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Parkland Trees under Severe Drought: An Assessment of Species Diversity and Abundance across Three Agroecological Zones of Northern Nigeria

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Abstract

The appraisal of tree stand structure on parklands is crucial for sustainable agroforestry management decisions, particularly in the drylands of Nigeria. An assessment of tree species distribution in farm plots across the three driest Agroecological zones (AEZ) within Northern Nigeria was performed to determine diversity and abundance in a changing climate. The AEZ include Sudan savannah (SS), Northern Guinea savannah (NGS) and Southern Guinea savannah (SGS). In each AEZ, 3 transects were laid per village and a total of 4 sample plots were located along each transect. Tree bole diameter of all the sampled woody perennials with dbh ≥ 10 cm was measured and identified to species level. The measurement and computation include basal area, species relative density and dominance as well as the important value index (IVI). Results showed that across the AEZs, *Parkia biglobosa* trees had the highest IVI but reduces from the driest zone, SS (50.25%) through the transitional zone, NGS (38.45%) to the wettest AEZ, the SGS (35.43%). The lowest IVI recorded were in *Gliricidia sepium* (0.62%), *Psidium guajava* (2.89%) and *Eucalyptus camaldulensis* (1.83) in the SGS, NGS and SGS respectively. *Parkia biglobosa* and *Mangifera indica* dominated the landscapes and are classified as the landscapes' habitat generalists. Despite the low organic matter content, Sudan savannah had more diverse species on its farm landscapes than the two other AEZ but with less tree popuplation density. The potential contribution of agroforestry parkland trees to agrobiodiversity in reducing drought and improving soil fertility is essential for sustainable agricultural productivity and landscape restoration.

Keywords

Agroforestry, Nigeria, Regeneration, Trees, Savannah

1. Introduction

The West African region land cover loss from 1975-2000 is one of the highest in the world. Each year, land use and land-use change caused the loss of about 50,000 square kilometeres of natural vegetation (Cotillon, 2017; Eva et al., 2000; FAO, 2018). According to Arowolo & Deng (2017) between 2000 and 2010, cultivated land use was the main driver of Land-use change process in Nigeria. The conversion rate increased significantly to about 5% of the total land area of Nigeria per year and conversion to agricultural land is the leading cause of forest and grassland loss. This is more intensified in the northern region, home to over half of the country's human population (World Bank Report, 2017). The adverse effect of cultivated land expansion includes threat to forest ecosystem, plant biodiversity and carbon emission (Zomer et al., 2016). Land-use change in sub-Saharan countries is still on the increase, resulting in community conflicts such as farmers-herdsmen struggle in some parts of Northern Nigeria over resources on parklands (Dimelu et al., 2017; Lubeck, 2014; Tenuche & Olanrewaju, 2009).

The sustainable management of parkland is significant to maintaining biodiversity and improving the productivity of Sahelian agroecosystems of West Africa (Bayala et al., 2015). The agricultural landscapes of Nigeria's dryland are part of the vast parklands cutting across West Africa and generally believed to be rich in economic woody perennial plant species, despite the soil low fertility (Aleza et al., 2015; Bayala et al., 2006). These parklands possess significant features of different tropical agroecosystems in the region (Leakey, 2014). They also host some threatened tree species, such as *Vitellaria paradoxa* that are important to sustainable agroecological services optimization (Amiebenomo, 2002).

Trees establishment in parkland systems is either by seed planting or natural regeneration of seedlings (Teklehaimanot et al., 1996). Coppicing is another method by which trees regenerate from cut stumps, commonly from deforestation remnants for agricultural purposes (Fentahun & Hager, 2010). The most common method is the management and protection of regenerating natural trees commonly referred to as the Farmer Managed Natural Regeneration (FMNR) (Haglund et al., 2011). Tree planting is a common practice in Nigeria's agroecological landscapes, and more pronounced in northern region due to intensive land use and drought (Ebenezer, 2015; Kayode & Francis, 2012).

Faye et al. (2011) reported that parkland tree species have traits of drought-resistant and nutritional supplement potentials among others. They also confirmed that the trees can equally grow food and cash crops for sustainable livelihoods and food security. Parkland trees have been used to reduce the challenges posed by food insecurity, malnutrition, energy shortage, high temperatures, soil fertility as well as sheet erosions (Bayala et al., 2006; Miller et al., 2016). Although the biodiversity of Nigeria is relatively well quantified in terms of species and ecosystem diversity of the dense forest and mangrove regions (Kayode and Ogunleye, 2008; Edet et al., 2011; Adeyemi et al., 2013; Bello et al., 2013), the parklands in the savannah agroecological zones mostly affected by anthropogenic forces are poorly documented in terms of tree species diversity and abundance on farms. This paper is important for identification of valuable savannah parkland trees on farm plots in the studied agroecological zones. It would also confirm the status of the preferred trees on farms as focused is on ecological restoration for improving rural economic post-COVID-19 era. Hence, the need to ascertain tree species diversity and status across three agroecological zones to enhance arable biodiversity through sustainable agroforestry parkland systems. This study therefore evaluates tree species richness and abundance across three agroecological zones in the dry and vast savannah landscapes of northern Nigeria.

2. Materials and Methods

2.1. Study Area Location

The field study was conducted across three agroecological zones lying in the dry tropical and semi-arid landscapes of Nigeria; the Sudan savannah, Northern Guinea savannah, and Southern Guinea savannah agroecological zones (AEZ). The field points are farm plots sampled from communities with drought-threatened across the three studied AEZ. **Figure 1** is a pictorial image showing the agricultural landscapes taken from sampled locations. Ethical permission to sample the trees on farms was sought from traditional community chiefs before the field work commenced.

2.2. Data Collection

The sample plot selection of the parklands was done adopting systematic sampling technique used in (Adeyemi et al., 2015) with modifications. Three (3) transects of 1000 m long separated at 1000m distance intervals were evenly distributed in each agroecological zone farm plots. Along each transect, four plots of 1.0 ha were laid at 200 m intervals (**Figure 2**). In each of the plots, all trees with diameter at breast height (DBH) ≥ 10 cm were sampled. The trees were identified to species level based on the features highlighted in Van Wyk et al. (2000). A total of 36 sample plots (36 ha) were used for this field study. **Figure 2** is a schematic diagram of the line transect layout for the studied sites. At each agroecological zone, soil sample was randomly collected only in 1 plot per transect in a triangular manner and at three points (50 m apart) in the depth of 0 - 15 cm and 16 - 30 cm using an auger in the sampled plots.

Figure 1. Images of parklands are used as field points in the three agroecological zones of Nigeria for this research.

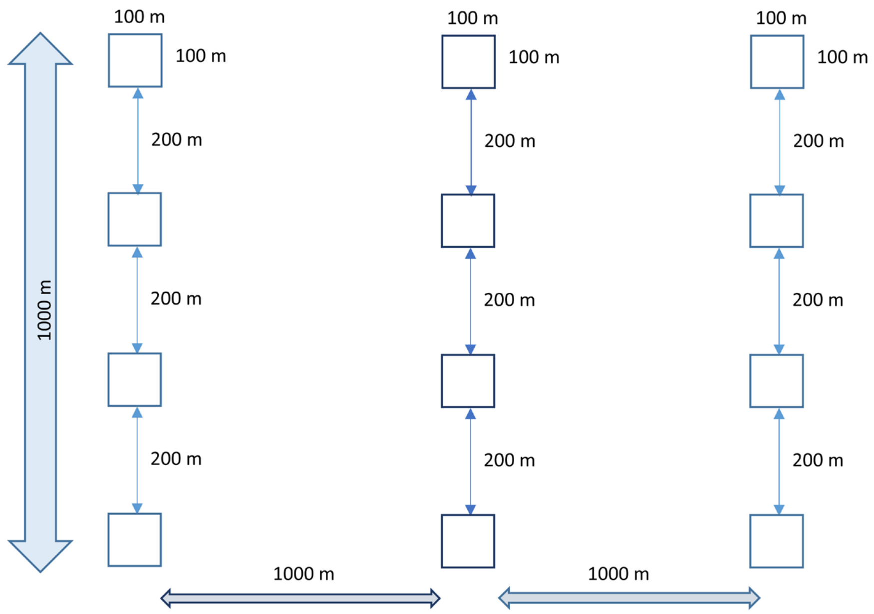

Figure 2. Plot layout using line-transect technique in a vertical orientation for each agroecological zone.

3. Growth Parameters and Biodiversity Indices Analysis

The following biodiversity indices and growth parameters computations were undertaken.

3.1. Basal Area

It is the diameter of the tree at 1.37 m off the ground. The trees basal area in the three zones were calculated using

$$BA = \frac{\pi dbh^2}{4}$$

BA = basal area (m^2), DBH = diameter at breast height (cm), and pi = 3.142. The total BA for each zone was computed by adding all trees BA in the sampled parkland sites.

3.2. Species Relative Density (RD)

Species relative density is an index for species relative distribution assessment, and calculated as follows:

$$RD = t_i / T \times 100$$

RD (%) = species relative density t = is the number of individuals of species i. T is the total number of all individual trees of all species in the entire community. The tree species are classified based on the relative densities (RD) using the methods in Edet et al. (2011) and Adeyemi et al. (2015) as follows:

abundant = RD ≥ 5.00;

frequent = 4.00 ≤ RD ≤ 4.99;

occasional = 3.00 ≤ RD ≤ 3.99;

rare = $1.00 \leq RD \leq 2.99$ and;

threatened/endangered = $RD < 1.00$.

3.3. Species Relative Dominance

Species Relative Dominance (RD_0 (%)), is the assessment of relative space occupancy of a tree in each area. The formula used for estimating is as follows:

$$RD_0 = Ba_i / Ba_n \times 100.$$

Ba_i = sum of basal area of all specific trees in each zone, Ba_n = Total sum of basal area of all trees for each zone.

3.4. Importance Value Index

Importance Value Index involves the measure of how dominant a species is in a specified area. The tree species Importance Value Index (IVI) was calculated for each agroecological zone using the following equation:

$$IVI = (RDo + RD)/2.$$

where RD = Relative density, RDo = Relative dominance as seen in Sections 5.3.2 and 5.3.3.

3.5. Species Diversity Index

The Shannon-Wiener diversity index (H') is the measure of diversity combination of tree species richness in a given area and their relative abundance. It involves characterization of species diversity in a community (Ifo et al., 2016). The index is employed to compute the Species diversity index in the following equation:

$$H' = -\sum_{i=1}^{R} p_i \ln p_i$$

where H' = Shannon-Wiener diversity index, t = total number of tree species in the plots, p_i = Proportion of S made up of the i_{th} species and ln = natural logarithm.

3.6. Shannon's Maximum Diversity Index

Shannon's maximum diversity index is the value that occurs when each species has same frequency. This normalizes the Shannon diversity index to a value between 0 and 1. Note that lower values indicate more diversity while higher values indicate less diversity (O'Keeffe, 2004). Shannon's maximum diversity index was calculated using

$$H_{max} = \ln S$$

H_{max} = Shannon's maximum diversity index, S = total number of species in the parklands in each AEZ.

3.7. Species Evenness

Species evenness refers tree species closeness equitabilty (mathematically) in an environmental niche. It is represented in the following equation

$$J' = \frac{H'}{H'_{\max}}$$

where $H'_{\max}$ = Shannon's maximum diversity index. H' = Shannon-Wiener diversity index J' = Species eveness.

3.8. Descriptive Statistics of the Tree Variables

Summary of the data using descriptive statistical analysis to evaluate the relationships among the biodiversity and growth variables of the three sampled agroecological zones. The analysis of all variables of parkland trees in the studied three agroecological zones were undertaken in R programming (3.4.4) software package, except otherwise stated.

4. Results

4.1. Variable Indices of Tree Biodiversity

The population status of trees for each of the agroecological zones sampled is presented in Table 1. A total of 278 individuals belonging to 19 species and 11 families were encountered across studied agroecological zones. Although the number of individual trees and species composition among the zones' parklands slightly differ, the number of species (14 each) and the species family (9 each) encountered is same between the Northern Guinea savannah and Southern Guinea savannah and the Sudan savannah (SS) and Southern Guinea savannah zones, respectively. Sudan savannah had two more species varieties and family of trees than the two sampled Guinea savannah zones. The tree species diversity index of all zones ranged from 1.27 to 1.39, with NGS having more diverse species composition than the SS and NGS. Shannon's index of species diversity of Northern Guinea savannah was slightly higher (H' [2.70] and $H_{\max}$ [4.50]) than Sudan and Southern Guinea savannah zones but less than 20% difference in quartile range. Similarly, the species evenness is also pronounced in the NGS (0.60) than the more arid SS zone, like the SGS zone. The trees biodiversity at the transitional zone exhibited abundance and diversity that are not different

Table 1. Biodiversity indices of the trees sampled across three agroecological zones.

Biodiversity indices	Sudan savannah	Northern Guinea savannah	Southern Guinea savannah
Tree Species diversity	1.27	1.39	1.35
Shannon Diversity index (H)	2.43	2.70	2.48
Shannon Maximum Diversity index ($H_{\max}$)	4.53	4.50	4.55
Equitability (Species evenness)	0.54	0.60	0.55
No. of individual trees	93	90	95
No. of tree species	16	14	14
No. of families	9	9	6

along the agroecosystem landscape changes between the arid land and the dry tropics of sub-Saharan Africa vegetation.

4.2. Tree Species Relative Status

The species relative density (RD) for trees in the sampled parklands plots of Sudan savannah (SS), Northern Guinea savannah (NGS) and Southern Guinea savannah (SGS) ranged from 0.1% to 42.74%, 4.5% to 14.6% and 4.21% to 16.8% respectively. *Parkia biglobosa* had the highest RD among the tree species across the studied AEZs, accounting to 15.22%, 16.41%, and 16.84% in SS, NGS and SGS, respectively. Other tree species like *Vitellaria paradoxa* (11.24% for NGS, 15.79% for SGS) and *Mangifera indica* (10.5% for NGS, 10.11% for SGS) also had higher relative density in two of the three studied AEZ parklands. Though *Gliricidia sepium* had one of the lowest densities in SS and NGS, the *Prosopsis africana* and *Phoenix dactylifera* tree species in SS are relatively very low in density just as NGS's *Balanites aegyptiaca* and *Eucalytpus camaldulensis*. It was also observed that species classified as low densities are rare across the agroecological landscapes.

There is a distinct variability in the species relative dominance among the studied agroecological zones. Sudan savannah had the highest variability, ranging from 0.1% (*Diospyrous mespilliformis*) to 42.73% (*Tamarindus indica*) thereby highlighting the unevenness in the species in the driest AEZ compared to other studied savannahs in the table. *Parkia biglobosa* still remain the most dominant parkland species across the three zones, having between 27.01% in SGS and 42.64% in SS. This is establishing the fact that tree species most preferred by the communities are densely populated on the farm plots across the zones. However, there is low relative dominance of *Vitellaria paradoxa* (1.06%) species in SS parklands, despite the species potentials in the Guinea savannah parklands is more evident.

The Importance Value Index (IVI) shows how dominant species is valued in a specified parkland area. The highest value for a parkland species in any zone suggests that the species is dominant on the agricultural landscape. In **Table 2**, the species with the highest IVI in the table, *Parkia biglobosa* cut across the three measured AEZ ranging between 31.2% - 50.25%. Other species with higher IVI in all the AEZs include *Mangifera indica* (14.18%), *Azadirachta indica* (13.7%), and *Adansonia digitata* (8%). On the species with the lowest IVI, *Eucalyptus camaldulensis* (1.78%), *Gliricidia sepium* (3.01%), and *Phoenix dactylifera* (1.35%) were lowest for SGS, NGS and SS, respectively. Furthermore, *Eucalyptus camadulensis* value almost doubled as the agrobiodiversity gradient shifts northward across the AEZs, SS fields had more IVI for the tree species than the other two zones. The IVI increases for all species at the transitional AEZ (NGS) than the other zones sampled.

The abundance status of tree species across the AEZ encountered is same (33.3% each) as presented in **Figure 3**. The Fabaceae family were found in abundance with Sudan savannah (SS) and Southern Guinea savannah (SGS)

Table 2. Tree species distribution frequency, relative status in all sampled plots.

AGROECOLOGICAL ZONE	TREE SPECIES	FAMILY	SPP FREQ.	RD	RDO	IVI	STATUS	TOTAL NO. OF TREES
Sudan savannah	*Mangifera indica*	Anacardiaceae	6	6.52	0.69	3.96	Abundant	92
	Phoenix dactylifera	Arecaceae	2	2.17	0.25	1.35	Rare	
	Diospyrous mespilliformis	Ebenaceae	4	4.35	0.10	2.277	Abundant	
	Vachellia nilotica	Fabaceae	4	4.35	0.28	2.46	Frequent	
	Tamarindus indica	Fabaceae	12	13.04	42.72	7.58	Abundant	
	Parkia biglobosa	Fabaceae	14	15.22	42.64	50.25	Abundant	
	Gliricidia spp	Fabaceae	1	1.09	0.08	0.62	Rare	
	Prosopsis africana	Fabaceae	1	1.09	0.82	1.36	Rare	
	Vitex altissima	Lamiaceae	4	4.35	0.73	2.90	Frequent	
	Adansonia digitata	Malvaceae	8	8.70	3.65	7.99	Abundant	
	Azadirachta indica	Meliaceae	19	20.65	3.37	13.69	Abundant	
	Ficus spp	Moraceae	4	4.35	0.96	3.13	Frequent	
	Eucalyptus camaldulensis	Myrtaceae	5	5.44	1.76	4.47	Abundant	
	Vitellaria paradoxa	Sapotaceae	4	3.26	1.06	3.23	Occasional	
	Balanites aegyptiaca	Zygophyllaceae	5	5.44	0.87	3.04	Abundant	
Northern Guinea savannah	*Mangifera indica*	Anacardiaceae	9	10.11	9.10	14.17	Abundant	89
	Phoenix dactilyfera	Arecaceae	5	5.62	5.55	8.36	Frequent	
	Diospyrous mespilliformis	Ebenaceae	4	4.49	3.71	5.96	Frequent	
	Vachellia nilotica	Fabaceae	4	4.49	5.41	4.43	Frequent	
	Tamarindus indica	Fabaceae	5	5.62	3.07	5.88	Abundant	
	Parkia biglobosa	Fabaceae	13	14.61	31.15	38.45	Abundant	
	Gliricidia spp	Fabaceae	4	4.49	0.76	3.01	Frequent	
	Vitex altissima	Lamiaceae	5	5.62	5.41	8.22	Abundant	
	Adansonia digitata	Malvaceae	10	11.24	12.50	18.11	Abundant	
	Azadirachta indica	Meliaceae	5	5.62	3.68	6.49	Abundant	
	Eucalyptus camaldulensis	Myrtaceae	10	11.24	0.41	6.03	Abundant	
	Psidium guajava	Myrtaceae	4	4.49	0.64	2.89	Frequent	
	Vitellaria paradoxa	Sapotaceae	10	11.23	19.61	25.24	Abundant	
	Balanites aegyptiaca	Zygophyllaceae	2	2.25	2.20	3.32	Rare	
Southern Guinea savannah	*Mangifera indica*	Anacardiaceae	10	10.54	7.66	12.92	Abundant	
	Anarcadium occidentale	Anacardiaceae	6	6.32	8.27	11.43	Abundant	95
	Vachellia nilotica	Fabaceae	5	5.26	3.45	6.08	Frequent	
	Tamarindus indica	Fabaceae	7	7.37	3.58	7.26	Abundant	
	Parkia biglobosa	Fabaceae	16	16.84	27.01	35.43	Abundant	
	Gliricidia spp	Fabaceae	5	5.26	3.67	6.29	Abundant	
	Prosopsis africana	Fabaceae	8	8.42	8.51	12.72	Abundant	
	Danilie oliveri	Fabaceae	4	4.21	4.65	6.75	Frequent	
	Adansonia digitata	Malvaceae	4	4.21	1.80	3.90	Frequent	
	Azadirachta indica	Meliaceae	5	5.26	1.66	4.28	Abundant	
	Khaya senegalensis	Meliaceae	4	4.21	1.61	3.72	Frequent	
	Psidium guajava	Myrtaceae	4	4.21	0.65	2.76	Frequent	
	Eucalyptus camaldulensis	Myrtaceae	2	2.11	0.73	1.78	Rare	
	Vitellaria paradoxa	Sapotaceae	15	15.78	26.76	34.66	Abundant	

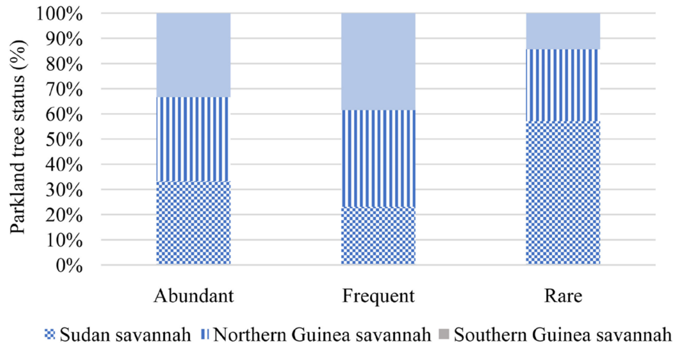

Figure 3. Tree species diversity status of studied parklands across the three agroecological zones.

zones having 5 and 6 tree species, respectively. Northern Guinea savannah had 4 species belonging to Fabaceae. Generally, Sudan savannah (SS) Fabaceae family status had more species as rare, the zone had other more families that were distinct (Meliaceae and Myrtaceae) with over 50% more than the other two AEZs. Though the no species were classified as occasional occurrence on the parkland landscapes, the SS had *V. paradoxa* species closest to being classified as one. Fewer tree species were classified in the frequent status of SS trees, the NGS and SS had equal percentage of species status.

4.3. Diameter Distribution of Parkland Trees in All Sampled Plots

The tree species diameter distribution graph revealed in Figure 4 below were all sampled within the three agroecological zones farm plots. The most frequent diameter class is 40 - 60 cm across the zones, with an average of at 18 - 30 trees/ha. The more frequent diameter class of parkland trees are the 20 - 40 cm and 60 - 80 cm with 10 and 15 trees/ha, respectively. The least number of boles (<10 trees/ha) in the diameter distribution class had the highest frequency in the Sudan savannah zone. This is because the zone had younger, slender, and diverse trees scattered on its landscapes, with thorny trees from *Acacia* and *Tamarindus* species having > 20 cm diameter at breast height (DBH). The Baobab trees dominated the monstrous (over 150 cm) bole size and increases as we go further into the driest agroecological zone. This result revealed that there is low regeneration rate of parkland trees per hectare (N/ha) and young trees decreases in dbh as the AEZ moves from SS to SGS. This is clearly confirming that most valuable trees by farmers are in the most frequent tree species dbh range (20 - 60 cm). These species include *Parkia biglobosa*, *Mangifera indica*, *Vitellaria paradoxa* and *Eucalyptus species*.

4.4. Chemical and Physical Properties of the Soil across the Parklands

The descriptive statistics summary of some soil chemical and physical properties in the three agroecological zones is shown in Table 3. The soil pH for the zones ranged between 5.0 and 8.4 with Sudan savannah (SS) having the highest mean

Table 3. Some chemical and physical properties of the sampled sites.

AGROECOLOGICAL ZONES	SUDAN SAVANNAH			NORTHERN GUINEA SAVANNAH			SOUTHERN GUINEA SAVANNAH		
Soil Properties	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD
pH level	5.4	8.4	6.67 ± 1.27	5	6	5.63 ± 0.45	5.1	7.8	6.33 ± 1.11
Available P (mg/l)	3	4.4	3.8 ± 0.59	4	9.4	6 ± 2.42	3	49.8	18.8 ± 21.8
Available K (mg/l)	18.2	54.4	40.8 ± 16.1	58	90.6	71 ± 14.1	28.2	184	87 ± 67.1
Available Mg (mg/l)	47.4	68	57.4 ± 8.42	67.2	124	83.1 ± 28.9	50.9	123	95.3 ± 31.72
Sand (2.00 - 0.063 mm)	85	87	86 ± 0.82	47	68	54.3 ± 9.7	78	81	79.3 ± 1.25
Silt (0.063 - 0.002 mm)	9	13	11 ± 1.63	24	43	36.3 ± 8.73	13	15	14 ± 0.82
Clay (<0.002 mm)	2	5	3 ± 1.41	8	10	9.33 ± 0.94	4	8	6.67 ± 1.89
Available Ca (mg/l)	249	430	328 ± 75.4	200	727	451 ± 215	572	909	773.3 ± 145.2
Organic Matter (w/w)	0.5	0.7	0.70 ± 0.16	1.6	2.2	1.8 ± 0.28	1	1.9	1.53 ± 0.39

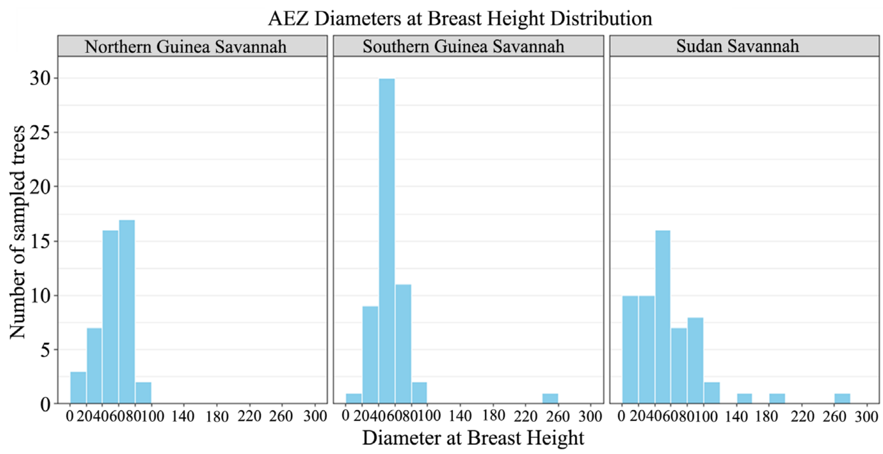

Figure 4. Tree species diameter distribution of studied parklands across the three agroecological zones of Nigeria.

value of 6.67 ± 1.27. Northern Guinea savannah (NGS) pH tends to be more acidic than others. The Sudan savannah and Southern Guinea savannah (SGS) have averagely same minimum amount of phosphorus (P), but the element availability increased exponentially in the SGS with the highest mean value of 18.86 ± 21.87. The soil available potassium (K) values for all the zones ranged between 18.2 and 184 mg/l with a high mean of 87 ± 67.1 and showing the highest deviation from mean at the SGS. The Mg mean range for all zones studied is between 57.47 and 95.3 mg/l. The highest and lowest mean of K sampled were found in NGS and SS, respectively.

Furthermore, Table 3 showed the Organic matter content ranged between 0.50 and 2.20 with the highest mean value of 1.8 ± 0.28 at the NGS. The general low organic matter content is because of extensive agricultural practices under low precipitation and high temperature with very low input for soil improvement. This is one of the main factors behind low agricultural productivity among small scale farmers scattered across Sub-Saharan Africa. The highest mean percentages for Sand, Silt and Clay in the AEZ were 54.33 ± 9.67, 36.33 ± 8.73, and 9.33 ± 0.94 at NGS zone, respectively.

5. Discussion

5.1. Variables Indices of Tree Biodiversity

This study confirmed that the parklands of northern Nigeria's agroecological zones are a repository of drought resistant indigenous and exotic but economic tree species scattered across major dry agroecosystems of West Africa (Adefisan & Abatan, 2015; Bayala et al., 2018; Weston et al., 2015). The tree species diversity of the three transitional AEZs is slightly lower than the reports on tree population study in urban and sub-tropical forests of Nigeria (Adekunle, 2006; Adeyemi et al., 2015; Agbelade et al., 2017). For instance, Agbelade et al. (2017) reported an average of 3.56 and 2.24 Shannon-Wiener diversity index of trees species in North-Central Nigeria, respectively. The similarity in tree species diversity indices among the AEZ studied also affirmed with the diversity study findings in the southern agroecological zones farmlands, exhibiting less than 5% tree species diversity in comparison to farms in forest zones (Lyam et al., 2012; Gonzalez, 2001). Thus, a large portion of economic tree species found in parklands is a fraction of tree species in tropical forest and farm landscapes across other agroecological zones in southern region Nigeria (Adeyemi et al., 2015; Agbelade et al., 2017). This tree species abundance (frequency and count) was also similar among the three studied AEZ just as reported in the findings of Agbelade et al. (2017) that there is no significant difference between urban and peri-urban areas of Guinea savannahs of Nigeria in terms of tree species diversity. Hence, parkland trees diversity serves as reservoir to biodiversity conservation, just as other forest landscapes despite the low rate in species richness.

Faye et al. (2011) reported that, traditionally, west African parklands have been classified as landscapes of significant biodiversity dominated by native species; evidence from this research as well as those from published data showed that dry tropical forest landscapes does contain relatively high biodiversity rate, including non-native species like *Mangifera indica* and *Eucalyptus camaldulensis* (Adeyemi et al., 2015; Brown, 2009). In contrary to the conclusion of Faye et al. (2011), there are indications that parklands contributed not only positively but also converting the negative functions to advantages through native and non-native trees outside forest to reduce drought and improve livelihoods. The results also showed that *Mangifera indica*, *Eucalyptus species*, *Azadirachta indica* are the three common exotic species found in the three studied AEZ. The high frequency of exotic species in the studied farmlands across the AEZ was reported as an invasive but useful trees contributing to livelihoods and managing environmental challenges facing savannahs of Africa (Amiebenomo, 2002; Ndegwa et al., 2017). For instance, *Anarcadium occidentale* is an agroforestry fruit tree gaining momentum across farms in Southern Guinea savannah zone mainly for its resilience thereby increasing the richness of parklands (Aliyu & Awopetu, 2006; Aliyu, 2007).

5.2. Relative Dominance of Trees across Parklands

The effect of climate change-induced anthropogenic activities on regeneration and distribution of tree species on parklands may have affected the dominant status of individual species in the agroecosystem, thereby favouring few species over other equally significant species (Bainbridge, 2017; Miller et al., 2016). The Fabaceae family was within the most prevalent family across the zones in the study. This might be because of their speedy regeneration potential, coupled with symbiotic characteristics enabling the species to establish a niche within dryland habitats. This finding is similar to studies by Adeyemi et al. (2015), Faye et al. (2010) and Oyebamiji et al. (2017) on parklands and forests in West Africa, the most prominent species were leguminous. Faye et al. (2010) reported that northern Mali had *Parkia biglobosa* and *Vitellaria paradoxa* as two of the most important parkland trees contributing to farmers' livelihoods and improving agrobiodiversity management and preservation. This is because of the similarity in agricultural landscape cover and the protection of tree species that are within same family hierarchy, such as fabaceae spreading across dryland geographical boundaries of sub-Saharan Africa. The dominance of Fabaceae and families in the results is also an adaptation strategy that relatively favours environmental factors such as dispersal of seeds, pollination of flowers for fruits and establishment of wildlings that eventually become protected and managed species (Jalloh et al., 2012; Leakey, 2014). The gradual disappearance of *Vitellaria paradoxa* in SS parklands is backed by some local community policy of managing conflict on land use resources through removal of the tree (especially along border lines of communal lands and farm plots). It is assumed that cutting down Shea trees will settle violent disputes among farmers in these arid communities where the species highly valuable nuts are used in soap making and as a product for merchants coming from Southern Nigeria (Lagos). Generally, the results in the table also indicated that species with the lowest relative dominance are like species observed with low relative density.

On the Importance Value Index (IVI), economic value was not considered while calculating the average between relative dominance and diversity of species in each AEZ but similar findings was reported in the species importance value in (Razavi et al., 2012) assessment of *Fagus orientali* species in Iran. Naidu & Kumar (2016) in their research confirmed wild mango and Cashew as some of the species among 2227 trees sampled with high IVI in the dry tropical landscapes of India. This important index is useful in forest management and biodiversity preservation. As it can be used to improve tree regeneration potential and the adoption of agroforestry on farmlands in dry landscapes using the available resources.

The relative diversity status of species across the AEZs is overwhelmingly abundant for parkland trees and more frequent for other hierarchical families among the zones. The frequency and diversity of trees are also reported in the West African study of tree functions by Adeyemi et al. (2015) & Aleza et al. (2015) where the driest landscapes had the highest number of species diversity that are leguminous and most preferred by farmers for improving fertility as well as income.

5.3. Tree Size Abundance in Parklands

In a participatory field work survey in Ghana, Lovett & Haq (2000) revealed how tree populations are selected by local farmers by eliminating unwanted woody species on parkland, favouring *V. paradoxa* based on size, spacing, growth and yield. The tree size matters as medium to large-diameter trees dominate the structure, function and dynamics of agroecosystems in sub-Saharan Africa landscapes (Brandt et al., 2016; Ilstedt et al., 2016; Wezel et al., 2006). The most frequent average tree diameter is at 40 - 60 cm across the AEZs but the driest zone (Sudan savannah) exhibited higher regeneration potentials (10 - 40 cm dbh) than other two zones, despite the drought threats. However, the species with the lowest dbh range are not necessarily the most dominant species just as confirmed in the tree dominance study by (Singh et al., 2016) in India where *Quercus* species are dominating as the most frequent (up to 80%) the tropical landscapes but with poor regeneration potential. This is in line with secondary succession of dry forests resilience strategy, where dominant species success to regenerate differs and is dependent on different environmental factors, including climate and anthropogenic effects of the location (Ademiluyi et al., 2008; Rishmawi & Prince, 2016).

5.4. Soil Capacity across the AEZ

Carsan et al. (2014) and Cerdán et al. (2012) explained that soil nutrients are an important edaphic factor that plays role in species richness and establishment of agroforestry species. They further highlighted that biodiversity variables responsible for the abundance and diversity of tree species across dryland landscapes are similar in soil nutrients. However, the Sudan savannah zone had more species diversity, despite the low fertility of the soil in that low rainfall zone. The scenario in the driest AEZ in this study contradicts the idea that higher the nutrient value in soils, the greater the species richness (Gonzalez, 2001). Resilient species (particularly the trees in Fabaceae family) can thrive even in extreme weather to provide manure for soil replenishment and thrive under harsh weather conditions as reported in studies done in West Africa landscapes (Bayala et al., 2003; Ilstedt et al., 2016; Ouedraogo et al. 2017).

6. Conclusion

McElhinny et al. (2005) concluded that there are no specific structural attributes for tree stands as different outcomes from multiple researches emphasised but mathematical system of indexing facilitates attributes usage and interpretation. This is in terms of actual stand conditions that link attributes to the provision of measurable agrobiodiversity such as this study. Here, the Important Value Index and Species evenness are the attributes that facilitated the real stand richness and diversity of the study sites. Briefly, the highest and lowest Important Value Index (IVI) values were found in *Parkia biglobosa* (50.25%) and *Gliricidia sepium* (0.62%) in the Susan savannah zone, *Parkia biglobosa* (38.45%) and *Psidium guajava* (2.89%) in the Northern Guinea savannah zone and *Parkia biglobosa* (35.43%) and *Eucalyptus camaldulensis* (1.83) in the Southern Guinea savannah zone. In other words, they are the parkland landscapes habitat generalists. This is because highest IVI value signifies species preference as strongly related to abundance/dominance on the agricultural landcapes. Other parkland species with high IVI values in the results include *Vitellaria paradoxa*, *Anarcardium occidentale Mangifera indica*, *Adansonia digitata*, *and Prosopsis africana*. These species are classified as abundant based on their relative density on the farms. On the species evenness, the Northern Guinea savannah slightly had provided more closeness in number of species because of the transitional vegetation attributes. This can be seen in the dominance of *Parkia biglobosa*, *Mangifera indica* and *Vitellaria paradoxa* in the zone. The species are the most significant agroforestry trees contributing to farmers' livelihoods in the drylands and improving agrobiodiversity management and the productivity of vast and vulnerable agricultural landscapes.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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