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Tree species diversity and tree damage assessment in IITA Forest, Ibadan, Nigeria

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Abstract
Assessment of tree species composition, richness and diversity analyses were carried out in the International Institute of Tropical Agriculture (IITA) forest with the aim of developing an efficient management plan for promoting biodiversity conservation in the study area. Limited research work has been done on diversity with an examination of what causes a reduction in the floristic composition in many tropical forests. Hence, this study was conducted to assess biodiversity and to give an in-depth understanding of the status of the forest and the reasons for the endemic tree species being currently endangered. Data used were collected from IITA forest Ibadan, Nigeria. Simple systematic line transect of four parallel transects of 200m apart were used for plot laying. Sixteen sample plots of 25m × 25m were laid for data collection, all trees with Diameter at Breast Height (dbh) ≥ 10cm were measured to determine No the number of stand per hectare(N_i/ha), Quadratic mean dbh per hectare (DQ/ha) and Volume per hectare (V/ha). Trees were sorted into species, families, frequency of occurrence, height and DBH classes. The DBH, TH, N/ha, DQ, TSC, V and CD ranged from 10– 170cm, 7.7m – 38.1m, 96 – 704, 18.047 – 52.655cm, 22 – 225%, 0.003 – 24.676m^3 and 3 – 13.7m, respectively. The stand comprises of 389 stem ha^{-1}belonging to 43 species in 19 families were recorded from this study. Apocynaceae family had the highest number of individual species of 87. The most abundant family was Fabaceae which comprises of 10 species. Funtumia elastica had the highest important value index of 11.03. The forest had a Shannon wiener and margalef index of 3.037 and 58.019, respectively. Moraceae family had the highest basal area per hectare (7.62m^2). Fabaceae family had the highest numbers of family Important Value Index (FIVI) of 60.21 and highest Shannon wiener diversity index of 0.65. Inverse J shape pattern was observed in the DBH distribution curve. The lowest DBH class (10 – 20cm) had 218 species (56.04%), while the highest DBH class (≥100) had 4 species (1.03%). The damages observed on the tree in the study area showed that 4% of the trees were affected by diseases, while 1% affected by anthropogenic activities and the tree that are healthy ones were 89%. This implied that the forest could be in a healthy state and protected for biodiversity conservation.

Keywords: *Biodiversity, Tree growth characteristics, Tree damages, IITA*

Introduction

The tropical rainforest ecosystem is among the most complex and species-rich single ecosystem in the world (Adekunle and Olagoke, 2008). One important feature of tropical forests is the diversity of tree species, which is essential to rainforest biodiversity; these tree species form a dense canopy that provides a variety of services such as raw material source, the reservoir for biodiversity, habitat for animals, source of timber, carbon sequestration, watershed protection, and a source of livelihood for human settlement (Olawoyin et al., 2020). Favourable environmental conditions and the canopy structure of this tropical forest are special characteristics features, which incredibly promote species diversity and the percentage of flora and fauna which depends on tree for survival in the rainforest ecosystem are estimated to about 70-90% as reported by Gillespie and Wright (2004).

Diversity simply means the abundance and different life forms found within forested areas. Forest biological diversity does not only describe trees, but also comprehensively described the associated genetic diversity between the plants, animals and microorganisms that makes up the forest areas (FAO, 2020). Biodiversity measurement basically focuses on species level while species diversity is one of the most important indices used for evaluating different scale of ecosystem as reported by Neumann and Starlinger (2001). Tree species diversity deals with the combination of species richness (number of species present) and species evenness (abundance of each species) in the forest (Akindele 2013). Tree species is one of the important components of the forest ecosystem because the compositions of the forest ecosystem are being influenced by vegetation diversity. The existence of many species worldwide are been threatened by the activities of man and other factors such as urbanization, a surge in the population of human and clear felling of trees for agricultural purposes (Ogundele and Omotayo, 2008; Varshney and Anis 2014). Biodiversity is known to be vital because they influenced the overall health status of the ecosystem (Naidu and Kumar, 2016; Wakawa *et.al.*, 2017). Various tree damages caused either natural or by human damages on the tree have been said to affect the growth of the tree and this also affects biological setting and processes within the forest area which has resulted to many endemic trees species now endangered tree species in the forest as asserted by Stjernquist *et al*.(2002).

However, the rate of loss of forest land to other activities is at an alarming rate, to protect trees from declining or extinction of some valuable tree species in the forest as such it is mandatory to examine the current status of the species diversity, the composition, abundance of tree species and to assess various causes of tree damages so as to serve as a guide for management and reference assessment in managing the forest.

This study was therefore carried out to assess the tree species richness, composition and diversity of IITA forest with the view of providing an update on the status of the forest in terms of stand growth characteristics, tree species composition and diversity for management and conservation purposes.

Materials and Method

Study area

This study was carried out in the International Institute of Tropical Agriculture (IITA) Forest (Figure 1). International Institute of Tropical Agriculture forest is geographically located in Akinyele Local Government Area of Oyo State, Nigeria. It lies between latitudes 7°30' 8" and 7°28'55.52"North and longitudes 3° 54'47.50"and 3°52'44.49"East in the city of Ibadan. IITA forest has a humid tropical climate with well-known wet and dry seasons, with the wet season commencing from March and ends in October and dry season that lasts from November to February, it has an average daily temperature of about 21°Cto 23°C and the maximum temperature ranges from 28°C to 34°C. The forest used to experience bimodal rainfall patterns between 1300 – 1500mm, which falls between the month of May and September. The mean daily relative humidity ranges between 64 -83% (Oluyinka, 2020). The forest reserve has a low-lying and gentle undulating topography with an elevation ranges between 243m to 292m. The parent rock materials of the soil is being formed through the underlying crystalline and banded gneiss which weathers to form site-specific soils. In the upland areas clay, quartz gravel and sand are predominant soil types while the bottom of the valley has poorly drained clay and sandy soils. Some part of IITA forest has highly diverse plant species. The vegetation of this area could be classified as a tropical semi-deciduous forest with diverse of vegetation types ranging from derived savanna, secondary forest and riparian types.

Sampling Techniques and Data Collection

Reconnaissance survey was done to get first-hand info about the forest. The survey carried out revealed that there was no evidence of logging in the forest, though the forest is a secondary forest that is currently undergoing a reservation phase for biodiversity conservation. Simple systematic line transect was adopted for this study for plots laying for data collection. A total number of 16temporary sample plots were used for this research work. In laying of plots for data collection, four parallel transects of equal distance (300m) was delineated at 200m apart for this study. A total number of 4 sample plots of equal size (25m x 25m) were laid alternatively on each transect and 50 meter interval distance offset away from each sample plot was observed so as to reduce replication of tree species. To minimize the edge effect, 20m offset was measured at the beginning of each transect (Figure 2). On each sample plot, all trees with Diameter at Breast Height (DBH) ≥ 10cm were identified, measured and classified into families with their frequency of occurrence obtained to ascertain tree species diversity. To estimate volume per stand, the diameters at the base, middle and top; merchantable height and the total height of all the trees (Dbh ≥ 10cm) in each plot were measured using Spiegel relaskop and haga altimeter.

Disclaimer

This study is a subset of a robust or big research/study carried out in the study area by the author.

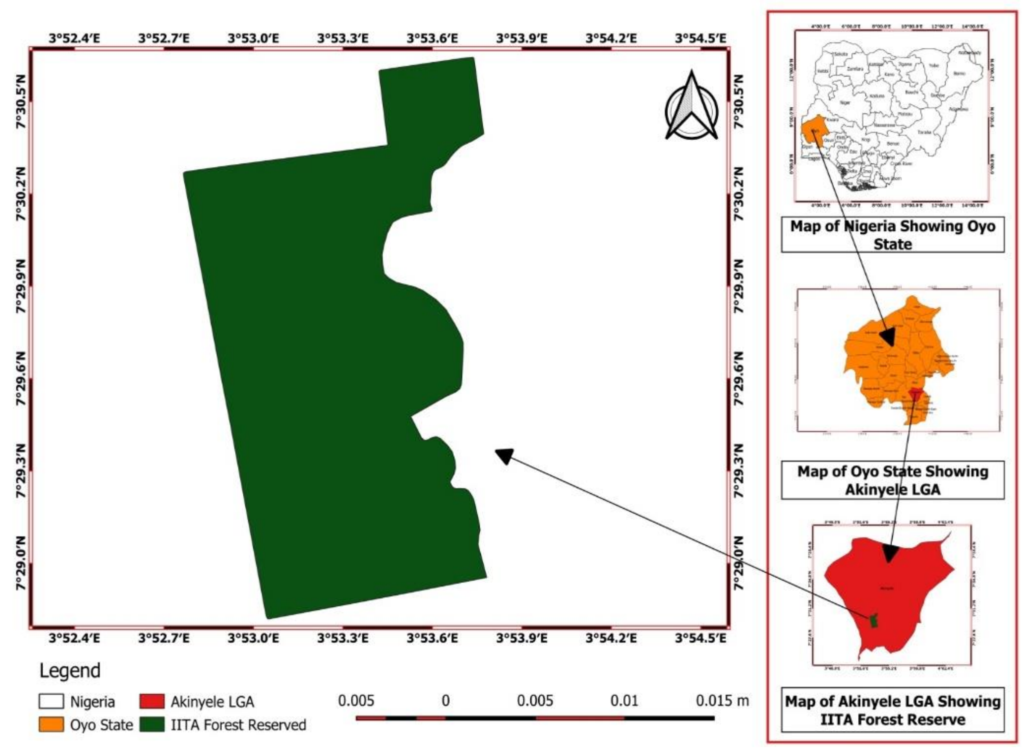

Figure 1: Map of IITA Forest Reserve.

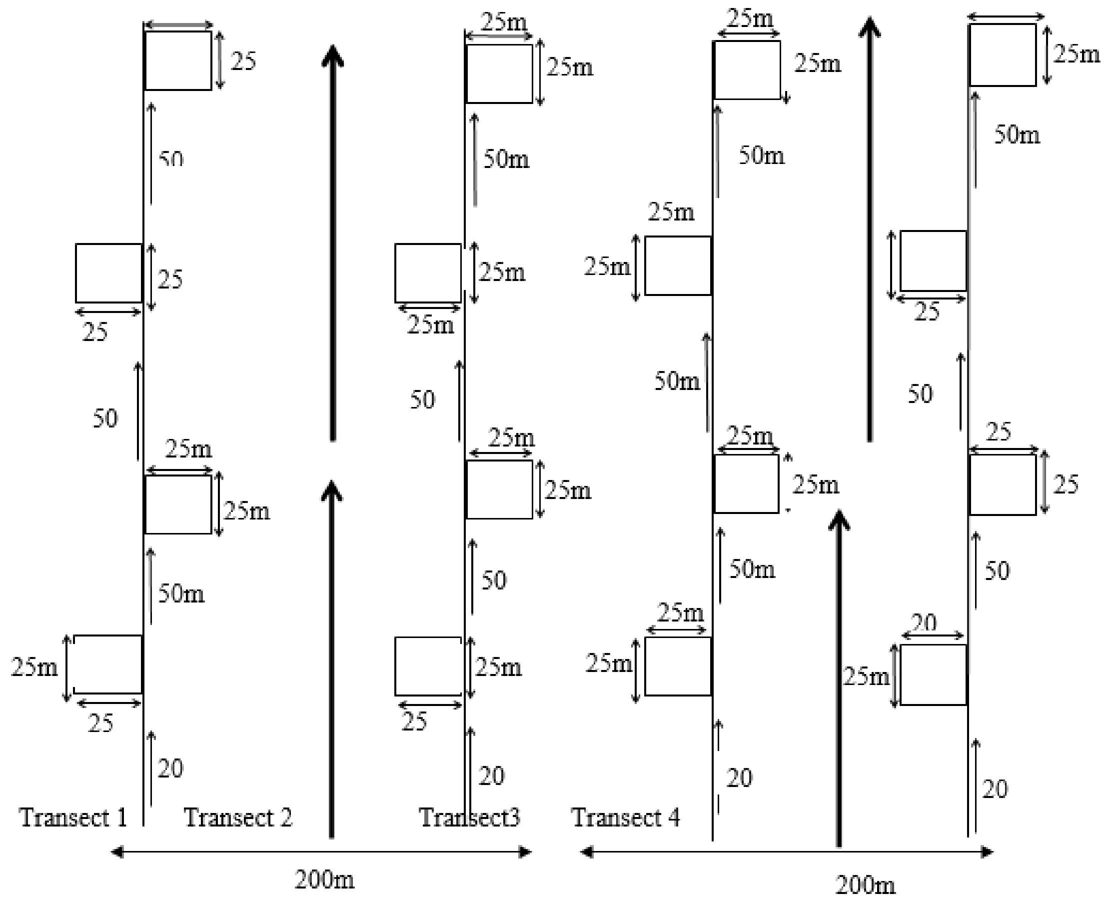

Figure 2: Systematic line transects sampling technique for Plot layout.

Data Analysis

- Basal Area Estimation

Basal area of each tree was estimated using this formula:

$$BA = \frac{\pi D^2}{4} \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where BA = Basal area (m^2), D = Diameter at breast height (cm) and π = Pie (3.142).

And total Basal area per plot was estimated using

Basal Area / Plot = $\sum_{i=1}^{n} BAi \ldots\ldots$ (2)

Where BA_i is the Basal area for each tree

- Volume Estimation

The volume of each tree per plot and per hectares was estimated using Newton's formula as used by Hush *et al*. (2003)

$$V = \pi H \left(\frac{Db^2 + 4Dm^2 + Dt^2}{24}\right) \ldots\ldots\ldots \text{(3)}$$

Where V=Stem volume (m^3) H=height (m), Db=Diameter at the base, Dm=Diameter at the middle, Dt=Diameter at the top and π=3.142

- Crown Ratio

Tree crown ratio was computed for each of the tree crown in the stand using this formula:

$$CrownRatio = \frac{CL_i}{THT_i} \ldots\ldots\ldots \text{(4)}$$

Where: CL_i is individual crown length and THT_i is the Total height of the tree

- Tree Crown Competition

Tree crown competition factor was computed using this formula as used by Oyebade and Onyeoguzoro (2017)

$$CW = b_0 + b_1 D \ldots\ldots\ldots \text{(5)}$$

Where: CW is the crown width, $b_0 and b_1$ are the regression parameter and D is the Diameter

- Crown Diameter

Crown diameter was computed using this formula:

$CD = \sum r_i/2$…………………..……. (6)

Where: CD is Crown diameter, $\sum r_i$ is the summation of the projected crown radii measured on four axes

- Biodiversity Indices

Since Biodiversity has to do with species richness and evenness, the status of the forest was assessed in terms of tree species diversity, abundance and evenness. All the species were classified into families and their frequency of occurrence was obtained to ascertain tree species diversity and abundance. All the trees were also grouped into diameter distribution classes based on the DBH measured. The following indices were used to determine the biodiversity of the study area.

A. species relative density was computed following Brashears *et al.*(2004)

$$RD = \frac{n_i}{N} \times 100 \text{ ………………………….. (7)}$$

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

B. Species relative dominance (RD_o)(%) was computed using the equation used by Akindele (2013)

$$RD_O = \frac{\sum Ba_i \times 100}{\sum Ba_n} \text{ ………………..... (8)}$$

Where: Ba_i = basal area of individual tree belonging to species i and Ba_n = stand basal area

C. Species diversity index was calculated using Shannon-Weinner index (Shannon-Weinner, 1963)

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i) \text{ ……………….……… (9)}$$

Where H' = Shannon diversity index, S = the total number of individuals of one species in the community, pi = proportion S (species in the family) made up of the ith species divided by total number of all individual (Pi = S / N), N = total number of all individuals in the site and In = logarithm

D. To determine the Species evenness (E), in each community Shannon's equitability equation was used following Kent and Coker, (1992)

$$E_H = \frac{H'}{H_{Max}} = \frac{\sum_{i=1}^{S} P_i \ln(P_i)}{\ln(S)} \text{ …………… (10)}$$

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

E. important value index was computed following the equation used by Brashears *et al.* (2004) and Vlot *et al*. (2008)) which is expressed as the sum ofRD and RD_0 divided by 2. This simply expresses the share of each species in the tree community

$$IVI = \frac{RD + RD_0}{2} \text{………………………… (11)}$$

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

F. Relative frequency (RF) was computed following the equation used by Ariyo (2020)

$$RF = \frac{\text{frequency of a woody plant species}}{\text{Total frequency of woody plant species}} \times 100 \text{……………..…. (12)}$$

G. Family Importance Value (FIV) was estimated following the equation used byAkindele (2013)

FIV= RD_o + RD + RF…………………… (13)

Where RD_o = relative dominance, RD = Relative Density and RF = Relative Frequency

Where relative frequency= (frequency of individual family/Sum frequencies of total families) × 100, relative density and relative dominance specified above in Eq. 3.10 and 3.11

H. Tree species richness in the study area was computed following the equation used by Akindele (2013)

$M = \frac{(S-1)}{lnN}$………………………………..…… (14)

Where d= Margalef's index of species richness, S = the number of species encountered and N = the total number of individuals of all the tree species and ln= Natural logarithm. **Results**

Tree Species Diversity and Abundance for the Study Area

The total number of trees (dbh ≥10cm) measured was 389stem ha^{-1} which belongs to 19 families which were spread among 43tree species. Family composition of tree species in the study area is presented in Table 1. The most abundant family is Fabaceae which comprises of 10 species, followed by Malvaceae and Moraceae with five and four species, respectively while Sapotaceae, Meliaceae, Sapindaceae, Irvingiaceae and Sapotaceae had two species each. However, Apocynaceae had the highest number of individual species of 87, followed by Fabaceae with 73 and Moraceae with 45 stems ha^{-1}(22.4%, 18.8% and 11.6%, respectively). Table 2 represents tree species abundance per hectare and the growth variables in the study area which shows their relative density, relative abundance and important value index. *Funtumia elastica* of Apocynaceae family had the highest number of stem per hectare (84 stemsha^{-1}) and relative density of 21.59, this made the species to be the most abundant tree species in the study area.*Celtis zenkerii* of Cannabaceae family follows with 32 stems$ha^{-1}$with a relative density of 8.23 while *Trilepisium madagascariense* had 28 stems ha^{-1} with relative density of 7.20. *Maesopsis eminii*, *Milicia excela*, *Monodora myristica*, *Pycnanthus angolensis*, *Leucaena leucocephala*, *Albizia ferrugini*, *Irvingia gabonense*, *Triplochiton scleroxylon* and *Musanga cecropioides* have the least number of stems ha^{-1} (1 stems ha^{-1}) each with relative density and relative dominance of 0.26 and 0.05, respectively. The highest mean diameter at breast height was recorded for *Musanga cecropioides* of Cecropiaceae family (94cm) follows by *Pterocarpus soyauxii* of Fabaceae family (81cm), *Cleistopholis patens*of Annonaceae family (56cm) and *Ceiba pentandra* of Malvaceae family (54.73cm). The least mean dbh(10.1cm) was recorded for *Pycnanthus angolensis* of Myristicaceae family. The highest and the lowest mean height was recorded for *Pterocarpus soyauxii* and *Pycnanthus angolensis* (35.6m and 10.3m respectively). *Albizia zygia* of Fabaceae family had the highest volume per hectare (50.698m^3/ha) followed by *Antiaris toxicaria* (49.16 m^3/ha) and the least volume was gotten from *Monodora myristica* of Annonaceae family (0.14 m^3/ha). *Antiaris toxicaria* have the highest basal per hectare of 4.04m^2 which was followed by *Trilepisium madagascariense* with basal area of 3.28 m^2. However, *Funtumia elastic*a had the highest important value index of 11.03, followed by *Celtis zenkerii* with IVI of 4.40 and closely followed by *Trilepisium madagascariense* with IVI of 4.02.

Table 1: Families Composition of tree species in the study area

Families	No of Species	No of individual	Percentage
Anacardiaceae	1	12	3.1
Annonaceae	2	8	2.1
Apocynaceae	2	87	22.4
Arecaceae	1	3	0.8
Bignoniaceae	2	21	5.4
Cannabaceae	2	34	8.7
Cecropiaceae	1	1	0.3
Fabaceae	10	73	18.8
Irvingiaceae	2	3	0.8
Leguminosae	1	8	2.1
Malvaceae	3	9	3.3
Meliaceae	2	29	7.5
Moraceae	4	45	11.6
Myristicaceae	1	1	0.3
Myrtaceae	1	2	0.5
Rhamnaceae	1	1	0.3
Sapindaceae	2	7	1.8
Sapotaceae	2	27	6.9
Sterculiaceae	3	18	3.6
Total	**43**		

Family Important Value Index

The families' important value index showing the Families relative density, relative dominance, margalef species richness and Shannon wiener diversity for the study is presented in Table 3. A total numbers of 19 different tree families were encountered. The Moraceae families had the highest basal area per hectare (7.62m^2) followed by Fabaceae with a basal area of 7.32 m^2 while Myristicaceae had the least basal area of 0.01 m^2. The family with highest volume per hectare was Fabaceae (116.15m^3), followed by Moraceae (86.98 m^3), Malvaceae with (44.25 m^3) while Bignoniaceae, Cannabaceae and Apocynaceae had volume per hectare of 26.96m^3, 24.56m^3 and 20.78m^3 respectively. The least volume (0.05m3) was observed from Myristicaceae. However, Fabaceae family, had the highest numbers of Family Important Value Index (FIVI) of 60.21, this was closely followed by Moraceae with FIVI of 46.69. Myristicaceae families had the lowest FIVI of 0.55. The fabaceae family had the highest Shannon wiener diversity index of 0.65 this was followed by Apocynaceae family with 0.37 while moraceae family had 0.36 and the least family with Shannon wiener value was Cecropiaceae (0.02). Apocynaceae family had the highest margalef�">s index species richness value of 14.25, while Fabaceae had 10.564. The least margalef‘s index species richness value was found to be zero for three (3) families which comprises of Cecropiaceae, Myristicaceae and Rhamnaceae.

Table 2: Tree species abundance per hectare and tree growth variables of individual trees in the study area

S/N	Tree Species	Family	Nha^{-1}	MDbh	MHt	B.A	Vol	RD	RD_0	IVI
1	*Albizia ferrugini*	Fabaceae	1	15	18	0.02	0.206	0.26	0.06	0.155
2	*Albizia zygia*	Fabaceae	20	33.045	23.645	2.71	50.698	5.14	8.38	2.920
3	*Antiaris toxicaria*	Moraceae	9	53.656	22.111	4.04	49.162	2.31	12.50	1.675
4	*Bauhinia spp*	Fabaceae	17	17.077	16.324	0.52	7.417	4.37	1.60	2.250
5	*Blighia sapida*	Sapindaceae	2	50.250	27.55	0.49	9.721	0.51	1.50	0.315
6	*Cassia biflora*	Fabaceae	19	37.147	24.874	2.56	33.526	4.88	7.92	2.770
7	*Ceiba pentandra*	Malvaceae	6	54.733	24.333	1.90	43.898	1.54	5.89	1.015
8	*celtis toka*	Cannabaceae	2	14.4	11.4	0.03	0.281	0.51	0.10	0.260
9	*Celtis zenkerii*	Cannabaceae	32	23.063	18.313	2.16	24.280	8.23	6.69	4.395
10	*Chrysophyllum albidum*	Sapotaceae	23	23.096	16.887	1.13	14.101	5.91	3.49	3.100
11	*Cleistopholis patens*	Annonaceae	7	56.886	27.6	1.97	31.146	1.80	6.11	1.885
12	*Cola gigantean*	Sterculiaceae	2	41.5	25.25	0.28	2.294	0.51	0.86	0.290
13	*Cola millenii*	Sterculiaceae	2	25.25	14.8	0.10	0.579	0.51	0.31	0.270
14	*Cola nitida*	Malvaceae	2	14.8	11.8	0.04	0.146	0.51	0.11	0.260
15	*Daniella oliverii*	Fabaceae	2	19.95	20.25	0.07	1.209	0.51	0.20	0.265
16	*Daniella orgia*	Fabaceae	7	22.633	22.15	0.26	3.252	1.80	0.81	0.935
17	*Elias guineensis*	Arecaceae	3	39.333	21.833	0.37	5.351	0.77	1.14	0.430
18	*Entandrophragma angolense*	Meliaceae	8	21.8	16.45	0.32	2.525	2.06	1.00	1.070
19	*Ficus exasperata*	Moraceae	7	12.514	15.029	0.09	0.874	1.80	0.28	0.910
20	*Funtumia elastic*	Apocynaceae	84	15.902	16.05	1.84	20.511	21.59	5.68	11.030
21	*Holarrhena floribunda*	Apocynaceae	3	12.3	14.37	0.04	0.271	0.77	0.11	0.390
22	*Irvingia gabonense*	Irvingiaceae	1	20	19	0.03	0.421	0.26	0.09	0.140
23	*Irvingia wombulu*	Irvingiaceae	2	14.9	20.75	0.04	0.473	0.51	0.11	0.260
24	*Lecaniodiscus cupanioides*	Sapindaceae	5	12.66	13.32	0.07	0.443	1.29	0.20	0.655
25	*Leucaena leucocephala*	Fabaceae	1	16	22.8	0.02	0.293	0.26	0.06	0.135
26	*Loncocarpus sericeus*	Leguminosae	8	34.85	24.18	0.88	9.718	2.06	2.74	1.145
27	*Maesopsis eminii*	Rhamnaceae	1	26.8	22.5	0.06	0.955	0.26	0.18	0.135
28	*Milicia excels*	Moraceae	1	52	38	0.21	4.226	0.26	0.66	0.158
29	*Monodora myristica*	Annonaceae	1	11.7	17	0.01	0.141	0.26	0.03	0.132

S/N	Tree Species	Family	Nha^{-1}	MDbh	MHt	B.A	Vol	RD	RD_0	IVI
30	*Musanga cecropioides*	Cecropiaceae	1	94	29.9	0.69	13.986	0.26	2.15	0.219
31	*Newbouldia laevis*	Bignoniaceae	18	23.52	12.34	2.16	16.370	4.63	6.68	2.592
32	*Poutaria alnifolia*	Sapotaceae	4	15.13	17	0.07	0.799	1.03	0.23	0.525
33	*Pterocarpos angolensis*	Fabaceae	2	15.65	21.5	0.04	0.544	0.51	0.12	0.260
34	*Pterocarpus soyauxii*	Fabaceae	2	81	35.55	1.04	19.078	0.51	3.20	0.388
35	*Pycnanthus angolensis*	Myristicaceae	1	10.1	10.3	0.01	0.047	0.26	0.02	0.131
36	*Spathodea campanulata*	Bignoniaceae	3	50.1	19.77	0.85	10.590	0.77	2.63	0.495
37	*Spondias mombin*	Anacardiaceae	12	25.04	19.33	0.62	5.607	3.08	1.93	1.620
38	*Sterculia tragacantha*	Sterculiaceae	14	20.235	18.479	0.52	4.996	3.60	1.59	1.866
39	*Syzygium guineense*	Myrtaceae	2	15.95	16.5	0.04	0.304	0.51	0.13	0.261
40	*Tetrapleura tetraptera*	Fabaceae	2	22.5	11.15	0.10	0.330	0.51	0.31	0.268
41	*Trichilia monadelpha*	Meliaceae	21	17.73	15.38	0.60	4.379	5.40	1.85	2.777
42	*Trilepisium madagascariense*	Moraceae	28	33.31	20.47	3.28	32.715	7.20	10.14	4.021
43	*Triplochiton scleroxylon*	Malvaceae	1	14.2	21.5	0.02	0.207	0.26	0.05	0.132
							427.67			

Where: Nha^{-1}= Number of Stem per hectare, MDbh= Mean diameter at breast height (cm), MHT= Mean height (m), B.A= Basal area (m^2), Vol. = Volume (m^3), RD= Relative density, RD_o= Relative dominance, IVI= Important value index

Table 3: Families Important Index for the study area

Families	Ba (m^2/ha)	Vol (m^3/ha)	RD	RDo	RF	FIVI	H’	M
Anacardiaceae	0.62	5.61	3.09	1.93	3.09	8.11	0.107	1.85
Annonaceae	1.98	31.29	2.06	6.14	2.06	10.26	0.09	1.01
Apocynaceae	1.87	20.78	22.37	5.80	22.37	50.54	0.37	14.25
Arecaceae	0.37	5.35	0.77	1.14	0.77	2.68	0.04	0.34
Bignoniaceae	3.01	26.96	5.40	9.31	5.4	20.11	0.18	3.19
Cannabaceae	2.19	24.56	8.74	6.79	8.74	24.27	0.23	5.37
Cecropiaceae	0.69	13.99	0.26	2.15	0.26	2.67	0.02	0
Fabaceae	7.32	116.15	18.77	22.67	18.77	60.21	0.65	10.56
Irvingiaceae	0.07	0.893	0.77	0.21	0.77	1.75	0.04	0.17
Leguminosae	0.88	9.72	2.06	2.74	2.06	6.86	0.08	1.17
Malvaceae	1.96	44.25	2.31	6.05	2.31	10.67	0.11	1.01
Meliaceae	0.92	6.90	7.46	2.85	7.46	17.77	0.24	4.53
Moraceae	7.62	86.98	11.57	23.55	11.57	46.69	0.36	6.88
Myristicaceae	0.01	0.05	0.26	0.03	0.26	0.55	0.02	0
Myrtaceae	0.04	0.30	0.51	0.13	0.51	1.15	0.03	0.17
Rhamnaceae	0.06	0.95	0.26	0.18	0.26	0.7	0.02	0
Sapindaceae	0.55	10.16	1.80	1.70	1.8	5.3	0.08	0.84
Sapotaceae	1.20	14.90	6.94	3.72	6.94	17.6	0.21	4.19
Sterculiaceae	0.89	7.869	4.63	2.76	4.63	12.02	0.17	2.52

Where: B.A= Basal area (m^2), Vol= Volume (m^3), RD= Relative density, RD_o= Relative dominance, RF=Relative frequency, FIVI= Family Important value index, H’= Shannon Wiener diversity, M= Margalef species richness

Distribution of Tree Species into Diameter Classes in the Study Area

Table 4 showed the grouping of the tree species into diameter classes with their relative numbers of species, numbers of families, number of individuals, basal area and volume respectively. The diameter were grouped into six classes, which were: 0 – 20cm, 21 – 40cm, 41 – 60cm, 61 – 80cm, 81 – 100cm and > 100cm. Size class 0 – 20cm had the highest number of species and number of individuals (N_i) of 33 and 218 respectively, followed by 25 species and 124 numbers of individuals in the diameter class of 21 – 40cm while the least number of species and number of individuals (3 and 4) was respectively observed in the diameter class of >100cm. The highest number of families was also recorded in the diameter class of 0 – 20cm and closely followed by 21 – 40cm (16 and 15 respectively). The least number of families was recorded in the class of >100cm. Diameter class of 81 – 100cm had the highest volume per hectare (105.62m^3), followed by diameter class of 21 – 40cm (88.31 m^3 of stem per hectare). The least volume of 32.81 m^3/ha was recorded in the diameter class of 0 – 20cm. Diameter class of 0 – 20cm had the highest basal per hectare of 7.76 m^2. Figure 3 showed diameter class distribution with their corresponding frequency numbers of tree per hectare and volume in each class for the study area. Obviously, a wide range of value was observed between the minimum and maximum dbh. The minimum diameter was 10cm while the maximum was 170cm. The lowest diameter class of 0 – 20cm had more numbers of stem per hectare than the higher class diameter of >100cm. The number of stem keep on decreasing except in the case of 81 – 100cm size class which had the number of stem per hectare that is relatively higher than the dbh class of 61 – 80cm (12 and 9 stem respectively). The diameter class of 0 – 20cm had the highest number of stem per hectare, highest number of families and highest number of species of 218, 16 and 33, respectively. The highest basal area was contributed by the diameter class of 21 – 40cm with 7.76 m^2/ha. Diameter class of 81 – 100cm had the highest volume (77.16m^3). Only four individual species were recorded for the dbh class of >100.

Distribution of Tree Species into Height Classes in the Study Area

Table 5 showed the distribution of the tree species into height classes with their relative numbers of species, numbers of families, number of individuals, basal area and volume respectively. The diameters were grouped into five classes, which were: 0 – 10m, 11 – 20m, 21 – 30m, 31 – 40m and > 40m. The height class of 11 – 20m had the highest number of species and no individuals (33 and 239 respectively). Highest number of volume and basal area were observed in the height class of 21 – 30 with a value of 217.15m^3 and 15.456m^2 respectively. Size class 0 – 10m had the least volume and basal (1.89m^3 and 0.409m^2).Figure 4 showed Height class distribution with their corresponding frequency numbers of tree per hectare and volume in each class for the study area.

Table 4: Grouping of the tree species into diameter classes with their relative status

Dbh Class	NS	NF	NI	Vol(m^3)	BA (m^2)	MDbh
0 – 20	33	16	218	32.81	3.44	13.92
21 – 40	25	15	124	88.31	7.76	27.69
41– 60	12	9	22	70.20	4.46	50.45
61 – 80	6	4	9	53.57	3.49	70.06
81 – 100	10	7	12	105.62	7.28	87.78
>100	3	3	4	77.16	5.82	133.25
		TOTAL		**427.67**	**32.25**	

Where Dbh Class = Diameter class (cm), NS= No of species, NF= Number of families, NI= Numbers of individuals, BA= Basal area(m^2) and MDbh= height. Mean Diameter at breast

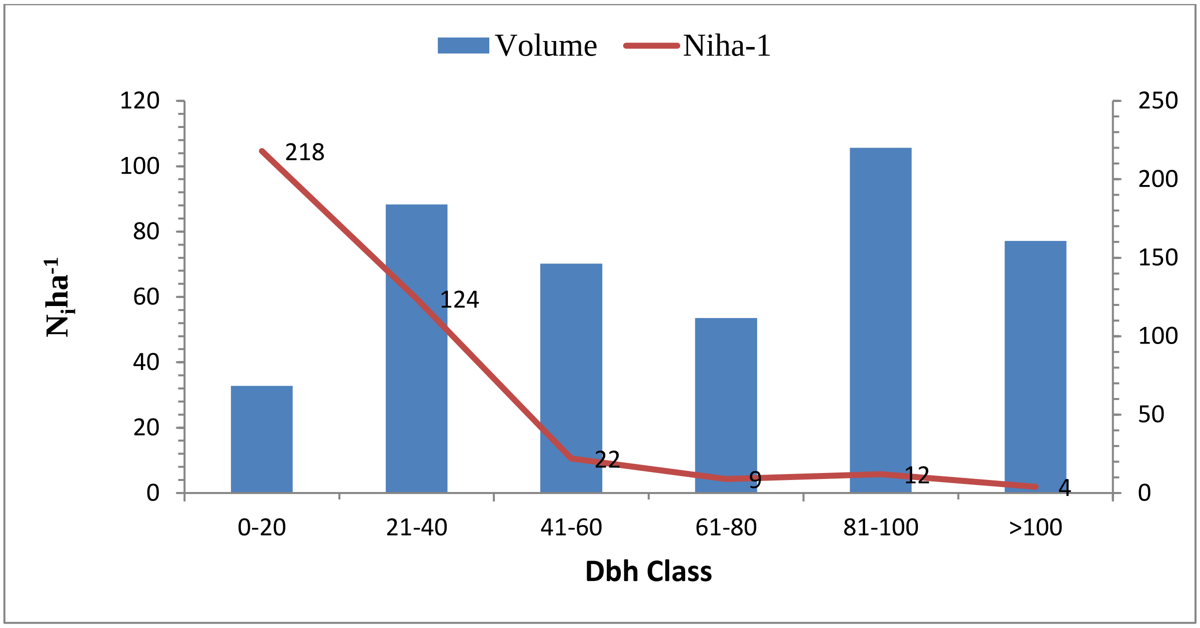

Figure 3: Diameter class (DBH) distribution with their corresponding frequency ($N_i ha^{-1}$) and volume in each class.

Table 5: Distribution of tree species into Height classes in the study area

Ht Class	NS	NF	NI	Vol. (m^3)	BA (m^2)	M.Ht
0 – 10	12	8	20	1.89	0.409	8.9
11 – 20	33	16	239	70.03	8.434	15.3
21– 30	28	17	109	217.15	15.456	24.5
31 – 40	14	8	21	138.60	7.953	34.2
>40	0	0	0	0	0	0

Where Ht Class= Height class (m), NS= No of species, NF= Number of families, NI= Numbers of individuals, BA= Basal area (m^2) and M.Ht= Mean height

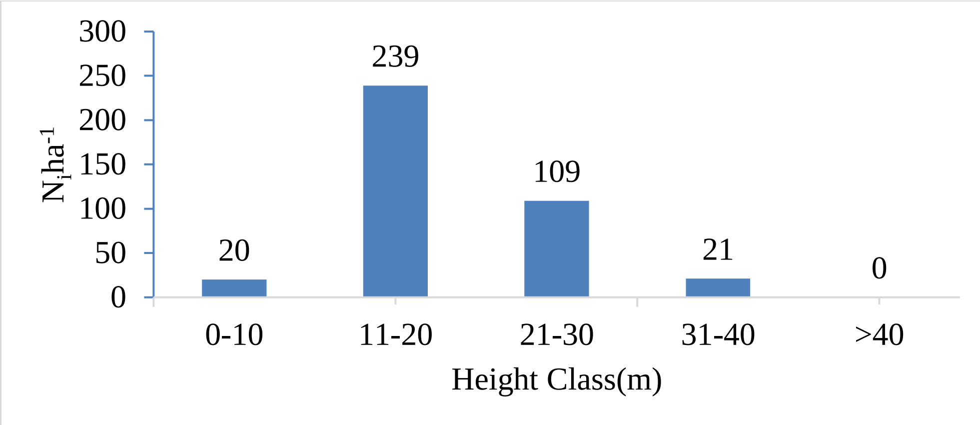

Figure 4: Number of individuals in each of the Height classes with their respective number of individual stem per hectare.

Tree Damages Indices

Various levels of damages were recorded for each tree. Damages were grouped into two, namely natural damages and anthropogenic damages. The natural are (Pest and diseases, termite infestation, windbreak, root damages and Thunderstorm storm) while the anthropogenic are the human-induced damages on the tree such as cutting, and debarking which were observed on each tree. Table 6 showed the trees species and the damages observed. Figure 5 showed the frequency of the tree damaged assessment for the study area. It was observed that 89% of the trees (347 trees) out of 389 trees encountered on the field are healthy. The number of trees that are been attacked by diseases was 4% while trees broken due to windbreak was 2%. The impact of anthropogenic on the forest was unnoticed as its percentage was just 1% (2) because the forest is well protected for biodiversity conservation. The damages recorded on individual tree species in the study area: *Celtis zenkerii* had the highest number of diseases recorded (4). *Funtumia elastica* had the highest number of trees affected from windbreak (3 trees) while *Chrysophyllum albidum* was being affected most in the study area with root damages. Termite infestation was found to be serious on *Cleistopholis paten*, three (3) trees of this species were being destroyed by termites

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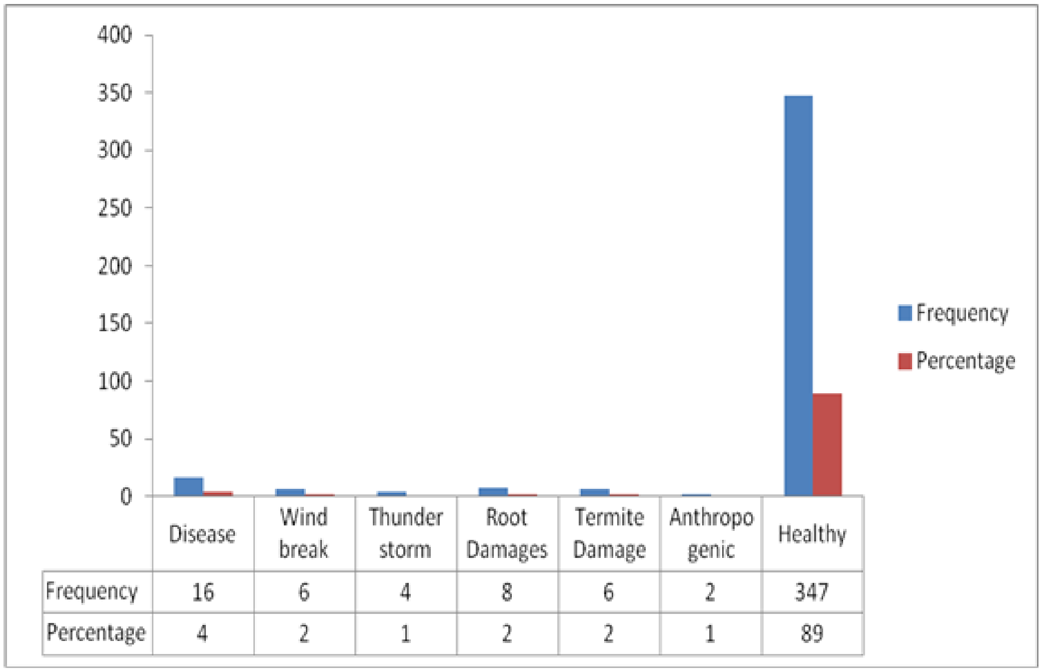
Table 6: Species Damages Assessment for the Study Area

Tree Species with Defect/ha^{-1}	Natural Damages					Anthropogenic Damages
	Diseases / Insect	Wind Breakage	Thunder Storm	Root Damage	Termites Damages	
Celtis zenkerii	4			1	2	1
Newbouldia laevis	2	1				
Chrysophyllum albidum	2	1	2	3	1	
Entandrophragma angolense	1					
Tetrapleura tetraptera	2	1				
Funtumia elastica	2	3				
Sterculia tragacantha	1					
Pterocarpus soyauxii	2			2		
Cleistopholis patens			1		3	1
Trichilia monadelpha				1		
Trilepisium madagascariense			1			



	Disease	Wind break	Thunder storm	Root Damages	Termite Damage	Anthropo genic	Healthy
Frequency	16	6	4	8	6	2	347
Percentage	4	2	1	2	2	1	89

Figure 5: Frequency of Tree damaged assessment based on visualization on the trees

Discussion

Basic principle to sustainable use of a forest basically deals with knowing the tree species diversity, tree species abundance, species richness and species structures in the forest. This study described the structure of tree species in the forest. Numerous researchers had pointed out the fact that density abundance and distribution of individual tree species are measureable indicator of plant diversity (Kanagaraj *et al*., 2017). Iyagin and Adekunle (2017) noted that tropical forest of south western Nigeria is noted for high tree species diversity, which was also observed in this study. A total number of 389 stem per hectare were encountered in this study, distributed among 43 species and 19 families. This is also in line with findings of Salami and Akinyele (2018) that got a total number of 405 stem per hectare in Omo biosphere reserve, Ogun State. But this forest is now undergoing conservation effort in restoring the forest biodiversity by regeneration processes. Species dominated in the forest is *Funtumia elastic*, having a total tree stem of 84 stem per hectare, belonging to Fabaceae family. It is also in agreement with the finding of Salami and Akinyele (2018) on floristic composition structure and diversity in Omo forest reserve. The study area had a Shannon Weiner index (H') of 3.04. This value obtained in the study area is in the range of values reported for tropical forest ecosystem (Akindele, 2013 and Onyewkwelu *et al*, 2010). The H' value for the study area was higher compared to the range values (2.30 – 3.47) reported by Duran *et al*. (2006) on structure and tree diversity patterns at the landscape level in a Mexican tropical deciduous forest. Some tree species are found to be relatively few in numbers such as *Irvingia gabonense*, *Milicia excelsa*, *Triplochiton scleroxylon*, *Leucaena leucocephala* and *Maesopsis eminii*. having one tree stem per hectare. The result of tree species distribution in this study area also confirmed what was opined by Adekunle (2006) that tropical lowland rainforest are often characterized with few tree species with large numbers of individual and many species with few numbers of individual. This could be attributed to as result of initial harvesting that has been carried out in the forest in time past (reason behind the forest being called secondary forest). Fabaceae had a relative density, and relative dominance and high family importance index of 18.77, 22.67 and 60.21, respectively. This was also observed and reported by Iheyen *et al.* (2009) on composition of tree species in Ehor forest reserve and also corroborated by Ogwu *et al.* (2016) on family diversity and abundance of tree species in University of Benin who observed Fabacaea family as the most abundant family species in their studies. Twenty-three tree species out 43 species encountered in the study area could be considered threatened because they had a relative density lower than 1.0, this also agrees with what was reported by Edet *et al*. (2012) in a preliminary assessment of tree species diversity in Afi Mountain Wildlife Sanctuary, Southern Nigeria. The species threatened could be as a result of initial harvesting that have taken place in the study area (secondary forest) before IITA now took over the place and converted the forest for research and biodiversity conservation purposes in which anthropogenic activities is at minimal in the study area.

Conclusion

The result of this study revealed the present assessment of stand growth characteristics and evaluation of selected health indices in the study area. The study area has an estimated number of 389 tree stems per hectare, which compares well with what is being observed in tropical forest ecosystem. Shannon wiener of 3.037 obtained falls within the tropical rainforest general limit of diversity index. Predominat tree species are found in the DBH class of 0 – 20cm. The most abundant species was found to be *Funtumia elastica*. However, tree species with one stem per hectare needed to be restocked in the forest in order to prevent the extinction of these valuable tree specie.

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