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VEGETATION DENSITY AND DIVERSITY IN THE DRYLAND OF NORTHWESTERN NIGERIA

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Abstract

Nigeria is endowed with diverse bio-resources. Despite high species diversity which distribution depends largely on climate, soils and human activities in the country, density measures low in the dry north. This study assessed vegetation density and diversity in the dryland of northwestern Nigeria with view to providing vital information on species density and diversity over large area for sustainable management of indigenous plants. Quadrat sampling was conducted to inventory plant species using 100m x 100m plot in each of the nineteen study locations. Result of this study indicated that a total of 50 plant species were encountered in the study area. These fall into 22 families, 35 trees, 13 shrubs and 2 herbs. Density and diversity found were low in the area. Analysis for these parameters showed that average density for the study area is 0.61/100m² while the highest density of 1.10/100m² was found in Asasaya (Jigawa) and the lowest of 0.25/100m² was found in Bugawa (Zamfara). Shannon index of 1.225 revealed that the diversity of species in the study area is low and well below 1.5 which is the typical lowest value in most ecological areas. Species evenness is low also as indicated by Pielou's index value of 0.172. Control of massive local exploitation of forest resources (wood fuel in particular) is recommended by this study.

Keywords: vegetation density, diversity, dryland, northwestern Nigeria

INTRODUCTION

Vegetation is a general term for the plant life of a region and a term without specific reference to particular taxa, life forms, structure, spatial extent or any other specific botanical or geographic characteristics (Jansen and Dengler, 2010). Vegetation involves the species (populations) of the local flora, which in turn involve different genetic, migration, historical or ecological elements (Box and Fujiwara, 2005).

Vegetation can be described in terms of structure, density, diversity, physiognomy, floristic composition, or varying combinations of these descriptors. This study assesses the density and diversity of plants because these are most important parameters for the stability and proper functioning of ecosystems (Schläpfer *et al*., 1999). Density is a measure of the numerical strength of species in a given community. It shows the number of stand obtained within a sampled area. Density is an important parameter for indicating human impact on species especially on dry landscapes. Species diversity is the identity and variety of elements in a population, including species lists and measures of species diversity and genetic diversity (Noss, 1990). Diversity concept relies on the apportionment of abundances (or some related quantities such as biomass or coverage) into a number of animal or plant categories forming the ecological community under study (Pielou, 1977).

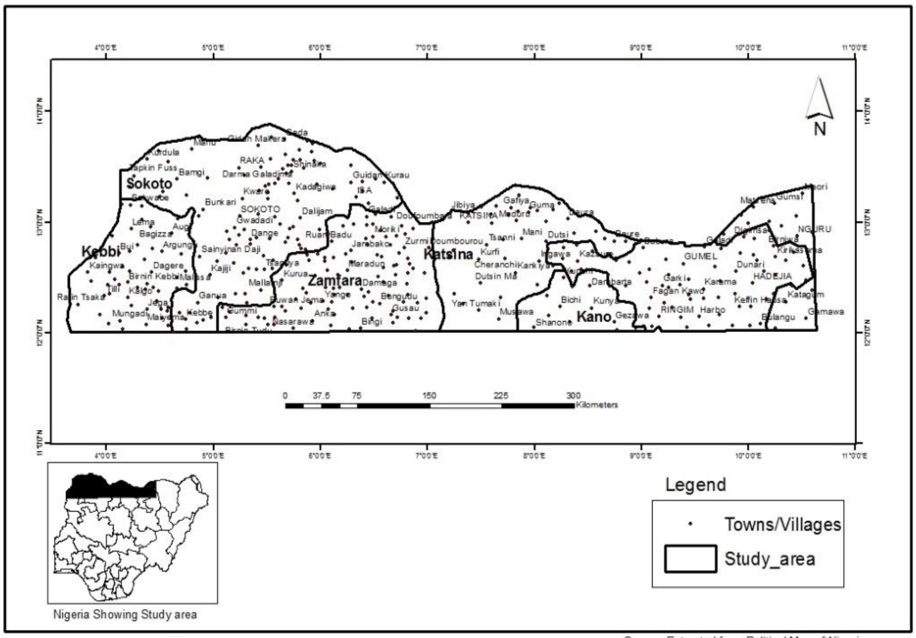
Although there are several studies on density and diversity of plants in northern Nigeria, assessment of these parameters is still needed in order to provide warning for increased vulnerability owing to the area's characterised seasonal climatic extremes and unpredictable rainfall patterns (Hess, 1999; Adakayi, 2012) as well as increasing population (Ickowicz *et al*., 2012) which have intense impact on vegetation over the last decades. Moreover, this was planned and worked out at broad geographic scales to provide information that will assist in developing sustainable programmes for the region. The hope is that comprehensive information provided by this work on vegetation density and diversity may inform debate about economic, social, and ecological sustainability of the region as well as improving public awareness and understanding of vegetation management in the dryland of northwestern Nigeria and in Nigeria at large.

STUDY AREA

Northwestern Nigeria is composed of three distinct geographic entities: Sokoto-Rima Basin, the Kano Region and the North Central Highlands (Udo, 1970). Of the Nigeria's total area of 923,768 km^2, northwestern region occupies a total of 226, 662 km^2. The dryland of Nigeria constitutes the Sudan and the Sahelian savanna with typical low rainfall and sparse vegetation. Mortimore and Adams (1999) noted that in Nigeria, the drylands are located north of latitude 12^{0}N. The study area lies within latitudes 12^{0}N and 14^{0}N and longitude 3^{0}E and 10.35^{0}E. It covers six states namely: Jigawa, Kano, Katsina, Zamfara, Sokoto and Kebbi. This study however covers Jigawa, Katsina, Zamfara and Sokoto.

Climate of northwestern Nigeria is the tropical wet and dry type. It is coded as 'Aw' by Koppen in which distinctive wet and dry seasons are caused by the fluctuations of the ITCZ (Inter-tropical convergence zone) or the ITD south to north to bring rainy season and north to south to bring dry season. The ITCZ separates humid maritime (mT) air mass originating from the Atlantic Ocean and dry desert air mass (cT). The ITCZ follows the apparent movement of the sun, (northwards in April – July and southwards in September – October).

Average annual rainfall in dryland of Nigeria varies from 500mm in the northeastern part to 1000mm in the southern sub-area, but it is unreliable in many parts. Unpredictability and unreliability characterize the pattern of rainfall in the area (Mortimore, 2001). In addition to high inter-annual variability, the rainfall regimes of dryland of Nigeria are highly concentrated in few months, often intermitted with violence of storms. Thus the region is, by nature, prone to recurrent and sometimes intense and persistent periods of drought (Mortimore and Adams, 1999).



Source: Extracted from Political Map of Nigeria

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Figure 1: Dryland of northwestern Nigeria

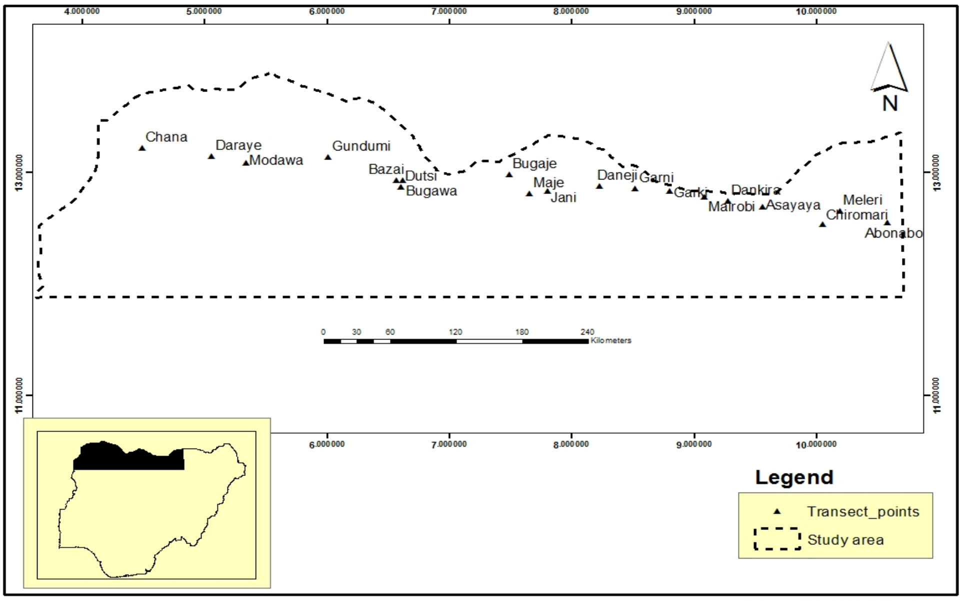
The vegetation type of northwestern Nigeria is of the West African type which follows the pattern of rainfall distribution. The northwestern Nigeria falls within Sudan Savanna zone of Nigeria, distinguished by large expanse of grasslands with widely spaced trees of varying heights and diversity. The Sudan savanna belt is found dominating the Sokoto Plains across to the Chad Basin, covering over a quarter of the country's land area. It is found in places with rainfall of about 600 - 1000 mm and 4 - 6 months of dry season. The vegetation is made up of grasses 1-2 m high and often stunted trees. Some of the most frequent trees in this environment are *Hyphaene thebaica*, *Parkia biglobosa, Adansonia digitata, Fadherbia albida, Tamarindus indica*, *Borassus aethiopum, Prosopis africana, Balanite aegyptiaca, Acacia nilotica* and exotic species such as *Azadirachta indica, Eucalyptus camaldulensis and Cassia siammea*.

RESEARCH METHODS

Sampling of Study Locations

Sampling of study villages was done using belt line transect method so as to capture the villages on either side of the line (Fewster, Laake, & Buckland, 2005). The line transect was plotted on a classified map of the study area diagonally, from the bottom right corner (latitude 12^0N and latitude 14^0N) to the top left corner (longitude 4.5^0E and longitude 10.8^0E) northwards.

The study area extends from Chana in the West to Abonabo in the East and cut across nineteen locations. These are: Abonabo, Chiromari, Meleri, Asayaya, Dankira and Mairobi (Jigawa State), Garki, Garni, Daneji, Jani, Maje, and Bugaje (Katsina State), Bugawa, Dutsi and Bazai (Zamfara), Gundumi, Modawa, Daraye and Chana (Sokoto State) (Figure 2).



Source: Data analysis (2016)

Figure 2: Study Locations in the Dryland of Northwestern Nigeria

Procedures for Data Collection and Analysis

Data for the study was sourced from quadrat sampling. The sampling was conducted using 100m x 100m tools in villages that are located on transect line which runs from Abonabo, Chiromari, Meleri, Asayaya, Dankira and Mairobi (Jigawa State); Garki, Garni, Daneji, Jani, Maje, and Bugaje (Katsina State); Bugawa, Dutsi and Bazai (Zamfara); Gundumi, Modawa, Daraye and Chana (Sokoto State). The choice of 100m x 100m is in line with Kindt & Coe (2005) who reported that quadrat should be large enough for differences related to vegetation to become apparent. The sampling which was conducted between January and March 2016 involved: quadrat laying, inventorying, identification and recording of species. Samples of unknown were collected on pressers and transported to herbarium of Department of Biological Sciences of Bayero University Kano for identification. Local names of plants were also collected. Data of collected from quadrat sampling is arranged in spreadsheet software (EXCEL) and analysed using formulae below as found in (Curtis & McIntosh, 1951). This is because the EXCEL program is particularly appropriate for data that are naturally arranged in a grid, such as the species recorded from a number of samples (Henderson, 2003). The following equations were used for data analysis:

1. Density was assessed using:

$$\textbf{Density} = \frac{\textbf{Number of Individual Species}}{\textbf{Size of Quadrat studied}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

2. Species diversity was determined using Shannon – Weiner index (Shannon and Weiner, 1963) as:

$$\mathbf{H=-\Sigma (Ni/N) \log_2 (Ni/N)\ I=1} \ldots\ldots 2$$

Where; **Ni**= Total number of individuals of a species, **N**= Total number of individuals of all species.

3. Species evenness which as a component of diversity was measured using Pielou's index:

$$\mathbf{J^I= H^I/H^I_{max}} \ldots\ldots 3$$

Where H^I is the number derived from the Shannon diversity index, $\mathbf{H^I_{max}}$ is the maximum possible value of $\mathbf{H^I= \ln(S)}$ and **S** is the total number of species.

RESULTS AND DISCUSSIONS

VEGETATION DENSITY

Density is a measure of the numerical strength of species in a given community. As an aspect of this study, density of plants was determined using a quadrat size of $100m^2$ in nineteen study locations of northwestern Nigeria. Table 1 shows that density of plants in the dryland of northwestern Nigeria.

Table 1: Vegetation Density

Villages	LGAs	States	Coordinates		Total No. of Plants Found	Density ($100m^2$)
			Nothings	Eastings		
Asayaya	Maigatari	Jigawa	$12^0 42^I 00.7^{II}$	$009^0 33^I 28.6^{II}$	110	1.10
Maje	Rimi	Katsina	$12^0 49^I 02.7^{II}$	$007^0 39^I 15.6^{II}$	100	1.00
Dankira	Sule tankarkar	Jigawa	$12^0 44^I 49.6^{II}$	$009^0 16^I 43.1^{II}$	92	0.92
Jani	Mani	Katsina	$12^0 50^I 14.5^{II}$	$007^0 48^I 10.1^{II}$	83	0.83
Garni	Zango	Katsina	$12^0 51^I 48.4^{II}$	$008^0 31^I 20.4^{II}$	75	0.75
Garki	Baure	Katsina	$12^0 50^I 29.3^{II}$	$008^0 48^I 09.2^{II}$	71	0.71
Abonabo	Gurri	Jigawa	$12^0 33^I 25.3^{II}$	$010^0 34^I 45.8^{II}$	69	0.69
Bugaje	Jibia	Katsina	$12^0 59^I 25.5^{II}$	$007^0 29^I 23.2^{II}$	63	0.63
Daneji	Dutsi	Katsina	$12^0 52^I 50.3^{II}$	$008^0 13^I 41.2^{II}$	59	0.59
Dutsi	Zurmi	Zamfara	$12^0 52^I 35.0^{II}$	$006^0 36^I 26.4^{II}$	56	0.56
Chana	Gudu	Sokoto	$13^0 13^I 19.7^{II}$	$004^0 29^I 17.2^{II}$	55	0.55
Chiromari	Malammadori	Jigawa	$12^0 32^I 31.8^{II}$	$010^0 03^I 15.5^{II}$	53	0.53
Mairobi	Babura	Jigawa	$12^0 47^I 00.0^{II}$	$009^0 05^I 01.1^{II}$	53	0.53
Gundumi	Goronyo	Sokoto	$13^0 08^I 31.8^{II}$	$006^0 00^I 38.4^{II}$	53	0.53
Bazai	Shinkafi	Zamfara	$12^0 56^I 06.4^{II}$	$006^0 34^I 06.6^{II}$	45	0.45
Meleri	Kirikasamma	Jigawa	$12^0 39^I 39.5^{II}$	$010^0 11^I 41.1^{II}$	36	0.36
Modawa	Kware	Sokoto	$13^0 05^I 42.5^{II}$	$005^0 20^I 15.8^{II}$	35	0.35
Daraye	Wamakko	Sokoto	$13^0 08^I 55.3^{II}$	$005^0 03^I 32.8^{II}$	35	0.35
Bugawa	Shinkafi	Zamfara	$12^0 56^I 06.5^{II}$	$006^0 37^I 07.1^{II}$	25	0.25

This study shows that density of plants in the study area is relatively low and ranges from 0.25 to $1.10/100m^2$ (Table 1). While an average density of $0.61/100m^2$ was found for the region, eight locations shows high species density. These are: Asayaya ($1.10/100m^2$), Maje

(1.00/100m^2), Dankira (0.92/100m^2), Jani (0.83/100m^2), Garni (0.75/100m^2), Garki (0.71/100m^2), Bugaje (0.63/100m^2) and Abonabo (0.69/100m^2). Low species densities in the region are found in Bazai (0.45/100m^2), Meleri (0.36/100m^2), Modawa (0.35/100m^2), Daraye (0.35/100m^2) and Bugawa (0.25/100m^2) (Table 1).

From the above, one can conclude that variations occur in terms of species density across the study area. According to a report by FORMECU (1998) this is always found when large geographical areas with distinct features are studied. Variations in density of species in northwestern Nigeria can be attributed to both natural and human-induced disturbances that characterize the area. Distinct seasonal and year-to-year fluctuation of rainfall may be responsible for the pattern. Kowal and Kassam (1973) had earlier computed a higher negative correlation (r = 0.77) between rainfall and latitudinal position in northern Nigeria. This value signifies that the higher the latitude the less the rainfall. All the study locations are located at the extreme northern end of Nigeria (their co-ordinates in Table 1), thus low annual rainfall could be the dominant factor influencing variations in species density in the area. Plate 1 showed the typical nature of the area during the long dry season.

Plate 1: A cross-section showing sparsely vegetated field with dotted short trees in Bazai Village, Shinkafi Local Government of Zamfara State, Nigeria

Although administrative boundaries do not matter in such as distribution, result in Table 1 reveals that most locations in Jigawa and Katsina have high densities than those in Sokoto and Zamfara States. Variations in amount of rainfall in the study area and its reduction northward may be one factor that explains the differences in density of the species across the region. This corroborates the finding of EC-FAO (2003) that the effect of rainfall on vegetation of Nigeria is such that it tends to thin out as one move from the rainforest of the south to the Sahel savanna of the extreme northern Nigeria.

This study found that high densities of species found in Asayaya, Dankira villages (Jigawa) and Maje (Katsina) villages (Table 1) may arise from strict enforcement of local law that permits only lopping and pollarding for fuel wood in the three villages. Discussions show that *Andropogon gayanus* and *Pennisetum hordoides* are collected during rainy season and stored in silos to feed animals in the dry season hence cutting of woody plants for fodder is not allowed in Dankira and Asayaya villages.

Possibly, a reason for high densities in Maje and Jani villages is agroforestry which was promoted through the intervention programmes of Katsina State Afforestation Programme Unit (KTAPU). As of the time of data collection, villagers in Maje mentioned that through KTAPU, tree seedling particularly *Parkia biglobosa* were distributed for planting on farms. In addition to that, strict local level laws are in place in the two villages which prohibit the cutting of trees without prior permission from the village authorities.

There are areas with low density as well. Species densities in Meleri ($0.36/100m^2$) and Daraye ($0.35/100m^2$) are low perhaps because field observations show that these villages provide fuel wood to Hadejia and Sokoto towns respectively. This corroborates the finding of Anderson and Fishwick (1984) that fuelwood consumption now exceeds natural regeneration by 70% in Sudan, 75% in northern part of Nigeria, about 150% in Ethiopia and 200% in Niger. This finding further corresponds to Anderson (1986) who reported that in southern and northern Nigeria, farm tree densities have declined from 15% per hectare in 1950's to 3% per hectare in 1970's as a result of fuel wood extraction.

Low species density in Bugawa ($0.25/100m^2$) occurred probably as a result of two factors. First is the soil texture that is coarse in the village which perhaps retards the growth and survival of species in the areas. This corroborates Traore *et al.* (2008) who reported that soil texture influences the differences in species distribution within plant community. A combination of low rainfall and fine-textured soils can lead to very low soil water potentials and impact the vegetation in a way reminiscent of even dryer conditions (Axelsson & Hanan, 2017). This study supports the findings of numerous authors including Veldhuis, Rozen-Rechels, Roux, Cromsigt, Berg, & Olff (2016) and Axelsson & Hanan (2017) who reported that woody densities were most strongly influenced by rainfall seasonality and that higher levels of vegetation aggregation in African Savannas are generally associated with high seasonality, low mean annual precipitation (MAP), fine-textured soils, and relatively flat terrain respectively. Secondly, local regulations in some parts of Zamfara that used tree cover as a criterion to define protected areas, as reported farmers choose to remove young trees to avoid future legal problems.

Land tenure security, often defined as the assurance that land-based property rights will be upheld by society is a critical determinant of forest outcomes that slow deforestation

(Robinson, Holland, & Naughton-Treves, 2011). Ordonez *et al*. (2014) also found that when farmers feel unsecured, their willingness to invest in tree regeneration subsides and protection fades. This may cause low species density in Bazai (0.45/100m^2) (Table 1). This confirms the report of a study that selective logging and fuelwood extraction are major causes of forest degradation worldwide (United Nations Framework Convention on Climate Change, 2006).

As observed, Modawa has low density of species (0.35/100m^2) probably because of dry season farming which compels people of the area to clear large hectares of land to grow onions, potatoes and vegetables. This confirms the findings of FORMECU (1998) who reported that in Nigeria agricultural lands increased from 53.8 percent to 60.8 percent of the total land area 1976 to 1995, with a concomitant loss of natural habitats like savannas and forests. The study also corroborates Gibbs *et al.* (2007) who reported that agricultural expansion has been the most important proximate cause of recent forest loss, accounting for 80% of deforestation worldwide, primarily during the 1980s and 1990s.

VEGETATION DIVERSITY

Species diversity can be partitioned into two components: *richness* and *evenness* (Chiarucci, Maccherini, & De Dominicis, 2001). Indexes are used to assess diversity of species. These, although *ad hoc* functions of the species abundance includes Shannon, Simpson, Magurran indexes. However, Shannon index was used for the assessment of plant diversity in this study.

Shannon index (H^I) is sensitive to rare and abundant species. Sensitivity to rare species increases as one decrease from 1 (Shannon, 1948). According to Kent & Coker (1992) Shannon index allows analysis of not only the number of species but how the abundance of the species is distributed among all the species in the community. Typical values are generally between 1.5 and 3.5 in most ecological studies and the index is rarely greater than 4 (Kent and Coker, 1992).

From Table 2, Shannon index ($H^{I)}$ value for 1222 species encountered in dryland of northwestern Nigeria is 1.225. As it appears the value is well below 1.5 and this indicates low diversity. By this value (Table 2), it can be concluded that there is low species richness and evenness as well as apparent lack of order (entropy) in the study area.

Table 2: Diversity Index for Vegetation

Botanical Names	Shannon Index
Piliostigma reticulatum	0.139
Faidherbia albida	0.117
Guiera senegalensis	0.105
Azadirachta indica	0.096
Ziziphus Mauritania	0.088
Acacia nilotica	0.057
Balanite aegyptiaca	0.054
Calatropis procera	0.037

Securinega virosa	0.035
Cassia sieberiana	0.034
Adansonia digitata	0.033
Lannea acida	0.032
Acacia seyal	0.032
Annona senegalensis	0.031
Perguleria tomentosa	0.027
Combretum micranthum	0.023
Hyphaene thebaica	0.022
Sclerocarya birrea	0.019
Parkia biglobosa	0.018
Mitragyna inermis	0.017
Dichrostachys cinerea	0.015
Ziziphus spina-christi	0.015
Tamarindus indica	0.014
Terminalia avicennoioides	0.014
Indigofera tictora	0.012
Commiphora Africana	0.011
Diosphyros mespiliformis	0.011
Alyscicarpus vaginalis	0.011
Acacia macrostachya	0.011
Waltheria indica	0.011
Hyphaene thebaica	0.008
Bauhinia rufescens	0.008
Borassus aethiophum	0.008
Rogeria adenophylla	0.008
Anogiessus leiocarpus	0.006
Diospyros mespiliformis	0.006
Ficus thonningii	0.006
Sesbania dalzielli	0.006
Bauhinia rufescens	0.004
Combretum lamprocarpum	0.004
Vitex doniana	0.004
Albizia chevalieri	0.004
Ficus iteophylla	0.004
Bauhinia rufescens	0.002
Lonchocarpus cyanescens	0.002
Prosopis Africana	0.002
Ficus spp.	0.002
Butyrospermum parkii	0.002
Cassia singuena	0.002
Ficus sycomorus	0.002
Feretia apodanthera	0.002
	H^I=1.225

H^I= Shannon index

Finding of this study on H^I (1.225) agrees with Dikko (2012) with H^I (1.45) who found that that lack of evenness in Dabagi Forest Reserve resulted to low H^I value in the area studied. It however disagrees with Ahmad (2012) with H^I (2.62) in Kogo Forest Reserve in Katsina State as well as Zakari (2015) with H^I (3.769), (3.767) and (2.628) in three sampled plots in Baturiya Wetlands in Jigawa State were high richness and evenness are observed.

It was also found out that the H^I of the study area is closer to what is obtained is some forest reserves in northwestern Nigeria. This finding reinforces the hypothesis that farmers raise species on farmlands which otherwise would only be found in the natural vegetation. This corresponds with Atta-Krah *et al.* (2004) who reported that the farmers rejuvenate plants in parkland system thereby contributing to species diversity. This corresponds with the opinions of many authors e.g (Atta-Krah *et al.,* 2004) regarding the specialty of farmers in rejuvenating plants in parkland system thereby contributing to species diversity. Trees (mainly *Adansonia digitata, Balanite aegyptiaca, Borassus aethiopum, Faidherbia albida*) are carefully protected by villagers as they provide shade, soil nutrients, fruit and wood in Seno plain, Dogon Mali (Brandt *et al*., 2014).

Diversity is determined by the combination of abiotic constraints, biotic interactions, and disturbances (Frelich *et al*., 1998; Misir *et al*., 2007). Likely factors for low Shannon index value in the study area are marginal climatic conditions of northern Nigeria. Rainfall is perhaps the dominant factor responsible for low diversity and evenness of species in the study area. Persistent erratic rainfall in the study area may slow regenerative capacity of most plants in the study area. There are scientific evidences suggesting rainfall to be a limiting factor in the dryland. Swaine (1996) reported that species diversity may show clear associations with climate, typically on regional scales of hundreds of kilometres. This agrees with Le Houérou (2009) and Brandt *et al.* (2017) who noted that persistent low rainfall affects the regenerative capacity of many indigenous species in Africa. Drought also has particular lethal effects on vegetation; causing dieback or death of established trees, preventing seedling establishment as well as eventual cover change (Allen *et al.*, 2010).

SPECIES EVENNESS FOR PLANTS

Species evenness is a measure of the relative abundance of species that make up the richness of an area, with evenness being maximum (J=1) when all species have similar population size. The higher the values of J, the more even the species are in their distribution within quadrat (Kent & Coker, 1992). Mayden (1997) noted that species richness and species evenness are probably the most frequently used measures of the total biodiversity of a region. Species evenness (E) is a measure of equitability of spread.

Species evenness for species in the dryland of northwestern Nigeria was calculated using Pielou's index (J). J value for the study area is 0.172 (Table 3). Being an indicator of evenness, this value is low. It indicates high unevenness in the distribution of species in the area. Finding of this study on low J value of the study area confirms Danjibo (2015) who reported J value of 0.12091 in Kuwanka Banza Forest Reserve, Kebbi. It also corroborates Ndah, Andrew and Becham (2013) with J (0.90) for trees and J (0.87) for shrubs in Takamanda Rainforest in Cameroon. It however disagrees with Ahmad (2012) with J (0.78) in Kogo Forest Reserve, Katsina State.

Table 3: Species Evenness

Shannon Index	1.225
Total No. of Species	1222
Species Evenness Index	**0.172**

This low J values may be connected to disproportionate human activities in the area which directly impinge on the evenness of plants especially on farmed parklands of the study area. There are no limits to destruction of bushes for fuelwood and other uses in most villages studied. This agrees with Soulé (1991) that human activities though not limited to the direct destruction, conversion, or degradation of ecosystems can result to loss of entire assemblages of species.

CONCLUSION

This study found high variation in the area in terms of density and diversity of species. Species density is perhaps one of the lowest in northern Nigeria. At an average vegetation density of $0.61/100m^2$ and lowest $0.25/100m^2$, one could argue that the next few generations will live in a region that may not sustain people. With the diversity index of 1.225 and evenness index of 0.172, very serious threats to the region's vegetation is the conclusion of this study. Those findings augment the currently available data of species decline in the northern Nigeria (Federal Government of Nigeria, 2001). This can serve as baseline data for projecting the impact of current and future climate change scenarios and human activities on plants and for guiding local, regional and national reforestation/afforestation efforts in Nigeria.

The dryland of northwestern Nigeria is in most pressing crises. Despite several efforts to ensure the survival of vegetation, this study calls for continuous monitoring and assessment because consequence of loss of biological diversity may threaten the supply of basic environmental services and genetic make-up of species in the study area. This low density and diversity of species in the study area if not addressed, may likely hamper important and costly ecosystem services like pollination and pest control and this could compromise the region's resilience.

RECOMMENDATIONS

1. Control of massive local exploitation of forest resources (wood fuel in particular) is recommended by this study. In order to achieve this, highly restrictive protected area management policies of the past should be complemented by new ones. Options with a minimal risk of increasing land conflicts such agroforestry should be encouraged in the surrounding areas.

2. Further research on the sustainability of NTFP collection, processing and marketing is necessary, as an option that can substitute the overexploitation of multipurpose trees resources by people of the region.

REFERENCES

Adakayi, P.A. (2012). *An Assessment of the Rainfall and Temperature Variations in Parts of Northern Nigeria.* A Thesis submitted to the School of Post-Graduate Studies, University of Jos, in fulfillment of the Requirements for the Award of Degree of Doctor of Philosophy in Environmental Resources Planning.

Ahmad, B. (2012). *Tree Species Diversity and Soil Status of Kogo Forest Reserve in North-western Nigeria*. Unpublished Master of Science (forest Biology and Silviculture) Dissertation, Usmanu Danfodio University, Sokoto, Nigeria

Allen, C.D., Macalady, A.K., Chenchouni, H., Bachelet, D., McDowell, N. *et al*. (2010). A Global Overview of Drought and Heat-induced Tree Mortality Reveals Emerging Climate Change Risks for Forests. *For. Ecol. Manag.*, 259:66- 84

Anderson, D. & Fishwick, R. (1984). *Fuelwood Comsumption and Deforestation in African Countries.* World Bank Staff Working Paper No. 704. The World Bank, Washington, DC

Anderson, D. & Fishwick, R. (1984). *Fuelwood Comsumption and Deforestation in African Countries.* World Bank Staff Working Paper No. 704. The World Bank, Wasington, DC

Anderson, D. (1986). Declining tree stocks in African countries. *World Development Report*, 14 (7):853-863.

Atta-Krah, K., Kindt, R., Skilton, J.N. & Amaral, W. (2004). Managing biological and genetic diversity in tropical agroforestry. *Agroforestry Systems*, 61:183-194.

Axelsson, C.R. & Hanan, N.P. (2017). Patterns in Woody Vegetation Structure across African Savannas. *Biogeosciences Discuss.*, doi:10.5194/bg-2017-7

Box, E.O. & Fujiwara, K. (2005).Vegetation types and their broad-scale distribution. **In:** van der Maarel, E. (ed.) (2005). *Vegetation Ecology*. Blackwell Science Ltd, Oxford, UK

Brandt, M., Verger, A., Diouf, A., Baret, F. & Samimi, C. (2014). Local Vegetation Trends in the Sahel of Mali and Senegal Using Long Time Series FAPAR Satellite Products and Field Measurement (1982–2010). *Remote Sens.*, 6:2408-2434; doi:10.3390/rs6032408

Brandt, M., Tappan, G., Diouf, A., Beye, G., Mbow, C. & Fensholt, R. (2017). Woody Vegetation Die off and Regeneration in Response to Rainfall Variability in the West African Sahel. *Remote Sens.,* 9:39; doi:10.3390/rs9010039

Chiarucci, A., Maccherini, S. & De Dominicis, V. (2001). Evaluation and monitoring of the flora in a nature reserve by estimation methods. *Biological Conservation,* 101:305-314.

Curits, J.T. & McIntosh, R.P. (1951). An Upland Forest Continuum in the Prairie-Forest Border Region on Wisconsin. *Ecology*, 32:476-496. http://dx.doi.org/10.2307/1931725

Danjibo, M. (2015). *Assessment of Land Use/Land Cover Change and Floristic Composition of Kuwanka Banza Forest Reserve Kebbi State, Nigeria.* An Unpublished Master of Science (forest biology and silviculture) Dissertation Submitted to the Department of Forestry and Environment, Usmanu Danfodiyo University, Sokoto, Nigeria.

Dikko, A.A. (2012). *Tree Species Density and Diversity Distribution in Dabagi Forest Reserve.* Unpublished B. Forestry project, Department of Forestry and Fisheries, Usmanu Danfodiyo University, Sokoto.

EC-FAO (2003). *Experience of Implementing National Forest Programmes in Nigeria*. EC-FAO Partnership Programme (2000-2003).

Federal Government of Nigeria (2001). *First National Biodiversity Report*. Nigeria

Fewster, R.M., Laake, J.L. & Buckland, S.T. (2005). Line transect sampling in small and large regions. *Biometrics,* 61:856-859.

Forestry Management, Evaluation and Co-ordinating Unit, FORMECU (1998). *The Assessment of Vegetation and Land Use Changes in Nigeria between 1976/78 and 1993/95,* FORMECU, Federal Department of Forestry/World Bank, Nigeria

Frelich, L.E., Sugita, S., Reich, P.B., Davis, M.B. & Friedman, S.K. (1998). Neighbourhood Effects in Forests: Implications for within stand patch structure. *Journal of Ecology*, 86:149-161

Gibbs, H.K., Brown, S., Niles, J.O. & Foley, J.A. (2007). Monitoring and estimating tropical forest carbon stocks: making REDD a reality. *Environ. Res. Lett.,* 213:054023

Henderson, P.A. (2003). *Practical Methods in Ecology*. Blackwell Publishing, Oxford, UK

Hess, T.M. (1999). *The impact of climatic variability over the period 1961- 1990 on the soil water balance of upland soils in the North East Arid Zone of Nigeria*. PhD Thesis submitted to the Institute of Water and Environment, Cranfield University, UK

Ickowicz, A., Ancey, V., Corniaux, C., Duteurtre, G., Poccard-Cappuis, R., Touré, I., Vall, E., & Wane, A. (2012). Crop-livestock production systems in the Sahel – increasing resilience for adaptation to climate change and preserving food security. . **In**: Meybeck, A., Lankoski, J., Redfern, S., Azzu, N. & Gitz, V. (2012). *Building Resilience for Adaptation to Climate Change in Agriculture Sector*. Proc. Joint FAO-OECD workshop, Roma, FAO, 23–24 April, 2012.

Jansen, F. & Dengler, J. (2010). Plant names in vegetation databases – a neglected source of bias. *Journal of Vegetation Science,* 21: 1179–1186.

Kent, M. & Coker, P. (1992). *Vegetation Description and Analysis. A Practical Approach.* John Wiley and Sons, Chichester, England

Kindt, R. & Coe, R. (2005).*Tree Diversity Analysis. A manual and software for common statistical methods for ecological and biodiversity studies.* World Agroforestry Centre (ICRAF), Nairobi

Kowal, J.M. & Kassam, A.H. (1973). An Appraisal of Drought affecting groundnut production in the Guinea and Sudan savanna areas of Nigeria. *Savanna,* 2(2): 159-64

Le Houérou, H.N. (2009). *Bioclimatology and Biogeography of Africa.* Springer-Verlag Berlin Heidelberg.

Mayden, R.I. (1997). A Hierarchy of species concepts: the denouement in tha saga of the species problem. **In**: Claridge, M.F., Dawah, H.A. and Wilson M.R (eds). *Species: the units of biodiversity*. Chapman and Hall, London UK

Misir, N., Misir, M., Karahalil, U. & Yavuz, H. (2007). Characterization of soil erosion and its implication to forest management. *Journal of Environmental Biology*, 28:185-191

Mortimore, M. & Adams, W.M. (1999). *Working the Sahel: Environment and Society in Nigeria*. Routledge, London

Mortimore, M. (2001). A Profile of Rainfall Change and Variability in the Kano – Maradi Region, 1960 – 2000. *Drylands Research Working Paper 25,* Dry land Research, Crewkerne, UK.

Ndah, N.R., Andrew, E.E. & Bechem, E. (2013). Species composition, diversity and distribution in a disturbed Takamanda Rainforest, South West, Cameroon. *African Journal of Plant Science*, Vol. 7 (12): 577-585

Noss, R.F. (1990). Indicators for monitoring biodiversity: A hierarchical approach. *Conservation Biology,* 4:355–364.

Ordonez, J.C., Luedeling, E., Kindt, R., Tata, H.L., Harja, D., Jamnadass, R. & van Noordwijk, M. (2014). *Current Opinion in Environmental Sustainability*, 6:54–60

Pielou, E.C. (1977). *Mathematical Ecology*. Wiley, New York

Robinson B.E., Holland M.B. & Naughton-Treves L. (2011). *Does secure land tenure save forests? A review of the relationship between land tenure and tropical deforestation*. CCAFS Working Paper no. 7. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Schläpfer, F., Schmid, B. & Seidl, I. (1999). Expert estimates about effects of biodiversity on ecosystem processes and services. *Oikos* 84: 346–352.

Shannon, C.E. (1948). A Mathematical Theory of Communications. *Bell System Technical Journal,* 27: 379-423

Shannon, C.E. & Weiner, W. (1963).*The mathematical theory of communication*. University of Illinois Press, Urbana, Illinois

Soulé, M.E. (1991). Conservation: Tactics for a constant crisis. *Science,* 253:744–750

Swaine, M.D. (1996). Rainfall and soil fertility as factors limiting forest species distributions in Ghana. *Journal of Ecology,* 84: 419-428.

Traore, S., Nygard, R., Guinko, S. & Lepage, M. (2008). Impact of *Macrotermes* termitaria as a source of heterogeneity on tree diversity and structure in a Sudanian savannah under controlled grazing and annual prescribed fire (Burkina Faso). *Forest Ecology and Management,* 255:2337-2346.

Udo, R.K. (1970).*Geographical Regions of Nigeria,* Heinemann, London

UNFCCC (2006). *Scientific, socio-economic, technical and methodological issues related to deforestation in developing countries.* Background Paper for the Workshop on Reducing Emissions from Deforestation in Developing Countries

Veldhuis, M.P., Rozen-Rechels, D., Roux, E., Cromsigt, J.P., Berg, M.P. & Olff, H. (2016). Determinants of patchiness of woody vegetation in an African savanna. *Journal of Vegetation Science,* Vol.28, Issue 2:1-12

Zakari, H.H. (2015). *Vegetation Composition and Conservation Status of Baturiya Wetland, Jigawa State, Nigeria.* A Thesis Submitted to the School of Postgraduate Studies, Ahmadu Bello University Zaria, Nigeria