# DIVERSITY AND REGENERATION POTENTIALS OF SOME NON-TIMBER FOREST PRODUCT SPECIES (NTFPS) IN BAGALE HILL FOREST RESERVE, GIREI LOCAL GOVERNMENT AREA OF ADAMAWA STATE


## 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 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, Detarrium microcarpum, Haematostaphis barteri, Hexalobus monopetalus, Parkia biglobosa, Tamarindus indica, Ximenia 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 *Detarrium 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 *Detarrium 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.


Key word: diversity, (NTFPs), regeneration, saplings and seedlings.

# INTRODUCTION

## 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 (Kuuluvainen and Laiho, 2004; Hammond *et al*., 2021). Natural regeneration facilitates the establishment and growth of native species (Danková and Saniga 2013) and hence enhances stability, resilience and diversity of forest ecosystems (Liira *et al*. 2011). It is influenced by disturbances because patterns of regeneration rely greatly on interactions between disturbance regimes (i.e., intensity, frequency, and scale) (de Carvalho *et al*., 2017). High intensity of anthropogenic disturbances adversely affects species abundance, diversity Bongers *et al*. (2009); Hammond *et al*. (2021) 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 (Abiyou *et al*., 2011).

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 (Grossnickle, 2000).

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 (Shiva, 2007). 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 (Dutta, 2013).

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 (Duchok *et al*., 2005;

Bogale *et al*., 2017). 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 (Bekele, 1994; Bogale *et al*., 2017). 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 (Tripathi and Khan, 2007; Bogale *et al*., 2017).

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.

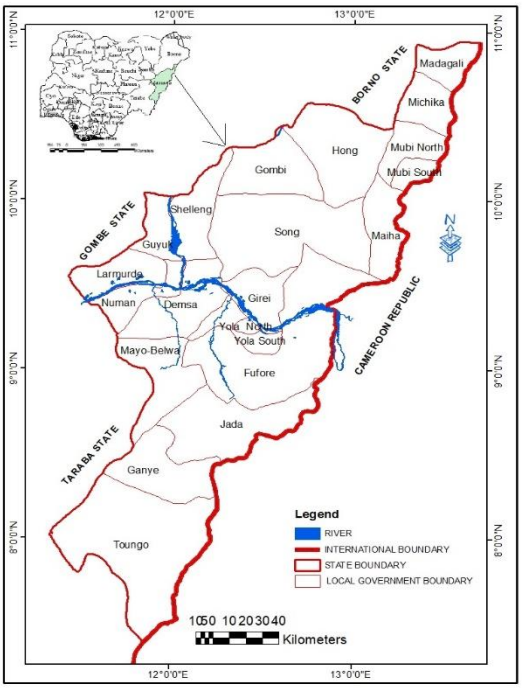
## MATERIALS AND METHOD

### Study Area

#### *Location*

Adamawa State is located at the North Eastern part of Nigeria. It lies between latitude $8^{o}$ and $11^{o}$ N of the equator and longitude $12^{o}$ E and $13^{o}$ E of the Greenwich meridian (Figure 1). The study was carried in Bagale Hills Forest Reserve, Girei Local Government Area of Adamawa State Nigeria. The area lies between Latitudes $10^{0}.3'$ N and $12^{0}.20'$ N and Longitude $12^{o}$ $12'$ and $12^{0}.21$ and $12^{0}$ .40' E of the State and has an elevation of 339metres above sea level (Figure, 2). The study Area is located within North Central part of Adamawa State (Adebayo *et al*., 2021).

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 (Adebayo *et al.*, 2020).



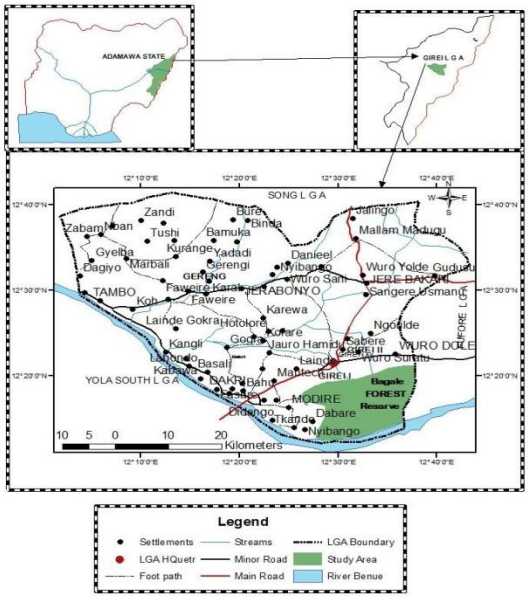




Figure 1 and 2: Map of Adamawa State and Girei showing the Study Area

### *3.1.6 Vegetation distribution*

The major vegetation formations in the state are the southern Guinea savannah, Northern Guinea Savannah, and the Sudan Savannah (Figure 2). Within each formation is an interspersion 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. 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 (Adebayo *et al.*, 2020).

**Study Design**

### *3.3.1 Reconnaissance Survey*

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

## 3.4 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*. (1964).
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 ≤ 2cm as recommended by Luoga (2004) and Lejju (2004) and each individual of the tree species in the regeneration transact 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).

## 3.5 Data Analysis

Importance value index (IVI), density, frequency, and the basal area of the data collected from the field were analyzed based on Mishra (2013) formulae and regeneration potentials as described by Yakubu *et al*., (2020);

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 = $\frac{Number\ of\ Individuals}{Area\ sampled}$

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

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

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

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

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

ix. *Importance value = relative density + relative dominance + relative frequency*

a. (The importance value ranges from 0 – 300) (Kent and Coker, 1992).

x. Regeneration Potential $(RP) = \frac{Number\ of \frac{Seedling}{Sapling} per\ ha}{Number\ of\ Parent\ tree \frac{per}{ha}}$

xi. Shannon's diversity index: H'= -∑ Pi ln pi

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

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.

## RESULTS

### 4.1 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. *Vitallaria 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. *Vitallaria paradoxa, Annona senegalensis, Tamarindus indica* and *Parkia biglobosa* are further shown to have the highest Importance Value Index in Transect I-V.

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 *Detarrium microcarpum*, was the most abundant in Transects III-V. *Vitellaria paradoxa*, *Annona senegalensis* and *Detarrium microcarpum* 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 | *Annona senegalensis* | - | x | - | - | - |
| 2 | Malvaceae | *Adansonia digitata* | - | - | - | x | - |
| 3 | Fabaceae | *Tamarindus indica* | x | - | x | - | x |
| 4 | Bombacaceae | *Bombax costatum* | - | x | - | - | - |
| 5 | Rhamnaceae | *Ziziphus Mauritania* | - | - | - | x | - |
| 6 | Rhamnaceae | *Ziziphus spina-christi* | - | - | x | - | - |
| 7 | Fabaceae | *Detarium microcarpum* | x | - | x | - | x |
| 8 | Oleaceae | *Ximania Americana* | - | - | x | - | - |
| 9 | Anacardiaceae | *Haematostaphis barterii* | - | - | - | - | x |
| 10 | Annonaceae | *Hexalobus monopetalus* | x | x | x | - | - |
| 11 | Sapotaceae | *Vitellaria paradoxa* | x | - | x | - | - |
| 12 | Mimosoideae | *Parkia biglobosa* | - | - | - | 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 | *Annona senegalensis* | - | x | - | - | x |
| 2 | *Adansonia digitata* | - | - | - | x | - |
| 3 | *Tamarindus indica* | x | - | - | - | x |
| 4 | *Bombax costatum* | - | - | - | - | - |
| 5 | *Ziziphus mauritania* | - | - | - | - | - |
| 6 | *Ziziphus spina-christi* | - | - | x | - | - |
| 7 | *Detarium microcarpum* | x | x | x | x | x |
| 8 | *Ximania Americana* | - | x | - | - | - |
| 9 | *Haematostaphis barterii* | - | - | - | - | - |
| 10 | *Hexalobus monopetalus* | x | - | x | - | x |
| 11 | *Vitellaria paradoxa* | x | - | - | - | - |
| 12 | *Parkia biglobosa* | - | - | - | 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 | *Annona senegalensis* | x | x | - | - | - |
| 2 | *Adansonia digitata* | - | - | x | - | - |
| 3 | *Tamarindus indica* | x | - | - | - | - |
| 4 | *Bombax costatum* | - | - | - | - | - |
| 5 | *Ziziphus mauritania* | - | - | x | - | - |
| 6 | *Ziziphus spina-christi* | - | - | - | - | - |
| 7 | *Detarium microcarpum* | x | x | - | - | x |
| 8 | *Ximania Americana* | - | - | x | - | x |
| 9 | *Haematostaphis barterii* | - | - | - | - | x |
| 10 | *Hexalobus monopetalus* | x | x | - | x | - |
| 11 | *Vitellaria paradoxa* | - | - | - | x | - |
| 12 | *Parkia biglobosa* | - | - | - | 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 | Annonacaceae | *Hexalobus monopetalus* | 1 | 0.001 | 9.1 | 4.2 | 9.1 | 22.4 |
| 2 | Fabaceae | *Detarium microcarpum* | 4 | 0.004 | 36.4 | 23.2 | 36.4 | 96.0 |
| 3 | Fabaceae | *Tamarindus indica* | 1 | 0.001 | 9.1 | 0.0 | 9.1 | 18.2 |
| 4 | Sapotacaceae | *Vitallaria paradoxa* | 5 | 0.005 | 45.5 | 72.5 | 45.5 | 163.4 |
| | **Total** | | 11 | | 100.0 | 100.0 | 100.0 | 300.0 |
| **Transect II** | | | | | | | | |
| 1 | Annonacaceae | *Hexalobus monopetalus* | 1 | 0.001 | 16.7 | 0.6 | 16.7 | 34.0 |
| 2 | Bombacaceae | *Bombax costatum* | 1 | 0.001 | 16.7 | 26.5 | 16.7 | 59.8 |
| 3 | Annonacaceae | *Annona senegalensis* | 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 | *Ximenia americana* | 2 | 0.002 | 15.4 | 12.5 | 15.4 | 43.3 |
| 2 | Sapotaceae | *Vitallaria paradoxa* | 2 | 0.002 | 15.4 | 0.7 | 15.4 | 31.4 |
| 3 | Fabaceae | *Detarium microcarpum* | 1 | 0.001 | 7.7 | 0.4 | 7.7 | 15.8 |
| 4 | Fabaceae | *Tamarindus indica* | 5 | 0.005 | 38.5 | 82.3 | 38.5 | 159.2 |
| 5 | Rhamnaceae | *Ziziphus spina-christi* | 2 | 0.002 | 15.4 | 4.0 | 15.4 | 34.8 |
| | Annonaceae | *Hexalobus monopetalous* | 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 | *Adansonia digitata* | 1 | 0.001 | 20.0 | 30.2 | 20.0 | 70.2 |
| 2 | Mimosoideae | *Parkia biglobosa* | 2 | 0.002 | 40.0 | 67.8 | 40.0 | 147.8 |
| 3 | Rhamnaceae | *Ziziphus mauritania* | 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 | *Parkia biglosa* | 2 | 33.3 | 33.3 | 32.5 | 33.3 | 99.2 |
| 2 | Fabaceae | *Tamarindus indica* | 2 | 33.3 | 33.3 | 13.9 | 33.3 | 80.6 |
| 3 | Anacasdiaceae | *Haematosphis barteri* | 1 | 16.7 | 16.7 | 23.6 | 16.7 | 56.9 |
| 4 | Fabaceae | *Detarium microcarpum* | 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 | Annonacaceae | *Hexalobus monopetalus* | 1 | 0.01000 | 10.0 | 2.927 | 10.0 | 20.1 |
| 2 | Fabaceae | *Detarium microcarpum* | 3 | 0.03000 | 30.0 | 10.359 | 30.0 | 60.5 |
| 3 | Fabaceae | *Tamarindus indica* | 1 | 0.01000 | 10.0 | 0.613 | 10.0 | 20.0 |
| 4 | Sapotacaceae | *Vitallaria paradoxa* | 5 | 0.05000 | 50.0 | 86.09 | 50.0 | 104.0 |
| | **Total** | | 10 | | 100.0 | 100 | 100.0 | 300.0 |
| **Transect II** | | | | | | | | |
| 1 | Annonacaceae | *Annona senegalensis* | 4 | 0.004 | 50.0 | 14.5 | 50.0 | 114.5 |
| 2 | Olacaceae | *Ximenia americana* | 1 | 0.001 | 12.5 | 2.4 | 12.5 | 27.4 |
| 3 | Fabaceae | *Detarium microcarpum* | 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 | *Detarium microcarpum* | 4 | 0.004 | 57.1 | 75.8 | 57.1 | 190.0 |
| 2 | Rhamnaceae | *Ziziphus spina-christi* | 2 | 0.002 | 28.6 | 19.7 | 28.6 | 76.7 |
| 3 | Annonaceae | *Hexalobus monopetalus* | 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 | *Adansonia digitata* | 1 | 0.001 | 16.7 | 71.4 | 16.7 | 104.8 |
| 2 | Mimosoideae | *Parkia biglobosa* | 1 | 0.001 | 16.7 | 26.1 | 16.7 | 59.5 |
| 3 | Fabaceae | *Detarium microcarpum* | 4 | 0.004 | 66.7 | 2.6 | 66.7 | 135.9 |
| | **Total** | | 6 | | 100.0 | 100 | 100.0 | 300 |
| **Transect V** | | | | | | | | |
| 1 | Fabaceae | *Tamarindus indica* | 1 | 0.001 | 12.5 | 11.321 | 12.5 | 36.3 |
| 2 | Fabaceae | *Detarium microcarpum* | 4 | 0.004 | 50 | 68.794 | 50 | 168.8 |
| 3 | Annonacaceae | *Annona senegalensis* | 1 | 0.001 | 12.5 | 16.339 | 12.5 | 41.3 |
| 4 | Annonacaceae | *Hexalobus monopetalus* | 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 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.

**4.2 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 | *Detarium microcarpum* | 5 | 35.7 |
| 2 | Annonacaceae | *Hexalobus monopetalus* | 7 | 50.0 |
| 3 | Annonacaceae | *Annona senegalensis* | 1 | 7.1 |
| 4 | Fabaceae | *Tamarindus indica* | 1 | 7.1 |
| **Total** | | | 14 | 100 |
| Transect II | | | | |
| 1 | Annonacaceae | *Annona senegalensis* | 6 | 35.3 |
| 2 | Annonacaceae | *Hexalobus monopetalus* | 3 | 17.6 |
| 3 | Fabaceae | *Detarium microcarpum* | 8 | 47.1 |
| **Total** | | | 17 | 100 |
| Transect III | | | | |
| 1 | Rhamnaceae | *Ziziphus mauritania* | 3 | 50 |
| 2 | Olacaceae | *Ximenia Americana* | 1 | 16.7 |
| 3 | Malvaceae | *Adansonia digitata* | 2 | 33.3 |
| **Total** | | | 6 | 100 |
| Transect IV | | | | |
| 1 | Annonacaceae | *Hexalobus monopetalus* | 4 | 50 |
| 2 | Sapotaceae | *Vitallaria paradoxa* | 1 | 12.5 |
| 3 | Mimosodeae | *Parkia biglobosa* | 3 | 37.5 |
| | Total | | 8 | 100 |
| Transect V | | | | |
| 1 | Anacasdiaceae | *Haematosphis barteri* | 2 | 25 |
| 2 | Fabaceae | *Detarium microcarpum* | 4 | 50 |
| 3 | Olacaceae | *Ximenia americana* | 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 |
|---|---|---|---|
| *Adansonia digitate* | 1(2.44) | 1(2.56) | 2(3.77) |
| *Annona senegalensis* | 4(9.76) | 5(12.82) | 7(13.21) |
| *Bombax costatum* | 1(2.44) | ___ | ___ |
| *Detarium microcarpum* | 6(14.63) | 18(46.15) | 17(32.08) |
| *Haematosphis barteri* | 1(2.44) | | 2(3.77) |
| *Hexalobus monopetalus* | 3(7.32) | 4(10.26) | 14(26.42) |
| *Parkia biglobosa* | 4(9.76) | 1(2.56) | 3(5.66) |
| *Tamarindus indica* | 3(7.32) | 2(5.13) | 1(1.89) |
| *Vitallaria paradoxa* | 7(17.07) | 5(12.82) | 1(1.89) |
| *Ximenia americana* | 2(4.88) | 1(2.56) | 3(5.66) |
| *Ziziphus Mauritania* | 2(4.88) | ___ | 3(5.66) |
| *Ziziphus spina-christi* | 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 | PilnPi |
|---|---|---|---|---|
| **Transect I** | | | | |
| *Hexalobus monopetalus* | 1 | 0.166667 | -1.79176 | -0.29863 |
| *Bombax costatum* | 1 | 0.166667 | -1.79176 | -0.29863 |
| *Annona senegalensis* | 4 | 0.666667 | -0.40547 | -0.27031 |
| **Total** | 6 | | | 0.86756 |
| **Transect II** | | | | |
| *Ximenia americana* | 2 | 0.153846 | -1.8718 | -0.28797 |
| *Vitallaria paradoxa* | 2 | 0.153846 | -1.8718 | -0.28797 |
| *Detarium microcarpum* | 1 | 0.076923 | -2.56495 | -0.1973 |
| *Tamarindus indica* | 5 | 0.384615 | -0.95551 | -0.3675 |
| *Ziziphus spina-christi* | 2 | 0.153846 | -1.8718 | -0.28797 |
| *Hexalobus monopetalous* | 1 | 0.076923 | -2.56495 | -0.1973 |
| **Total** | 13 | | | 1.62602 |
| **Transect III** | | | | |
| *Ximenia americana* | 2 | 0.153846 | -1.8718 | -0.28797 |
| *Vitallaria paradoxa* | 2 | 0.153846 | -1.8718 | -0.28797 |
| *Detarium microcarpum* | 1 | 0.076923 | -2.56495 | -0.1973 |
| *Tamarindus indica* | 5 | 0.384615 | -0.95551 | -0.3675 |
| *Ziziphus spina-christi* | 2 | 0.153846 | -1.8718 | -0.28797 |
| *Hexalobus monopetalous* | 1 | 0.076923 | -2.56495 | -0.1973 |
| **Total** | 13 | | | 1.62602 |
| **Transect IV** | | | | |
| *Adansonia digitate* | 1 | 0.2 | -1.60944 | -0.32189 |
| *Parkia biglobosa* | 2 | 0.4 | -0.91629 | -0.36652 |
| *Ziziphus Mauritania* | 2 | 0.4 | -0.91629 | -0.36652 |
| **Total** | 5 | | | 1.05492 |
| **Transect V** | | | | |
| *Parkia biglosa* | 2 | 0.333333 | -1.09861 | -0.3662 |
| *Tamarindus indica* | 2 | 0.333333 | -1.09861 | -0.3662 |
| *Haematosphis barteri* | 1 | 0.166667 | -1.79176 | -0.29863 |
| *Detarium microcarpum* | 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 10: Shannon's Diversity index of Sapling species in Transect I – V

| Sapling Species | F | Pi | lnPi | PilnPi |
|---|---|---|---|---|
| Transect I | | | | |
| *Hexalobus monopetalus* | 1 | 0.1 | -2.30259 | -0.23026 |
| *Detarium microcarpum* | 3 | 0.3 | -1.20397 | -0.36119 |
| *Tamarindus indica* | 1 | 0.1 | -2.30259 | -0.23026 |
| *Vitallaria paradoxa* | 5 | 0.5 | -0.69315 | -0.34657 |
| **Total** | 10 | | | 1.16828 |
| Transect II | | | | |
| Annona senegalensis | 4 | 0.5 | -0.69315 | -0.34657 |
| Ximenia americana | 1 | 0.125 | -2.07944 | -0.25993 |
| Detarium microcarpum | 3 | 0.375 | -0.98083 | -0.36781 |
| **Total** | 8 | | | 0.97431 |
| Transect III | | | | |
| *Detarium microcarpum* | 4 | 0.571429 | -0.55962 | -0.31978 |
| *Ziziphus spina-christi* | 2 | 0.285714 | -1.25276 | -0.35793 |
| *Hexalobus monopetalus* | 1 | 0.142857 | -1.94591 | -0.27799 |
| **Total** | 7 | | | 0.9557 |
| Transect IV | | | | |
| *Adansonia digitate* | 1 | 0.166667 | -1.79176 | -0.29863 |
| *Parkia biglobosa* | 1 | 0.166667 | -1.79176 | -0.29863 |
| *Detarium microcarpum* | 4 | 0.666667 | -0.40547 | -0.27031 |
| **Total** | 6 | | | 0.86756 |
| Transect V | | | | |
| Tamarindus indica | 1 | 0.125 | -2.07944 | -0.25993 |
| Detarium microcarpum | 4 | 0.5 | -0.69315 | -0.34657 |
| Annona senegalensis | 1 | 0.125 | -2.07944 | -0.25993 |
| Hexalobus monopetalus | 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 12: Shannon's Diversity index of NTFPs Tree Species in the Study Area

| Species | F | Pi | lnPi | PilnPi |
|---|---|---|---|---|
| *Hexalobus monopetalus* | 3 | 0.073171 | -2.61496 | -0.19134 |
| *Detarium microcarpum* | 6 | 0.146341 | -1.92181 | -0.28124 |
| *Tamarindus indica* | 3 | 0.073171 | -2.61496 | -0.19134 |
| *Vitallaria paradoxa* | 7 | 0.170732 | -1.76766 | -0.3018 |
| *Bombax costatum* | 1 | 0.02439 | -3.71357 | -0.09057 |
| *Annona senegalensis* | 4 | 0.097561 | -2.32728 | -0.22705 |
| *Ximenia americana* | 2 | 0.04878 | -3.02042 | -0.14734 |
| *Tamarindus indica* | 5 | 0.121951 | -2.10413 | -0.2566 |
| *Ziziphus spina-christi* | 2 | 0.04878 | -3.02042 | -0.14734 |
| *Adansonia digitate* | 1 | 0.02439 | -3.71357 | -0.09057 |
| *Parkia biglobosa* | 4 | 0.097561 | -2.32728 | -0.22705 |
| *Ziziphus Mauritania* | 2 | 0.04878 | -3.02042 | -0.14734 |
| *Haematosphis barteri* | 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 13: Shannon's Diversity index of NTFPs Sapling Species in the Study Area

| Species | F | Pi | lnPi | PilnPi |
|---|---|---|---|---|
| *Hexalobus monopetalus* | 4 | 0.102564 | -2.27727 | -0.23357 |
| *Detarium microcarpum* | 18 | 0.461538 | -0.77319 | -0.35686 |
| *Tamarindus indica* | 2 | 0.051282 | -2.97041 | -0.15233 |
| *Vitallaria paradoxa* | 5 | 0.128205 | -2.05412 | -0.26335 |
| *Annona senegalensis* | 5 | 0.128205 | -2.05412 | -0.26335 |
| *Ximenia americana* | 1 | 0.025641 | -3.66356 | -0.09394 |
| *Ziziphus spina-christi* | 2 | 0.051282 | -2.97041 | -0.15233 |
| *Adansonia digitate* | 1 | 0.025641 | -3.66356 | -0.09394 |
| *Parkia biglobosa* | 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 14: Shannon's Diversity index of NTFPs Seedling Species in the Study Area

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

## DISCUSSION

### 5.1 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.* (2020). The different NTFPs tree species and their families are also similar to that reported by Sa'ad (2021) 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 (2021) 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 (2014) at the parklands of Katsina State. Nuraddeen (2014) 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 (2021) 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 (2021) 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.

### 5.2 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 (2021) 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 (Kent and Coker, 1992).

## CONCLUSION AND RECOMMENDATIONS

### 6.2 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.

### 6.3 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.

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