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ASSESSMENT OF THE NATURAL REGENERATION STATUS OF *Irvingia gabonensis* (BUSH MANGO) IN GASHAKA GUMTI NATIONAL PARK, TARABA STATE, NIGERIA

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ABSTRACT

The objectives of the study assessed the natural regeneration status of Irvingia gabonensis (Bush Mango) by the use of number of regenerants such as seedlings, saplings,juveniles, and matured. The research was carried out in Gashaka Gumti National Park Taraba State, Nigeria. A biophysical survey of trees, based on diameter classess was used. Opportunistic sampling design was employed to establish plots of 30m x 30m square where data on various different class-sizes of Irvingia gabonensis were collected. Chain was used to establish plots.The locations of Irvingia gabonensis were spotted and marked out using the Global Positioning System (GPS). Different class-sizes were determined by measuring the diameter at breast height (dbh) of the matured tree of Irvingia gabonensis species encountered in each plot, while vernier calliper was used to measure the collar diameter of the seedlings. Results showed that there was an increasing trend of Irvingia gabonensis seedlings with good regeneration status while, saplings and matured were fair in regeneration. Juveniles had poor regeneration. In other words, there was an apparent diminishing of the natural regeneration trend of Irvingia gabonensis trees among juvenile classes in the Forest as a result of constant invasion and disturbances of bush pigs feedings on the ripe fruits thereby creating a setback on regeneration trend. By considering the various stages of natural regeneration, researchers and conservationists can assess the current and future population dynamics of Irvingia gabonensis. This assessment enables the identification of factors that may hinder or enhance natural regeneration, such as habitat fragmentation, climate change, or animal activities. Ultimately, such assessments aid in the development of effective conservation strategies to ensure the long-term survival of Irvingia gabonensis and its associated ecosystem.

Keywords: Natural, Regeneration status, Seedlings, Saplings, Poor regeneration.

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INTRODUCTION

Bush mango (*Irvingia gabonensis)* is a species of African trees (because it is native to western Africa) in the genus Irvingia and the family Irvingiaceae sometimes known by the common names wild mango, African mango, Bush mango or Ogbono, and Gabon chocolate (Aigbe and Brown 2001)**.** They bear edible mango-like fruits and are especially valued for their fat- and protein-rich nuts according to Wikipedia (2022). The fleshy fruit somewhat resembles the unrelated mango and is eaten fresh or processed into jellies and jams. The tree produces a hardwood that is useful for heavy construction. The fat is extracted from the seeds for soap and candle making. The seed kernels are commonly roasted like coffee beans, then pounded and poured into a mould before being added to boiling meat and vegetables (Ewane *et al.*, 2009).

Irvingia gabonensis is one of the forest tree species of immense domestic importance to rural and urban dwellers in many countries in West and Central Africa where it occurs naturally. It provides an assortment of food

necessary for nutritional diversity and survival and provides rural employment. Out of 171 indigenous woody plants of economic importance identified within the forest zone of Nigeria, *Irvingia gabonensis* ranks among five principal fruit trees which occur in traditional farms as compared to natural forests (Ewane *et al.*, 2009).

The assessment provides valuable information on the species' reproductive success, population dynamics, and overall health of its natural regeneration process because both the fruits and seeds of the *Irvingia gabonensis* are consumed and therefore play important roles for food security. While the fruit pulp is eaten fresh, the kernel is used in making a variety of products but it is mostly used to prepare a special soup known as "Ogbono soup" which is loved across cultural, educational, economical, social, and religious boundaries. Consequently, the history of the tree species has been largely that of the extraction and often over-extraction of its product (Aigbe and Brown, 2001).

Due to its immense economic importance to people and the increasing local and regional demand, coupled with the increasing price, bush mango has been under intense exploitation, which has resulted in its stocks diminishing at an alarming rate (Arowosoge, 2017).. Consequently, *Irvingia gabonensis* has been classified as highly endangered tree species (Agbelade and Onyekwelu, 2013). As of the year 2013, the International Union for Conservation of Nature (IUCN) describes *Irvingia. gabonensis* species as currently listed in the "lower risk/near threatened" category of the IUCN red-list (IUCN, 2013).

In other words, the forest was rich with abundance of *Irvingia. gabonensis* species, but due to poverty, economic hardship, and human search for non-timber forest products as alternative means of survival, *Irvingia. gabonensis* species has likely been overexploited or affected by wildfire. Therefore, there is a need to carry out assessment to ascertain its survival rate in the near future (Ndakidemi and Ndakidemi 2013). As such the study intends; to determine the abundance of *Irvingia. gabonensis* species with respect to age classes; seedlings, saplings, juveniles, and matured, to investigate the vegetative composition and also the status of natural regeneration on different ecological zones of the forest and to also determine indigenous knowledge on *Irvingia gabonensis* by locals around the forest.

MATERIALS AND METHODS

Study area

Gashaka-Gumti National Park (GGNP) is in a mountainous region of Taraba and Adamawa States in North-eastern Nigeria, adjacent to the international border with Cameroon. It lies on latitude 06°55′ - 08°05′ N and 11°11′ - 12°13′ E and covers 6731 km² (Figure 1) (Sommer and Ross, 2011).

Climate and season

The Gashaka Gumti climate is broadly characteristic of the Guinea savannah zone. However, the climate of Gashaka-Gumti National Park (GGNP) differs from most other central habitats because of its prolonged and marked dry season. It is not unusual to have no rain at all for up to 3 months. Typically, the rainy season begins in March or early April and ends in mid-November. Rainfall ranges from 1200 mm in the North to nearly 3000 mm in the South of the park (Dunn, 1993). The high rainfall is aided by the mountains of the area since humidity from the Atlantic is forced up into higher elevations, cools down, and condenses to rain-bearing clouds. This, in turn, allows the growth of moist forests.

Vegetation

The combined and long-term effects of fire, farming, and grazing practices have significantly altered much of the original natural vegetation of the region (Dunn, 1993). Now, there are seven habitat types found in within GGNP. Lowland gallery forest, riverine or riparian forest, montane forest, derived savanna, Southern and Northern guinea savanna, and montane grassland. The Northern (Gumti) sector is more of woodland, characterized by tall grasses and trees with usually short boles and broad leaves (Ajibode, 2002).

Chapman (1993) and Akinsoji (1996) reported some of the commonly occurring trees species in the sector to include *Acacia spp*., *Afzelia africana*, *Khaya senegalensis Daniela oliverii*, *Isober liniadoka*, and *Vitelleria paradoxa*. In the Southern (Gashaka) sector, moist Southern Guinea savanna predominates and the dominant tree species include: *Albizia gummifera*, *Afzelia*

africana, *Symphonia globulifera*, *Malletia spp.*, *I. gabonensis*,*Troplochiton schleroxylon*, and *Aubrevillea kerstingii*. Trees are often engulfed by woody climbers that are a substantial food source for primates (Adanu, 2002).

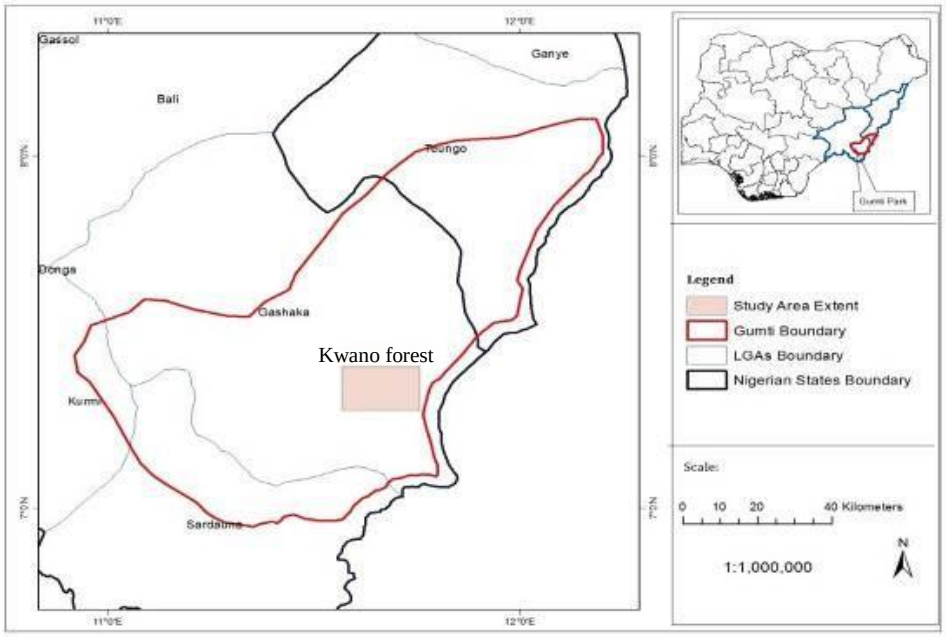


Figure 1: Map of Gashaka-Gumti National Park showing Kwano adopted from Akinsoji *et al*. (2016)

Reconnaissance Survey

A reconnaissance survey was conducted to become familiar with the study sites and the relevant information was collected from Kwano Forest of Gashaka Gumti National Park. To have an idea of abundance and composition of *Irvingia gabonensis* species of the whole study area.

Study Design

Opportunistic sampling design was employed to establish plots measuring 30m x 30m square where data on the various age classes of *Irvingia gabonensis* was collected. The ranging poles was used as pegs to establish the plots. Areas where *Irvingia gabonensis* were spotted growing were marked out using the Global Positioning System (GPS). The different age classes was determined by measuring the diameter at breast height (dbh) of matured tree *Irvingia gabonensis* species encountered in each plot using diametre tape a vernier caliper to determine collar dimater for seedlings. The Flagging tape was used to marked out in each established plot.

i. The regeneration status of tree species was determined based on the population sizes of seedlings, saplings, and adults, according to Khan *et al* (1987), Shankar (2001), and Khumbongmayum et al (2006). Regeneration was categorized as follows*:*
ii. good if seedlings > saplings > adults;
iii. fair if seedlings > saplings ≤ adults;
iv. poor if there were saplings but no seedlings (irrespective of the relative numbers of saplings and adults);
v. none if only adults were present, with no seedlings or saplings;
vi. new if only saplings and/or seedlings were present, with no matured.

Two hundred and fifty (250) respondents were randomly selected for face-to-face Interviews within purposefully selected five communities that surround the park namely; Karamti, Gashaka village, Serti, Goje and Mayo Selbe fifty (50) respondents from each community).

Data Collection

All *Irvingia gabonenesis* individuals in the seedling, sapling, juvenile and matured tree size

classes located within the sample plot (30m x 30m) were identified to species level and measured. Seedlings were only counted. For saplings, juveniles and small trees, a collar diameter was mesured using a vernier calliper. Diameter was measured for the tree juveniles, sapling and matured classes at breast height (1.3 m on upper side of the stem) from the ground.
Data on the various class-sizes of *Irvingia gabonenesis* were collected within the established plots as described above. The *Irvingia gabonenesis* trees with a DBH of 1cm-5cm were considered seedlings, 6cm-10cm as saplings, 11cm-15cm as juveniles and 16cm and above as matured.

Data Analysis
Descriptive statistical techniques such as; percentages, graphical depictions and frequency counts were used indigenous knowledge of the locals living around the park using semi-structured questionnairesto evaluates their understanding on the economic important of *Irvingia gabonensis* in the area.
Shannon Weiner equitability and was used to determine the abundance of each class-size of *Irvingia gabonensis*. The index is stated as follow:

$$H^1 = -\sum Pi\,(\ln Pi) \ldots\ldots\ldots (1)$$

Where: H^I = the Shannon Index, Pi is the proportion of the i^{th} species in the sample, ie ni/N (ni= abundance of each species and N = total number of individual species), and InPi is the natural logarithm of the species proportion.
The Margalef's index was used to measure regeneration richness among regenerants was determined. Margalef's index was calculated using the equation below as adopted by Victor *et al*., (2014):

$$D = \frac{S-1}{\ln N} \ldots\ldots\ldots\ldots\ldots (2)$$

where:
S = number of species
N = number of individual
The following indices was also used for data analysis:

Basal Area (B_A): ofall trees in tl es plots were calculated using the formula**:**

$$B_A = \frac{\pi(D)^2}{4} \ldots (2)$$

B_A=Basal Area (m^2),

Species Relative Frequency (RF)
Species Relative Frequency (RF) is calculated by dividing the frequency by the sum of the frequencies of all species, multiplied by 100 (to obtain a percentage);

$$\text{Frequency} = \frac{Number\ of\ plots\ in\ which\ species\ occurs}{Total\ of\ plots\ Sampled} \ldots\ldots\ldots (3)$$

$$\text{Relative Frequency} = \frac{Frequency\ value\ for\ a\ species}{Total\ of\ frequency\ for\ all\ speies} \ x\ 100 \ldots\ldots (4)$$

Species Relative Density (RD)
Species relative density is an index for species relative distribution assessment, and calculated as follows:

$$\text{Density} = \frac{Number\ of\ Individuals}{Area\ Samples}$$

$$\text{Relative Density} = \frac{Density\ of\ a\ Species}{Total\ Density\ for\ all\ Species}\ x\ 100 \ldots (5)$$

Species Relative Dominance
Species Relative Dominance (RD0 (%)), is the assessment of relative space occupancy of a tree in each area. The formula used for estimating is as follows:

$$\text{Dominance} = \frac{Total\ of\ Basal\ Area\ or\ Area\ Coverage\ values}{Area\ Sampled} \ldots\ldots (6)$$

$$\text{Relative Dominance} = \frac{Dominance\ for\ a\ species}{Total\ number\ of\ plots\ Sampled}\ x\ 100 \ldots (7)$$

Importance Value Index (IVI)
Importance Value Index involves the measure of how dominant a species is in a specified area. The tree species Importance Value Index (IVI) was calculated for each ecological zones using the following equation:
IVI = (RDo + RD)/2 .....(8)
Where;
RD= Relative Density, RDo = Relative Dominance,

The different class-sizes of regeneration status of all *Irvingia gabonenesis*tree encountered in the Kwano Forest were categorised into good, fair, poor, and none (Gebeyehu *et al*., 2019). Class-sized of *Irvingia gabonenesis* was considered to be of good regeneration status if their seedlings are more than saplings and saplings are more than the adult tree, and fair regeneration if seedlings are more than saplings and saplings are less than the adult trees (Neelo

et al., 2015 and Storch *et al*., 2018). While poor regeneration is when the tree species appeared only in adult and sapling stages without seedlings, and none regenerate tree species are found only at the adult stage without saplings and seedlings (Maua *et al*., 2020). We calculated the density of seedlings, saplings, juveniles and matured trees as the total number of stems divided by the sampled area (Mohammed *et al.*, 2021 and Idrissa *et al*., 2018), while tree basal area (m^2), relative abundance, relative dominance, relative frequency, and the importance value index were computed using. Descriptive statistics for diameter, height, and density were performed were used.

RESULTS

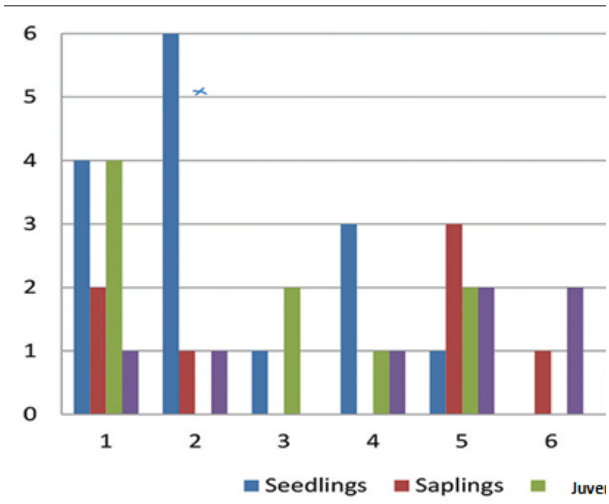
Generally the results showed that seedlings dominated the Kwano forest with considerable populations of *Irvingia gabonensis* especially at seedling and sapling stages. These illustrate both seedlings showed a good regeneration status and fair adult's trees.The limited frequency of the saplings and poles classes may be due to disturbances of Bush pigs (*Potamochoerus larvatus*) on the fresh fruits which had significantly contributed to the deterioration of trees and lower regeneration status, abundance and frequency in the Kwano forests of Gashaka-Gumti National Park (GGNP)because of their high encroach ability which lower-stocked and degraded *Irvingia gabonensis* in the forest dueto their fast growth and invasion property this is the case of saplings and poles with poor regeneration status and limited matured trees as shoed in Figure1.

The limited frequency of the saplings and poles classes may be due to disturbances of Bush pigs (*Potamochoerus larvatus*) on the fresh fruits which had significantly contributed to the deterioration of trees and lower regeneration status, abundance, and frequency in the Kwano forests of GGNP because of their high encroach ability which lower-stocked and degraded *Irvingia gabonensis* in the forest due to their fast growth and invasion property, this is the case of saplings and poles with poor regeneration status and limited matured trees.

Results of Abundance and regeneration status of *Irvingia gabonensis* in GGNP

A total of seventy-six (76) *Irvingia gabonensis* wereencountered in the ten (10) plots sampled during the study. Four (4) class-sizes enccountered for regeneration statuses of each class size were; seedlings, saplings, juveniles, and matured. Although the number of *Irvingia gabonensis* abundance among the plots' differed; the number of Seedlings (33), saplings (15), juveniles (4), and then matured (24). Figure 1; shows that seedlings are more abundance in all the plots followed by saplings, juveniles and matured trees are least in terms of abundance.

Fig. 1: High-class distribution of *Irvingia gabonensis* Abundance in GGNP



Diversity indices of *Irvingia gabonensis* in Kwano Forest of GGNP

The summary of diversity indices of *Irvingia gabonensis* tree class-sizes across the sampled plots at the Kwano Forest of Gashaka Gumti National Park (GGNP) is presented in Table 1a. The results showed generally that, Shannon Weiner diversity index of seedlings, sapling, juveniles and matured in the study area recorded (2.1497), Simpson's index (0.9979), Pielou eveness index (0.9299), and Margelef index recorded (2.1640) as showed in Table 1b.

Table 1a: Overall *Irvingia gabonensis* diversity in the study area

S/No.	Diversity indices	Index value
1	Shannon-Weiner index	2.1407
2	Simpson's index	0.9979
3	Pielou evenness index	0.9299
4	Margalef index	2.1640

Table 1b: The Shannon Wiener diversity of Regenerants

Plot	Abundance(Ni)	Pi	Lnpi	Pi*lnpi
1	7	0.0921	-2.3848	-0.2196
2	22	0.2895	-1.2396	-0.3589
3	2	0.0263	-3.6382	-0.0957
4	8	0.1053	-2.2509	-0.2370
5	1	0.0132	-4.3275	-0.0571
6	2	0.0263	-3.6382	-0.0957
7	1	0.0132	-4.3272	-0.4084
8	20	0.2632	-1.3348	-0.3513
9	1	0.0132	-4.3272	-0.0571
10	12	0.1250	-2.0794	-0.2599
Total	**76**			**-2.1407**

Distribution of *Irvingia gabonensis*

The results ofdistributionof *Irvingia gabonensis* seedlings, saplings, juveniles and matures shown that, the class-size and relative density of seedlings *was* the best in the four classes of the samples studied with 43 %, perhaps because it shows more tolerance in an open canopy condition. Nevertheless, it was equally tolerance under shade in the forest compartments. This was closely followed by matured *Irvingia gabonensis* trees was 32 % while, saplings had 20 %, the juveniles with the least of 5 %.

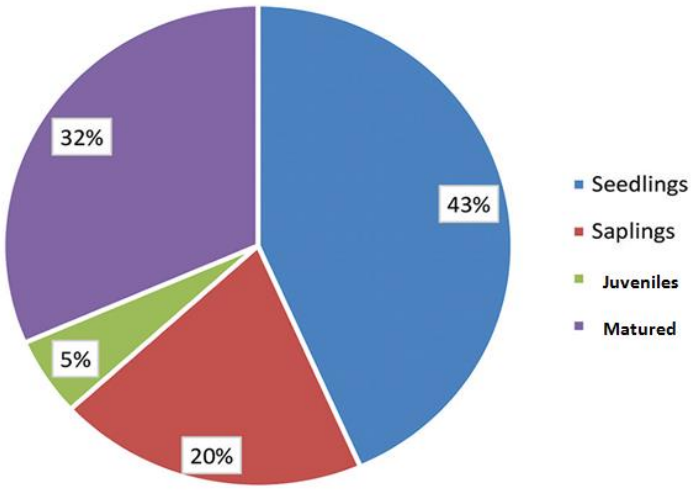


Figure. 2: The distribution *Irvingia gabonensis* based on class-sizes

Growth variables of *Irvingia gabonensis* of Kwano Forest in GGNP

The result showed that the variables of *Irvingia gabonensis* class-sizes indicate seedlings and had the highest relative frequency of (43.42%) followed by adults (31.58%), and saplings recorded a relative frequency of (19.74%). The least relative frequency of (5.26%) was recorded in juveniles class-sizes Table 2. The result of the highest relative dominance (99.69%) was recorded in adults, followed by poles (0.27%), and saplings (3.089%). The least relative dominance was obtained in seedlings (0.001%).

The result found the total densities of seedling sapling, juveniles, and matured trees of the

Kwano forest were 0.00825m^2/plot, 0.00375m^2/plot,0.001m^2/plot and 0.006m^2/plot respectively.

The basal area of seedlings, saplings, poles, and adults of *Irvingia gabonensis* in Kano Forest showed variations in the forests (Table 2). Based on the result, the basal area of adult was the largest with the value of 166.29 m^2/ha, followed by poles with 0.44 m^2/ha, saplings had a value of 0.07 m^2/ha while seedlings had the least basal area of 0.0016 m2/ha, seedlings have smallest class-sized, this may be due to their renewal nature of the forest: A large number of seedlings in a forest indicates that the forest is in a state of renewal, with the potential to grow and sustain itself for a long time.The important value index (IVI) of *Irvingia gabonensis* class-sizes showed that adults recorded the highest IVI of 65.63%, followed by seedlings (21.71%) and saplings (9.89%). The lowest IVI of 2.76% was in juveniles (Table 2).

Table 2: Important Value Index of *Irvingia gabonensis* at Kwano Forest

Class-Sizes	Abundance	Density (m^2/plot)	BA (cm^2/ha)	RD (%)	RDo (%)	IVI	Status
Seedlings	33	0.00825	0.0016	43.42	0.00096	21.71	Good
Saplings	15	0.00375	0.07	19.74	0.042	9.89	fair
Juveniles	4	0.001	0.44	5.26	0.26704	2.76	Poor
Matured	24	0.006	166.29	31.58	99.69	65.63	fair
Total	**76**	**0.019**	**166.8**	**100.00**	**100.00**		

Fig. 4: Fruits of Bush mango trees in Kwano Forest, Gashaka-Gumti National Park

DISCUSSION

Basal area (BA) in the study provides a better measure of the relative importance of the regeneration status of *Irvingia gabonensis* than just simple stem count (Tamrat, 1994). Thus, *Irvingia gabonensis* class-sizes with the largest contribution to the basal area in Kwano Forest are found among the matured and juveniles. The variations in basal area may be due to differences in measurements of the cross-sectional area occupied by matured trees at breast height. Therefore, basal area was strongly correlated with tree biomass and productivity. The differences in class-sizes found in the study were similar to Amare and Wubetie (2023) who said that basal area an important factor in determining the diversity of tree species present in a forest.

By measuring the basal area of different tree species, forest managers can determine the relative abundance of each species, providing important information about biodiversity as showed in the plots in Table 1a. In general, the results in the table 2, also indicated that class-sizes of *Irvingia gabonensis* with the highest relative dominance as well as classes observed with high relative density. This indicates that adult Bush Mango with high relative density provide habitat and food for a wide variety of wildlife, including birds, insects, and mammals. Their presence also promotes biodiversity in the forest ecosystems. These findings confirmed the works of David *et al*., (2012) said that bush pigs, otherwise known as red river hogs, (*Potamochoerus porcus*) are known seed predators in Afrotropical. Seed predators are key species affecting plant population demographics by influencing the survival of early successional stages, such as seeds and seedlings, thereby playing a pivotal role in the regeneration, colonization ability, and spatial distribution of plants (Adeyemi *et al*.,2013).

Regeneration status of all the class-sizes of *Irvingia gabonensis* in a given stand is considered to be good if numbers of seedlings are greater than saplings and saplings are greater than pole trees. Conversely, regeneration status of all the class-sizes is considered to be fair if seedlings are greater than saplings and saplings are less or equal to adult trees (Neelo *et al*., 2015; Storch *et al*., 2018). The results of this study (Table 2) revealed that there are a large number of seedlings in a forest indicating that the forest is in a state of renewal, with the potential to grow and sustain itself for a long time. More seedlings of *Irvingia gabonensis* in Kwano forest mean a greater chance of plant diversity in the forest, which can promote a healthier and more stable ecosystem. This is because new seedlings can contribute to the improvement of soil health and nutrient cycling in the forest.

The highest regeneration potentials were recorded in seedlings, followed by adults, saplings, and the least in poles. The differences in value could be attributed to the management practices adopted in the forest. The regeneration potential in the study area was generally good, fair, and poor in some cases. The fair in saplings and poor in pole have a serious implication on the regeneration and conservation of the various classes of *Irvingia gabonensis* encountered, on the renewal of the forest in general this is because, saplings and poles are often surrounded by adult trees that compete for resources such as sunlight, moisture, and nutrients, which can limit their ability to regenerate and grow are often more susceptible to damage from animals, weather events, and human activity than mature trees, which can reduce their regeneration potential. Wale *et al*. (2012) also noted that lack of adequate regeneration is an issue recognized by foresters and ecologists. Malik and Bhat (2016) also observed limited regeneration and subsequently declining populations of some dominant native tree species .

The results of distribution of *Irvingia gabonensis* seedlings, saplings, poles, and adults are shown in Fig. 2. The class-size and relative density of seedlings were the best represented of the four classes in the samples studied. The high percentages showed in seedlings and adults, perhaps because it showed more tolerance of an open canopy condition. Nevertheless, it equally showed tolerance for shade in the forest compartments. This is similar to the works of Kochare *et al*., (2018), who reported that although various savannah tree species have been reported as drought and browse-tolerant species, extreme weather, and over-browsing can interrupt their growth and population dynamics.

The dominate class-size in the Kwano forest of GGNP had considerable populations of *Irvingia*

gabonensis in seedling and sapling stages. These indicated that seedlings had showed a good regeneration status and fair regeneration status among matured trees encountered. The limited frequencies of the sapling and juveniles classes may be due to disturbances of bush pigs (*P. larvatus*) on the fresh fruits which had significantly contributed to the deterioration of trees and lower regeneration status, abundance and frequency in the Kwano forests of GGNP, this is because of their high encroachability which lower-stocked and degraded *Irvingia gabonensis* in the forest as observed by David *et al.,* (2012) that bush pigs have powerful jaws adapted to crush hard food like seeds (Herring, 1985). For example, even seeds protected by thick shells, such as I. gabonensis, can be crushed. The mean force needed to crack an Irvingia shell was calculated to be 2.06–3.67 kN and this ability to destroy seeds could lead to bush pig-mediated density-dependent effects (Ogunsina *et al*., 2008).

Importance Value Index *Irvingia gabonensis* class-sizes in the forest were grouped into four, namely; seedlings, saplings, poles, and adults IVI classes based on their IVI values for conservation priority as adopted by Amare and Wubetie (2023). Priority Class 1 (IVI <1) should get 23 uppermost conservation priority since these species are at risk of local extinction. Those classes with lower IVI values need high conservation efforts, while those with higher IVI values (IVI >14.1) need monitoring management. Based on their higher IVI value, adult tree class was found to be the most dominant and ecologically most significant *Irvingia gabonensis* trees in Kwano forest. Esor *et al*. (2023) also added that the high importance value index IVI of a species indicates its dominance and ecological success, its good power of regeneration, and greater ecological amplitude; these plants also need conservation management. This finding is similar to the works of Omokhua *et al*. (2012); they assessed the importance as the fruit is similar to a mango and is used for food. The seeds are used to make medicine. *Irvingia gabonensis* is sometimes used for weight loss, high cholesterol, and diabetes, but there is no good scientific evidence to support these uses. Despite the nutritional importance of *Irvingia gabonensis*, there are no large-scale plantations of the species for seed and fruit yield data collection.

Existing stands are mainly found in traditional agroforestry system and compound farm or homestead. This creates the need for awareness in both yield potential and economic roles, so as to encourage more people to embark on large-scale plantation development and probably set up small-scale industries for seed export to many countries. The seedlings had the second important values because seedlings assess age and size of the tree; hence, through seedlings regeneration status can often be determined by the age and size of the tree. Young, small trees suggest active regeneration while large, old trees may indicate a lack of regeneration. Similar to the results of Mohammed *et al*., (2021), a tree species was considered to be of good regeneration status if their seedlings are more than saplings and saplings are more than the adult tree, and fair regeneration if seedlings are more than saplings and saplings are less than the adult trees. While poor regeneration is when the tree species appeared only in adult and sapling stages without seedlings and no regenerated tree species are found only at the adult stage without saplings and seedlings (Maua *et al*., 2020).

Market survey was carried out to ascertained the indigenous knowledge of bush mango among the surrounding communities to the forest, it was discovered that there were few or none existances fresh fruit collector of bush mango in the forest. This is due to tight security surveillance initiated by African Nature Investment (ANI) in the Kwano forest. The Kwano forest is situated in a very difficult terrain where accessibility is not easy; the distance to be covered even by the closest dwellers to the forest is far about 15 km from Gashaka village. The second reason is due to the fact that Bush Pigs (*P. larvatus*) do feast on the fresh fruits when they fall on the forest floors. During, field data collections, remnants of the freshly eaten fruits of bush mango by Bush Pigs were seen littered around. Field assistants have been working in the forest for at least 10 years and also ascertained to the fact that bush pigs feast so much on the fallen fruits making it very difficult even for them to have access to fallen matured fruits. There are times that they are opportune to get some of the matured fruits but not in large quantities that can be sold. These could be the reasons why none of the traders were seen in Gashska Village to be selling bush mango and that is

why the quantity of the products are now decreasing compare to what use to obtain within the past 5 years. This is most likely due to the fact that there is a decrease in the quantity produced and harvested from the source.

The traders encountered reported that the sources of *Irvingia gabonensis* around Gashaka were majorly brought from Kurmi Local Government Area of Taraba State and they also gets their supplies from Eastern part of Nigeria, from the States like; Enugu, Anambra, Abia States, and from the point of production in South-west parts of Nigeria. This distribution area was similar to the findings of Njoku (2016) who discovered that the majority of the wholesalers and retailers do buys their *Irvingia gabonensis* from Uli in Anambra state with a percentage of 30% and 25%, respectively. Njaba in Imo state has the same number of wholesalers and retailers who buy within the area that is 10%. Abakaliki in Ebonyi state also had an equal number of wholesalers and retailers that patronizes the area that is 20%. The remaining retailers bought or sourced their product from Nsukka (Enugu). All the traders in the surrounding communities to Kwano forest affirmed that there was a change in the price of the *Irvingia gabonensis* within the last 3 years and that the price was increasing.

Of all the respondents, only few traders about 10% do trade on bush mango (*Irvingia gabonensis*). In surrounding markets visited like; Mayo-Selbe, Karamti, Baruwa, and Goje to find out the units of measurement and selling prices, the market survey showed that dried kernel of 18.5 g cost N 100.00 k. One (1) mudu which is equivalent to 1488 g cost N 6000.00 k ($7.9365). As of the time of this study, a bag of dry kernel of *Irvingia gabonensis* weighted 83.33 Kg/bag was sold at N 330,000.00 k ($ 436.508) by communities merchant. According to respondents, bush mango is very expensive and this is because finished products pass through different marketing channels. This confirmed the work of Arowosoge (2017) who observed that the marketing channel revealed that "ogbono" passed through the hands of several middlemen known as intermediary buyers before reaching the wholesalers in the main markets. The situation where several middlemen are engaged is not a normal marketing channel for better profit to wholesalers and retailers while consumers are at the receiving end of the higher prices. The wholesalers would have to sell at higher prices to retailers while the retails' prices are also high to accommodate transportation cost and the profit taken by the middlemen. It was observed during this study that this abnormal marketing channel coupled with the distance covered since traders traveled outside the state had a serious effect on the marketing efficiency of *I. gabonensis* locally known as "ogbono". Reason being that retailers had to struggle to bring their goods to market in the study area after purchase.

CONCLUSION

In general, there was an increase of *Irvingia gabonensis* seedlings, saplings, and adult trees per hectare in Kwano Forest. Meanwhile, with the largest number of seedlings, so, collectively there is an apparent increasing of the natural regeneration trend of *Irvingia gabonensis* trees in the Kwano forest. Basically, the increasing seedlings meant that there was a potential for new growth and regeneration of the forest. This is a positive indication of a healthy and thriving ecosystem. The seedlings will eventually grow into trees, providing shade and shelter for wildlife as well as contributing to the natural beauty of the forest. In addition, more trees mean more fruits to explore for food. However, it is important to note that the success of the seedling depends on the various factors such as suitable weather conditions, soil quality, and competition with other tree species as well as conservation toward preservation and sustainable utilization of the tree species in the forest. Hence by considering the various stages of natural regeneration, researchers and conservationists can assess the current and future population dynamics of *Irvingia gabonensis*. This assessment enables the identification of factors that may hinder or enhance natural regeneration, such as habitat fragmentation, climate change, or animal activities. Ultimately, such assessments aid in the development of effective conservation strategies to ensure the long-term survival of *Irvingia gabonensis* and its associated ecosystem.

RECOMMENDATIONS

i. Studies should be expanded to other vital areas such as, other tree species like; *Irvingia wombolu*,*Treculia*

africana, Dacryodes edulis, Canarium, schweinfurthii.

ii. Activities of Bush Pigs should be constantly monitored avoid being eaten or wasted by the animals.

iii. freshly matured fruits of *Irvingia gabonensis* should be collected and processed for nursery establishment in the study area.

iv. (vi) Indigenous knowledge of *Irvingia gabonensis* (bush mango) should be a priority to the local communities in collaboration with the natural resource managers to effectively manage the tree species before they become critically endangered.

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