Ethiopian Journal of Environmental Studies & Management 19(2): 150 – 162, 2026
ISSN:1998-0507 doi: https://ejesm.org/doi/v19i2.2
Submitted: September 12, 2025 Accepted: March 27, 2026

FLORISTIC COMPOSITION OF REDD$^+$ PILOT SITES, CROSS RIVER STATE, NIGERIA

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Abstract

The dynamics of composition and stand structure of selected forest reserves in REDD$^+$ pilot sites in Cross River state was assessed. Four forests used for this study were: Afi Mbe, Ekuri and Mangrove respectively. Alternate line transect method were used in laying and selecting 50 m X 50 m for detailed enumeration in both Afi Mbe and Ekuri but haphazardly for Mangrove due to terrain. Twelve sample plots of 50 m X 50 m were used to assess all plants ≥ 10cm at diameter at breast height (DBH) (1.3m) in each plot for density, height, dbh and frequency. A total of 720 trees (238.33 trees/ha) from 75 species and 27 families were encountered. Dominant families include Fabaceae and Malvaceae. Rhizophora racemosa had the highest density with (202 trees/ha) with Importance Value Index (IVI) of 67.13% while Pterocarpus santalinoides, Lecaniodiscus cupanioides, Afzelia bipindensis, Celecaryon botryoides and Lannea fruticosa had the least IVI of 0.3, 0.3, 0.31, 0.32, and 0.32 respectively. Species such as Rhizophora racemosa, Treculia obovoidea, Staudtia stipitata, Diospyros spp, Allanblackia floribunda and Pycnanthus angolensis were identified as a universal species. Simpson's diversity indices ranged from 0 – 0.641 for all plots. The Evenness_e^H/S index ranged from 0.475 to 0.622, while the Density ranged from 0.3 to 67/ha. Conclusively, REDD$^+$ pilot sites are not only important in terms of plant biodiversity but also, they are considered as important destination point for rich timber resources. In this forest, economically and ecologically very important tree species such as Rhizophora racemosa, Diospyros spp, Treculia obovoidea, Afzelia africana, Staudtia stipitata, Pycnanthus angolensis, Lophira alata, Strombosia pustulata etc are found. Hence, it is very crucial to protect these important forests from biodiversity, sustainable management and environmental perspectives.

Keywords: *REDD$^+$, Species, Density, Importance Value Index, Dominant*

Introduction

Tropical rainforest has been identified as the most biologically diverse terrestrial ecosystem on earth (USAID, 2008). Unarguably, trees are often the most conspicuous plant life form in a typical tropical rainforest. According to Hill and Hill (2001) review of a typical tropical rainforest, their work defined it as a complex community, whose framework is provided by trees of many sizes. Upon the framework of the trees and within the microclimate of the canopy of the trees, grow a range of other kinds of plants, which are of immense benefits to man (Olajide *et al.,* 2008).

In the past, a tract of rainforest was often viewed as a crop of merchantable timber trees rather than an independent high diversity ecosystem of potential multiple values (Ikojo *et al.,* 2003). Thus, in Nigeria in the past, the tropical rainforests were commonly exploited for their timber resources and the respective studies have been centred on aspect such as growth, yield etc (Adekunle *et al.,* 2004; Oyebade *et al.,* 2012). Until recently where the concept of REDD+ was unanimously agreed by the world for the reduction of both deforestation and greenhouse gases, encouragement of conservation, and livelihood enhancement of the inhabitant of tropical rainforest. In Nigeria, however, the tropical rainforest remains cornucopia of livelihoods for millions of people from time immemorial. This is because many of the trees in the forests produce a variety of highly valuable non-timber products like edible and medicinal fruits, seeds, nuts and oils. Also, a considerable number of trees produce industrial materials like latex, tannin, gum exudates, dyes and resin, and harbour many valuable fauna species (Goldsmith, 2012).

It has been observed that forests have been affected by large scale anthropogenic and natural changes due to rapid population increase (Basiru, 2016). According to Ojo (2004), better understanding of the ecological changes in natural forest depends on progress in monitoring network of tropical forest plots. Nigeria, being the most populous country in Africa, her populace exerts extreme pressures on biodiversity of the remaining forests. Trees, many plants and wildlifes are over-exploited and poached, and the natural environment faces increased degradation (USAID, 2008). This may not be unconnected to with lack of strong conservation ethics, law enforcement, corruption and extreme poverty, leading to severe encroachment and illegal exploitation of forest tree resources, which amounted to depletion in biodiversity of the existing forests, reduced productivity and tree species extinction and contribute to greenhouse gases emission for climate change.

Today, Reduced Emission from Deforestation and Forest Degradation (REDD+) piloted sites (remaining 50% of tropical rainforest in Nigeria) remains a centre of richness and endemism for floral and fauna species. However, it faces a number of growing threats, which may have resulted from inadequate information of structure and physiognomy on trees distribution, which forms the framework for biodiversity conservation, and $C0_2$ and GHG mitigation in the pilot sites. Structure and floristic composition information about a stand is as important as the information on total volume and stocking. Many authors have worked on several other aspects of research on REDD+ pilot sites, among are: Akanni 2006 (Assessment of Social and Economic Indicators), Onoghejuo *et al.,* 2016 (community participation in forest management), Asiyanbi, 2016b (political ecology of REDD$^+$), Nuesiri 2016 (REDD$^+$ representation), Isyaku, 2017 (implementation and institutional complexity of environmental governance), Isyaku *et al.* 2017 (framing justice in REDD$^+$), Van den Bragt, 2020 (access to natural resources of independent communities), Amuyou, (2023) (regional carbon stock) but none have addressed the floristic and ecologically related of species in REDD$^+$ pilot sites. Therefore, it is imperative to carry out the structure and floristic composition of REDD$^+$ pilot site in order to know whether the initial objectives of REDD$^+$ in terms of conservation, deforestation reduction and livelihood enhancement are to be achieved.

Study Area

Cross River State (CRS) is one of the six states that are located around the coast of Niger Delta in the southern part of the country. Geographically, Cross River State is located between latitude 4° 28′ and 6° 55′ North of the equator and, Longitude 7° 50′ and 9° 28′ East of the Greenwich Meridian (Figure 3). It shares the same boundaries with Benue State in the north, Atlantic Ocean in the South, Abia and Ebonyi states in the West, and an extensive border with the Republic of Cameroon in the East. For this study, three key sites (known as REDD$^+$ pilot sites/clusters) were purposively selected as the only approved pilot sites for the on-going United Nation's REDD$^+$ program (Reducing Emissions from Deforestation and Forest Degradation$^+$) currently ongoing in CRS, Nigeria. The sites/clusters of interest include: The Afi–Mbe, Ekuri–Iko, and mangrove forest clusters (about 16 communities with approximately a population size of 30,000 peoples) from which communities were selected purposively. (Figure 2). The Afi–Mbe REDD$^+$ sites border the Cross River State Forest Reserve. The reserve lies between the Afi Mountain Wildlife Sanctuary and Mbe Mountains Community Forest while Ekuri–Ukpon clusters are made up of community forests and forest reserves, jointly managed by local communities, the government (Cross River Forestry Commission) and the foreign conservation Society). In the Afi–Mbe cluster, the existing protected areas include the Afi Mountain Wildlife Sanctuary, Afi River Forest Reserve, Mbe Mountains and a community forest south of the Cross River National Park. The Ekuri–Iko cluster is made of the Ukpon River Forest Reserve, Ekuri Community Forest, parts of the Oban Block Forest Reserve and the Cross River South Forest River Ekuri Cluster, a collection of communities located on the edge of the Cross River National Park buffer zone, while the mangrove forest was bordered by the creek in Akpabuyo local government of the state (Isyaku, 2017).

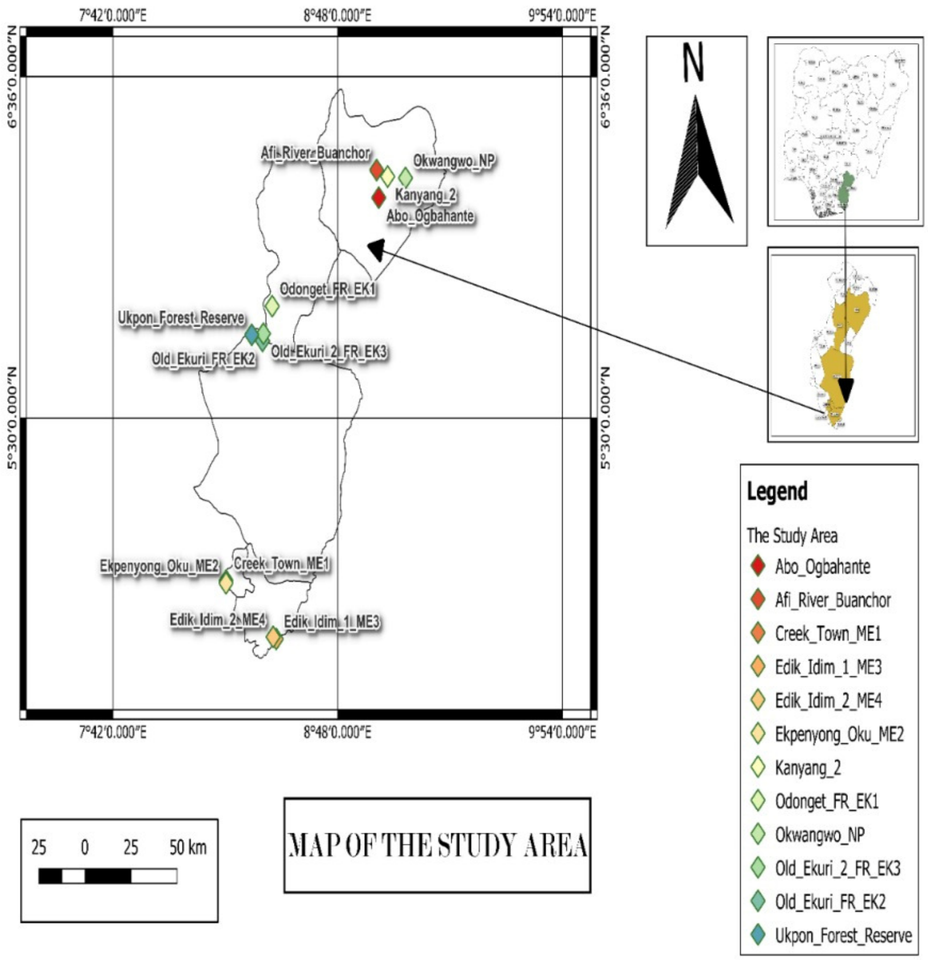

Fig. 1: Map of the study area showing the three REDD+ pilot sites

Relief and Vegetation

The relief of Cross River State consists of the coastal creeks towards the southern border with the Atlantic Ocean, Cameroon Mountains, and part of Bamenda highland in the east, as well as the Cross River basin in the west. Altitude ranges from sea level, gently undulating basins to volcanic hills of Oban and Ogoja that extend up to 1,829 metres. Cross River State has 4 main types of vegetation that reflect the main ecological zones within the state. These are (1) freshwater swamps and mangroves (2) evergreen wet forests (3) southern guinea savanna, and (4) montane forests and grasslands.

These vegetation zonations are greatly influenced by the topography of the area. The mangrove belt covers about 10–15 km along the coast where the ocean mixes with fresh waters. Predominantly, the mangrove trees are shrubby with heights of about 40 meters, consisting of both local and exotic species of palm trees and Rhizophora. The freshwater swamp has a wider coverage of about 10–25 km extending towards the north of the mangrove belt. The height of the freshwater swamp forest canopy is about

30 meters and consists of mostly woody and non-woody species arranged in different layers. The largest portion of forests in the state is the evergreen lowland rainforest which extends southwest into Cameroon. This zone is considered the remaining pristine rainforest vegetation in the whole of Nigeria and has been managed by Cross River National Park, forest reserves, and indigenous forest communities (Oyebo *et al.,* 2010)

In Cross River State, savannah-like vegetation is found around the northern and central portions consisting of various species of trees and grasses. Montane vegetation is also seen around the north-eastern portion on the border with Cameroon. These areas include the Obudu Plateau, Sankwala Mountains, and Ikwete hills with elevations of about 1800 m above sea level. This place is of high species richness and diversity including both vascular and nonvascular plants that reflect the local microclimatic conditions (Oyebo *et al*., 2010)

Climate

In Cross River, there is an annual alternation of distinct wet and dry seasons mostly determined by the movement of Inter Tropical Convergence Zone (ITCZ). Normally, annual rainfall starts in April and ends in October with a peak usually in August in most parts of the country. However, the southern regions experience 4 distinct seasons consisting of (1) a long rainy season from February to July, (2) a period of decline known as August break, (3) a short period of heavy rainfall from September to November (4) dry season from mid-November to February. The amount of rainfall decreases northwards from the coastal regions with an annual range of 1854 mm and 508 mm, respectively.

In some remote corners of the north-east, especially near the border with Chad, annual rainfall can be as low as 1 inch for 5–7 months. There is also temperature variability throughout the country. Annual mean maximum temperatures could be up to 36°C in the northern savannah regions, while the annual mean minimum temperature of –5°C is usually recorded in the southern regions. The mean annual temperature in Cross River State ranges from 22.4°C to 30.1°C. Additionally, mean annual rainfall also varies significantly locally from 2018 mm to 3063 mm (Edet *et al.*, 1998)

Materials and Methods

Procedure for Data Collection and Analysis

Assessment of plant diversity in relation to REDD$^+$ pilot sites

Vegetation sampling

Tree variables that were recorded include (1) Species availability (2) Total number of species (3) Total number of stems (stem density) (4) Diameter at breast height (DBH) of each trees (5) Total tree height. Twelve 50 x 50m sample plots were randomly laid in the forest reserve. In each sampling plot, all trees ≥ 10cm in DBH were measured with the aid of diameter tape and total height following the Spiegel relaskop method described by Oladoye (2012). Within each plot, all live woody vegetation were identified. Breakdown of total number of twelve (12) plots used for the data collection from the study sites were: Four (4) plots from Afi Mbe, Ekuri and Mangrove. 50m X 50m plots were randomly laid in both Afi Mbe and Ekuri forest reserve with a minimum of 100m apart. Due to difficult terrain of Mangrove forest, the random laying of 50m X 50m was not feasible, consequently, using watercourse as a baseline, five (5) 10m X 10m were haphazardly measure inward for easy measurement and identification of tree species diversity to make a 50m X 50m plot, and this was replicated more in four places to make five (5) plots.

Standard procedures using the formular below were used in calculating density, frequency, abundance, relative density (R.D), relative frequency, relative dominance and important value of index (IVI) of the species. Density, relative density and important value of index was calculated according to the formulae adopted by Oladoye (2012). Similarity and diversity was also computed to study interrelationship between the species and the sites using PAST Version 3 (Paleontological Statistics Software Package).

Density

Density of species $\frac{\text{Total Number of Individuals of the species in all the plots}}{\text{Total Numbers of plots studied}}$…………………..…..(1)

Frequency

Frequency of a species

$\frac{\text{Number of plots in which species occurred}}{\text{Number of plots studied}}$………………………………...(2)

Abundance

Abundance of a species

$\frac{\text{Number of individuals in all the plots}}{\text{Number of plots in which the species occurred}}$ ………………………..….(3)

Importance value index (IVI)

IVI

(relative frequency + relative density + relative dominance…………………(4)

Relative frequency

$\text{R.F} = \frac{\text{Frequency of one species}}{\text{Sum of all frequency}} \text{x}100$ ………………………………… (5)

Relative Density

$\text{R.D} = \frac{\textbf{\textit{Number of individual of a species}}}{\textbf{\textit{Total number of individual of all species}}} \boldsymbol{x100}$ ……………….……(6)

Simpson Diversity Index

$(\text{SDI}) = \frac{\sum n(n-1)}{N(N-1)}$ ……………………..…………………..................(7)

Where n = total number of species

N = total number of all species

Similarity indices

Sorensen Similarity Indices (SSI) = $\frac{a}{a+b+c} x100$ ………………………….....(8)

Where a = number of species common to both sites

b = number of species present in first site but not in other site

c = number of species present in second site but not in the first site

The data were entered and analyzed by Paleontological Statistics Software Package (PAST) (version 3) for the density, frequency, abundance, relative density (R.D), relative frequency, relative dominance and important value of index (IVI) of the species. Similarity and diversity indices was also computed to study interrelationship between the species and the sites using PAST Version 3.

Results

Floristic Composition and Structure of Tree Species in the study area

A total of 720 trees representing 75 species from 27 families were encountered during the study (Table 1). Fabaceae had the highest number of species (17) followed by Malvaceae (6), Apocynaceae and Anacardiaceae (4), Sapotaceae, Clusitaceae, Phyllanthaceae, Meliaceae, Myristicaceae, Olaceae and Moraceae were represented by (3) species each. Sapindaceae, Burseraceae, Cannabaceae, Annonaceae, Ebenaceae, Putranjivaceae and Irvingiaceae had (2) species each while Cupressaceae, Lecythidaceae, Simaroubaceae, Ochnaceae, Utricaceae, Rhizophraceae, Euphorbiaceae, Combretaceae and Lamiceae had 1 species each (Table 1). Number of species present per plot in the study area ranged from 1-85 species/plot.

Among the identified tree species in the study area, *Rhizophora racemosa* (202), *Treculia obovoidea* (83), *Diospyros* spp (40) are the species with high frequency of 202, 83, 40 each, *Allanblackia floribunda, Staudtia stipitata, and Cola* spp had frequency of 25, 38 and 22 respectively. The least frequency (1) was found in *Afzelia africana*, *Afzelia bipindensis* and other 25 species. (Table 6). The stocking density of dominant trees species/ha in the study area ranged from 0.33tree/ha to 67.00 trees/ha. *Rhizophora racemosa* had the highest Relative Density (RD) of 67.00, followed by *Treculia obovoidea* (27.33), *Staudtia stipitata* (12.67), and *Cola* spp (7.33) while *Afzelia africana*, *Afzelia bipindensis* and other 25 species had the least RD (0.33) and relative importance value (IVI) ranging from 0.30 to 0.60 respectively. Highest IVI of (67.13) with density of 67.00 tree/ha was found in *Rhizophora racemosa* followed by *Treculia obovoidea* (26.34; 27.33 trees/ha), *Staudtia stipitata* (15.38: 12.67 trees/ha), *Diospyros* spp (12.58: 13.33), *Cola* spp (29: 7.33 trees/ha) respectively (Table 1).

Table 1: Frequency, Density, Dominance and IVI of Tree species in the study area

Plant Species	Family Name	FREQ	DENSITY	DOMINANCE	RD	RF	Rdo	IVI
Afzelia africana	Fabaceae	1	0.33	0.06	0.14	0.14	0.19	0.47
Afzelia bipindensis	Fabaceae	1	0.33	0.01	0.14	0.14	0.03	0.31
Albizia gummifera	Fabaceae	5	1.67	0.26	0.70	0.70	0.86	2.26
Allanblackia floribunda	Clusiaceae	24	8.33	0.61	3.50	3.50	2.06	9.05
Alstonia boonei	Apocynaceae	1	0.33	0.12	0.14	0.14	0.40	0.68
Baillonella toxisperma	Sapotaceae	1	0.33	0.29	0.14	0.14	0.97	1.25
Berlinia confusa	Fabaceae	2	0.67	0.04	0.28	0.28	0.12	0.68
Blighia sapida	Sapindaceae	14	4.33	0.91	1.82	1.82	3.07	6.71
Brachistegia nigerica	Fabaceae	6	2.00	0.46	0.84	0.84	1.53	3.21
Brachystegia eurycoma	Fabaceae	2	0.67	1.23	0.28	0.28	4.15	4.71
Bridelia micrantha	Phyllanthaceae	6	2.00	0.16	0.84	0.84	0.54	2.22
Bridelia speciosa	Phyllanthaceae	1	0.33	0.15	0.14	0.14	0.50	0.77
Canarum spp	Burseraceae	6	2.00	0.49	0.84	0.84	1.64	3.31
Carapa procera	Meliaceae	7	2.33	0.08	0.98	0.98	0.26	2.22
Celecaryon botryoides	Cannabaceae	1	0.33	0.01	0.14	0.14	0.04	0.32
Celtis africana	Cannabaceae	2	0.67	0.03	0.28	0.28	0.10	0.65
Celtis zenkeri	Sapotaceae	13	4.33	0.75	1.82	1.82	2.52	6.15
Chrysophyllum albidum	Annonaceae	1	0.33	0.03	0.14	0.14	0.12	0.40
Cleistopholis patens	Myristicaceae	4	1.33	0.02	0.56	0.56	0.05	1.17
Coclocaryon botryoides	Malvaceae	3	1.00	0.07	0.42	0.42	0.23	1.06
Cola spp	Lecythidaceae	22	7.33	0.48	3.08	3.08	1.63	7.78
Combrectodendion africanum	Cupressaceae	3	1.00	0.22	0.42	0.42	0.75	1.59

Cornifera milabraedii	Burseraceae	1	0.33	0.06	0.14	0.14	0.22	0.50
Dacryodes klaineani	Fabaceae	1	0.33	0.05	0.14	0.14	0.16	0.44
Daniellia ogea	Fabaceae	2	0.67	0.04	0.28	0.28	0.14	0.70
Dialium guineense	Fabaceae	2	0.67	0.13	0.28	0.28	0.44	1.00
Diospyros abysinnica	Ebenaceae	3	1.00	0.03	0.42	0.42	0.10	0.94
Diospyros spp	Ebenaceae	40	13.33	0.41	5.59	5.59	1.40	12.58
Distemonathus benthamianus	Fabaceae	1	0.33	0.02	0.14	0.14	0.06	0.34
Drypetes gabonensis	Putranjivaceae	1	0.33	0.02	0.14	0.14	0.06	0.34
Drypetes spp	Putranjivaceae	3	0.33	0.08	0.14	0.14	0.28	0.56
Duboscia macrocarpa	Malvaceae	3	1.00	0.09	0.42	0.42	0.30	1.14
Funtumia elastica	Apocynaceae	1	0.33	0.04	0.14	0.14	0.13	0.41
Garcinia kola	Clusiaceae	2	0.67	0.03	0.28	0.28	0.09	0.65
Guaerea cedrata	Meliaceae	8	2.67	0.60	1.12	1.12	2.01	4.25
Hannoa klaineana	Simaroubaceae	1	0.33	0.03	0.14	0.14	0.09	0.37
Hylodendron gabunense	Fabaceae	3	1.00	0.13	0.42	0.42	0.44	1.28
Irvingia gabonensis	Irvingiaceae	11	3.67	0.63	1.54	1.54	2.13	5.21
Klainedoxa gabonensis	Irvingiaceae	15	5.00	0.98	2.10	2.10	3.30	7.50
Lannea barten	Anacardiaceae	1	0.33	0.07	0.14	0.14	0.23	0.51
Lannea fruticosa	Anacardiaceae	1	0.33	0.01	0.14	0.14	0.04	0.32
Lannea microcarpa	Anacardiaceae	1	0.33	0.02	0.14	0.14	0.06	0.34
Lannea nigritiania	Anacardiaceae	1	0.33	0.12	0.14	0.14	0.40	0.68
Lecaniodiscus cupanioides	Sapindaceae	1	0.33	0.02	0.14	0.14	0.06	0.34
Lophira alata	Ochinaceae	8	2.67	1.28	1.12	1.12	4.30	6.54
Lovoa trichiloides	Meliaceae	4	1.33	0.22	0.56	0.56	0.74	1.85
Margaritania discodiens	Sapotaceae	1	0.33	0.21	0.14	0.14	0.71	0.99
Musanga cercropioides	Urticaceae	7	2.33	0.02	0.98	0.98	0.07	2.02
Oxystigma mannii	Fabaceae	12	3.67	0.23	1.54	1.54	0.76	3.84
Parkia bicolor	Fabaceae	9	3.00	1.90	1.26	1.26	6.40	8.92
Pentaclethra macrophylla	Fabaceae	7	2.33	0.66	0.98	0.98	2.21	4.17
Pentadesma butyracea	Clusiaceae	1	0.33	0.00	0.14	0.14	0.02	0.30
Piptadeniastium africanum	Fabaceae	9	3.00	1.46	1.26	1.26	4.92	7.44
Pterocarpus osun	Fabaceae	9	3.00	0.68	1.26	1.26	2.29	4.81
Pterocarpus santalinoides	Fabaceae	1	0.33	0.01	0.14	0.14	0.02	0.30
Pterygota macrocarpum	Malvaceae	1	1.00	0.19	0.42	0.42	0.64	1.48
Pycnanthus angolensis	Myristicaceae	20	6.67	1.64	2.80	2.80	5.52	11.11
Rauvolfia vomitoria	Apocynaceae	2	0.67	0.01	0.28	0.28	0.04	0.60
Rhizophora racemosa	Rhizophoraceae	202	67.00	3.23	28.11	28.11	10.90	67.13
Ricinodendron heudelotii	Euphorbiaceae	2	0.67	0.41	0.28	0.28	1.38	1.94
Santaria trimera	Burseraceae	11	3.33	0.19	1.40	1.40	0.65	3.45
Staudtia stipitata	Myristicaceae	38	12.67	1.41	5.31	5.31	4.75	15.38
Sterculia oblonga	Malvaceae	3	1.00	0.03	0.42	0.42	0.10	0.94
Sterculia rhinopetala	Malvaceae	1	0.33	0.02	0.14	0.14	0.05	0.33
Sterculia spp	Malvaceae	13	4.33	0.28	1.82	1.82	0.95	4.58
Strombosia grandifolia	Olacaceae	13	0.33	0.24	0.14	0.14	0.82	1.10
Tabernacmontana pachysifon	Apocynaceae	5	1.33	0.07	0.56	0.56	0.25	1.37
Terminalia superba	Combretaceae	3	1.00	0.03	0.42	0.42	0.10	0.94
Tetrapleura tetraptera	Fabaceae	1	0.33	0.70	0.14	0.14	2.35	2.63
Treculia africana	Moraceae	11	3.67	0.20	1.54	1.54	0.66	3.74
Treculia obovoidea	Moraceae	83	27.33	1.01	11.47	11.47	3.40	26.34
Treculia spp	Moraceae	5	0.33	1.23	0.14	0.14	4.16	4.44
Uapaca guinesis	Phyllanthaceae	7	1.67	0.26	0.70	0.70	0.88	2.28
Vitex grandifolia	Lamiaceae	1	2.33	1.34	0.98	0.98	4.53	6.49
Xylopia aethiopica	Annonaceae	1	0.33	0.09	0.14	0.14	0.32	0.60
		720	**238.33**	**29.65**	**100**	**100**	**100.00**	**300.00**

Legend: RD- Relative Density, RF-Relative Frequency, Rdo- Relative dominance, IVI- Importance Value Index

Species Similarities Indices between the study locations

Table 2 shows that the species similarities (Simpson's similarities indices) between the study locations ranged from 0% to 64% for all the plots. Afi Mbe and Ekuri have high similarity indices of 64%%, while Mangrove with Afi Mbe and Mangrove with Ekuri doesn't record any similarities. The higher the value of the similarity indices between the plots, the more related they are in species composition. This implies that Afi Mbe and Ekuri are more related floristically than Mangrove with Afi Mbe and Mangrove with Ekuri.

Dominance was generally low in all the study location with average of 0.34. However, relatively the dominance was high in Mangrove (0.90) and Afi Mbe (0.07) which contains mainly *Rhizophora racemosa* and *Treculia obovoidea*, the lowest was found in Ekuri (0.05), species distributions was even (Evenness = 0.5703). The average diversity index (Simpson) for all the plots is (0.662). Simpson's diversity indices revealed high diversity values in Ekuri (0.9555) and the least was found in Mangrove (0.0984) which was dominated by *Rhizophora racemosa*. Both Ekuri and Afi Mbe were more dominated by other species as reflected by Simpson's and Fisher_alpha values (Table 3).

Table 2: Similarity indices of tree species in the three pilot study area

	Mangrove	Afi Mbe	Ekuri
Mangrove	1		
Afi Mbe	0	1	
Ekuri	0	0.64151	1

Table 3: Diversity Index of the species of the study area

Species	Afi Mbe	Ekuri	Mangrove
Taxa_S	58	53	2
Individuals	283	220	212
Dominance_D	0.06647	0.04453	0.9016
Evenness_e^H/S	0.4751	0.6226	0.6132
Simpson_1-D	0.9335	0.9555	0.09839
Fisher_alpha	22.01	22.1	0.3056
Berger-Parker	0.186	0.1312	0.9481

Discussion

Ecological investigations into the floristic compositions and structure of forest are essential for providing information on species richness of the plants and the changes they undergo, which can potentially be useful for management purpose and assist in understanding the forest and ecosystems functions as a whole (Pappoe *et al.,* 2010). Tree species richness of a forest ecosystem depends on the number of species per unit area; the more species there per unit area, the higher species richness. A total of 720 tree species/ha observed in this study is averagely low compared to the typical 887 species that have been observed in other studies in the same forest division (Asuk, 2016). However, the floristic richness of the present study site could be attributed partly to lowering the diameter at the breast height (Asuk, 2016), and community forest management (Onoghejuho *et al.,* 2016). High species richness of the REDD⁺ piloted study area could also be due to geographical location of the study sites and favourable climatic condition and protection from government and communities around the forest. The families represented in the present study were Fabaceae, Malvaceae, Apoceaceae, Anacardiceae, and Moraceae with Fabaceae having the highest number of species (17) contrary to Asuk, (2016) who recorded mostly Leguminosae such as Caesalpiniaceae, Mimosaceae and Palpilonaceae family.

Majority of the prominent species found in the present study have been listed in the previous study of Asuk, (2016). The abundance of *Terminalia superba, Allanblackia floribonda, Blighia sapida, Treculia obovoidea, Diospyros* spp *etc* is a distinctive feature of this particular type and are all widely characteristic of disturbed lowland rainforest vegetation. The dominance of these species in the flora of the REDD$^+$ sites is considered as the main characteristics of lowland rainforest vegetation (Asuk, 2016). The presence of some species such as *Rhizophora racemosa, Treculia obovoidea, Diospyros* spp, *Allanblackia floribunda, Staudtia stipitata, Cola* spp, *Afzelia africana*, *Afzelia bipindensis* is an indication recovery of disturbed vegetation. The stocking density of dominant trees species/ha in the study area ranged from 0.33tree/ha to 67.00 trees/ha. *Rhizophora racemosa* had the highest Relative Density (RD) of 67.00, followed by *Treculia obovoidea* (27.33), *Staudtia stipitata* (12.67), and *Cola* spp (7.33) while *Afzelia africana*, *Afzelia bipindensis* recorded the least. This results agrees with similar results of Zhigila *et al.* (2016) in assessment of plant species diversity, abundance and distribution in communities of Zamfara state, Nigeria.

The density of (238.33 stems/ha) of woody species ≥5cm also recorded at the present study is comparable to tropical woodland ecosystem of India with 390 stems/ha, the value was higher (Shirima *et al.,* 2015). It has become common practice in quantitative ecological studies to use IVI, which combines relative density, relative dominance and relative frequency into a single measure to analyze plant community. Though vegetation can be described in terms of a number of parameters including frequency, density, and cover, the use of any these quantitative parameters could lead to over simplification or under estimation of the status of the species (Mishira *et al.,* 2012). Certain points have to be acknowledged, to understand the argument, the IVI is providing. Species occurring singular but with a high basal area may be giving the same rank as widely spread but small species. Also, some species may be dominant in one site but do not occur at other site. Therefore, their local dominance is not displayed in the overall statistics; still the IVI is giving a figure with the overall importance of species. Overall, the IVI of the species were generally low, ranging from 0.30% to 67.13%, only 10 species have IVI value above 10% and this included *Rhizophora racemosa* (67.13), *Treculia obovoidea* (26.34), *Staudtia stipitata* (15.38), *Diospyros spp* (12.58) and *Pycnanthus angolensis* (11.11). Their relative frequency contributed to IVI was more than other species. *Pentadesma butyracea* (0.31), *Afzelia bipindensis* (0.31), *Lecaniodiscus cupanioides* (0.34), *Lannea fruticosa* (0.32*), Celecaryon botryoides* (0.32), had the least IVI values and were encountered between the range of one (1). Low ecological status of most of the species in this study, as evidenced by the low IVI of most tree species may be attributed to lack of dominance by any one of the species, which suggest positive interactions among the tree species. In order words, resource spaces are shared to minimize negative species interactions and plant can obtain resources with relative ease (Pappoe *et al.,* 2010). The low IVIs may also imply that most of the species in this forest are rare (Mishra *et al.,* 2012) as reflected in the distribution of trees according to Raunkaier's classification scheme. It should be noted that the summary of the parameters into one has the effect of increasing the difference between the same species among area of similar species composition (Mishra *et al.,* 2012). The species similarity (Simpsons) between the plots which varied from 0-64% for all the study locations implies the higher the similarities indices between the plots, the more related they are in species floristic composition.

In term of tree species diversity, Simpson's diversity average index of 0.662 was recorded for all the plots. In addition, the Evenness and Simpson's diversity of (0.475 – 0.622) and (0.098 – 0.95) respectively for each of the plots implies that 47% to 62% of the trees were evenly distributed among the species/plots (Pappoe *et al.,* 2010). Species dominance was generally low with average of 1.07 however, it was high in *Rhizophora racemosa* (3.23) and (1.90). The higher values of diversity indicate greater stability of community structure (Mishra *et al.,* 2012) and this may be attributed to improved soil quality as a result of high organic matter content and high pH. The lowest dominance was found in *Pentadesma butyracea* (0.00). Higher number of species in *Fabaceae* (17) in this study is a reflection of their tendency for natural inclination to grow very large. This can be compared with the study of Ogunlusi (2025). Compared with other forest, Afi Mbe, Ekuri and Mangrove is vertically presented a high structural complexity, for instances, Belair and Eisenhaure, (2016) classified emergent layer at an average height of 71.3m in 118 acres Moore Field owned by University of New Hemisphere against >34m in comparison with the value observed in this study.

Conclusion and Recommendation

REDD^{+} pilot sites is not only important in terms of rich timber resources but also they are considered as important destination for plant biodiversity. In the studied REDD^{+} sites, economically and ecologically very important tree species such as *Rhizophora racemosa*, *Diospyros spp, Treculia obovoidea, Afzelia africana, Staudtia stipitata, Pycnanthus angolensis, Lophira alata, Strombosia pustulata* etc are found. Hence, it is very crucial to protect these important forests from biodiversity, sustainable management and environmental perspectives. The presence of *Musanga cecropioides* in the study area, is an indication that the vegetation has been disturbed in the recent past, but currently displays signs of recovery. Exploitation of timber resources need to be drastically reduced to allow the forest to regenerate itself through gender mainstreaming forest management approach.

Research conducted has also shown REDD^{+} forest may act as catalyst for successful natural succession provided microclimatic condition. Ultimately, this may be leading to conserving biological diversity. The study eventually concludes that a continuous protection of REDD^{+} pilot sites from human interferences and scientific management of tree species of the study area may lead a biodiversity conservation baseline for other states in Nigeria ready for the adoption of REDD+ intiative.

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