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Research Article

ASSESSMENT OF THE NATURAL REGENERATION STATUS OF *IRVINGIA GABONENSIS* (BUSH MANGO) IN THE KWANO FOREST OF GASHAKA GUMTI NATIONAL PARK, NIGERIA

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ABSTRACT

The objectives of the research assess the natural regeneration status of *irvingia gabonensis* (bush mango) *gabonensis* by the use of number of regenerants such as seedlings, saplings, poles, and adults. The research was carried out in Kwano Forest of Gashaka Gumti National Park in Nigeria. A biophysical survey of trees, based on diameter classess was used. Opportunistic sampling design was employed to establish plots measuring 30m x 30m square where data on various different class-sizes of *Irvingia gabonensis* was collected. The ranging poles were used as pegs to establish the plots. Area where *Irvingia gabonensis* were spotted growing was marked out using the Global Positioning System (GPS). The different class-sizes was determined by measuring the diameter at breast height (dbh) of each *Irvingia gabonensis* species encountered in each plot using diameter tape and vernier calliper. The results showed that there was an increasing trend of *I. gabonensis* seedlings with good regeneration status and saplings and adults are fair in regeneration. Poles had poor regeneration. In other words, there was an apparent diminishing of the natural regeneration trend of *I. gabonensis* trees among pole classes in the Kwano Forest as a result of constant invasion and disturbances of bush pigs feedings on the ripe fruits thereby creating a setback on regeneration trend. Based on the results of this study, the need for concurrent development of possible and efficient alternative method of regeneration is necessary.

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, *I. gabonensis* ranks among five principal fruit trees which occur in traditional farms as compared to natural forests (Ewane *et al.,* 2009).

Both fruits and seeds of the species 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. Consequently, *I. 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 *I. 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 *I. gabonensis* species, but due to poverty, economic hardship, and human search for non-timber forest products as alternative means of survival, *I. gabonensis* species has likely been overexploited or affected by wildfire. Therefore, there is a need to carry out a natural regeneration status to ascertain its survival rate in the near future (Ndakidemi and Ndakidemi 2013). As such the study intends; to determine the abundance of *I. gabonensis* species with respect to age classes; seedlings, saplings, poles, 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 *I. gabonensis* by locals around the forest (Adekunle, 2007).

MATERIALS AND METHODS

Study area description

This study will be carried out in Kwano forest (approx. 583 m^2; 07° 30' N–011° 30' E) at the foot of the hill of Chappal Tale which is about 3 h walk (11 aerial km) from the nearest village of Gashaka the Southern part of the park. Kwano forest lies at an altitude of about 500–800 m (Buba, 2013) (Fig. 1).

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

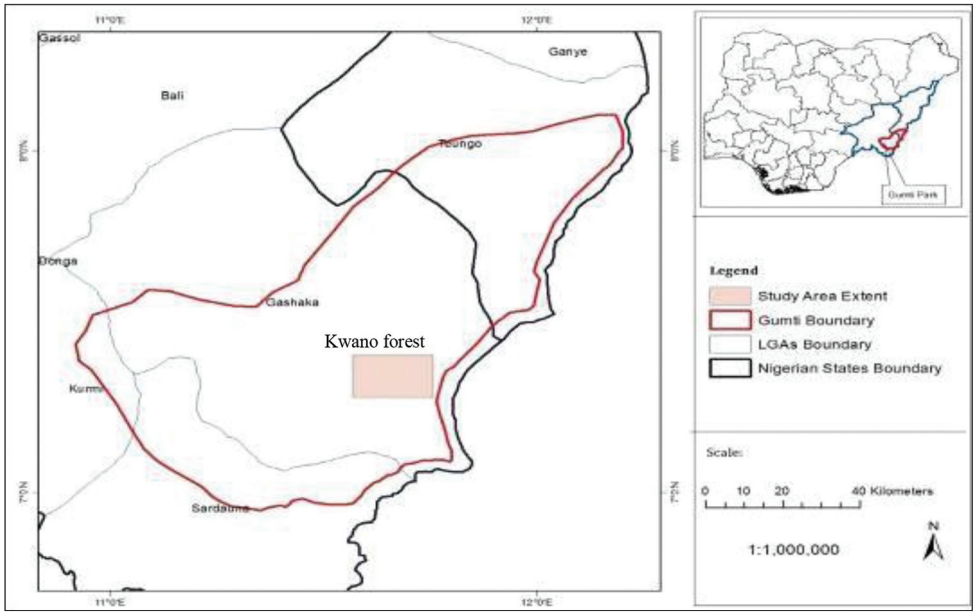

Fig. 1: Map of Gashaka-Gumti National Park showing Kwano adopted from Akinsoji *et al*. (2016)

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).

Study design

At first, 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 *I. gabonensis* species of the whole study area, a number of field visits were conducted at the advent of the field work adopted as designed by Humphrey (2015).

Opportunistic sampling design was employed to establish plots measuring 30m x 30m square where data on the various age classes of *I. gabonensis* were collected. The ranging poles will be used as pegs to establish the plots. Areas where *I. gabonensis* were spotted growing were marked out using the global positioning system. The different age classes will be determined by measuring the diameter at breast height (DBH) of each *Irvingia gabonensis* species encountered in each plot using a Vernier caliper. The Flagging tape will be used to mark out each established plot. Two hundred and fifty 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 (50 respondents from each community).

Data collection and analysis

All *Irvingia gabonenesis* individuals in the seedling, sapling, pole, and adults tree size classes located within the sample plot (20 m × 20 m) were identified to species level and measured. Seedlings were only counted. For saplings, poles, and small trees, a diameter tape or a diameter caliper was used. Diameter was measured for the tree, pole, sapling, and adults classes at breast height (1.3 m on the upper side of the stem) from the ground.

Data on the various class-sizes of *I. gabonenesis* were collected within the established plots as described above. The *I. gabonenesis* trees with a DBH of 1–5 cm were considered seedlings, 6–10 cm as saplings, 11–15 cm as poles, and 16 cm and above as adults.

Information on indigenous knowledge of the locals on *I. gabonensis* was gathered through interview with the various communities using semi-structured questionnaire as mentioned above.

Shannon Weiner equitability and Mangalef's indices were used to determine the abundance of each class-size of *I. gabonensis*.

Descriptive statistical techniques such as the ratios, percentages, graphical depictions and frequency counts, and measurement units used to evaluate indigenous knowledge, sources, and prices of *I. gabonensis*.

The following indices will be used to analyze the data collected;

Basal Area (B_A): of all trees in the sample plots were calculated using the formula:

$$B_A = \frac{\pi(D)^2}{4} \quad (1)$$

B_A=Basal area (m^2),

D=DBH (cm) and π =(3.142)

Species relative frequency (RF)

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

$$\text{Frequency} = \frac{\text{Number of plots in which species occurs}}{\text{Total of plots sampled}} \quad (2)$$

$$\text{Relative frequency} = \frac{\text{Frequency value for a species}}{\text{Total of frequency for all speies}} \times 100 \quad (3)$$

Species relative density (RD)

Species RD is an index for species relative distribution assessment and calculated as follows:

$$\text{Density} = \frac{\text{Number of individuals}}{\text{Area samples}}$$

$$\text{Relative density} = \frac{\text{Density of a species}}{\text{Total density for all species}} \times 100 \quad (4)$$

Species relative dominance (RDo)

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

$$\text{Dominance} = \frac{\text{Total of basal area or area coverage values}}{\text{Area sampled}}$$

$$\text{Relative dominance} = \frac{\text{Dominance for a species}}{\text{Total number of plots sampled}} \times 100 \quad (5)$$

Importance value index (IVI)

IVI involves the measure of how dominant a species is in a specified area. The tree species IVI was calculated for each ecological zones using the following equation:

IVI=(RDo+RD)/2

Where;

RD=Relative density,

RDo=Relative dominance

Data analysis

The different class-sizes of regeneration status of all *I. gabonenesis* tree encountered in the Kwano Forest were categorized into good, fair, poor, and none (Gebeyehu *et al*., 2019). Class-sized *I. 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; 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, poles, and adult trees as the total number of stems divided by the sampled area (Mohammed *et al.,* 2021; 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 and were used.

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:

- Good if seedlings > saplings > adults;
- Fair if seedlings > saplings ≤ adults;
- Poor if there were saplings but no seedlings (irrespective of the relative numbers of saplings and adults);
- None if only adults were present, with no seedlings or saplings;
- New if only saplings and/or seedlings were present, with no adults.

RESULTS

The results of distribution of *I. 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 with 43 %, perhaps because it showed more tolerance of an open canopy condition. Nevertheless, it equally showed tolerance for shade in the forest compartments. This was closely followed by adults *I. gabonensis* trees with class-sizes of 32 % while saplings had 20 %, the poles with the least tree class-size of 5.26%.

In general, the results showed that seedlings dominate the Kwano forest with considerable populations of *I. 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 GGNP because of their high encroach ability which lower-stocked and degraded *I. 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 adults trees.

Abundance and regeneration status of *I. gabonensis* in Kwano forest

A total of 76 *I. gabonensis* encountered in the sampled 10 plots in the Kwano Forest of four class-sizes were identified for regeneration statuses of each class size, namely; seedlings, saplings, poles, and adults were encountered across Kwano Forest. Although the number of *I. gabonensis* abundance among the plots' was slightly differ, the number of Seedlings (33), saplings (15), poles (4), and adults (24) as shown in Fig. 3.

Diversity indices of *I. gabonensis* in Kwano Forest

The summary of diversity indices of *I. gabonensis* tree class-sizes across the sampled plots at the Kwano Forest is presented in Table 1b. The results showed that the Shannon Weiner diversity indices in the study area; Shannon Weiner index recorded (2.1497), Simpson's index (0.9979), Pielou eveness index (0.9299), and Margelef index recorded (2.1640).

Growth variables of *I. gabonensis* in Kwano Forest

The result found the total densities of seedling, sapling, poles, and adult plants of the Kwano forest were 0.00825 ha^{-1}, 0.00375 ha^{-1}, 0.001 ha^{-1},

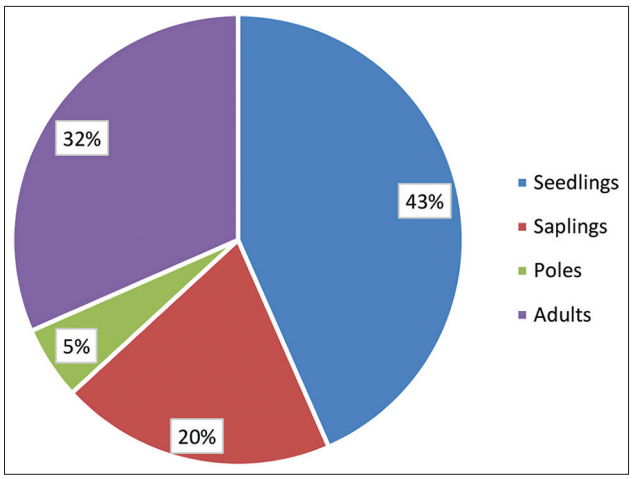

Fig. 2: The distribution *Irvingia gabonensis* based on class-sizes

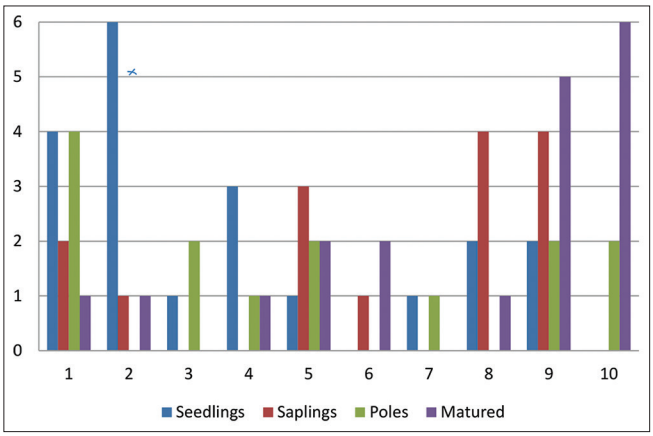

Fig. 3: High-class distribution of *Irvingia gabonensis* Abundance in Kwano Forest

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

Table 1a: The Shannon Wiener diversity index in the study area

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

Table 1b: 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

and 0.006 ha^{-1}, respectively. The basal area of seedlings, saplings, poles, and adults of *I. 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 m^2/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 result showed that the variables of *I. 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 poles 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 important value index (IVI) of *I. 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 poles (Table 2).

DISCUSSION

Basal area (B_A) in the study provides a better measure of the relative importance of the *I. gabonensis* than simple stem count (Tamrat, 1994). Thus, *I. gabonensis* class-sizes with the largest contribution to the basal area in Kwano Forest are found in adults and poles. The variations in basal area may be due to variation in measurements of the cross-sectional area occupied by trees at breast height. Therefore, basal area is strongly correlated with tree biomass and productivity. The differences in class-sizes found in the study are 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 also indicated that class-sizes of *I. gabonensis* with the highest relative dominance are like 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 *I. 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

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

Class sizes	Abundance	Density	BA (m^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
Poles	4	0.001	0.44	5.26	0.26704	2.76	Poor
Adults	24	0.006	166.29	31.58	99.69	65.63	fair
Total	76	0.019	166.8	100.00	100.00		

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 *I. 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 *I. 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 *I. 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.

In general, the results showed dominate class-sizes in the Kwano forest with considerable populations of *I. gabonensis* in seedling and sapling stages. These illustrate that 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 (*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 because of their high encroach ability which lower-stocked and degraded *I. gabonensis* in the forest due to their fast growth and invasion property 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 *I. 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 *I. 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. *I. 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 I. 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 and units of measurement and selling prices

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*) due feast on the fresh fruits when they fall on the forest floors.

While, during field data collections, remnants of the freshly eaten fruits by bush mango were observed. 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 (Fig. 4) 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 *I. gabonensis* are majorly brought from Kurmi Local Government Area of Taraba State and some said they do to get their supplies from Eastern part of Nigeria, namely; Enugu, Anambra, Abia States, and from the point of production in South-west Nigeria. This distribution area is similar to the findings of Njoku (2016) who discovered that the majority of the wholesalers and retailers bought 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 *I. gabonensis* within the past 3 years and that the price was increasing.

Of all the respondents, only few traders about 10% do trade on bush mango (*I. 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 ($7.9365). As of the time of this study, a bag of dry kernel of *I. gabonensis* weighted 83.33 Kg/bag was sold at N 330,000.00 k ($ 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 *I. 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 *I. 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.

RECOMMENDATIONS

(i) Studies should be expanded to other vital areas such as, other tree species, soil nutrient, soil seed bank, anthropogenic impact, and others of the forest, should be studied to identify the environmental factors responsible for the observed pattern.

(ii) Analysis of IVI and species structure shows that some important class-sizes of *Irvingia gabonensis* in poles and saplings are poor in regeneration and recruitment conditions, and this may be due to bush pig's activities in the forest with the ability to destroy seeds could lead to bush pig-mediated density-dependent effects thereby affecting seed survival for many trees.

(iii) Indigenous knowledge on *I. gabonensis* (bush mango) sustainability should be a priority to the management of the forest and few marketers in the communities around the forest should be encouraged to engage in further education programs such as seminars.

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