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Biodiversity Conservation: Measures of Forest Tree Species Composition and Distribution in a Relic Forest

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Abstract

The determination of tree species composition, relative density and distribution (richness and diversity) of a forest reserve in Southeastern Nigeria formed the basis of this research. A sample plot measuring 1.5 hectare (150x100)m^2 was outlined and divided into four components within the forest reserve. A total of 151 tree count was recorded in the reserve area: belonging to nine different tree species. They were distributed in nine genera and of seven (7) families. Considering species richness, Verbenceae and Rubiaceae family had the highest number of 2 species in 2 genera, while five (5) other families had one (1) specie each. *Tectona grandis* species had the highest relative density and dominance (35.10% and 35.59% respectively). *Gmelina arbozea* (27.81% and 27.95%); while *Elaesis guineesis* and *Mitragyna ciliate* shared relative density of 3.311% and 3.974% respectively. The least specie was *Pinus caribea* have relative density and abundance of 1.987% and 2.2%. Generally, the forest location had immoderate diversity as a result of excessive exploitation and there is need to restrict forest exploitation thereby allowing forest full regeneration. This restriction policy is hereby advocated and projected to enhance the soil fertility and retention for full regeneration of forest species.

Keywords: Global change ecology; Tree species composition; Relic forest; Biodiversity conservation; Species; Composition; Distribution and abundance

Introduction

Tropical rainforests are composed of myriad of species that are beneficial to man and other life forms directly or indirectly. Conservation awareness and plant ecosystem management has been an important aspect of biodiversity conservation as supported by [1]. Some direct benefits include food, medicine, timber, forest products are obtained directly from the forest. Some indirect ecosystem benefits of forest biodiversity include protection of watershed and habitats of flora/fauna, cycling of soil materials, carbon repatriation and regulation of microclimate. Diversity functions those natural systems adapt, evolve and thrive. Biodiversity can be seen to be synonymous with ecosystem health, however, diverse ecosystem does increased stability, productivity, resistance to invasion and other disturbances. [2] on scale and species richness and [3] are key supports in the importance of this investigation. Vegetation analysis and tree population structure of tropical wet evergreen forests become an important aspect of tree biodiversity conservation and approach which [4] documented in their research in India. Generally, biodiversity is considered to exist at three levels: genetics, species and ecosystems. The three levels are defined where genetic diversity means the total number of genetic characteristics in the genetic make of specie; whereby genetic diversity allows specie to adapt to changing environments.

The aim of diversity is to ensure that some species survive adverse or drastic changes and thus exists along their desirable genes. This helps the survival of individuals to ensure the survival of their population. Species diversity is defined as a ratio of one specie population over total number of organisms across all species in the given biome. In its sense, "zero" Rayers to "infinite" diversity and "one" represents single specie present. Ecosystem diversity refers to the diversity of a place at the level of ecosystems. The earth as a biosphere and the variation of ecosystem within the earth's biosphere is considered a measure of ecosystem diversity. Generally, biodiversity is measured by two major components. The components are species richness and species evenness. Species richness simply measures the total number of species in an ecosystem. While species evenness gauges the proportion of species at a given site and it simply refers that low evenness indicates that a few species dominate a particular site.

Considering the global impacts of climate change and global ecology, there are specific locations and sites identified with enormous species diversity which has been observed to be under threat over the globe. The threatening as a result of human activities is known as Biodiversity hotspot. Gomez A et al. [5] identified the idea of Hotspot under two criteria of a) Endemic, meaning an area must contain at least 0.5% or 1.500 species of plants that is predominant in the specific area. This endemic area is expected to host at least 70% of the location primary vegetation. Globally, it has been documented that at least 25 areas around the world meet these criteria/qualifications; they thereby support nearly 60% of the earth plant, bird, mammal, reptile and amphibian species that has a very high endemic species. However, [6] considers b) The intense human activities as Hotspot thereby presenting unique species under threat from human impacts around the world.

The 1992, UNCE created (CBD) Convention on Biodiversity where 192 nations including the EU made committed and significant effort to reduce biodiversity loss targeting 2010. The benefits of a health diversity support various components of ecosystem services such as protection of water resources, soil formation, protection, nutrient storage/recycling, contribution to climate stability and other biological services and biological resources. Biodiversity loss has continued to increase at recent years due to habitat loss and degeneration, climate change and over-exploitation, unsustainable use and invasive species. Generally, species composition and distribution of plant species are influenced by biodiversity loss, climate change and global change ecology. These factors have forced species to migrate, extinct and adapt. In this case, there is need for species conservation and reintroduction as a top priority for global conservation.

Biodiversity Inventories

Forest produces and diversity are considered to be used at a sustainable level that enhances the benefits of forest ecosystem. Forest management operations and biodiversity inventories are used to determine the nature and distribution of biodiversity in any managed region. It becomes necessary to conduct long term empirical data on vegetation changes that eventually determine species composition and distribution in a forest community (natural forest) is generally scarce for relic forest such as the study location in Ohaji/Egbema in Imo state, Southeast Nigeria. In this case, efficient management plans is needed to enhance forest inventory data collection. Liu H et al. [7] is in support that biodiversity is essential for human survival and economic well-being and for the ecosystem function and stability. Anthropogenic activities result to destruction of the forest reserve at the study site while many kinds of environmental changes influence or determine processes that impact distribution of species while these disturbances have been considered as important factor in structuring communities [8].

Plant species diversity/composition is an important aspect that provides resources and habitat for many arboreal species [9]. In general terms, biodiversity promotes a balanced ecosystem, which is accounted one in which living species co-exist for nocturnal benefit. It is anticipated that the study site has lost about 370,000 species of seedlings which is as a result of rural community encroachment and the government lack of policy to control the rural population. However, some plants species were observed to be of medical value while some tree species within the forest reserve have gone extinct of indiscriminate logging. The justification is on the fact that for effective forest plantation management, it is paramount to understudy plant species composition and distribution for forest resources sustainability. However, the study objective measures and determines species composition/abundance as well as, assesses the tree (plant) distribution in a relic forest. In this regard, it is recommended that effective forest policy covering plantation encroachment must be put in place.

Study Area

The study is conducted in Ohaji Egbema forest reserve now relic, that is to say the forest is surviving from an earlier time of disturbance. The forest is located at the outskirts of Owerri-the capital of Imo state, Southeast Nigeria. It is on the latitude 5^0 29^0N and 7^0 2^0E of the equator with an elevation of 45m and it is bounded by Egbema community. The average annual rainfall in the area is 1550.5mm with a relative humidity, though the vegetation in the area is dense and canopies appear close while there are varied plant association with variable species.

Forest inventory and data collection

The major forest inventory conducted was to understand the forest species composition (diversity), distribution and estimation of the available stock in the woodland. Myers N [10] on a tribute to Claude Shennon (1916-2001) and a plea for rigorous use of species richness, species diversity and Shannon-Wiener' index is considered here as a strong field background while this study considers the disturbance and relic nature of the reserve. This study was concentrated on the vegetation by considering tree species that are less than 10cm trunk diameter. The forest inventory here means the procedure for obtaining on the quantity and quality of the resources and other characteristics of the land in which the trees are growing. A reconnaissance survey of the study was conducted to establish physical and current state of the area and

to determine variations between vegetative cover, indicators of human disturbances such as cutting of trees for logging and poles.

Sampling Procedure

The area is estimated to cover 986 hectares, and for effective evaluation, a fraction of 1.5 hectares was taken for the sampling study. The physical condition compelled the site assessment to consider the variations inconsistencies in the vegetation composition of the forest reserve due to the intensity of human disturbances. To this, a sample of 150mx100m (1.5 hectares) was selected and divided into four distinct plots and used for the forest inventory of the site. The field application was based on the following parameters that was estimated and recorded in all sample plot and individual sample plots:

a) Consideration of family, species and frequency of trees encountered in the sample plot

b) Number of trees within all plots and single sample plots

c) Percentage composition of species within all plots and individual plots

d) Relative abundance/diversity (%) of species in the entire sample plot and single sample plots.

Field Data Analysis

In simple application of acquired field data, various data results were presented using descriptive statistics in form of tables, charts and figures (Table 1). The field data was based on

Table 1: Composition of forest tree species, considering families and species frequency in the forest reserve of 1.5 hectares.

Species richness=0.7324

Verifiable forest tree stands in each sample plot

Total number of tree stands in plot 1=40

Total number of tree stands in sample plot 2=41

Total number of tree stands in sample plot 3=26

Total number of tree stands in sample plot 4=44.

Family	Common Name	Species	Observed Frequency
Apocynaceae	Cheese wood	*Alstonia boonei*	10
Arecaceae	Oil palm tree	*Elaiesis guineesis*	5
Casuarinaceae	Beach oak	*Casuarina equsitifolia*	8
Fabaceae	Mututi	*Pterocarpus santalinoides*	9
Pinaceae	Pine	*Pinus caribea*	3
Rubiaceae	Abura	*Mitragyna ciliata*	6
Rubiaceae	African Peach	*Nauclea diderichii*	15
Verbenaceae	Beech wood	*Gmelina arborea*	42
Verbanaceae	Teak	*Tectonia grandis*	53
		Total	151

a) Species Relative Density (SRD) which is the number of individual species and determined by the formulae:

$$RD(\%) = \frac{n}{N} \times 10$$

(%) = × 100 and defined

where,

n=Number of individual species

N=Total number of species in the entire forest community

b) Species Relative Dominance (RDo) was computed using:

$$= \sum - \times 100$$

$$RD_0 = \sum \frac{n}{N} \times 1$$

Where,

n=Number of individual trees belonging to a given species

N=Number of all species in the sampling unit

c) Species Richness or Variety Index

d) that is determined by Myers N [11]

$d = \sqrt[s]{N}$ as defined

where S = Number of species N = Number of individuals of all species.

Relative Density of Individual species observed in the entire sample plot of 1.5 hectares using $\%composition = \frac{n}{N} \times \frac{100}{1}$ while number of species in the entire sample plot is 151 (Figure 1).

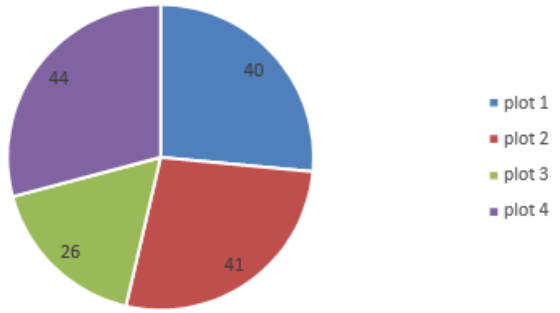

Figure 1: Verifiable forest tree stands in each sample plot.

Discussion

Tree species composition and distribution: an effective tool for forest biodiversity management Effective plant diversity conservation requires periodic and sound environmental management of vegetation ecosystem and spatial assessment of species distributions. Forest plantation plays specific roles and forest reserve is mostly kept and reserved, protected or saved by policy for either future use or special biodiversity purposes. These were established to conserve habitats in its natural state, conserved for scientific research and education purposes or being protected from vulnerable or endangered species or for natural landscapes which aims at protection and maintenance of biological diversity using natural and associated cultural and policy resources of legal or other effective means [12]. Generally, IUCN describes natural forest as a forest where human impact has not surpassed the impact of other indigenous species and may not have affected the ecosystem structure [13] documented that there are 445 gazetted forest reserve located in different parts of Nigeria while 137 accounted to the bulk of the Nation's natural forest wealth (Tables 2-4).

Table 2: Determination of percentage of species.

Species	Percentage
Alstonia boonei	6.623%
Elaiesis guineesis	3.311%
Casuarina equsitifolia	5.298%
Pterocarp santalinoides	5.960%
Pinus caribea	1.987%
Mitragy naciliata	3.974%
Nauclea diderichii	9.934%
Gmelina arborea	27.81%
Tectonia grandis	35.10%

Table 3: Evaluation of species relative density covering the entire sample plot (1.5 hectares).

Ab, Eg, Ce, Ps, Pc, Mc, Nd, Ga, Tg = 99.997.

Species	Relative Density
Alstoni aboonei	6.623
Elaiesis guineesis	3.311
Casuarina equsitifolia	5.298
Pterocarpus santalinoides	5.960
Pinus caribea	1.987
Mitragyna ciliata	3.974
Nauclea diderichii	9.934
Gmelina arborea	27.81
Tectonia grandis	35.10
Total Observed Species	99.997%

Table 4: Relative percentage abundance (%) distribution of individual species (Assessment of specific tree stands in a sample plot 1=40 stands using).

Distribution of Individual Species	Relative Percentage Abundance
Alstoni aboonei	10%
Elaiesis guineesis	5%
Casuarina equsitifolia	7.5%
Pterocarpus santalinoides	7.5%
Pinus caribea	7.5%
Mitragyna ciliate	0%
Nauclea diderichii	10%
Gmelina arborea	30%
Tectonia grandis	22.5%

However, out of 60 vegetation species currently considered commercially important, 35 species have attracted restriction [14]. On this regard, there is the tendency of overexploitation of the few available commercial species. Considering the nature of the relic site in Ohaji Egbema forest reserve it is evidently identified that the poor attention on conservation and biodiversity sustainability particularly in the tropical forests is a consequence of the threat posed by overexploitation of forest resources leading to depletion of flora and fauna. In the same vein regeneration and forest management supports biodiversity as documented by Shengji P [15] whereby species diversity accounts to the variety of different kinds of organisms that make up the community; thereby refers to the number and distribution of species in a location. Though the study site has been under intensive exploitation, in which defining species richness in the total number of different species in the plant community while relative abundance is the proportion each species represents to the total individuals in a forest community as in Figures 2-4. However, the greater effect on plant species diversity is mostly of the influences of destruction of habitat, greenhouse gas emissions and global warming while other anthropogenic effects liking logging, fuel wood and others are on the increase in the scramble for forest resources. The species composition of 151 tree stands accounted to Nine (9) different tree species in the 150mx100m (1 hectare) in the reserve. It was observed and documented that; Verbenaceae family had the highest number of 2 species in 2 different genera followed by Rubiaceae of 2 species belonging to 2 different genera while others had one (Table 5). These variations may largely be as a result of differences in climatic adaptation as well as edaphic factors that characterize the ecological zone.

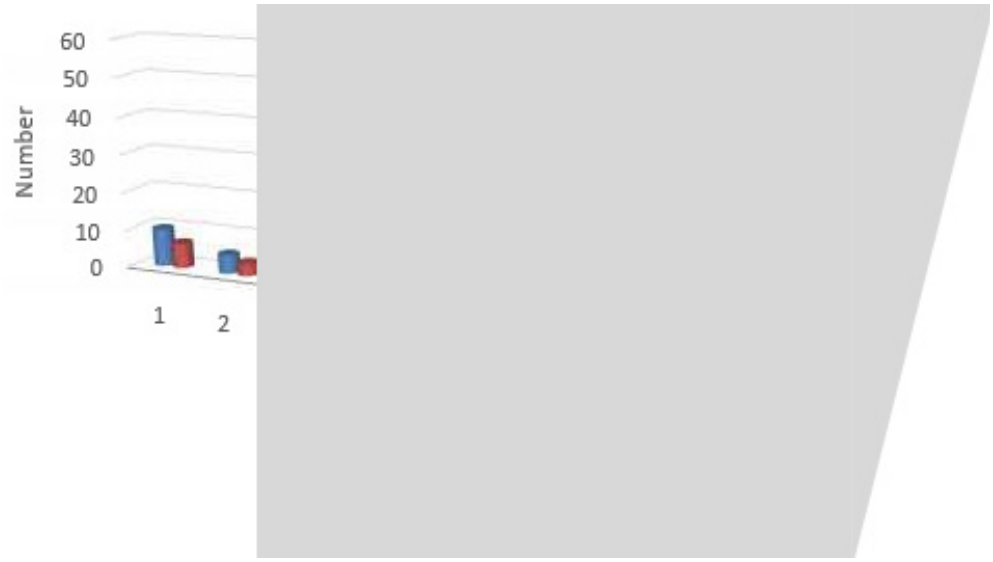

Figure 2: Field graphical representation in number by percentages of species richness.

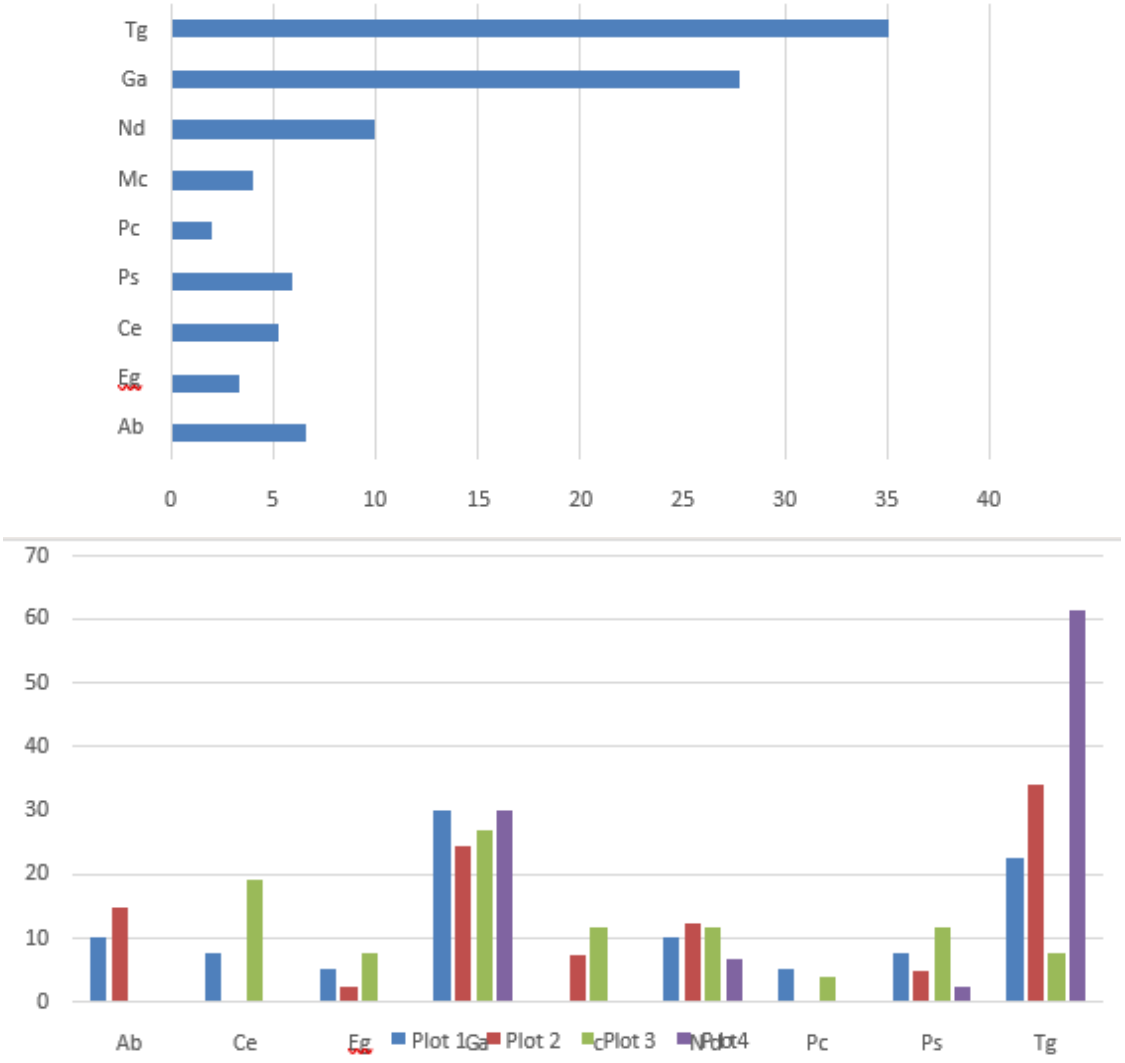

Figure 3: Relative abundance sample calculation of individual species extended to evaluate plot 1, 2, 3 and 4 in percentage spread.

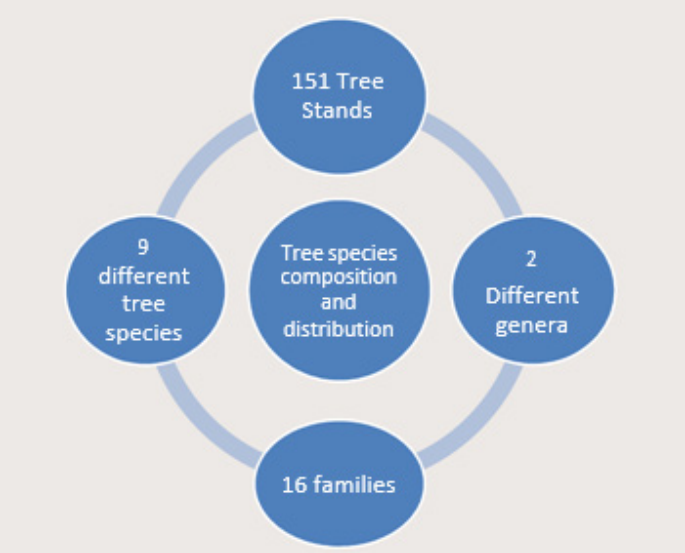

Figure 4: Tree species composition and distribution in classification of stands, genra, families and species 16 families.

Table 5: Relative abundance simple calculations of individual species extended to evaluate plots 1, 2, 3, and 4 in percentage spread.

S/N	Species	Plot 1	Plot 2	Plot 3	Plot 4
1	Ab	10	14.63	0	0
2	Ce	7.5	0	19.23	0
3	Eg	5	2.44	7.69	0
4	Ga	30	24.39	26.92	29.92
5	Mc	0	7.32	11.54	0
6	Nd	10	12.19	11.54	6.82
7	Pc	5	0	3.85	0
8	Ps	7.5	4.88	11.54	2.27
9	Tg	22.5	34.15	7.69	61.36
	Total(Percentage)	97.5	99.99	100	100.4

Analysis of species composition and distribution

The forest site evaluation identified a total of 151 tree stands among completed plots measuring 150mx100m (1 Hectare). Considering that the ecological variation is virtually same, the field explanation may be as a result of over exploitation of the woody genetic resources as supported [16]. Also, another reason could be as a result of plant habitat destruction whereby survival and tree species among the plots which shows *Tectona grandis* had the highest relative density (35.99%), *Gmelina arborea* (27.81%, *Naudea diderichii* (9.94%). The tree dominance assessment indicated that *Alstoni aboonei* (6.623%), *pterocarpus santalinoides* (5.96%), *Casuarina equisitifolia* (5.29%) *Elaeisis guineesis* and *mitragyna ciliate* (5.96%), 5.29%, 3.32% and 3.97% respectively (Figure 5). *Pinus caribea* was identified most vulnerable tree species which is considered under threat of extinction in the forest reserve which may be influenced by factors of over exploitation, competition and edaphic factors considering distributions of plant species abundance (variations and distributions among individual sample plot, *Gmelina arborea* recorded 30% richness, *Tectonia grandis* (22.5%) while *Alstoni aboonei* and *Nauclea diderichii* had 10% relative abundance. *Casuarine equisitifolia* and *pterocarpus santalinoides* had 7.5% abundance respectively. It was observed that some of the plot recorded no stand of some tree species such as plot one had no *mitragyna oiliata casuarinas sequisitifolia* had no stand in plot two, also *Alstoni aboonei* had no stand in plot three. Species diversity and relative abundance could be attributed to intensive logging activities especially used fuel wood and other wood resources in the area. *Tectona grandis* is observed highly composed and had long exited before the reserve is considered relic.

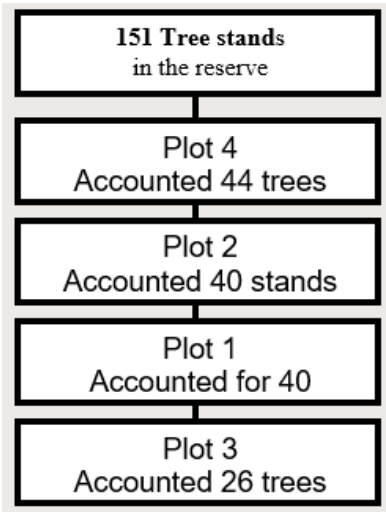

Figure 5: Accounting of trees among plots covering 151 tree stands in the forest reserve.

Conclusion

The forest reserve is composed of sparsely populated nine tree species. The low plant (tree) species density of stand is a strong

evidence of the degree of devastation the forest reserve has been subjected by logging activities and other form of exploitation on non-timber and forest products. It becomes necessary and for urgent attention for the protection of the forest reserves to avoid some species going to extinction and the need to provide requiring time for natural regeneration. The poor canopy and frequent exploitation exposed the soil surface that could be the likely reason for low nutrient status of the forest soils. To this understanding, there is need to develop Integrated Conservation Approach (ICA) that will restore the diminishing potential of the forest reserve, however, not only developing ICA but to effectively implement them and strongly supported in practice by the works of [17,18] that identified biodiversity and conservation as well as conserving plant diversity. Generally, the following recommendations are considered very necessary and priority for the conservation of biological diversity in line and support of [7].

1. Community participation in forest conservation should be encouraged to avoid disputes [19].
2. In this case of the study site, the reserve should be restricted for exploitation for a period of time, this could allow for the forest to fully regenerate while this forest soil will regain its fertility.
3. There is need for alternative energy and affordable to the community, this will reduce the dependence on the forest trees for fuel wood [20].
4. Government should enact laws that reposition the sub sector, to this need employ more manpower with incentives to guard the forests. Furthermore, training and re- training of forest personnel in order to completely address the problem of illegal exploitation and other challenges of the forestry sector.
5. It will be strongly suggested for proper and documented management plan of reserved forest, with clearly stated objectives to forest reserves and strictly adhered.
6. Non-Government Organizations (NGOS) should intervene in the campaign against indiscriminate falling and exploitation of the forest reserved areas.

Conflict of Interest

The authors hereby declare no form of interest either of economic interest or any other form of conflict interest exists.

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