

Diversity and Regeneration Potentials of Some Non-Timber Forest Product Species (NTFPS) in Bagale Hill Forest Reserve, Girei Local Government Area of Adamawa State

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study assessed diversity and regeneration of some Non-Timber Forest Products (NTFPs) species in Bagale Hills Forest Reserve Girei Local Government Area of Adamawa State, Nigeria. Parameters evaluated included; species diversity of NTFPs in the study area and regeneration potentials of NTFPs in the study area. A sampling design consisting of an approximately 250m baseline and 5 transects of 20m was used. Thus, all NTFPs individuals, from seedlings to adult individuals, of each species were recorded and their DBH measured. The distance between consecutive transects was 50m. Diversity indices and Importance Value Index (IVI) of the species were determined using relevant formulae. One-way Analysis of Variance (ANOVA) was used to compare results of Shannon Weiners Diversity Indices amongst transects and amongst tree, sapling and seedling species. The results of tree, saplings and seedling species in study site revealed 12, 9 and 10 species respectively. The individual trees, saplings and seedlings species were 41, 39 and 53 belonging to 7 families in the study site respectively. Analysis of Variance (ANOVA) indicated that there was no significant difference in Shannon Weiners Diversity Indices

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among tree, sapling and seedling species in the forests ($p \geq 0.05$). Results show species of NTFPs tree which included; *Annona senegalensis*, *Adansonia digitata*, *Bombax Costatum*, *Detarium microcarpum*, *Haematostaphis barteri*, *Hexalobus monopetalus*, *Parkia biglobosa*, *Tamarindus indica*, *Ximeria americana*, *Vitellaria paradoxa*, *Ziziphus Mauritania* and *Ziziphus spina-christi*. The families with the highest number included Annonaceae, Fabaceae and Rhamnaceae which had 2 species each. *Vitellaria paradoxa*, *Annona senegalensis* and *Tamarindus indica* were the most abundant in Transects I-III, while *Parkia biglobosa*, and was the most abundant in Transects IV-V. *Vitellaria paradoxa*, *Annona senegalensis*, *Tamarindus indica* and *Parkia biglobosa* are further shown to have the highest Importance Value Index in all Transects. Results further showed saplings species as they occurred in all the Transects with *Vitellaria paradoxa*, *Annona senegalensis* and *Detarium microcarpum* as the most abundant saplings species and highest Importance Value Index. Results showed seedling species of NTFPs encountered in all transects in which *Hexalobus monopetalus*, *Ziziphus Mauritania* and *Detarium microcarpum* occurred as the most abundant seedling species. Shannon-Weiner (H') Diversity Indices were; $H' = 1.16223$, $H' = 0.86756$, $H' = 1.62602$, $H' = 1.05492$ and $H' = 1.32966$ in the respective transects. Shannon-Weiner (H') Diversity Indices of all NTFPs trees, saplings and seedlings were; trees $H' = 2.39016$, saplings $H' = 1.70359$ and seedlings $H' = 1.86854$ respectively.

Keywords: Diversity; (NTFPs); regeneration; saplings and seedlings.

1. INTRODUCTION

1.1 Background of the Study

Forests are vital natural environments for the conservation of biological diversity and the delivery of several ecological functions and services. Natural regeneration promotes the sustainability of natural forest ecology as it involves the silvicultural practice of 'close-to-nature' forestry [1,2]. Natural regeneration facilitates the establishment and growth of native species [3] and hence enhances stability, resilience and diversity of forest ecosystems [4]. It is influenced by disturbances because patterns of regeneration rely greatly on interactions between disturbance regimes (i.e., intensity, frequency, and scale) [5]. High intensity of anthropogenic disturbances adversely affects species abundance, diversity Bongers et al. [6]; Hammond et al. [2] and regeneration in general. Population structure is the distribution of individuals of each species in arbitrarily to provide the overall regeneration profile of the forest based on tree density, height, frequency, diameter at breast height, species importance value and basal area (Temesgen and Warkineh, 2020). Examination of patterns of species population structure could provide valuable information about their regeneration and/or recruitment status as well as viability status of the population that could further be employed for devising evidence-based conservation and management strategies [7].

Regeneration is the ability for a cell tissue or organism to recover from damage. It can also be

used to describe the ability of an ecosystem specifically, the environment and its living population to recover from damage. Regeneration is basic to the continuation of forest, as well as to the afforestation of treeless land. Regeneration can take place through self-sown seed ("natural regeneration"), by artificially sown seed, or by planted seedlings. In either case, the performance of regeneration depends on its growth potential and the degree to which its environment allows the potential to be expressed [8].

Seed, of course, is needed for all regeneration modes, both for natural or artificial sowing and for raising planting stock in the nursery. "Human-assisted natural regeneration" means establishment of a forest age class from natural seeding or sprouting in an area after harvesting in that area through selection cutting, shelter (or seed-tree) harvest, soil preparation, or restricting the size of a clear-cut stand to secure natural regeneration from the surrounding trees [9]. The process of natural regeneration involves the renewal of forests by means of self-sown seeds, root suckers, or coppicing. In natural forests, conifers rely almost entirely on regeneration through seed. Most of the broadleaves, however, are able to regenerate by the means of emergence of shoots from stumps (coppice) and broken stems [10].

Seedlings are young plant (Sporophyte) developing out of a plant embryo, seedlings also refer to a very young tree which are less than 2.5cm in context to Diameter at Breast Height (DBH). Saplings are plants which are generally

marked by 2.5 to 15cm in context to DBH. Seedling and Saplings are two different juvenile life stages of a tree (Raghubanshi and Tripathi, 2009). The regeneration status/potential of species in a community can be accessed from the total population dynamics of seedlings and saplings in the forest community [11,12]. The overall pattern of population dynamics of seedlings, saplings and adults of a plant's species can exhibit the regeneration profile, which is used to determine their regeneration status [13,12]. A population with sufficient number of seedlings and saplings depicts satisfactory regeneration behavior, while inadequate number of seedlings and saplings of the species in a forest indicates poor regeneration [14, 12].

There is little or no current information on the diversity and regeneration potentials of NTFPs in Bagale Hills Forest Reserve Girei Local Government Area of Adamawa State. The increasing deterioration of non-timber forest products (NTFPs) forest resources as a result of anthropogenic activities, as well as the expanding consequences of climatic variability and change, necessitate a shift in natural resource management practices.

There is not been sufficient documentation on density and natural regeneration potential on selected NTFPs species in the study area. Moreover, there is little information on density and natural regeneration on juvenile plant and coppice that have established naturally to replace those which died or have been killed in the Sudan savannah zone. There is a need to provide information on the species that are naturally regenerated and potentials of NTFPs and also provide more awareness on unknown species selected for NTFPs that will provide more income and food security to both urban and rural populace.

2. MATERIALS AND METHODS

2.1 Study Area

2.1.1 Location

Adamawa State is located at the North Eastern part of Nigeria. It lies between latitude 8° and 11° N of the equator and longitude 12° E and 13° E of the Greenwich meridian (Fig. 1). The study was carried in Bagale Hills Forest Reserve, Girei Local Government Area of Adamawa State Nigeria. The area lies between Latitudes $10^{\circ}.3'$ N and $12^{\circ}.20'$ N and Longitude $12^{\circ} 12'$ and

$12^{\circ}.21$ and $12^{\circ}.40'$ E of the State and has an elevation of 339metres above sea level (Fig. 2). The study Area is located within North Central part of Adamawa State [15].

The annual rainfall in the state range from 700 mm in the north – west part to 1600 mm in the Southern part. Generally, mean annual rainfall is less than 1000 mm in the central and north – western part of the state. The mean length of rainy season ranges from 120 – 210 days in the state [15].

2.1.2 Vegetation distribution

The major vegetation formations in the state are the southern Guinea savannah, Northern Guinea Savannah, and the Sudan Savannah (Fig. 2). Within each formation is an interspersed of thickets, tree savannah, open grass savannah and fringing forests in the river valleys. It is however necessary to note that large scale deforestation resulting from indiscriminate extraction of wood for fuel and expansion of agricultural land areas have left large areas within each vegetation type with few indigenous woody plant species [16,17]. Most areas especially those close to settlements are covered with exotic species such as the neem and eucalyptus trees. However, the original forest types could still be found in patches in each zone and particularly along the Nigerian –Cameroon borders where there has been little or no disturbance on the forest ecosystem [15].

2.2 Study Design

2.2.1 Reconnaissance survey

A rapid assessment of the area was conducted to ease data collection for the study and identify various study location.

2.3 Data Collection

1. A sampling design consisting of an approximately 250m baseline and 5 transects of 20m was used. The distance between consecutive, transects was 50m.
2. Identification of tree species were done with the help of Trees, Shrubs and Lianas of West Africa dry zones and Trees of Nigerian by Arbonnier (2004) and Keay et al. [18].
3. Thus, all NTFPs individuals, from seedlings to adult individuals, of each species were recorded and their DBH measured. Saplings are the young trees

with diameter size class of 2cm to 6cm. The tree seedlings are those with diameter size class $\leq 2\text{cm}$ as recommended by Luoga [19] and Lejju [18] and each individual of the tree species in the regeneration transect were enumerated.

4. The girths were measured at breast height 1.3m. The height of each tree was measured using Haga altimeter following the procedures of (Pearson et al., 2013).

2.4 Data Analysis

Importance value index (IVI), density, frequency, and the basal area of the data collected from the field were analyzed based on Mishra [20] formulae and regeneration potentials as described by Yakubu et al. [21]

- i. Species listing was done using tables.

- ii. Basal Area = $\frac{g^2}{4\pi}$

Where, g = Girth, $\pi = \frac{22}{7} = 3.14$

- iii. Density = $\frac{\text{Number of Individuals}}{\text{Area sampled}}$

- iv. Relative Density = $\frac{\text{Density for a species}}{\text{Total Density for all species}} \times 100$

- v. Dominance = $\frac{\text{Total basal area or arial coverage values}}{\text{Area sampled}}$

- vi. Relative Dominance = $\frac{\text{Dominance for a species}}{\text{Total number of plots sampled}} \times 100$

- vii. Frequency = $\frac{\text{Number of plots in which species occurs}}{\text{Total of plots sampled}}$

- viii. Relative Frequency = $\frac{\text{Frequency value for a species}}{\text{Total of frequency values for all species}} \times 100$

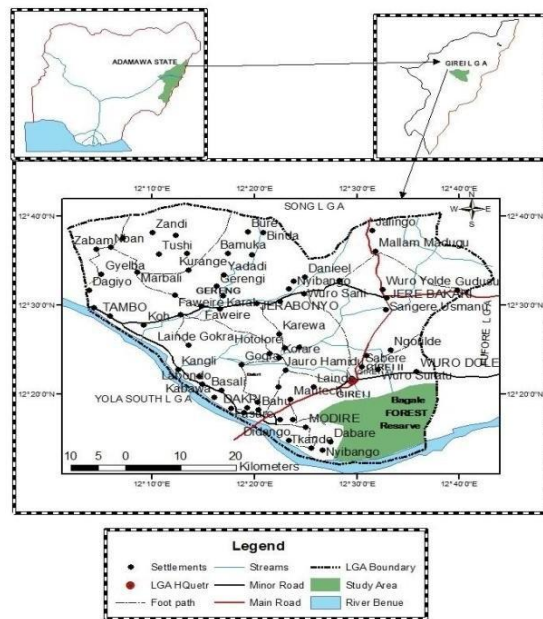
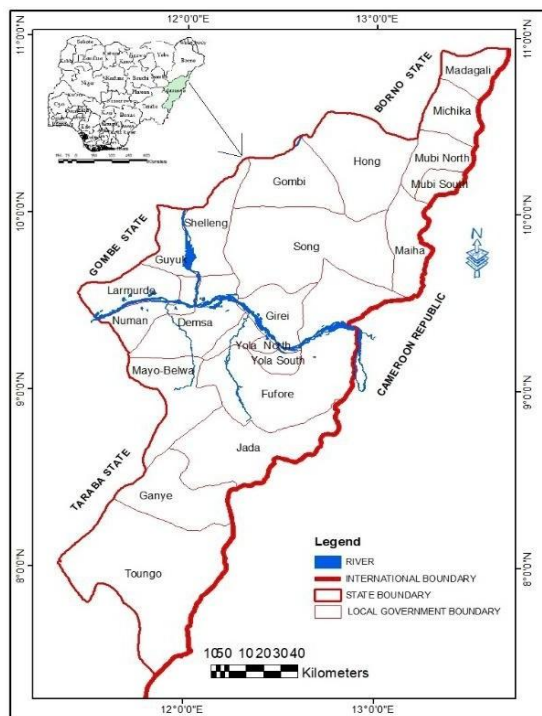
- ix. Importance value = relative density + relative dominance + relative frequency
 - a. (The importance value ranges from 0 – 300) [22].

- x. Regeneration Potential

$$(RP) = \frac{\text{Number of Seedling per Sapling}}{\text{Number of Parent tree per ha}}$$

- xi. Shannon's diversity index: $H' = -\sum P_i \ln p_i$

Where, H' = Shannon diversity and P_i = proportion of individual species, \ln = natural logarithm.



Figs. 1 and 2. Map of Adamawa State and Girei showing the study area

One-way Analysis of variance (ANOVA) was performed to examine whether NTFPs Shannon-Weiner (H') Diversity Indices varied among transect for NTFPs tree and saplings species.

3. RESULTS

3.1 NTFPs Trees, Saplings and Seedlings Regeneration Potentials in the Study Area

Tables 1-3 shows the various NTFPs which included trees, saplings and seedlings as they occurred in the study site. The species included, *Annona senegalensis*, *Adansonia digitata*, *Bombax costatum*, *Detarium microcarpum*, *Haematostaphis barterii*, *Hexalobus monopetalus*, *Parkia biglobosa*, *Tamarindus indica*, *Ximania americana*, *Vitellaria paradoxa*, *Ziziphus mauritania* and *Ziziphus spina-christi*.

A total of 12 different NTFPs Tree species were found belonging to 9 families. The checklist of NTFPs sapling species found in all the Transects enumerated in the Forest Reserve is shown in Tables 1-3. From the study area a total of 53 seedlings from 10 tree species and 39 saplings from 9 tree species were recorded. The families with the highest number included Annonaceae, Fabaceae and Rhamnaceae which had 2 species each while other families had 1 species each. Results in Table 4 showed species diversity indices of NTFPs tree as they occurred in the various transects. *Vitellaria paradoxa*, *Annona senegalensis* and *Tamarindus indica* were the most abundant in Transects I-III, while *Parkia biglobosa*, as the most abundant in Transects IV-V. *Vitellaria paradoxa*, *Annona senegalensis*, *Tamarindus indica* and *Parkia biglobosa* are further shown to have the highest Importance Value Index in Transect I-V.

Table 1. Checklist of tree species by transects in the study sites

S/No.	Family	Species	Per transects				
			I	II	III	IV	V
1	Annonaceae	<i>Annona senegalensis</i>	-	x	-	-	-
2	Malvaceae	<i>Adansonia digitata</i>	-	-	-	x	-
3	Fabaceae	<i>Tamarindus indica</i>	x	-	x	-	x
4	Bombacaceae	<i>Bombax costatum</i>	-	x	-	-	-
5	Rhamnaceae	<i>Ziziphus Mauritania</i>	-	-	-	x	-
6	Rhamnaceae	<i>Ziziphus spina-christi</i>	-	-	x	-	-
7	Fabaceae	<i>Detarium microcarpum</i>	x	-	x	-	x
8	Oleaceae	<i>Ximania Americana</i>	-	-	x	-	-
9	Anacardiaceae	<i>Haematostaphis barterii</i>	-	-	-	-	x
10	Annonaceae	<i>Hexalobus monopetalus</i>	x	x	x	-	-
11	Sapotaceae	<i>Vitellaria paradoxa</i>	x	-	x	-	-
12	Mimosoideae	<i>Parkia biglobosa</i>	-	-	-	x	x

Source: Field Survey (2021)

Key: x = Present, - = Absent

Table 2. Checklist of sapling species by transects in the study sites

S/No.	Species	Per transects				
		I	II	III	IV	V
1	<i>Annona senegalensis</i>	-	x	-	-	x
2	<i>Adansonia digitata</i>	-	-	-	x	-
3	<i>Tamarindus indica</i>	x	-	-	-	x
4	<i>Bombax costatum</i>	-	-	-	-	-
5	<i>Ziziphus mauritania</i>	-	-	-	-	-
6	<i>Ziziphus spina-christi</i>	-	-	x	-	-
7	<i>Detarium microcarpum</i>	x	x	x	x	x
8	<i>Ximania Americana</i>	-	x	-	-	-
9	<i>Haematostaphis barterii</i>	-	-	-	-	-
10	<i>Hexalobus monopetalus</i>	x	-	x	-	x
11	<i>Vitellaria paradoxa</i>	x	-	-	-	-
12	<i>Parkia biglobosa</i>	-	-	-	x	x

Source: Field Survey (2021)

Key: x = Present, - = Absent

Table 3. Checklist of seedlings species by transects in the study sites

S/No.	Species	Per transects				
		I	II	III	IV	V
1	<i>Annona senegalensis</i>	x	x	-	-	-
2	<i>Adansonia digitata</i>	-	-	x	-	-
3	<i>Tamarindus indica</i>	x	-	-	-	-
4	<i>Bombax costatum</i>	-	-	-	-	-
5	<i>Ziziphus mauritania</i>	-	-	x	-	-
6	<i>Ziziphus spina-christi</i>	-	-	-	-	-
7	<i>Detarium microcarpum</i>	x	x	-	-	x
8	<i>Ximania Americana</i>	-	-	x	-	x
9	<i>Haematostaphis barterii</i>	-	-	-	-	x
10	<i>Hexalobus monopetalus</i>	x	x	-	x	-
11	<i>Vitellaria paradoxa</i>	-	-	-	x	-
12	<i>Parkia biglobosa</i>	-	-	-	x	-

Source: Field Survey (2021)

Key: x = Present, - = Absent

Table 4. Trees species diversity indices in Transect I – V

S/No	Family	Species	F	D	RD	Rdo	RF	IVI
Transect I								
1	Annonaceae	<i>Hexalobus monopetalus</i>	1	0.001	9.1	4.2	9.1	22.4
2	Fabaceae	<i>Detarium microcarpum</i>	4	0.004	36.4	23.2	36.4	96.0
3	Fabaceae	<i>Tamarindus indica</i>	1	0.001	9.1	0.0	9.1	18.2
4	Sapotaceae	<i>Vitallaria paradoxa</i>	5	0.005	45.5	72.5	45.5	163.4
	Total		11		100.0	100.0	100.0	300.0
Transect II								
1	Annonaceae	<i>Hexalobus monopetalus</i>	1	0.001	16.7	0.6	16.7	34.0
2	Bombacaceae	<i>Bombax costatum</i>	1	0.001	16.7	26.5	16.7	59.8
3	Annonaceae	<i>Annona senegalensis</i>	4	0.004	66.7	72.9	66.7	206.2
	Total		6		100.0	100.0	100.0	300.0
Transect III								
1	Olecaceae	<i>Ximania americana</i>	2	0.002	15.4	12.5	15.4	43.3
2	Sapotaceae	<i>Vitallaria paradoxa</i>	2	0.002	15.4	0.7	15.4	31.4
3	Fabaceae	<i>Detarium microcarpum</i>	1	0.001	7.7	0.4	7.7	15.8
4	Fabaceae	<i>Tamarindus indica</i>	5	0.005	38.5	82.3	38.5	159.2
5	Rhamnaceae	<i>Ziziphus spina-christi</i>	2	0.002	15.4	4.0	15.4	34.8
	Annonaceae	<i>Hexalobus monopetalous</i>	1	0.001	7.7	0.0	7.7	15.4
	Total		13		100.0	100.0	100.0	300.0
Transect IV								
1	Malvaceae	<i>Adansonia digitata</i>	1	0.001	20.0	30.2	20.0	70.2
2	Mimosoideae	<i>Parkia biglobosa</i>	2	0.002	40.0	67.8	40.0	147.8
3	Rhamnaceae	<i>Ziziphus mauritania</i>	2	0.002	40.0	2.0	40.0	82.0
	Total		5		100.00	100.00	100.00	300.00
Transect V								
1	Rhamnaceae	<i>Parkia biglosa</i>	2	33.3	33.3	32.5	33.3	99.2
2	Fabaceae	<i>Tamarindus indica</i>	2	33.3	33.3	13.9	33.3	80.6
3	Anacardiaceae	<i>Haematosphis barteri</i>	1	16.7	16.7	23.6	16.7	56.9
4	Fabaceae	<i>Detarium microcarpum</i>	1	16.7	16.7	30.1	16.7	63.4
	Total		6		100	100	100	300

Source: Field Survey (2021) Key: F = Frequency

D = Dominance

RD = Relative Density RDo = Relative Dominance RF = Relative Frequency

IVI = Importance Value Index

Table 5. Saplings diversity indices in Transect I - V

S/No	Family	Sapling Species	F	D	RD	Rdo	RF	IVI
Transect I								
1	Annonaceae	<i>Hexalobus monopetalus</i>	1	0.01000	10.0	2.927	10.0	20.1
2	Fabaceae	<i>Detarium microcarpum</i>	3	0.03000	30.0	10.359	30.0	60.5
3	Fabaceae	<i>Tamarindus indica</i>	1	0.01000	10.0	0.613	10.0	20.0
4	Sapotacaceae	<i>Vitellaria paradoxa</i>	5	0.05000	50.0	86.09	50.0	104.0
Total			10		100.0	100	100.0	300.0
Transect II								
1	Annonaceae	<i>Annona senegalensis</i>	4	0.004	50.0	14.5	50.0	114.5
2	Olcaceae	<i>Ximania americana</i>	1	0.001	12.5	2.4	12.5	27.4
3	Fabaceae	<i>Detarium microcarpum</i>	3	0.003	37.5	7.7	37.5	82.7
Total			8		100.0	100.0	100.0	300.0
Transect III								
1	Fabaceae	<i>Detarium microcarpum</i>	4	0.004	57.1	75.8	57.1	190.0
2	Rhamnaceae	<i>Ziziphus spina-christi</i>	2	0.002	28.6	19.7	28.6	76.7
3	Annonaceae	<i>Hexalobus monopetalus</i>	1	0.001	14.3	4.7	14.3	33.3
Total			7		100.0	100.0	100.0	300.0
Transect IV								
1	Malvaceae	<i>Adansonia digitata</i>	1	0.001	16.7	71.4	16.7	104.8
2	Mimosoideae	<i>Parkia biglobosa</i>	1	0.001	16.7	26.1	16.7	59.5
3	Fabaceae	<i>Detarium microcarpum</i>	4	0.004	66.7	2.6	66.7	135.9
Total			6		100.0	100	100.0	300
Transect V								
1	Fabaceae	<i>Tamarindus indica</i>	1	0.001	12.5	11.321	12.5	36.3
2	Fabaceae	<i>Detarium microcarpum</i>	4	0.004	50	68.794	50	168.8
3	Annonaceae	<i>Annona senegalensis</i>	1	0.001	12.5	16.339	12.5	41.3
4	Annonaceae	<i>Hexalobus monopetalus</i>	2	0.002	25	3.526	25	53.5
Total			8		100.0	100	100.0	300

Source: Field Survey (2021)

Key: F = Frequency; D = Dominance; RD = Relative Density; RDo = Relative Dominance
RF = Relative Frequency; IVI = Importance Value Index

Results in Table 5 further showed species diversity indices of saplings species as they occurred in all the Transects. *Vitellaria paradoxa* and *Annona senegalensis* were the most abundant saplings species in Transects I-II, while *Detarium microcarpum*, was the most abundant in Transects III-V. *Vitellaria paradoxa*, *Annona senegalensis* and *Detarium microcarpum* are further shown to have the highest Importance Value Index in Transect I-V.

Results in Table 6 showed seedling species of NTFPs encountered in Transects I - V. *Hexalobus monopetalus* was the most abundant with 7 (50 %) in Transect I, *Detarium microcarpum* with 8 (47.1 %) seedling species in

Transect II, *Ziziphus mauritania* species with 3 (50 %) seedling species in Transect III, *Hexalobus monopetalus* with 4 (50 %) seedling species in Transect IV and *Detarium microcarpum* with 4 (50 %) seedling species in Transect V. Results in Table 7 show regeneration potentials of trees, saplings and seedlings species as they occurred in the study area.

3.2 Tree and Saplings NTFPs Shannon-Weiner (H') Diversity Indices of Species

Table 8 showed Shannon-Weiner (H') Diversity Indices of trees species in Transects I – V. The

respective Shannon-Weiner (H') Diversity Indices of Transects I – V stood at $H' = 1.16223$, $H' = 0.86756$, $H' = 1.62602$, $H' = 1.05492$ and $H' = 1.32966$. Appendix i show the ANOVA carried out on Shannon-Weiner (H') Diversity index of Transects I – V showed that there was no significant difference ($P \leq 0.05$).

Table 9 showed Shannon-Weiner (H') Diversity Indices of saplings species in Transects I – V. The respective Shannon-Weiner (H') Diversity Indices of Transects I – V stood at $H' = 1.6828$, $H' = 0.97431$, $H' = 0.9557$, $H' = 0.86756$ and $H' = 1.21301$. Appendix ii showed the ANOVA carried out on Shannon-Weiner (H') Diversity

index of Transects I – V showed that there was no significant difference ($P \leq 0.05$) amongst the sapling species in Transects I – V.

Results in Tables 10 - 12 showed Shannon-Weiner (H') Diversity Indices of all NTFPs trees, saplings and seedling. The respective Shannon-Weiner (H') Diversity Indices were trees $H' = 2.39016$, saplings $H' = 1.70359$ and seedlings $H' = 1.86854$ respectively. Appendix iii showed the ANOVA carried out on Shannon-Weiner (H') Diversity index of trees, saplings and seedling which showed that there was no significant difference ($P \leq 0.05$).

Table 6. Percentage of seedlings species in transect I - V

S/No	Family	Species	F	%
Transect I				
1	Fabaceae	<i>Detarium microcarpum</i>	5	35.7
2	Annonaceae	<i>Hexalobus monopetalus</i>	7	50.0
3	Annonaceae	<i>Annona senegalensis</i>	1	7.1
4	Fabaceae	<i>Tamarindus indica</i>	1	7.1
Total			14	100
Transect II				
1	Annonaceae	<i>Annona senegalensis</i>	6	35.3
2	Annonaceae	<i>Hexalobus monopetalus</i>	3	17.6
3	Fabaceae	<i>Detarium microcarpum</i>	8	47.1
Total			17	100
Transect III				
1	Rhamnaceae	<i>Ziziphus mauritania</i>	3	50
2	Olacaceae	<i>Ximania Americana</i>	1	16.7
3	Malvaceae	<i>Adansonia digitata</i>	2	33.3
Total			6	100
Transect IV				
1	Annonaceae	<i>Hexalobus monopetalus</i>	4	50
2	Sapotaceae	<i>Vitallaria paradoxa</i>	1	12.5
3	Mimosodeae	<i>Parkia biglobosa</i>	3	37.5
Total			8	100
Transect V				
1	Anacardiaceae	<i>Haematosphis barteri</i>	2	25
2	Fabaceae	<i>Detarium microcarpum</i>	4	50
3	Olacaceae	<i>Ximania americana</i>	2	25
Total			8	100

Source: Field Survey (2021) Key: F = Frequency

Table 7. Regeneration potentials of trees, saplings and seedlings in the study area

Species	Trees	Saplings	Seedlings
<i>Adansonia digitate</i>	1(2.44)	1(2.56)	2(3.77)
<i>Annona senegalensis</i>	4(9.76)	5(12.82)	7(13.21)
<i>Bombax costatum</i>	1(2.44)		
<i>Detarium microcarpum</i>	6(14.63)	18(46.15)	17(32.08)
<i>Haematosphis barteri</i>	1(2.44)		2(3.77)
<i>Hexalobus monopetalus</i>	3(7.32)	4(10.26)	14(26.42)
<i>Parkia biglobosa</i>	4(9.76)	1(2.56)	3(5.66)
<i>Tamarindus indica</i>	3(7.32)	2(5.13)	1(1.89)
<i>Vitallaria paradoxa</i>	7(17.07)	5(12.82)	1(1.89)
<i>Ximenia americana</i>	2(4.88)	1(2.56)	3(5.66)
<i>Ziziphus Mauritania</i>	2(4.88)		3(5.66)
<i>Ziziphus spina-christi</i>	2(4.88)	2(5.13)	

Source: Field Survey (2021) Key: Values in parenthesis are %

Table 8. Shannon's diversity index of trees species in Transect I - V

Species	F	Pi	lnPi	Pi lnPi
Transect I				
<i>Hexalobus monopetalus</i>	1	0.166667	-1.79176	-0.29863
<i>Bombax costatum</i>	1	0.166667	-1.79176	-0.29863
<i>Annona senegalensis</i>	4	0.666667	-0.40547	-0.27031
Total	6			0.86756
Transect II				
<i>Ximenia americana</i>	2	0.153846	-1.8718	-0.28797
<i>Vitallaria paradoxa</i>	2	0.153846	-1.8718	-0.28797
<i>Detarium microcarpum</i>	1	0.076923	-2.56495	-0.1973
<i>Tamarindus indica</i>	5	0.384615	-0.95551	-0.3675
<i>Ziziphus spina-christi</i>	2	0.153846	-1.8718	-0.28797
<i>Hexalobus monopetalous</i>	1	0.076923	-2.56495	-0.1973
Total	13			1.62602
Transect III				
<i>Ximenia americana</i>	2	0.153846	-1.8718	-0.28797
<i>Vitallaria paradoxa</i>	2	0.153846	-1.8718	-0.28797
<i>Detarium microcarpum</i>	1	0.076923	-2.56495	-0.1973
<i>Tamarindus indica</i>	5	0.384615	-0.95551	-0.3675
<i>Ziziphus spina-christi</i>	2	0.153846	-1.8718	-0.28797
<i>Hexalobus monopetalous</i>	1	0.076923	-2.56495	-0.1973
Total	13			1.62602
Transect IV				
<i>Adansonia digitate</i>	1	0.2	-1.60944	-0.32189
<i>Parkia biglobosa</i>	2	0.4	-0.91629	-0.36652
<i>Ziziphus Mauritania</i>	2	0.4	-0.91629	-0.36652
Total	5			1.05492
Transect V				
<i>Parkia biglosa</i>	2	0.333333	-1.09861	-0.3662
<i>Tamarindus indica</i>	2	0.333333	-1.09861	-0.3662
<i>Haematosphis barteri</i>	1	0.166667	-1.79176	-0.29863
<i>Detarium microcarpum</i>	1	0.166667	-1.79176	-0.29863
Total	6			1.32966

Source: Field Survey (2021)

Key: F = Frequency; Pi = Proportion of individual species; ln = Natural logarithm

Table 9. Shannon’s diversity index of sapling species in Transect I – V

Sapling Species	F	Pi	lnPi	Pi lnPi
Transect I				
<i>Hexalobus monopetalus</i>	1	0.1	-2.30259	-0.23026
<i>Detarium microcarpum</i>	3	0.3	-1.20397	-0.36119
<i>Tamarindus indica</i>	1	0.1	-2.30259	-0.23026
<i>Vitallaria paradoxa</i>	5	0.5	-0.69315	-0.34657
Total	10			1.16828
Transect II				
<i>Annona senegalensis</i>	4	0.5	-0.69315	-0.34657
<i>Ximenia americana</i>	1	0.125	-2.07944	-0.25993
<i>Detarium microcarpum</i>	3	0.375	-0.98083	-0.36781
Total	8			0.97431
Transect III				
<i>Detarium microcarpum</i>	4	0.571429	-0.55962	-0.31978
<i>Ziziphus spina-christi</i>	2	0.285714	-1.25276	-0.35793
<i>Hexalobus monopetalus</i>	1	0.142857	-1.94591	-0.27799
Total	7			0.9557
Transect IV				
<i>Adansonia digitate</i>	1	0.166667	-1.79176	-0.29863
<i>Parkia biglobosa</i>	1	0.166667	-1.79176	-0.29863
<i>Detarium microcarpum</i>	4	0.666667	-0.40547	-0.27031
Total	6			0.86756
Transect V				
<i>Tamarindus indica</i>	1	0.125	-2.07944	-0.25993
<i>Detarium microcarpum</i>	4	0.5	-0.69315	-0.34657
<i>Annona senegalensis</i>	1	0.125	-2.07944	-0.25993
<i>Hexalobus monopetalus</i>	2	0.25	-1.38629	-0.34657
Total	8			1.21301

Source: Field Survey (2021) Key: F = Frequency
 Pi = Proportion of individual species ln = Natural logarithm

Table 10. Shannon’s diversity index of NTFPs tree species in the study area

Species	F	Pi	lnPi	Pi lnPi
<i>Hexalobus monopetalus</i>	3	0.073171	-2.61496	-0.19134
<i>Detarium microcarpum</i>	6	0.146341	-1.92181	-0.28124
<i>Tamarindus indica</i>	3	0.073171	-2.61496	-0.19134
<i>Vitallaria paradoxa</i>	7	0.170732	-1.76766	-0.3018
<i>Bombax costatum</i>	1	0.02439	-3.71357	-0.09057
<i>Annona senegalensis</i>	4	0.097561	-2.32728	-0.22705
<i>Ximenia americana</i>	2	0.04878	-3.02042	-0.14734
<i>Tamarindus indica</i>	5	0.121951	-2.10413	-0.2566
<i>Ziziphus spina-christi</i>	2	0.04878	-3.02042	-0.14734
<i>Adansonia digitate</i>	1	0.02439	-3.71357	-0.09057
<i>Parkia biglobosa</i>	4	0.097561	-2.32728	-0.22705
<i>Ziziphus Mauritania</i>	2	0.04878	-3.02042	-0.14734
<i>Haematosphis barteri</i>	1	0.02439	-3.71357	-0.09057
Total	41			2.39016

Source: Field Survey (2021) Key: F = Frequency
 Pi = Proportion of individual species ln = Natural logarithm

Table 11. Shannon's diversity index of NTFPs sapling species in the study area

Species	F	Pi	lnPi	Pi lnPi
<i>Hexalobus monopetalus</i>	4	0.102564	-2.27727	-0.23357
<i>Detarium microcarpum</i>	18	0.461538	-0.77319	-0.35686
<i>Tamarindus indica</i>	2	0.051282	-2.97041	-0.15233
<i>Vitallaria paradoxa</i>	5	0.128205	-2.05412	-0.26335
<i>Annona senegalensis</i>	5	0.128205	-2.05412	-0.26335
<i>Ximenia americana</i>	1	0.025641	-3.66356	-0.09394
<i>Ziziphus spina-christi</i>	2	0.051282	-2.97041	-0.15233
<i>Adansonia digitate</i>	1	0.025641	-3.66356	-0.09394
<i>Parkia biglobosa</i>	1	0.025641	-3.66356	-0.09394
Total	39			1.70359

Source: Field Survey (2021) Key: F = Frequency
Pi = Proportion of individual species ln = Natural logarithm

Table 12. Shannon's diversity index of NTFPs Seedling Species in the Study Area

Species	F	Pi	lnPi	Pi lnPi
<i>Detarium microcarpum</i>	17	0.320755	-1.13708	-0.36472
<i>Hexalobus monopetalus</i>	14	0.264151	-1.33123	-0.35165
<i>Annona senegalensis</i>	7	0.132075	-2.02438	-0.26737
<i>Tamarindus indica</i>	1	0.018868	-3.97029	-0.07491
<i>Ziziphus mauritania</i>	3	0.056604	-2.87168	-0.16255
<i>Ximenia americana</i>	3	0.056604	-2.87168	-0.16255
<i>Adansonia digitate</i>	2	0.037736	-3.27714	-0.12367
<i>Vitallaria paradoxa</i>	1	0.018868	-3.97029	-0.07491
<i>Parkia biglobosa</i>	3	0.056604	-2.87168	-0.16255
<i>Haematosphis barteri</i>	2	0.037736	-3.27714	-0.12367
Total	53			-1.86854

Source: Field Survey (2021) Key: F = Frequency
Pi = Proportion of individual species ln = Natural logarithm

4. DISCUSSION

4.1 NTFPs Trees, Saplings and Seedlings Regeneration Potentials in the Study Area

A checklist of NTFPs tree species found in the forest revealed a total of 12 different species belonging to 9 families. These similarly reported in the vegetation zones of the state where this study was undertaken by Akosim et al. [23]. The different NTFPs tree species and their families are also similar to that reported by Sa'ad [24] in a study of assessment of tree regeneration potential in Bagale Hills Forest Reserve, Girei Local Government Area. This, notwithstanding, the species abundance in the studied sites appeared moderate. The result obtained had lower regenerating species compared to 213 documented by Sa'ad [24] in his study of assessment of tree regeneration potential in Bagale Hills Forest Reserve, Girei Local Government Area. The result had lower

regenerating species compared to 15 species documented by Nuraddeen [25] at the parklands of Katsina State. Nuraddeen [25] further reported a pattern of regeneration in which there were higher density of more mature stems and lower density of smaller stems (seedlings and saplings). The little differences may perhaps be attributed to variations in the level of exploitation.

Floristic inventory and diversity parameters help to know the composition and assortments of the forests (Phillips et al., 2003) which also recommend valuable information regarding to conservation aspects. The leading dominance of *Vitallaria paradoxa*, *Annona senegalensis*, *Tamarindus indica* and *Parkia biglobosa* species is similar to that reported by Sa'ad [24] in his study of assessment of tree regeneration potential in Bagale Hills Forest Reserve, Girei Local Government Area. Priority for conservation should be given based on their Importance value index values. i.e. the priority for species with

least Importance value index because they are at risk of local extinction and the last priority of conservation for species with highest Importance value index.

The regeneration status of NTFPs trees, saplings and seedlings species in the forest as summarized based on the total count of NTFPs trees, seedlings and saplings of each species across all Transects revealed that *Detarium microcarpum* contributed higher across species. The finding is in conformity to that reported by Sa'ad [24] in his study of assessment of tree regeneration potential in Bagale Hills Forest Reserve, Girei Local Government Area where *Detarium microcarpum* contributed 46.36% as tree, 43.7% as saplings and 45.3% as seedlings. The pattern of distribution shows maximum number of matured plant than saplings and seedlings. These might be as a result of seeds in seed banks being eaten before they germinate and delay in germination due to various types of the dormancy; or death of seedlings for various reasons. And also, the environmental conditions of soil moisture, temperature and light conditions alter the germination and/or survival of seedlings.

4.2 Diversity Indices of NTFPs Tree, Saplings and Seedlings Species

Depending on the available tree species in the study area, the diversity indices varied among the different Transects and also between Tree ($H' = 2.39016$), Saplings ($H' = 1.70359$) and Seedlings ($H' = 1.86854$) Species respectively. The findings on species diversity of this study varied with that reported by Sa'ad [24] in his study of assessment of tree regeneration potential in Bagale Hills Forest Reserve, Girei Local Government Area which shows that the tree species had the highest diversity of ($H' = 1.8628$), saplings ($H' = 1.2359$) and seedlings ($H' = 1.09264$) respectively. The Shannon Weiners diversity index of this study falls within the general limits of 1.5 - 3.5 [22].

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

There is evidence of anthropogenic interference in the study Area as shown by the species composition and diversities. Nevertheless, the NTFPs species diversity was seen to be moderate. The present rate of degradation is unsustainable through harvesting of trees for charcoal production, for firewood and other human uses, these further affect the

regeneration processes of the forest; it will be more if no action is taken.

5.2 Recommendations

In view of the findings of this study, the following recommendations are made:

- i. Reforestation should commence as soon as possible to restore the forest ecosystem in order to serve ecosystem functions.
- ii. Species with low Importance Value indices and those species with none to poor regeneration status should be prioritized for conservation.
- iii. Detailed regeneration studies are recommended to fully understand the causes and probable mechanisms that could promote natural regeneration.
- iv. A more integrated approach that creates exploitation quotas for the different NTFPs could allow for natural regeneration to occur, under which more diverse species can result in improved functional relationships.
- v. More detailed studies are essential to better inform government conservation policy at this site, as a way forward.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDICES

Appendix I: Shannon's Diversity index ANOVA for NTFPs Trees among Transects

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.017874	4	0.004468	1.37982	0.287803	3.055568
Within Groups	0.048576	15	0.003238			
Total	0.06645	19				

Source: Field Survey (2021)

Appendix II. Shannon's Diversity index ANOVA for NTFPs Saplings among Transects

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.003154	4	0.000788	0.285303	0.8819	3.259167
Within Groups	0.033161	12	0.002763			
Total	0.036315	16				

Source: Field Survey (2021)

Appendix III. Diversity index ANOVA of NTFPs Tree, Sapling and Seedling Species

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.000161	2	8.05E-05	0.009982	0.990071	3.327654
Within Groups	0.233749	29	0.00806			
Total	0.23391	31				

Source: Field Survey (2021)

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