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Tree Species Diversity and Structure of Illo-Kaoje Forest Reserve, Kebbi State, Nigeria

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ABSTRACT
This study was carried out to examine tree species diversity and structure of Illo-Kaoje Forest Reserve. Twenty sample plots (20m×25m) were laid at random within the forest reserve. In each plots, the number and type of tree species were identified and recorded. Diameter at breath height (dbh) and Tree height of each stand was also measured. A total of 568 tree species distributed in 13 families, 27 genera and 31 species were recorded. *Vitaleria paradoxa* had the highest number of trees (91) followed by *Daniellia oliveri* (76) while *Strichnos spinosa* and *Nauclea diderrichii* had 3 stand each. Shannon Wiener diversity index was 2.92; Species richness 1.30; Evenness 0.85 while Hmax and Density stood as 0.85 and 0.06 respectively. Illo-Kaoje Forest Reserve has a moderate diversity and therefore, the need to manage the existing forest resources for continual production of goods and services is hereby recommended.
Keywords: Diversity, forest reserve, Dbh, tree height and density

INTRODUCTION
Forests provide significant economic and ecological benefits to man. They play important role in protecting soil and water resources and provide a vast array of products and services for the population (Thomas, 2006). The total number of plants, their types and appearances within the environment make up the vegetation of that area, thus vegetation means the plant cover of an area (Thomas, 2006). Forests are important source of fuel (firewood and charcoal). Timber from the trunk of woody plants is still the most dominant structural material for building and construction purposes. Forests are also imperative in watershed management and amelioration of hostile environment e.g. sand dunes fixation, minimization of soil erosion and desertification control. They also provide food, raw materials for industries, fodder for animals, recreation opportunities, shelter for wild animals etc. Forests also serve as an effective sink for carbon dioxides (sequestration) and

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also release oxygen from its photosynthesis process which helps in stabilization of climate. Forests therefore constitute significant element in the national economies and ecological stabilization of many tropical countries. Forests are important in the maintenance of an attractive forest environment, provision of opportunity for relatively intense outdoor recreation, provision of habitat for wildlife, watershed management, general conservation including minimization of soil erosion and the production of wood for various uses (Aweto, 1990). Forest also serves as effective sink for carbon dioxide and releases oxygen from its photosynthetic activity.

In Nigeria, population growth coupled with urbanization and industrialization have put more pressures on the dwindling forest resources which increases demand on renewable natural resources and often resulted to over exploitation and clearance of forests. According to Oyebo (2006) about 350, 000 to 400,000 ha of forests are being lost per annum through over exploitation (mainly as food, fuel, fodder, illegal logging, overgrazing etc.) and non-replacement of the natural vegetation. Forest reserves were therefore created in order to harness the forest resources through protection and conservation for the use of present generation as well as generations yet to come. The overall objectives of forest reserves in Nigeria include; production of goods and services, conservation for future uses, protection of flora and fauna, gene pool conservation and research purposes. Other objectives are recreation, environmental protection and production of timber and non-timber products.

Pressures on forests, especially in the tropical world, to provide economic resources have been increasing rapidly as a result of geometric increase of human population in the region (Salami, 2006). This has led to unabated deforestation, which has been recognized as one of the major drivers of biodiversity loss (Ojonigu *et al.*, 2010). According to FAO (2005), each year about 13 million hectares of world's forest are lost due to deforestation. Groombridge (1992) observed significant pressures on biodiversity of forest reserves through anthropogenic activities such as over exploitation of forest resources, grazing in forest reserves and conversion of forest areas to other

forms of use such as residential, schools, industries, road constructions etc and unstable climate conditions. The overall impacts are reduction, fragmentation and impaired natural ecosystem functions. Forest reserves plays significant role in the socio-economic of (rural) dwellers around the reserve as well as ecological benefits derived there from.

The Illo-Kaoje Forest Reserve is the richest reserve in both flora and fauna in Kebbi State. Its location in guinea savannah ecological zone in the state provides the area with diversified plant species and a variety of wildlife habitats. This rich reserve has been seriously degraded and some part of the area has been converted to other land uses. This has resulted in the decline of land area and loss of biodiversity (both fauna and flora). The major objectives of this research were to determine the tree species composition, diversity as well as structure of tree species in Illo-Kaoje Forest Reserve of Kebbi State, Nigeria.

MATERIALS AND METHODS

Study Area

The research was carried out in Illo-Kaoje Forest Reserve No.7, as identified in the Gwandu Native Authority (N.A.) Forest Reserve No.7 (Illo-Kaoje Forest), under the Forestry Ordinance 1950 of the Northern Region of Nigeria. It was published as N.A Public Notice No.104 of 1950 at page 11 as a supplement to Gazette No.68 of 21st December 1950. It is now located in Bagudo Local Government Area of Kebbi State on longitude $3^{\circ}\ 45^{1} - 3^{\circ}\ 58^{1}$ E and latitude $11^{\circ}\ 10^{1} - 11^{\circ}\ 26^{1}$N of the Equator (Singh and Babaji, 1989). The mean annual temperature varies from 28°C - 34°C while mean annual rainfall totals to more than 1000mm but the rainfall distribution is erratic, often resulting in extended periods of drought (FORMECU, 1998). The reserve is bounded by Benin Republic to the Southwest and Republic of Niger to the Southeast. The Reserve covers a total land area of 590.5 km^2 of Illo and Kaoje Districtsof Kebbi State (Figure 2).

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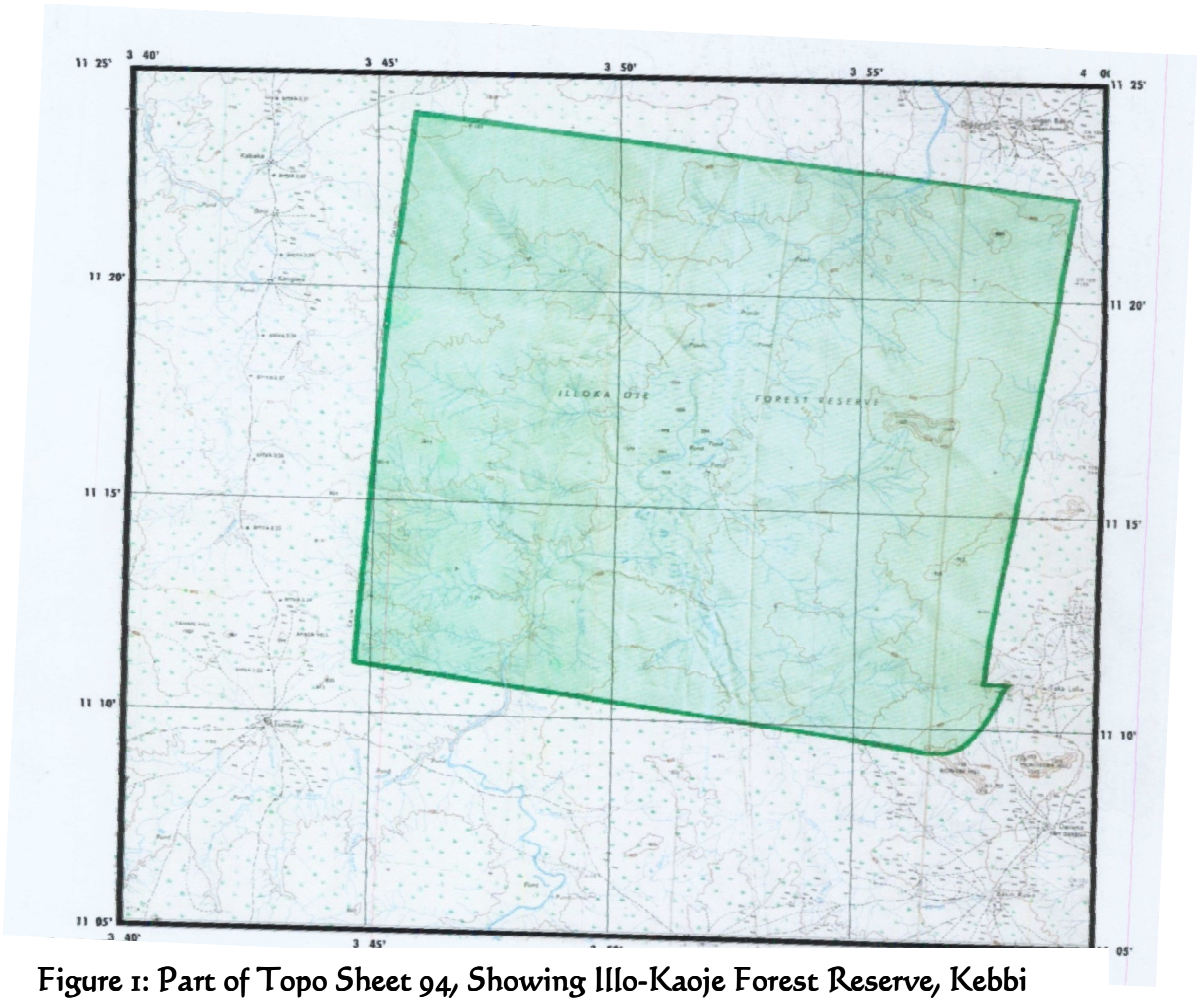

Figure 1: Part of Topo Sheet 94, Showing Illo-Kaoje Forest Reserve, Kebbi

Source: Ministry of Land and survey, Sokoto State (2013).

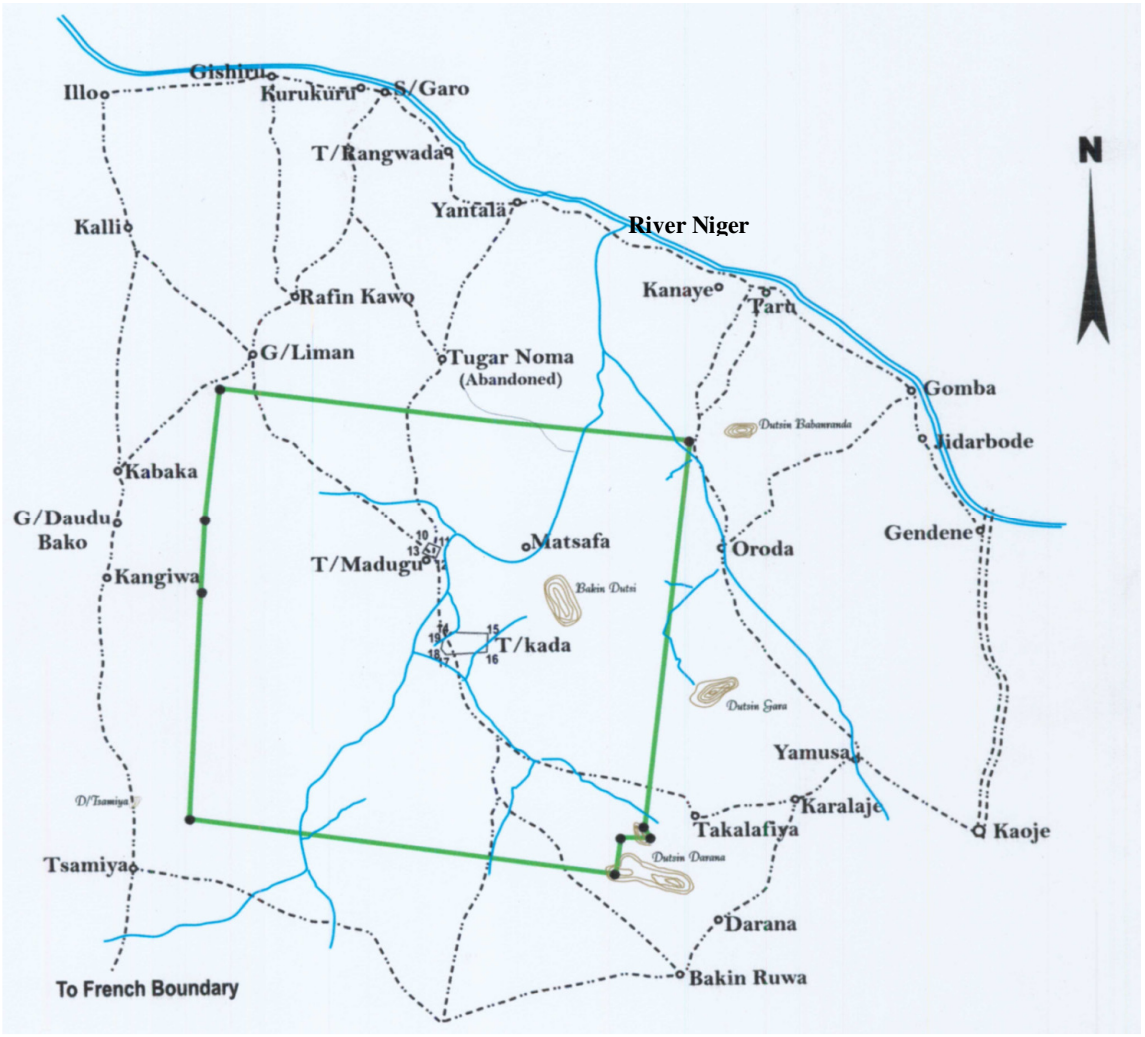

Figure 1: Map of Nigeria showing Kebbi State
Source: Dodo *et al.*, 2011

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Data Collection

The entire forest reserve was divided into rectangular plots of 100 x 100 m (1 ha) in size and twenty sample plots measuring 20m x 25m were selected using the simple random sampling technique. Within each of the selected sample plots, measurement and identification were limited to all woody plants with diameter at breast height (dbh) of ≥ 10 cm. The tree data collected in each sample plot for further analysis were dbh and height of all tree species in each plot using Spiegel relaskop. The number and scientific names of all the tree species encountered in each plot were recorded. When it was difficult to identify the species in the field, the common/local name were recorded, and plant specimens such as leaves, fruits were collected for identification using Hopkins and Standfield (1966) and Ghazanfar (1989).

Data Analysis

Tree species diversity

The following indices were also employed following Kent and Coker (1992).

i. Shannon wiener diversity index

$$H' = \sum_{i=1}^{S} pi \ln (pi) \quad \ldots\ldots (1)$$

Where; H'= Shannon diversity index, S = number of species in the community, Pi = proportion of individuals found in the ith species. And Pi = ni/N where ni = number of individuals of species i in the sample, N = total number of individuals sampled.

ii. Pielou's species evenness index

$$E_H = H'/H \quad \ldots\ldots (2)$$

iii. Margale f's index of species richness (M)

$$M = \frac{S-1}{LnN} \quad \ldots\ldots (3)$$

Forest Structure Analysis

i. Basal area

The basal area of all trees in the sample plots were calculated using the formula:

$BA = (\prod D^2)/4$ ..... (4)

Where, BA = Basal area (m2), D = Diameter at breast height (cm) and Л = pie (3.142). The total BA for each plot was obtained by adding all trees BA in the plot.

ii. Volume

The volume of each tree was calculated in every plot using the Huber's formula, as described by Charles (1989).

$V = h\ (BA)$..... (5)

Where, h = Height and BA = Basal area. Plot volumes were also obtained by adding the volumes of all the trees in the plot.

iii. Relative density (%) of each species was computed following the equation of Brashears *et al.* (2004)

iv.

$RD = (\frac{ni}{N})\ X\ 100$ ..... (6)

Where, RD is the relative density of the species; ni is the number of individuals of species *i* and N is the total number of all individual trees.

v. Relative dominance

Relative dominance (%) of each species was estimated using the following equation:

$RDo = \frac{\Sigma_{B_{ai}\ x\ 100}}{\Sigma_{B_{an}}}$ ..... (7)

Where, RDo is the relative dominance of the species; Ba*i* is the basal area of all individual trees belonging to a particular species i; Ba*n* is the basal area of all species in the study area.

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vi. Importance value index

The sum of the RD and RDo divided by 2 (RD x RDo/2) gave the importance value index for each species (Brashears *et al.* 2004; Yang *et al.,* 2008). This was used to express the share of each species in the tree community (Rajkumar and Partha- sarathy, 2008).

RESULTS

A Checklist of Plant Species in Illo-Kaoje Forest Reserve

A checklist of plant species (>10cm dbh) revealed a total number of 568 tree species distributed in 18 families, 27 genera and 31 species (Table 3). A species in *Saponaceae* with only 1 genus account for 16% of the total population followed by a species in *Caesalpinaceae* (*Daniellia oliveri* with 13.4%). Most of the families are represented by only 1 or 2 genera except *Caesalpinaceae* that has 5 genera, followed by *Combretaceae* 4, while *Mimosaceae* and *Moraceae* had 3 genera each.

Tree Species Diversity and Abundance in Illo-Kaoje Forest Reserve

Table 1 shows that *Vitaleria paradoxa* had highest number of species (91) followed by *Daniellia oliveri* (76) and *Anogeissus leiocarpus* (61). *Nauclea diderrichii, Annona senegalensis* and *Strichnos spinosa* had the least number of species (3 each). *Khaya senegalensis* has the highest dbh of 48.1cm, followed by *Anogeissus leiocarpus* with 44.6cm while the least dbh was recorded on *Combretum nigricans* (14cm); *C. glutinosum* (15.2cm) and *Terminalia avicennoides* (16.7cm). The highest (42m) and lowest (4.2m) height were recorded for *Isoberlinia doka* and *C.nigricans* respectively. The highest basal area (0.14m^2) and volume (4.6m^3) were attributed to *Anogeissus leiocarpus* and *Khaya senegalensis* respectively while the least basal area (0.013m^2) and volume (0.14m^3) were contributed to *Combretum nigricans*.

Daniellia oliveri had the highest IVI (16.8%) followed by *Anogeissus liocarpus/13.58%/* as well as *Vitaleria paradoxa* and *Piliostigma thonningii* had similar IVI of 13.3%. *Annona senegalensis* has the least IVI (0.3%)

followed by *Parinari microphylla, Lannea acida* and *Tamarindus indica* with same IVI of 0.76%. The total basal area and volumes of the reserve were 23.92m^2 and 688.02m^3 respectively. While Shannon wiener diversity index was 2.92; Species evenness was 0.85; Species richness was 1.30; Shannon's maximum diversity index (Hmax) was 3.34 and Density index stood at 0.06.

Table 1: Dbh distribution for Trees in Illo-Kaoje forest reserve

Dbh (cm)	No. of Plants	Percentage %
10-20	64	11.3
21-30	239	42.1
31-40	216	38.0
41-50	49	8.6
Total	568	100

Source: Field Survey, (2014)

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Table 2: Height Distribution for Trees in Illo-Kaoje Forest Reserve

Height (m)	No. of Plants	Percentage %
<5	47	8.3
6-10	121	21.3
11-15	224	39.4
16-20	85	15.0
21-25	76	13.3
26-30	14	2.5
>30	1	0.2
Total	568	100

Source: Field Survey, 2014.

Table 3: Checklist of Plant Species in Illo-Kaoje Forest Reserve

Family	Scientific name	Frequency	V/N (Hausa)
Anarcadaceae	*Lannea acida*	6	Farun tudiya
	Lannea microcapa	15	Faru
Annonaceae	*Annona senegalenisis*	3	Gwadardaji
Amlidaceae	*Cissus populnea*	5	Dafara
Bombaceae	*Bombax costatum*	8	Kurya
Caesalpinaceae	*Danielllia oliveri*	76	Maje
	Detarium microcarpum	22	Taura
	Isoberlinia doka	34	Doka
	Piliostigma thonningii	10	Kalgo
	Tamaridus indca	5	Tsamiya
Combretaceae	*Anogeissus leiocarpus*	61	Marke
	Combretum glutinosum	10	Tsiriri
	Combretum nigircans	13	Tsiriri
	Terminalia avicennoides	38	Baushe
Ebanaceae	*Diospyros mespiliformis*	13	Kaiwa
Fabacceae	*Piptadeniastum africanum*	3	Dorawarbiri
Leguminoceae	*Pterocarpus erinaceus*	39	Madobiya

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Table 3. Cont'd.

Logamaceae	*Strichnos spinosa*	3	Kokiya
Meliaceae	*Khaya senegalensis*	4	Madaci
	Parkia biglobosa	28	Dorawa
	Prosopis Africana	18	Kirya
Moraceae	*Ficus platyphylla*	6	Gamji
	F. polita	4	Durumi
	F. sycomorus	8	Baure
Palmae	*Borassus aethiopium*	8	Giginya
Rosaceae	*Parinari microphylla*	4	Gawasa
Rubiaceae	*Nauclea diderrichii*	3	Tafashiya
Saponaceae	*Vitaleria paradoxa*	91	Kadanya
Verbanaceae	*Vitex doniana*	13	Dinya
Total		568	

Source: Field Survey (2014)

Species	F	Ht	Dbh	BA(m^2)	Vol.(m^3)	pilnpi	RD	Rdo	IVI
Acacia sieberiana	12	7.6	28.2	0.034971	0.262284	-0.0817	2.112312	1.3854	1.74642
Annona senegalensis	3	7.2	21.1	0.028957	0.196905	-0.02777	0.535423	0.2132	0.37103
Anogeissus liocarpus	61	23.6	40.8	0.138562	3.276505	-0.24009	10.744534	16.4243	13.5823
Bombax costatum	8	19	38.2	0.109873	2.086754	-0.0602	1.408451	1.941338	1.674895
Combretum glutinosum	10	7.5	26.2	0.023238	0.169639	-0.07131	1.760563	0.93023	1.345397
C. nigricans	13	6.8	17.8	0.038713	0.270988	-0.08667	2.288732	0.766123	1.527428
Daniellia oliveri	76	26.2	37.8	0.102367	2.221367	-0.26961	13.38028	20.2428	16.81154
Detarium microcarpum	22	6	18.5	0.025734	0.156976	-0.12623	3.87239	1.429771	2.651081
Diospyros mespiliformis	13	7.5	26.4	0.066061	0.594545	-0.08667	2.288732	1.830048	2.05939
Ficus platyphylla	6	16.5	38.1	0.102367	1.822135	-0.0482	1.056338	1.414861	1.2356
F. polita	4	8.4	27.8	0.109873	2.086754	-0.0602	1.408451	1.941338	1.674895
F. sycomorus	8	6.6	24.2	0.023238	0.169639	-0.07131	1.760563	0.93023	1.345397
Isoberlinea doka	34	20.8	39.6	0.038713	0.270988	-0.08667	2.288732	0.766123	1.527428

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Khaya senegalensis	4	22.2	41	0.181734	4.616045	-0.035	0.704225	1.379309	1.041767
Lannea acida	6	18.8	30.4	0.055475	0.454394	-0.04178	0.880282	0.6484	0.764341
L. microcarpa	15	17.9	35.1	0.020615	0.115442	-0.18134	6.690141	2.952631	4.821386
Nauclea diderrichii	3	9.6	30.5	0.076464	0.77993	-0.02777	0.528169	0.502244	0.515207
Parinari microphylla	4	5.5	23.4	0.055475	0.454394	-0.04178	0.880282	0.6484	0.764341
Parkia biglobosa	28	16.4	34.5	0.020615	0.115442	-0.18134	6.690141	2.952631	4.821386
Piliostigma thonnongi	10	6.5	25.4	0.039766	0.457308	-0.29386	16.02113	10.68383	13.35248
Piptadeniastrum africanum	3	9.4	24.5	0.045623	0.506411	-0.08667	2.288732	1.800613	2.044673
Prosopis africana	18	10.2	28.7	0.090804	0.771832	-0.0602	1.408451	1.65143	1.529941
Pseudocedrela kotschyi	4	12.7	28.4	0.181734	4.616045	-0.035	0.704225	1.379309	1.041767

Table 4: Tree species Diversity and Abundance in Illo Kaoje Forest Reserve

Table 4: Cont'd

Species	F	Ht	DBH	BA (m²)	Vol. (m³)	pi*ln pi	RD	RDo	IVI
Pterocarpus erinaceus	39	19.6	34.8	0.114623	2.120531	-0.18432	6.866197	7.33233	7.099264
Cissus populnea	5	11.2	28.2	0.045623	0.506411	-0.08667	2.288732	1.800613	2.044673
Strichnos spinosa	3	10.2	25	0.09O804	0.771832	-0.0602	1.408451	1.65143	1.529941
Tamarindus indica	5	8.5	27.4	0.055475	0.454394	-0.04178	0.880282	0.6484	0.764341
Terminalia avicennoides	38	6.7	23.4	0.020615	0.115442	-0.18134	6.690141	2.952631	4.821386
Vitaleria paradoxa	91	9.8	28.6	0.039766	0.457308	-0.29386	16.02113	10.68383	13.35248
Vitex doniana	13	9.4	29.5	0.045623	0.506411	-0.08667	2.288732	1.800613	2.044673
Borassus aethiopium	8	9.6	38.3	0.09O804	0.771832	-0.0602	1.408451	1.65143	1.529941
Total	568					-2.92219	100	100	100

Key: F=Frequency, DBH=Diameter at breath height, BA=Basal Area, Vol.=Volume, RD=Relative Density, RDo=Relative dominance, IVI=Important Value Index

Source: Field Survey (2014)

Index	Value
Shannon wiener diversity Index (H′)	2.92
Species Evenness	0.85
Species Richness	1.30
Shannon's maximum Diversity (Hmax)	3.34
Density	0.06

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DISCUSSION

Forest contains high diversity in terms of species, genetic materials and ecological processes of ecosystems on terrestrial environment. Forest habitat plays a central role in the functioning of biosphere as they are the origin of many cultivated plants and animals (EU, 2008). A total number of 568 tree species were encounted which were distributed in 18 families, 27 genera and 31 species with families *Saponaceae, Caesalpinaceae* and *Mimosaceae* dominating. This is close to what Muazu (2010) found in Kuyambana Forest Reserve, Zamfara State, Nigeria. He reported the dorminance of *Caesalpinaceae, Mimosaceae* and *Combretaceae* families. In comparison to a similar research done in the Southern part of the country, where Ihenyen *et al.*(2009) reported 2062 tree stands (in just 3 compartments of the forest reserve) belonging to 99 different species distributed into 87 genera and 36 families in Ehor Forest Reserve, Edo State (Forest zone) of Southern Nigeria. These differences may be attributed to variability in terms of weather and climate between savanna and forest ecological zones of Nigeria.

The results obtained from the diameter and height classes of the trees in Illo-Kaoje forest reserve revealed that, the reserve is made up of 3 distinct types of vegetation; namely shrub land, savanna woodland and forest. Each class has a distinctive feature from one another in terms of species diversity. Atiku *et al.,* (2011) found a similar vegetation cover in Tangaza North Forest Reserve of Sokoto State, where they reported that some species were more established than others, some were taller, while others were higher in dominance and that the well established species were not necessarily the indigenous ones. The number of tree species encountered in the study area was adopted as an identifier for the actual species richness in this study (Magnusan *et al.,* 2010).

The diameter and height classes of the trees in Illo-Kaoje forest reserve revealed that, the reserve is made up of 3 distinct types of vegetation; namely shrub land, savanna woodland and forest. Each class has a distinctive feature from one another in terms of species diversity (Table 1 and 2).

Vitaleria paradoxa had the highest number of occurance (with 91 stands) and a relative density of 16.02 (Table 4). So, it could be regarded as the most abundant species in Illo-Kaoje forest reserve. The results further indicate that *Daniellia oliveri* had the highest RD and RDo of 13.38% and 20.24% followed by *Anogeissus leiocarpus* with 10.74% and 16.42% while the low RD and RDo were recorded by *Annona senegalensis* with 0.52% and 0.21% and *Nauclea diderrichii* with 0.53% and 0.56% respectively. Bello *et al.* (2013) reported similar results in Kogo Forest Reserve, where they reported *Anogeissus leiocarpus* with highest RD and RDo of 24.5% and 23.2% followed by *Isoberlinea doka* with 18% and 13.1% while tree species with low RD and RDo were *Annona senegalensis* and *Acacia sieberiana* accordingly.

Biodiversity indices are generated to bring the diversity and abundance of species in different habitats to similar scale for comparison and the higher the value, the greater the species richness (IIRS, 2002). The estimate of species diversity could come from different sources of which forest surveys, adopted in this present study, and biodiversity monitoring programmes have been reported as major sources (Baffetta *et al.,* 2007). But, Beck & Kitching (2007) reported that the observed richness can only be a good approximation of the true richness when it can be demonstrated that the survey is very unlikely to have missed any forest tree species. Therefore, the species richness (1.30) recorded in the reserve is the correct estimate since all the tree species within the sample plots has been counted. The Shannon wiener diversity index of tree species was computed as 2.92. This is similar to 2.63 reported by Bello *et al.* (2013) for Kogo forest reserve of North-Western Nigeria. This value of the diversity index for this study falls within the general limit of diversity index of 1.5-3.5 (Kent and Coker, 1992). The dominant woody tree species in the reserve was *Vitaleria paradoxa* which appeared in almost all the 20 sample plots (20m x 25m) with a total of 91 stands per hectare.

CONCLUSION AND RECOMMENDATIONS

The species diversity indices and abundance obtained in this research compared favorably with other similar forest ecosystems. The Shannon-

wiener diversity index (2.92) obtained from this research falls within the general limit of diversity index of 1.5 – 3.5 (Kent and Coker, 1992) which indicates that tree species are very diverse in the reserve. This shows the potentiality of the reserve in terms of biodiversity conservation and hence the need for effective management of the resources. A fair tariff should also be imposed on logging with specification of trees to harvest; this will discourage illegal logging which destroys habitat and threaten some important tree species.

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