of IITA perimeter fence.[12] The villagers are permitted into the forest twice a week to collect NTFPs such as dried firewood, fruits and kernels of *Elaeis guineensis*, and shoot of *Talinum triangulare*. Some other NTFPs are also collected illegally by these villagers along with what they are permitted to collect. Part of the area of block A forest was also used for arboretum and experimental plot [Figure 1], this gives opportunity to IITA staff to collect pegs, poles, and stakes for the experimental, thereby reducing the number of threes and shortening their growth. A lot of research has been done in the two forests but no works have estimated and compare the tree stem volume of the two forests. It is against this backdrop this study was designed with the aim of comparing the tree stem volume estimated from the two forests. The study was executed using non-destructive approach method (DBH) as provided in the volume equation for trees developed by FORMECU.[13]

MATERIALS AND METHODS

Study Area

The study was conducted in the two forest reserved (west bank and block A forest) of IITA, Ibadan, Oyo State, Nigeria. The study area has a coordinate of longitude 7°30′8″N, latitude 3°54′37″E, and 243 m above sea level.[14] The vegetation is within the forest-savanna transition zone and can be group into tropical semi-deciduous forest with various pockets of vegetation types ranging from derived savanna, secondary forest, and riparian types. The area resembles mature Guinea-Congo lowland rainforest with scattered emergence of trees which include *Ceiba, Milicia,* and *Terminalia* spp.[15] Large clumps of bamboo (*Bambusa vulgaris)* are common; stands of *Raphia farinifera* are found along watercourses while scattered oil palms *E. guineensis* grow in both low-lying and the relatively better drained upland areas. The site is characterized with two distinct seasons. The wet season, it lasts for 8 months, and it extends from March to October while the dry season lasts for 4 months from November to February. The rainfall pattern is bimodal with an annual total which ranges from 1300 to 1500 mm most of which falls between May and September.[9,16,17] The average daily temperature ranges between 21°C and 23°C, while the maximum is between 28°C and 34°C. Radiation is about 5285 MJ/m^2/year. Mean relative humidity is in the range of 64%–83%.[14,16,17]

Methods of Data Collection

Vegetation survey using transect and plot sampling techniques following [9,16-18][8,19][20][21][22] were used to collect data for the study. Tree transect each (A [270°W], B [90°E], and C [180°S]

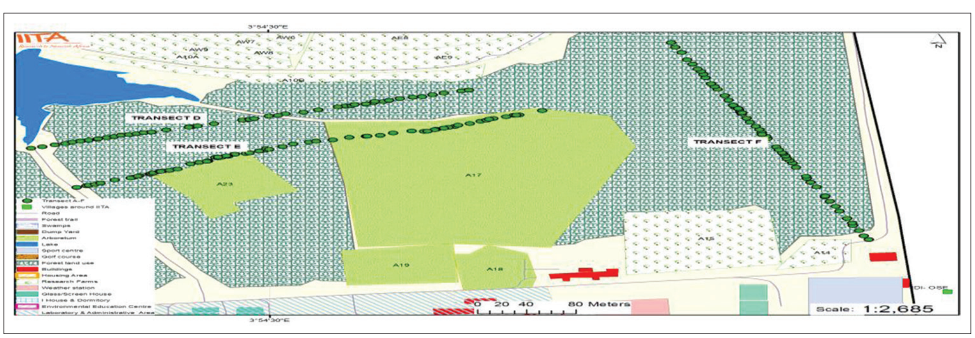

Figure 1: Map of block A forest showing the location of transect D, E, and F. Source: Field Survey, 2017

were constructed in west bank forest and transects D, E [0°N], and F [180°W]) was laid in block A forest with the aid of prismatic compass. Each transect with a length of 500 m was demarcated with 10 sampling plots of 10 m by 10 m [Figure 2].

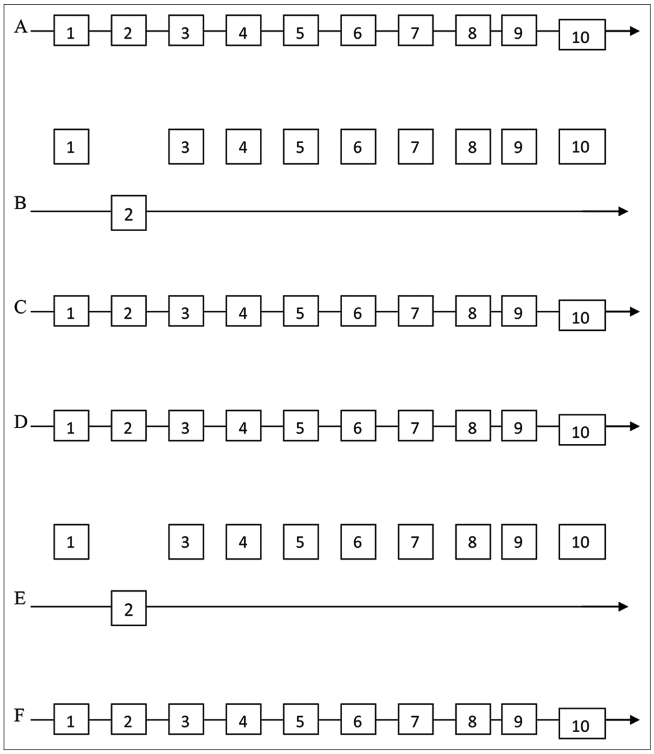

Figure 2: Transects and plots design. Each line A, B, C, and D is 500 m long transect while 1, 2, 3, --------10 are plots of 10 m by 10 m each

A total number of 60 sampling plots (6 transect by 10 plots) were used for the study. All trees and shrubs with DBH ≥10 cm (DBH ≥10 cm) were identified with their scientific and family names in each plot. The trees and shrubs were enumerated and DBH measured at 1.3 m above the soil level. The assistance of retired taxonomist from Forestry Research Institute of Nigeria (FRIN) was sought for the identification of the plant species. Samples of trees that cannot be identified on the field were coded and taken to the herbarium of FRIN for proper identification. The species of trees and shrubs, number of individual of each species, and total number of each species were recorded from each plot and the data pooled together per forest. The study location map [Figures 1 and 3] was produced by taken the coordinates of the plots, transects, entire forests areas, and the adjoining villages of the IITA perimeter fence. The coordinates were downloaded and plotted on the GPS arc view.

Data Analysis

The vegetation data collected were analyzed with descriptive statistics such as tables, frequency counts, percentages, and mean. Analysis of basal area and volume estimation using volume equation developed by FORMECU[13] was carried out following.[17,9]

Calculation of Trees Basal Area

The calculation of basal area of all individual trees belonging to a particular species i (Ba_i) was obtained with basal area model

$BA = \pi D^2/4$

Where: BA = Basal area in m^2 per ha

$\pi = 3.142$

D = Diameter at breast height in meter.

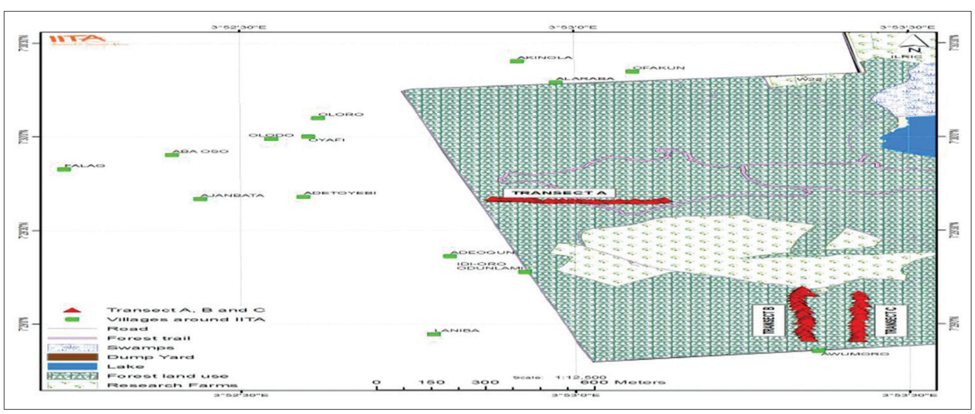

Figure 3: Map of west bank forest showing the location of transect A, B, and C. Source: Field Survey, 2017

Table 1: Vegetation survey: Growth habit classification of woody plants and frequency in the two forests

Form	West bank forest				Block A forest				West bank and block A forest			
	NOS	NOS (%)	SF	SF (%)	NOS	NOS (%)	SF	SF (%)	NOS	NOS (%)	SF	SF (%)
Shrub	16	24.62	83	14.29	21	30.88	109	28.02	24	25.81	131	13.51
Tree	49	75.38	498	85.71	47	69.12	280	71.98	69	74.19	839	86.49
Total	65	100	581	100	68	100	389	100	93	100	970	100

Source: Computed from Vegetation Survey Data, 2016, NOS: Number of species, % NOS: Percentage number of species, SF: Species frequency, SF%: Species frequency percentage

In this study, the trees circumference was measured and the tree diameters were determined using the relationship d = c/π

All the individual trees basal area within the three transects, in each forest (0.3 ha) and in the two forest combined (0.6 ha), were added together and converted to hectare to obtained the basal area of a specie.

Determination of the Trees Volume

The volume of individual tree was determined using volume equation of tree developed by FORMECU,[13] The volume equation is expressed as:

$$V= e^{-8.433 + 2.331 \ln (D)}$$

Where, V is volume (m^3) and D is DBH in meter.

RESULTS AND DISCUSSION

Comparison of Floristic Composition in the Two Forest

The results of the study showed a total number of 581 per 0.3 ha woody plants from 65 species and 28 families recorded in west bank forest while block A forest had 389 per 0.3 ha of wood plants from 68 species and 27 families [Tables 1 and 2]. This showed that west bank forest is more diverse in terms of number of individual woody plants while block A forest is richer in terms of number of species. The data pooled together showed that 970 per 0.6 ha of woody plants comprising trees and shrubs with the (gbh) ≥10 cm belonging to 93 species and 32 families were encountered in the two forests reserved. Aminu and Yakubu[23] in their study of tree volume equation for Sahelian ecosystem in North Nigeria found a total of 181 species from eight families. In the two forests under study, exotic species such as *Delonix regia*, *Gmelina arborea*, *Hura crepitans,* and *Manihot glaziovii* were recorded

Growth Habit Classification of Woody Plants and Frequency in the Two Forests

The distribution of plant into their growth form or growth habit classification on Table 2 showed that in the west bank forest, trees had the highest percentage of 75.38% species while shrubs had 24.62% species with frequency of 85.71% and 14.29%, respectively. In the block A forest, trees had 69.12% species and frequency of 71.98% while shrubs had 30.88% species and frequency of 28.02%. The growth habit classification of plants in the two forest reserved showed that tree had the highest percentage; this showed that trees dominated both the west bank forest and block A forest. The percentage of trees in the west bank forest was higher than that of block A forest. This could be due to protection which the west bank forest has undergone over many years and also could be due to the removal of poles, pegs, and firewood from block A forest by IITA staff for experimental plots.[9,16] Combining the results from the two forests revealed that trees had 74.19% species and shrubs 25.81%. The frequency of trees and shrubs in the two forests was 86.49% and 13.51%, respectively.

Family Distribution of Woody Plant Species in the Two Forests

The distribution into families of all woody plants encountered in the two forests is shown in Table 2. Among the 32 families, *Fabaceae* with subfamilies of *Caesalpinioideae*, *Mimisoideae,* and *Papilinoideae* was found to be the most abundant family in the west bank forest. It had the highest number of 8 species, 43 individuals represented by *Albizia ferruginea*, *Albizia zygia*, *Baphia nitida*, *D. regia*, *Leucaena leucocephala*, *Lonchocarpus sericeus*, *Millettia* sp., and *Millettia thonningii*. It had family relative density of 12.31% and species frequency relative density7.36%. This was followed by *Meliaceae* and *Moraceae* which had 10.77% and 9.23% family relative density and species frequency relative density of 11.70% and 15.32%, *Apocynaceae* and *Euphorbiaceae* had equal family relative density of 7.69% and species frequency relative density of 8.26% and 6.37%, respectively, while *Malvaceae* had 6.15% and 5.85% relative density and species frequency relative density. Furthermore, *Rubiaceae*, *Sapindaceae* and *Ulmaceae*, *Rutaceae* and *Sapotaceae* had 4.62% and 3.08% family relative density and species frequency relative density of 0.69%, 9.98%, 4.82%, 0.69%, and 3.44%, respectively. Other families had between 3.08% and 1.54% relative densities and 9.81% and 0.17% species frequency relative densities, respectively.

The same trend was observed in block A forest with *Fabaceae* subfamilies of *Caesalpinioideae*, *Mimisoideae,* and *Papilinoideae* been the most abundant family with the highest number of 12 species, 74 individuals represented by *A. ferruginea, Albizia adianthifolia*, *A. zygia, Anthonotha macrophylla, Brachystegia eurycoma, Cassia siamea, Daniellia ogea, L. leucocephala, Philenoptera cyanescens, L. sericeus, M. thonningii,* and *Senna siamea*. It had family relative density of 17.64% and species frequency relative density of 19.02%. This was followed by *Euphorbiaceae* with family relative density of 10.29% and species frequency relative density of 10.54%. *Moraceae* and *Rubiaceae*, *Apocynaceae* and *Malvaceae* had equal family relative density of 8.82% and 7.35% and species frequency relative density of 13.37% and 2.31%, 3.86% and 7.35%, respectively. Other families in the block A forest had between 2.94% and 1.47% relative densities and species frequency relative densities of 8.74% and 0.26%, respectively.

In the two forest combined, west bank and block A forest, *Fabaceae* subfamilies of *Caesalpinioideae*, *Mimisoideae,* and *Papilinoideae* were found to be the most abundant family with the highest number of 15 species, 111 individuals represented by *A. ferruginea*, *A. adianthifolia*, *A. zygia*, *A. macrophylla*, *B. nitida*, *B. eurycoma*, *S. siamea*, *D. ogea*, *D. regia*, *L. leucocephala*, *P. cyanescens*, *L. sericeus*, *Millettia* sp., and *M. thonningii.* It had family relative density of

Table 2: Vegetation survey: Family distribution of woody plant species in west bank forest and block A forest of IITA

S. No.	Families	West bank forest				Block A forest				West bank and block A forest			
		NOS	RD %	SF	SFRD %	NOS	RD %	SF	SFRD %	NOS	RD %	SF	SFRD %
1	*Anacardiaceae*	2	3.08	13	2.24	2	2.94	6	1.54	2	2.15	19	1.96
2	*Annonaceae*	1	1.54	5	0.86	2	2.94	21	5.40	2	2.15	13	1.34
3	*Apocynaceae*	5	7.69	48	8.26	5	7.35	15	3.86	5	5.38	73	7.53
4	*Bignoniaceae*	1	1.54	57	9.81	2	2.94	34	8.74	2	2.15	91	9.38
5	*Bombacaceae*	1	1.54	4	0.69	2	2.94	6	1.54	1	1.08	10	1.03
6	*Capparidaceae*	.	.	.	.	1	1.47	9	2.31	1	1.08	1	0.10
7	*Caricaceae*	1	1.54	2	0.34	.	.	.	.	1	1.08	2	0.21
8	*Dichapetalaceae*	1	1.54	6	1.03	1	1.47	2	0.51	1	1.08	9	0.93
9	*Ebenaceae*	2	3.08	8	1.38	1	1.47	3	0.77	2	2.15	13	1.34
10	*Euphorbiaceae*	5	7.69	37	6.37	7	10.29	41	10.54	8	8.60	60	6.19
11	*Lamiaceae*	.	.	.	.	1	1.47	1	0.26	1	1.08	1	0.10
12	*Guttiferae*	1	1.54	2	0.34	.	.	.	.	1	1.08	2	0.21
13	*Lecythidaceae*	1	1.54	2	0.34	1	1.47	8	2.06	1	1.08	10	1.03
14	*Leeaceae*	.	.	.	.	1	1.47	28	7.20	1	1.08	1	0.10
15	*Fabaceae-Caes.*	1	1.54	2	0.34	5	7.35	33	8.48	6	6.45	16	1.65
16	*Fabaceae*-Mim.	3	4.62	23	3.96	4	5.88	28	7.20	4	4.30	56	5.77
17	*Fabaceae*-Pap.	4	6.15	18	3.10	3	4.41	13	3.34	5	5.38	39	4.02
18	*Meliaceae*	7	10.77	68	11.70	1	1.47	16	4.11	9	9.68	139	14.33
19	*Moraceae*	6	9.23	89	15.32	6	8.82	52	13.37	6	6.45	100	10.31
20	*Myristicaceae*	1	1.54	9	1.55	1	1.47	4	1.03	1	1.08	13	1.34
21	*Myrtaceae*	.	.	.	.	1	1.47	2	0.51	2	2.15	2	0.21
22	*Olacaceae*	1	1.54	2	0.34	1	1.47	2	0.51	3	3.23	6	0.62
23	*Palmae*	1	1.54	10	1.72	1	1.47	5	1.29	1	1.08	19	1.96
24	*Pandaceae*	1	1.54	23	3.96	1	1.47	3	0.77	1	1.08	26	2.68
25	*Rhamnaceae*	1	1.54	1	0.17	.	.	.	.	1	1.08	1	0.10
26	*Rubiaceae*	3	4.62	4	0.69	6	8.82	9	2.31	7	7.53	11	1.13
27	*Rutaceae*	2	3.08	4	0.69	.	.	.	.	2	2.15	4	0.41
28	*Sapindaceae*	3	4.62	58	9.98	4	5.88	10	2.57	4	4.30	95	9.79
29	*Sapotaceae*	2	3.08	20	3.44	.	.	.	.	2	2.15	20	2.06
30	*Malvaceae*	4	6.15	34	5.85	5	7.35	27	6.94	5	5.38	67	6.91
31	*Tiliaceae*	1	1.54	4	0.69	2	2.94	10	2.57	2	2.15	9	0.93
32	*Ulmaceae*	3	4.62	28	4.82	1	1.47	1	0.26	3	3.23	42	4.33
	Total	65	100	581	100	68	100	389	100	93	100	970	100

16.13% and species frequency relative density of 11.44%. *Meliaceae*, *Euphorbiaceae*, *Rubiaceae,* and *Moraceae* had 9.68%, 8.60%, 7.53%, and 6.45% family relative density and species frequency relative density of 14.33%, 6.19%, 1.13%, and 10.3%, respectively. *Apocynaceae* and *Malvaceae* had equal family relative density of 5.38% and species frequency relative density of 7.53% and 6.91%, respectively. Other families had family relative densities ranging from 4.30% to 2.15% and 9.79% to 0.41%. Families such as *Bombacaceae*, *Capparidaceae*, *Caricaceae*, *Dichapetalaceae*, *Fabaceae*, *Guttiferae*, *Lecythidaceae*, *Leeaceae*, *Myristicaceae*, *Palmae*, *Pandaceae,* and *Rhamnaceae* were represented by only one species and are less well represented families in the two forests. The result corroborate the findings of Aminu and Yakubu[23] with recorded the highest number of species (6) for *Fabaceae* family and followed by the family *Arecaceae* with two species (2).

Most Abundant Trees in the Forest

The most abundant trees in the west bank forest are *N. laevis* (57), *T. monadelpha* (44), *Antiaris toxicaria var. africana* (40),

Table 3: Basal area and volume of woody plants obtained in the two forests reserved

S. No.	Scientific name	Family	Form	West bank forest				Block A forest				West bank and block A forest			
				T	D	BA/ha	V(m^3) /ha	T	D	BA/ha	V(m^3) /ha	T	D	BA/ha	V (m^3) /ha
1	*Albizia adianthifolia*	*Fabaceae*- Mim.	Tree	-	-	-	-	1	5.09	67.90	0.71	1	5.09	67.90	0.71
2	*Albizia ferruginea*	Fabaceae- Mim.	Tree	1	10.18	271.59	1.01	7	27.33	1955.08	1.44	8	18.76	460.51	1.28
3	*Albizia zygia*	Fabaceae- Mim.	Tree	21	27.36	1959.42	1.44	19	28.41	2113.28	1.46	40	27.88	1017.81	1.45
4	*Alchornea cordifolia*	*Euphorbiaceae*	Shrub	-	-	-	-	3	6.68	116.96	0.83	3	6.68	116.96	0.83
5	*Alchornea laxiflora*	*Euphorbiaceae*	Shrub	23	17.80	59.33	0.68	8	6.88	124.03	0.84	31	5.82	44.37	0.77
6	*Allophylus africanus*	*Sapindaceae*	Shrub	-	-	-	-	1	19.10	954.81	1.28	1	19.10	954.81	1.28
7	*Alstonia boonei*	*Apocynaceae*	Tree	2	50.76	6747.36	1.71	1	36.92	3568.85	1.57	3	43.84	2516.32	1.46
8	*Anthonotha macrophylla*	*Fabaceae-Caes.*	Tree	-	-	-	-	6	8.17	174.72	0.91	6	8.17	174.72	0.91
9	*Antiaris toxicaria var africana*	*Moraceae*	Tree	40	15.63	640.06	1.20	26	14.16	525.21	1.15	66	14.90	290.61	1.18
10	*Baphia nitida*	*Fabaceae*- Pap.	Shrub	4	7.77	157.90	0.89	-	-	-	-	4	7.77	157.90	0.89
11	*Blighia sapida*	*Sapindaceae*	Tree	34	7.44	145.01	0.87	6	19.36	981.51	1.29	40	13.40	235.13	1.13
12	*Blighia unijugata*	*Sapindaceae*	Tree	2	4.61	55.76	0.67	2	6.21	100.85	0.80	4	5.41	38.32	0.74
13	*Bombax buonopozense*	*Bombacaceae*	Tree	4	27.69	2007.48	1.44	5	29.47	2274.23	1.47	9	28.58	1069.39	1.46
14	*Brachystegia eurycoma*	*Fabaceae- Caes.*	Tree	-	-	-	-	2	8.43	186.25	0.93	2	8.43	186.25	0.93
15	*Bridelia micrantha*	*Euphorbaceae*	Shrub	2	5.41	76.65	0.74	3	8.17	174.72	0.91	5	6.79	60.35	0.83
16	*Canthium venosum*	*Rubiaceae*	Shrub	1	4.77	59.68	0.68	-	-	-	-	1	4.77	59.68	0.68
17	*Carica papaya*	*Caricaceae*	Tree	2	13.37	467.85	1.13	-	-	-	-	2	13.37	467.85	1.13
18	*Cassia siamea*	*Fabaceae- Caes.*	Tree	-	-	-	-	1	28.17	2077.30	1.45	1	28.17	2077.30	1.45
19	*Ceiba pentandra*	*Bombacaceae*	Tree	-	-	-	-	1	7.96	165.76	0.90	1	7.96	165.76	0.90
20	*Celtis philippensis*	*Ulmaceae*	Tree	1	9.23	223.05	0.97	-	-	-	-	1	9.23	223.05	0.97
21	*Celtis wightii*	*Ulmaceae*	Tree	10	7.80	159.20	0.89	-	-	-	-	10	7.80	159.20	0.89
22	*Celtis zenkeri*	*Ulmaceae*	Tree	17	18.68	914.06	1.27	14	17.41	793.99	1.24	31	18.05	426.48	1.26
23	*Chrysophyllum albidum*	*Sapotaceae*	Tree	19	16.50	712.82	1.22	-	-	-	-	19	16.50	712.82	1.22
24	*Cleistopholis patens*	*Annonaceae*	Tree	-	-	-	-	1	57.29	8593.25	1.76	1	57.29	8593.25	1.76
25	*Cola gigantea*	*Malvaceae*	Tree	-	-	-	-	2	10.72	300.62	1.03	2	10.72	300.62	1.03

(Contd...)

Table 3: (Continued)

S. No.	Scientific name	Family	Form	West bank forest				Block A forest				West bank and block A forest			
				T	D	BA/ha	V(m^3) /ha	T	D	BA/ha	V(m^3) /ha	T	D	BA/ha	V (m^3) /ha
26	*Cola millenii*	*Malvaceae*	Tree	11	8.01	168.18	0.91	18	10.36	281.27	1.02	29	9.19	110.56	0.97
27	*Cola nitida*	*Malvaceae*	Tree	2	37.24	3630.65	1.57	-	-	-	-	2	37.24	3630.65	1.57
28	*Daniellia ogea*	*Fabaceae- Caes.*	Tree	-	-	-	-	2	73.20	14030.34	1.87	2	73.20	14030.34	1.87
29	*Delonix regia*	*Fabaceae- Caes.*	Tree	2	9.55	238.70	0.98	-	-	-	-	2	9.55	238.70	0.98
30	*Dichapetalum madagascariense*	*Dichapetalaceae*	Shrub	6	3.71	36.10	0.57	3	3.29	28.32	0.52	9	3.50	16.05	0.55
31	*Diospyros mespiliformis*	*Ebenaceae*	Shrub	1	11.14	324.90	1.05	-	-	-	-	1	11.14	324.90	1.05
32	*Diospyros monbuttensis*	*Ebenaceae*	Shrub	7	4.59	55.22	0.66	5	9.55	238.70	0.98	12	7.07	65.44	0.85
33	*Elaeis guineensis*	*Palmae*	Tree	10	32.69	2797.39	1.52	9	37.06	3595.27	1.57	19	34.87	1591.92	1.54
34	*Entandrophragma angolense*	*Meliaceae*	Tree	1	35.96	3386.64	1.56	-	-	-	-	1	35.96	3386.64	1.56
35	*Entandrophragma cylindricum*	*Meliaceae*	Tree	4	19.97	1044.34	1.30	-	-	-	-	4	19.97	1044.34	1.30
36	*Entandrophragma* sp.	*Meliaceae*	Tree	1	5.41	76.65	0.74	-	-	-	-	1	5.41	76.65	0.74
37	*Euadenia trifoliolata*	*Capparidaceae*	Shrub	-	-	-	-	1	3.82	38.19	0.58	1	3.82	38.19	0.58
38	*Ficus exasperata*	*Moraceae*	Tree	5	12.79	428.61	1.11	10	17.05	760.71	1.23	15	14.92	291.42	1.18
39	*Ficus mucoso*	*Moraceae*	Tree	4	24.03	1511.84	1.38	4	48.14	6067.41	1.68	8	36.08	1704.58	1.56
40	*Funtumia elastica*	*Apocynaceae*	Tree	37	10.55	291.20	1.03	7	14.72	567.33	1.17	44	12.63	208.93	1.10
41	*Garcinia kola*	*Guttiferae*	Tree	2	3.82	38.19	0.58	-	-	-	-	2	3.82	38.19	0.58
42	*Glyphaea brevis*	*Tiliaceae*	Shrub	4	4.54	53.86	0.66	3	5.09	67.90	0.71	7	4.81	30.34	0.68
43	*Gmelina arborea*	*Lamiaceae*	Tree	-	-	-	-	1	44.24	5124.39	1.65	1	44.24	5124.39	1.65
44	*Grewia pubescens*	*Tiliaceae*	Shrub	-	-	-	-	2	6.84	122.60	0.84	2	6.84	122.60	0.84
45	*Holarrhena floribunda*	*Apocynaceae*	Tree	7	-	-	-	9	13.78	496.94	1.14	16	13.78	496.94	1.14
46	*Hura crepitans*	*Euphorbiaceae*	Tree	-	-	-	-	1	16.23	689.85	1.21	1	16.23	689.85	1.21
47	*Keetia venosa*	*Rubiaceae*	Shrub	1	6.52	111.46	0.82	-	-	-	-	1	6.52	111.46	0.82
48	*Khaya grandifoliola*	*Meliaceae*	Tree	4	4.30	48.34	0.64	-	-	-	-	4	4.30	48.34	0.64
49	*Kigelia africana*	*Bignoniaceae*	Tree	-	-	-	-	1	4.46	51.98	0.65	1	4.46	51.98	0.65
50	*Lannea welwitschii*	*Anacardiaceae*	Tree	6	17.45	797.45	1.24	1	63.65	10608.95	1.81	7	40.55	2152.96	1.61
51	*Lecaniodiscus cupanioides*	*Sapindaceae*	Tree	22	7.96	165.76	0.90	28	10.30	277.73	1.02	50	9.13	109.08	0.96

(Contd...)

Table 3: (Continued)

S. No.	Scientific name	Family	Form	West bank forest				Block A forest				West bank and block A forest			
				T	D	BA/ha	V(m^3) /ha	T	D	BA/ha	V(m^3) /ha	T	D	BA/ha	V (m^3) /ha
52	*Leea guineensis*	*Leeaceae*	Tree	-	-	-	-	1	3.82	38.19	0.58	1	3.82	38.19	0.58
53	*Leucaena leucocephala*	*Fabaceae- Mim.*	Tree	1	9.87	254.88	1.00	6	13.23	458.62	1.12	7	11.55	174.66	1.06
54	*Lonchocarpus sericeus*	*Fabaceae*- Pap.	Tree	5	21.96	1262.73	1.34	14	25.08	1646.29	1.40	19	23.52	724.08	1.37
55	*Maesopsis eminii*	*Rhamnaceae*	Tree	1	24.51	1572.51	1.39	-	-	-	-	1	24.51	1572.51	1.39
56	*Mallotus oppositifolius*	*Euphorbiaceae*	Tree	3	4.77	59.68	0.68	1	4.77	59.68	0.68	4	17.90	29.84	0.68
57	*Manihot glaziovii*	*Euphorbiaceae*	Tree	-	-	-	-	4	15.91	663.06	1.20	4	15.91	663.06	1.20
58	*Margaritaria discoidea*	*Euphorbiaceae*	Tree	5	41.69	4551.51	1.62	-	-	-	-	5	41.69	4551.51	1.62
59	*Microdesmis puberula*	*Pandaceae*	Shrub	23	4.33	49.12	0.64	3	4.77	59.68	0.68	26	4.55	27.13	0.66
60	*Milicia excelsa*	*Moraceae*	Tree	3	124.12	40340.55	2.10	-	-	-	-	3	124.12	40340.55	2.10
61	*Millettia* sp.	*Fabaceae*-Pap.	Tree	1	5.09	67.90	0.71	-	-	-	-	1	5.09	67.90	0.71
62	*Millettia thonningii*	*Fabaceae*-Pap.	Tree	8	9.23	223.05	0.97	5	10.44	285.34	1.02	13	9.83	126.62	0.99
63	*Monodora tenuifolia*	*Annonaceae*	Tree	5	13.18	454.58	1.12	7	9.18	220.86	0.97	12	11.18	163.65	1.05
64	*Morinda lucida*	*Rubiaceae*	Tree	-	-	-	-	1	7.92	164.11	0.90	1	7.92	164.11	0.90
65	*Morus mesosygia*	*Moraceae*	Tree	2	3.34	29.24	0.53	2	11.78	363.09	1.07	4	10.46	143.32	1.02
66	*Myrianthus arboreus*	*Moraceae*	Tree	-	-	-	-	4	17.58	809.61	1.25	4	17.58	809.61	1.25
67	*Napoleona vogelii*	*Lecythidaceae*	Shrub	2	5.57	81.22	0.75	8	4.30	48.34	0.64	10	6.74	59.53	0.83
68	*Nesogordonia papaverifera*	*Malvaceae*	Tree	-	-	-	-	1	13.37	467.85	1.13	1	13.37	467.85	1.13
69	*Newbouldia laevis*	*Bignoniaceae*	Tree	57	7.00	128.37	0.85	33	8.70	198.29	0.94	90	7.85	80.72	0.90
70	*Olax subscorpioidea*	*Olacaceae*	Shrub	2	5.73	85.93	0.76	-	-	-	-	2	5.73	85.93	0.76
71	*Oxyanthus tubiflorus*	*Olacaceae*	Shrub	-	-	-	-	2	4.77	59.68	0.68	2	4.77	59.68	0.68
72	*Pavetta corymbosa*	*Rubiaceae*	Shrub	-	-	-	-	3	3.71	36.10	0.57	3	3.71	36.10	0.57
73	*Philenoptera cyanescens*	*Fabaceae*- Pap.	Shrub	-	-	-	-	2	4.30	48.34	0.64	2	4.30	48.34	0.64

(Contd...)

Table 3: (Continued)

S. No.	Scientific name	Family	Form	West bank forest				Block A forest				West bank and block A forest			
				T	D	BA/ha	V(m³) /ha	T	D	BA/ha	V(m³) /ha	T	D	BA/ha	V (m³) /ha
74	*Psidium guajava*	*Myrtaceae*	Tree	-	-	-	-	2	18.46	892.21	1.27	2	18.46	892.21	1.27
75	*Psydrax parviflora*	*Rubiaceae*	Shrub	2	4.77	59.68	0.68	1	10.50	288.83	1.02	3	7.64	76.38	0.89
76	*Pycnanthus angolensis*	*Myristicaceae*	Tree	9	22.31	1303.73	1.35	4	25.06	1644.80	1.40	13	23.69	734.66	1.38
77	*Rauvolfia vomitoria*	*Apocynaceae*	Shrub	1	4.46	51.98	0.65	1	9.55	238.70	0.98	2	7.00	64.18	0.85
78	*Ricinodendron heudelotii*	*Euphorbiaceae*	Tree	4	33.42	2924.09	1.53	3	46.89	5757.24	1.67	7	40.15	2110.92	1.61
79	*Rothmannia hispida*	*Rubiaceae*	Shrub	-	-	-	-	1	9.23	223.05	0.97	1	9.23	223.05	0.97
80	*Rytigynia umbellulata*	*Rubiaceae*	Shrub	-	-	-	-	1	5.09	67.90	0.71	1	5.09	67.90	0.71
81	*Senna siamea*	*Fabaceae*-Ceas.	Tree	-	-	-	-	3	30.34	2410.47	1.48	3	30.34	2410.47	1.48
82	*Spondias mombin*	*Anacardiaceae*	Tree	7	18.19	866.04	1.26	5	11.71	359.18	1.07	12	14.95	292.58	1.18
83	*Sterculia tragacantha*	*Malvaceae*	Tree	11	14.29	534.91	1.16	22	16.78	737.37	1.23	33	15.54	316.04	1.19
84	*Strombosia pustulata*	*Olacaceae*	Tree	-	-	-	-	2	15.91	663.06	1.20	2	15.91	663.06	1.20
85	*Synsepalum dulcificum*	*Sapotaceae*	Shrub	1	3.18	26.52	0.51	-	-	-	-	1	3.18	26.52	0.51
86	*Trichilia emetica*	*Meliaceae*	Tree	1	10.15	269.66	1.01	-	-	-	-	1	10.15	269.66	1.01
87	*Trichilia monadelpha*	*Meliaceae*	Tree	44	8.59	193.35	0.94	16	17.74	824.33	1.25	60	13.95	254.62	1.15
88	*Trichilia prieuriana*	*Meliaceae*	Tree	13	5.73	85.93	0.76	-	-	-	-	13	5.73	85.93	0.76
89	*Trilepisium madagascarense*	*Meliaceae*	Tree	35	18.58	903.68	1.27	9	21.89	1254.61	1.34	44	20.23	535.98	1.31
90	*Triplochiton scleroxylum*	*Meliaceae*	Tree	10	50.33	6633.03	1.70	1	5.41	76.65	0.74	11	27.87	1016.97	1.45
91	*Voacanga africana*	*Apocynaceae*	Tree	1	11.14	324.90	1.05	7	11.09	322.25	1.05	8	11.12	161.79	1.05
92	*Zanthoxylum zanthoxyloides*	*Rutaceae*	Tree	3	8.70	198.15	0.94	-	-	-	-	3	8.70	198.15	W0.94
93	*Zanthoxylum rubescens*	*Rutaceae*	Tree	1	37.24	3630.65	1.57	-	-	-	-	1	37.24	3630.65	1.57
	Total			581	1044.96	98215.79	\68.19	389	1147.01	89685.02	74.50	970	1545.65	69991.25	99.66
	Average				16.08	1511.01	1.05		16.87	1318.90	1.10		16.62	752.59	1.07

T: Total number of individual, D: Diameter, BA/ha: Basal area per hectare, V (m^3)/ha: Volume of tree per hectare

Funtumia elastica (37), *Trilepisium madagascarense* (35), *Blighia sapida* (34), *Alchornea laxiflora* (23), *Microdesmis puberula* (23), *L. cupanioides* (22), *A. zygia* (21), and *Chrysophyllum albidum* (19). Other tree species had between 17 and 1 abundant [Table 3].

In the block A forest, the most abundant trees in the forest are *N. laevis* (33), *L. cupanioides* (28), *A. toxicaria var. africana* (26), *Sterculia tragacantha* (22), *A. zygia* (19), *Cola millenii* (18), and *T. monadelpha* (16). *L. sericeus* and *Celtis zenkeri* had equal abundant of 14 while *Ficus exasperata* has 10 abundant. Three species such as *Trilepisium madagascariense*, *Holarrhena floribunda,* and *E. guineensis* had equal abundant of 9. Other tree species had abundant ranging from 8 to 1.

The most abundant trees when the result from the two forests is combined showed that *N. laevis* (90), *A. toxicaria var. africana* (66), *T. monadelpha* (60), *L. cupanioides* (50), *T. madagascariense* and *F. elastica*, *B. sapida,* and *A. zygia* had equal abundant of 44 and 40, respectively. *S. tragacantha* had 33 while *C. zenkeri* and *A. laxiflora* had equal value of 31. Other tree species had value ranging between 29 and 1 abundant.

Species which occur once in the forest are considered rare, they include *A. adianthifolia*, *Allophylus africanus*, *Canthium venosum, C. siamea*, *Ceiba pentandra, Celtis philippensis*, *Cleistopholis patens*, *Diospyros mespiliformis*, *Entandrophragma angolense*, *Euadenia trifoliolata*, *G. arborea*, *H. crepitans*, *Keetia venosa*, *Kigelia africana*, *Leea guineensis*, *Maesopsis eminii*, *Morinda lucida*, *Nesogordonia papaverifera*, *Rothmannia hispida*, *Rytigynia umbellulata*, *Synsepalum dulcificum*, *Trichilia emetica* and *Zanthoxylum rubescens*, *Alstonia boonei*, *Psydrax parviflora*, *Ceiba pentandra*, *C. patens*, *E. trifoliolata*, *Kigelia africana*, *Lannea welwitschii*, *L. guineensis*, *Mallotus oppositifolius*, *M. lucida*, *N. papaverifera*, *G. arborea*, *Rauvolfia vomitoria*, *R. hispida*, *R. umbellulata,* and *Triplochiton scleroxylum*.

Basal Area and Volume of Woody Plants in the Two Forest Reserve

The basal area and volume of woody plant species in Table 3 showed that *M. excelsa* had the highest basal area and volume of 40.34 m^2/ha and 2.10 m^3/ha in the west bank forest. *A. boonei*, *T. scleroxylum,* and *Margaritaria discoidea* were next in that order with 6.75 m^2/ha, 6.63 m^2/ha, and 4.55 m^2/ha basal area and volume 1.71 m^3/ha, 1.70 m^3/ha, and 1.62 m^3/ha, respectively. *Cola nitida* and *Z. rubescens* had equal volume of 1.57 m^3/ha and basal area of 3.63 m^2/ha. Other species of woody plants had between 2.65 m^2/ha and 3.39 m^2/ha basal area and volume 0.51 m^3/ha and 1.56 m^3/ha. The forest recorded total and average basal area of 98.22 m^2/ha and 15.11 m^2/ha with total and average tree volume of 68.19 m^3/ha and 1.05m^3/ha, respectively

In the block A forest, *Daniellia orgea* had the highest basal area and volume of 14.03 m^2/ha and 1.87 m^3/ha. *Lannea welwitschii* and *C. patens* had 10.61 m^2/ha and 8.593 m^2/ha basal area, volume 1.81 m^3/ha and 1.76 m^3/ha while *Ficus mucoso* had basal area of 6.07 m^2/ha and volume 1.68 m^3/ha, respectively. *Ricinodendron heudelotii* and *G. arborea* had basal area of 5.76 m^2/ha and 5.12 m^2/ha and volume 1.67 m^3/ha and 1.65 m^3/ha. Other woody plants in block A forest had basal area and volume ranging between 0.28 m^2/ha to 3.57 m^2/ha and 0.52 m^3/ha to 1.57 m^3/ha, respectively. The total and average basal area of 89.69 m^2/ha and 13.18 m^2/ha with total and average tree volume of 74.50 m^3/ha and 1.10 m^3/ha were obtained in the block A forest. This result showed that west bank forest had higher total and average basal area (98.22 m^2/ha, 15.11 m^2/ha), total and average volume of trees (68.19 m^3/ha and 1.05m^3/ha) as compared with block A forest. This further revealed that the west bank forest is more and well-stocked with trees, this could be due to active protection of the forest day and night by the forest rangers while block A forest is susceptible to NTFPs collection by the villages permitted by IITA and pegs, poles and stakes removal for experimental field by IITA staff.[9,16]

Pooling the data from the two forests together shows that *M. excelsa* had the highest basal area and volume of 40.34 m^2/ha and 2.10 m^3/ha. This was followed by *D. orgea* and *C. patens* with 14.03 m^2/ha and 8.59 m^2/ha basal area and volume1.87 m^3/ha and 1.76 m^3/ha, respectively. *G. arborea* and *M. discoidea* had 5.12 m^2/ha and 4.55 m^2/ha basal area and volume 1.65 m^3/ha and 1.62 m^3/ha, respectively. Other species of woody plant had basal area ranging between 0.26 m^2/ha to 2.15 m^2/ha per ha and volume 0.51 m^3/ha to 1.61 m^3/ha, respectively. The overall average basal area of 7.53 m^2/ha and average volume of 1.07 m^3/ha were recorded for the two forests. The basal area values is much lower than 18.42 m^2/ha and 28 m^2/ha obtained for Oluwa forest reserve and tropical rainforest area in Trinidad.[1,24]

CONCLUSION

It can be concluded from the findings of the study that the two forests are repository of many indigenous tropical tree species with few exotic species. Trees dominated the two forests but are more, well stocked in west bank forest than block A forest and are merchantable considering their volume. West bank forest is more diverse in terms of number of individual woody plants while block A forest is richer in terms of number of species. A total number of 970 per 0.6 ha of woody plants comprising trees and shrubs with the (gbh) ≥10 cm belonging to 93 species and 32 families were encountered in the two forests reserves. *Milicia excelsa* had the highest basal area and volume in the west bank forest while *D. orgea* had the highest basal area and volume in block A forest. Some species of woody plants were recorded once or twice in the two forests.

RECOMMENDATION

To prevent the extinction of these woody plants species and their families, there is a need for adequate and continuous protection of the two forests. It is, therefore, recommended that continuous forest inventory is required for proper monitoring of the trees volume in the two forests reserved.

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INTEREST

Authors have declared that no competing interest exists.

REFERENCES

1. Clubbe CP, Jhilmit S. A case study of natural forest management in Trinidad. In: Miller FR, Adam KL, editors. Wise Management of Tropical Forests. Oxford: Proceedings of the Oxford Conference on Tropical Forests; 1992. p. 201-9.
2. Makero JS, Malimbwi RE, Eid T, Zahabu E. Models Predicting Above-and Belowground Biomass of Thicket and Associate Tree Species in Itigi Thicket Vegetation of Tanzania. Agric Forest Fisher 2016;5:115-25.
3. Mauya EW, Mugasha WA, Zahabu E, Bollands OM, Eid T. Models for estimation of tree volume in the miombo woodlands of Tanzania. Southern Forests 2014;10:1-11.
4. Mwakalukwa E, Meilby H, Treue T. Volume and aboveground biomass models for dry Miombo woodland in Tanzania. Int J Forest Res 2014;11:1-11.
5. Akindele SO, LeMay VM. Development of tree volume equations for common timber species in the tropical rainforests of Nigeria. Forest Ecol Manage 2006;230:96-104.
6. Shuaibu RB. Developing tree volume equations for *Azadirachta indica* (Neem Tree) in Katsina state, Nigeria. Gashua J Irrigat Desertific Stud 2015;1:1-2.
7. Ariyo OC. Population structure of woody plants in block a forest of international institute of tropical agriculture (IITA) Ibadan, Oyo State, Nigeria. Sustainable development goals through appropriate forest management strategies. In: Adekunle VA, Ogunsanwo OY, Adewole NA, Oni PI, editors. Proceeding of the 41st Annual National Conference of the Forestry Association of Nigeria held at Abuja, Federal Capital Territory. Nigeria: IITA; 2019a. p. 952-60.
8. Ariyo OC, Oluwalana SA, Akinyemi O, Ariyo MO, Awotide OG. Structure and demographics patterns of woody plant community in IITA forest reserve. Obeche J 2011;29:259-69.
9. Ariyo OC. Socio-economic and Botanic Analysis of West Bank Forest and Block a Forest of IITA, Ibadan, Oyo State, Nigeria. Unpublished Ph.D. Thesis Submitted to the Department of Forestry and Wild life Management. Abeokuta, Ogun State, Nigeria: University of Agriculture; 2018. p. 1-357.
10. Ariyo O, Adedokun MO, Ariyo MO. Determinants of the quantity of non-timber forest products collected from forests of the international institute of tropical agriculture in Ibadan, Nigeria. Asian J Res Agric Forest 2018a;1:1-13.
11. Ariyo OC, Oluwalana SA, Ariyo MO, Aasa OS. Indigenous knowledge of the uses of forest plants found in and around IITA forest reserve in Ibadan, Oyo State, Nigeria. In: Ogunsanwo OY, Akinwale AO, Azeez IO, Adekunle VA, Adewole NA, editors. Sudano-Sahelian Landscape and Renewable Natural Resources Development in Nigeria. Niger: Proceeding of the 37th Annual National Conference of the Forestry Association of Nigeria held in Minna; 2014. p. 304-19.
12. Ariyo OC, Oluwalana SA, Ariyo MO. Profitability analysis of non-timber forest products collected from block a and golf course forests of international institute of tropical agriculture (IITA), Ibadan, Oyo State, Nigeria. Adv Res 2018b;14:1-12.
13. FORMECU. Forest Resources Study, Nigeria. Revised National Report. Vol. 2. Abuja, Nigeria: Prepared for FORMECU by Break and Geomatics International; 1999. p. 224.
14. Tenkouano A, Baiyeri KP. Adoption pattern and yield stability of banana and plantain genotypes grown in contrasting agro-ecology zone in Nigeria. Afr Crop Sci Conf Proc 2007;8:377-84.
15. Ezealor AU. Critical sites for biodiversity conservation in Nigeria. Lagos, Nigeria: Nigeria Conservation Foundation; 2002. p. 110.
16. Ariyo OC. Comparative analyses of diversity and similarity indices of West Bank forest and block a forest of the international institute of tropical agriculture (IITA) Ibadan, Oyo State, Nigeria. Int J Forest Res 2020a;2020:4865845.
17. Ariyo OC. Tree stem volume estimation from West Bank forest ecosystem of IITA, Ibadan, Oyo State, Nigeria. J Forest Res Manage 2020b;17:99-110.
18. Ariyo OC. Comparison of woody plants population structure in two distinct forest of international institute of tropical agriculture (IITA) Ibadan, Oyo State, Nigeria. J Forest Res Manage 2019b;16:87-103.
19. Ariyo OC, Oluwalana SA, Faleyimu OI, Ariyo MO. Assessment of vegetation structural diversity and similarity index of IITA forest reserve in Ibadan, Oyo state, Nigeria. Agrosearch J 2012;12:135-57.
20. Lawal A, Adekunle VA. Impact of enrichment planting on biodiversity restoration in degraded forest. In: Popoola L, Ogunsanwo K, Idumah F, editors. Forestry in the Context of the Millennium Development Goals. Proceedings of the 34th Annual Conference of the Forestry Association of Nigeria held in Osogbo, Osun State, Nigeria. Vol. 1. Nigeria: Forestry Association of Nigeria; 2011. p. 558-71.
21. Onefeli AO, Opute OH, Oluwayomi TI. Biodiversity assessment of Okpe Sobo forest reserve, Delta state. In: Popoola L, Ogunsanwo OY, Oni PI, Idumah FO, Akinwole AO, editors. Proceeding of the 36th Annual National Conference of the Forestry Association of Nigeria held at University of Uyo, Akwa-Ibom State Nigeria. Nigeria: University of Uyo; 2013. p. 490-5.
22. Onyekwelu JC, Adekunle AJ, Adeduntan SA. Does tropical rainforest ecosystem possess the ability to recover from severe degradation. In: Popoola L, Mfon P, Oni PI, editors. Sustainable

Forest Management in Nigeria: Lessons and Prospects. Proceedings of the 30th Annual Conference of the Forestry Association of Nigeria held in Kaduna, Kaduna State, Nigeria. Nigeria: Forestry Association of Nigeria; 2005. p. 145-63.

23. Aminu SA, Yakubu I. Tree volume equation for Sahelian ecosystem in Northern Nigeria. J Pharmacogn Phytochem 2019;8:2138-40.
24. Akinsanmi FA, Akindele SO. Timber yield assessment in the natural forest area of Oluwa forest reserve, Nigeria. Niger J Forest 2002;32:16-22.