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Population Structure and Regeneration Status of Trees Used in Making Wooden Mortar and Pestle in the Takamanda Rainforest South West Region, Cameroon

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Authors' contributions

This work was carried out in collaboration between all authors. Authors NRN and ELC designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors TY and NRN managed the literature searches, analyses of the study performed the spectroscopy analysis and author LCFB managed the experimental process and authors LCFB and NRN identified the species of plant. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Forest situated at the vicinity of communities hardly attained a fixed climax community over long period due to anthropogenic and natural factors. We investigated the density, population structure and regeneration status of six tree species (*Annickia chlorantha*, *Baphia nitida*, *Irvingia gabonensis*, *Pterocarpus soyauxii*, *Terminalia ivorensis* and *Melicia excelsa*) harvested for making of wooden mortars and pestles in three forest dependent communities. Data were collected through survey and focus group discussions with wood carvers. Results showed that, the highest tree density of 142.1 trees ha⁻¹ and 54.4 trees ha⁻¹ were recorded for *Baphia nitida* in unprotected and protected forest stands:

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respectively. The *Melicia excelsa* had density of 3.1 trees ha⁻¹. Most of the trees diameters were within the class sizes 0.0-4.9cm and 5.0-9.9cm in unprotected and protected stands. A total of 248 mortars and 477 pestles were produced in 2007-2012 while in 2001-2006 a total of 155 mortars and 304 pestles were produced in the protected and unprotected stands of the Takamanda rainforest. Kajifu 1 recorded the highest mortar (179) and Pestles (437) while Kekukesem recorded the lowest mortars (96) and pestles (136) produced from 2001-2012. We noticed that, all targeted tree species were found facing harvesting pressure from the increasing human population.

Keywords: Tree; Population; Management; structure; diameter class; protected and unprotected forest.

1. INTRODUCTION

Wooden mortar and pestle are essential in the culture of many ethnic groups in Cameroon. They are used daily in a variety of ways in both urban and rural areas of Cameroon. In the North and Far North regions, it is used in the pounding of millets and maize, in the East region it is used to pound dried cassavas tubers to cassava flour, in the Central region to pound *Gnetum africanum*, in the North-west to pound *Colocosia sp* "Achu" and in the South-west in pounding cassava "water fufu". The wooden mortars and pestles in the Takamanda communities are used in the preparation of cultural dishes, preparation of spices and crushing of plant parts for medicines. The wooden mortars and pestles are made in different sizes and shapes based on the need of the family or community. The larger mortars and pestles are used in palm nut processing and cassavas paste preparation "water fufu". The medium and smaller sizes are used for spices preparation and medicine crushing. Wooden mortars and pestles making is an important livelihood activities in most of the communities in the Takamanda rainforest (Fig. 1). Wooden mortars and pestles making provides full and part time employment for the local inhabitants.

The Takamanda rainforest is an area noted for its richness and diversity in plant and animal species which are widely distributed in different habitat types [1,2,3,4]. This area harbours some African threatened species which are paramount for conservation interests. Some of these tree species included *Terminalia ivorensis*, *Pterocarpus soyauxii*, *Melicia excelsa*, *Balonella toxisperma*, *Staudtia stapitata*, *Azelia bipindensis*, *Diospyros sp.* [1]. Apart from plant species, the forest equally harbours animals of conservation interest, amongst these are the Nigeria-Cameroon chimpanzee (*Pan troglodytes vellerosus*), drill (*Mandrillus leucophaeus*) and Preuss's guenon (*Cercopithecus preussi*) [5,6]. The Cross River gorilla, *Gorilla gorilla diehlii* is an endangered and endemic species in this forest [5,1].

The wooden mortars and pestles are made from a variety of tree species (*Nauclea diderrichii*, *Melicia excelsa*, *Terminalia ivorensis*, *Pterocarpus soyauxii* and *Irvingia spp*) harvested from the Takamanda rainforest (Table 1). In the past few years the social and ecological impacts from the subsistence exploitation and production of pestles and mortars have been very rare.

Recently, with the high birth rate and subsequent establishment of adult children to their own homes, this will definitely increase the demand for wooden mortar and pestle making in the area. This will therefore add more pressure on the trees exploitation for mortar and pestle making. Increasing demand for these mortars and pestles by neighboring countries which have similar traditional meals and medicine preparation has also encouraged the exploitation

of these species. With the high demands as a result of overexploitation of these tree species have caused them locally extinct. Besides, the overexploitation of these tree species there has been the destruction of fragile habitats, modification of microclimate for other plants and animal species hampered growth and establishment as evidenced by many earlier global studies [7,8,9,10,11,12,13].

Although the high demand for these trees for wooden mortars and pestles in the communities of the Takamanda rainforest, it is imperative to estimate the population structure of these tree species as a prerequisite for developing sustainable use and management strategies. Knowledge of the population structure of the target tree species provides an insight into the availability, survival and habitat characteristics of the species used in making mortar and pestles.

Table 1. Common name/ Trade name, articles produced and other uses of species

Species	Family	Common/ trade name	Articles produced	Other uses
<i>Annickia chlorantha</i> (Oliv.) Setten & Maas	Annonaceae	none	mortar	medicinal
<i>Baphia nitida</i> Lodd.	Fabaceae	None	Pestle	Timber
<i>Pterocarpus soyauxii</i> Taub	Fabaceae	Camwood	mortar/Pestle	Timber/medicinal
<i>Melicia excelsa</i> Welw.C.C Berg	Moraceae	Iroko	mortar/Pestle	Timber/medicinal
<i>Terminalia ivorensis</i> Chev	Combretaceae	Afara	mortar/Pestle	Timber
<i>Irvingia gabonensis</i> Aubrey-Lecomteex. Rorke	Irvingiaceae	Bush mango	Mortar /Pestle	Condiment/ medicinal

Different sites in the Takamanda rainforest have experienced different levels of harvesting pressure. This study was considered important on three main points. Firstly, there is a need to generate scientific information that can be utilized in the conservation, preservation and management of trees used in making mortars and pestles in rainforest species. Secondly, wooden mortar and pestles makers need to know the most appropriate ways of utilizing the slow growing indigenous species. Thirdly, baseline information is needed for monitoring changes in population of the target tree species in the natural forest. The above objectives of this study were (i) to determine the population structure of six tree species commonly harvested by mortars and pestles maker in unprotected and protected forest stands of the Takamanda rainforest. and (ii) to compare the regeneration pattern of the target species in the above forest and the implications for sustainable harvest.

1.2 Study Sites

The study was carried out in the unprotected and protected sites of Takamanda rainforest in the south west Cameroon (05°59'-06°21' N and 09°11'-09°30'E, covering 67,599 ha).The Rainforest stretches along the eastern border of Nigeria [14]. The Takamanda area lacks accurate climatological data, which undoubtedly vary due to the undulated gradient of the area which has favoured its rich diversity in flora and fauna. In general, the region has two distinct seasons (rainy and dry) with most rainfall occurring from April to November [5]. The annual rainfall is about 4,500 mm per year [15]. From November to April, the climate is mainly dry. Some months, usually January and February, may receive no rain at all. The

mean annual temperature is 27°C. Normally, the temperatures are cooler in the rainy season than in the dry season.



(a)



(b)



(c)



(d)



(e)

Fig. 1. Show (a) carving of new mortar and pestle, (b) and (c) processing of palm oil (d) and (e) preparation of water fufu in the Takamanda area

2. MATERIALS AND METHODS

The four selected villages were based on their proximity to the forest as well as the importance of mortars and pestles in the culture of the people of the Takamanda rainforest (Fig. 2). Information was collected using interview and survey [16,13] on tree species used in making mortars and pestles.

2.1 Questionnaires and Interview Establishment

Data collected from semi structured questionnaires, group discussions and field observations were based on the types of trees commonly used for making wooden mortars and pestles in Kajifu 1, Kajifu 2, Kekukesem communities (Fig. 2). Prior to the administration of the questionnaires and interviews to the informants (mortars and pestles makers), the aim of the study and the need for the research was explained. Within a period of 35 days stay in the villages the questionnaires were administered only to wood carvers (mortars and pestles makers, drum makers and canoes makers) in the respective villages.

The information recorded on the data sheets includes village of origin, main occupation, number of persons in the household, when you started making mortars and pestles, which types of trees are used, why the type of trees, which of the trees are preferable, which of the trees are commonly used, which sizes are commonly done, estimated quantity produced in a month, estimated quantity produced in a year, estimated quantity produced before (2001-2006), estimated quantity produced after (2007-2012), sizes commonly produced cost of the bowls and other uses of the trees used in making mortars and pestles.

2. 2 Vegetation Assessment

Eight transects of 10 x 500 m long and running north, northeast, east, southeast, south, southwest, west and northwest were established in each site (primary and secondary forests) radiating from a point approximating the centre of the site. The measurement of seedlings, saplings, poles and mature trees were measured at Diameter at breast height (DBH). These were recorded from 35 sample plots measuring 20 x 20 m in undisturbed 50 ha plot and 16 sample plots of 20 x 20 m in disturbed 16ha plot laid 80 m intervals along transects (Figure 2). Transects traversed swamps, hilltops and mid slopes. Diameter of each tree was measured at breast height (1.3 m above the ground) using a diameter tape and seedling stems were measured at the 'root collar' (ground level) using vernier calipers. Diameters of trees with buttresses were measured at the point just above the buttresses. Slope was determined using a clinometer. Target trees for bowls and pestles making were enumerated on the basis of diameter class in nested plots. For each species, seedlings (diameter <5 cm), saplings (diameter 5–9.9 cm), poles (DBH 10–19.9 cm) and mature trees (DBH >20 cm) were identified, counted and diameter determined. All trees found in the plots were enumerated and identified using vegetative field characteristics and scientific identification keys and with the help of experienced botanists at the Limbe botanical garden (SCA). Specimens which were not identified were carried to the Limbe botanical garden for identification. Voucher specimens of the target tree species used were collected and deposited in the University of Buea Teaching and the Limbe Botanical Garden Herbariums.

Frequency, density, basal area and abundance of plant species were calculated following [17,18]. The importance value index (IVI) for trees was calculated by summing the relative frequency, relative density and relative dominance for trees. Importance value index was calculated from the values of relative frequency and relative density.

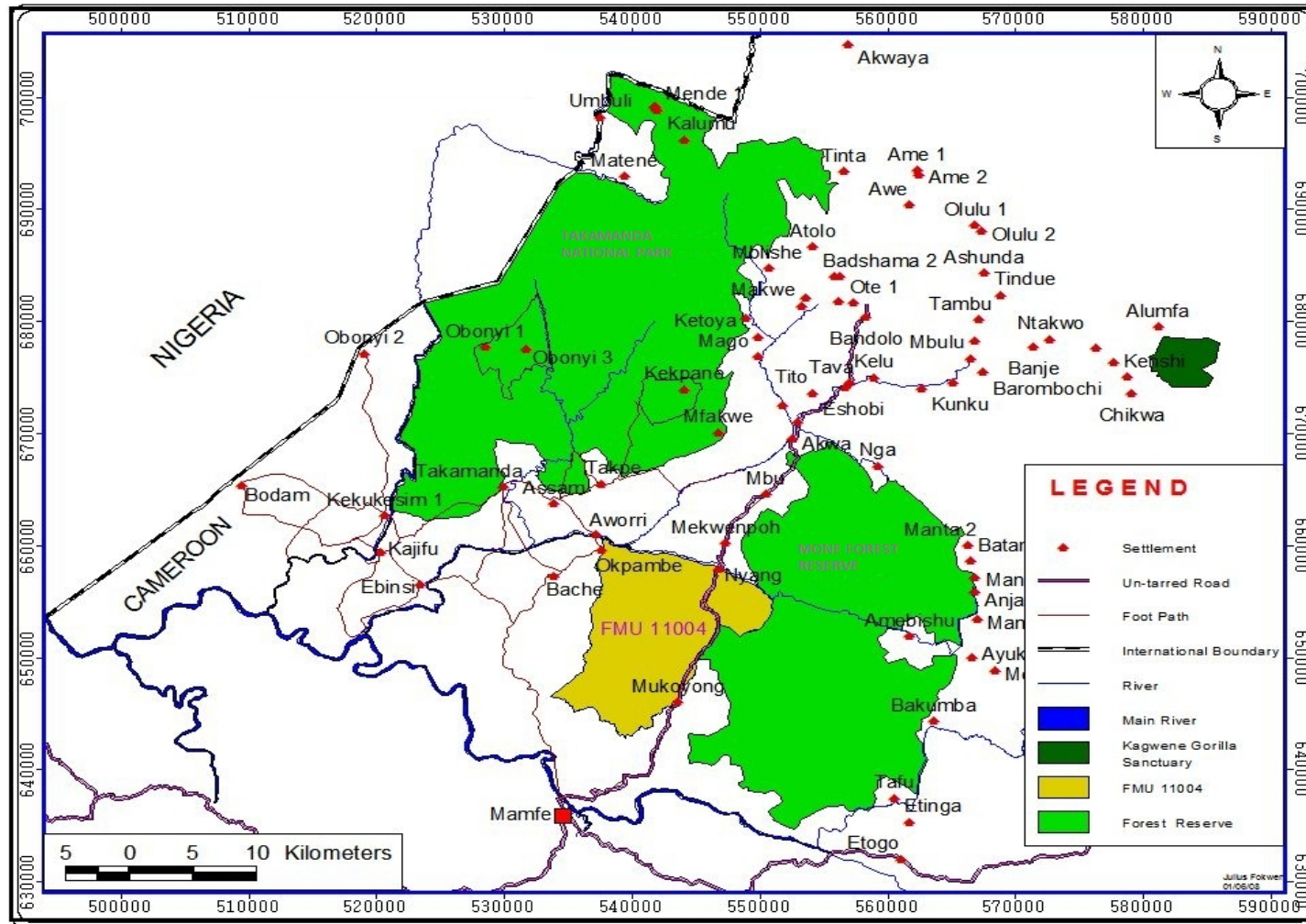


Fig. 2. Map of the Takamanda rainforest

The data were entered in Microsoft Excel 2007 to create data files and these were sorted to generate percentage number of mortars and pestles produced in the respective villages, percentage estimates of mortars and pestles produced in the past and present in the different villages and diameter size classes. The regeneration status of sampled species was assessed based on phytosociological data [19] in the following categories: (a) "good", if present in seedlings > saplings > mature strata; (b) "fair", if present in seedlings > saplings < mature strata; (c) "poor", if a species survives only in the sapling stage, but not as seedlings (even though saplings may be less than, or more than, or equally to mature); (d) "none", if a species is absent both in sapling and seedling stages but present as mature; and (e) "new" if a species has no mature, but only saplings and / or seedling stage. The population structures of the forest stands were determined across four diameter classes (seedlings, saplings, poles and mature trees) following references 2 and 10.

3. RESULTS

3.1 Vegetation Structure of Species Used in Making Wooden Mortar and Pestle

A total of six tree species were recorded as materials used for making mortar and pestle in the Takamanda community (Tables 1 and 2). *Baphia nitida* was recorded having highest stem densities in both unprotected (142.2 ± 22.13 trees ha^{-1}) and protected (54.4 ± 8.41 trees ha^{-1}) forests (Table 2). These were closely followed by *Pterocarpus soyauxii* (31.3 ± 22.13 trees ha^{-1}) and *Annickia chlorantha* (30.9 trees ha^{-1}) in the unprotected and protected forest respectively (Table 2). *Melicia excelsa* (3.1 ± 22.13 trees ha^{-1}) had the lowest stem density recorded in unprotected forest stand (Table 2). This was closely followed by *Terminalia ivorensis* (4.7 ± 22.13 trees ha^{-1} and 5.1 ± 8.41 trees ha^{-1}) in both protected and unprotected forest stands (Table 2).

3. 2 Regeneration Pattern

In the unprotected site the proportion of seedling size classes (0.0-4.9cm and 5.0-9.9cm) were generally dominant (Fig. 3). The older tree size class (15.0-19.9cm) and (> 20cm) were represented negligible or nil (Fig. 3). The proportion of seedling size class (0.0-4.9cm) to a higher size class (>20cm) decreased gradually (e.g *Annickia chlorantha*, *Baphia nitida*, *Irvingia gabonensis* and *Pterocarpus soyauxii*) (Fig. 3a, b, c, d). The protected site represented that seedling size class (0.0-4.9cm) was higher followed by saplings size class (5.0-9.9cm) and young trees (10.0-14.9cm) as exemplified by *Annickia chlorantha*, *Baphia nitida* and *Irvingia gabonensis*. The older tree size class (>20cm) are negligible for *Annickia chlorantha*, *Baphia nitida* and *Irvingia gabonensis* (Fig. 3 a, b and c). *Annickia chlorantha* was absent in tree size class 5.0-9.9cm, 15.0-19.9cm and > 20cm in the unprotected forest (Fig. 3a). *Terminalia ivorensis* were absent in the seedling size class (0.0-4.9cm) and saplings size class (5.00-9.9cm) in both forest sites (Fig. 3e). They were also absent in the older size class (>20cm) in the unprotected forest site. *Melicia excelsa* were totally absent in all size classes in the protected forest site but were represented in the seedling size class (0.0-4.9cm) and the older size class (>20cm) in the unprotected forest site. Generally, *Annickia chlorantha*, *Baphia nitida* and *Irvingia gabonensis* were represented in seedlings size class (0.0-4.9cm), sapling size class (4.9-9.9cm), young trees (10-14.9cm) and older trees (>20cm) in both forest sites.

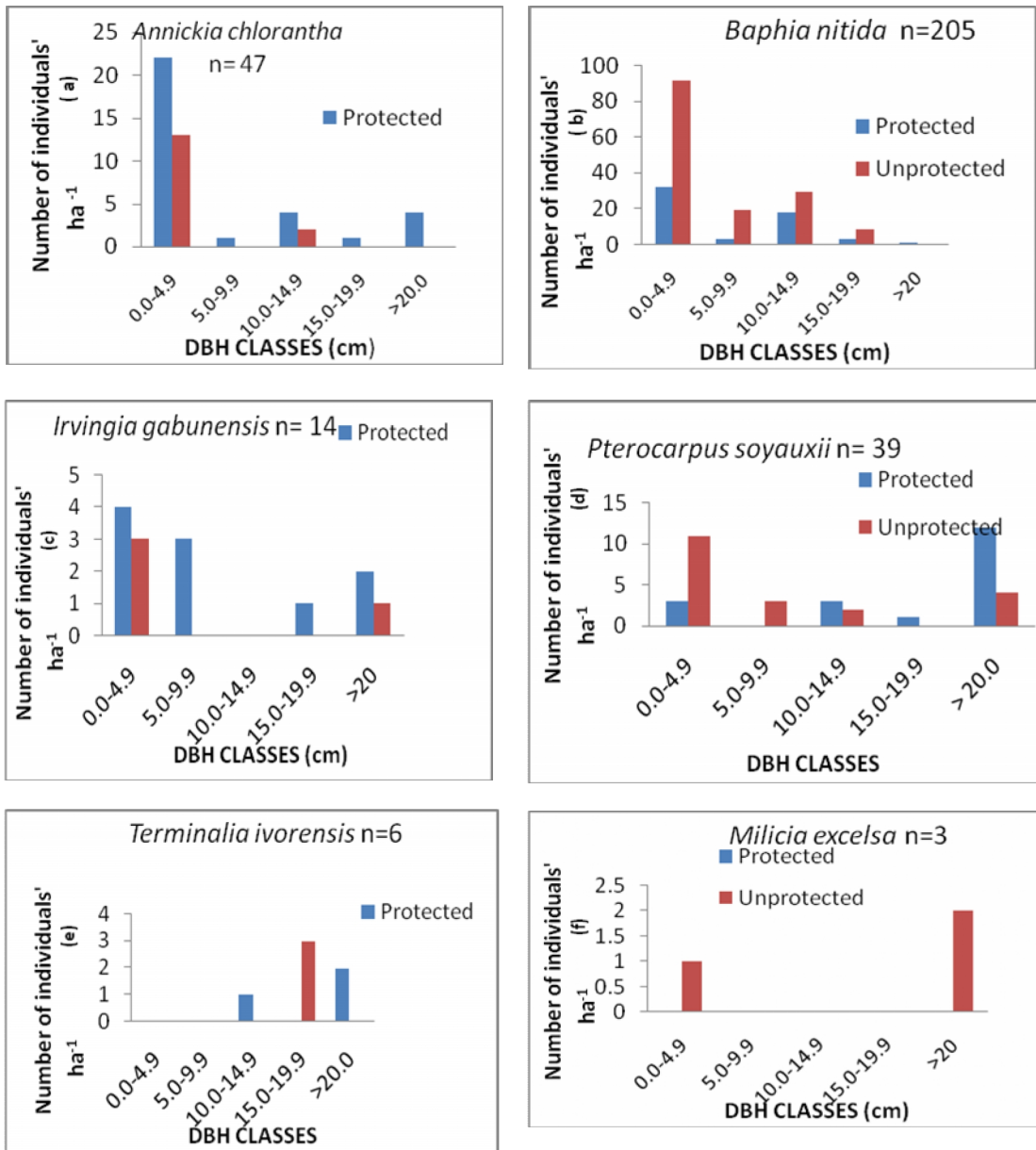


Fig. 3. Diameter classes of the selected tree species in the protected and unprotected forest

3.3 Variation in Number of Wooden Mortar and Pestle Produced over the Years in three Communities

Generally, the number of estimated mortar and pestle produced increased over the years in three villages closest to the unprotected and protected forest stands (Fig. 4 and 5). An estimated total of 248 mortars and 477 pestles were produced in 2007-2012 (Fig. 4) while in 2001-2006 a total of 155 mortars and 304 pestles were produced in the three communities.

Kajifu 1 recorded the highest mortar (104) and pestle (274) produced in 2007-2012 and (75) mortars and (163) pestles produced in 2001-2006 (Figs. 4 and 5). The lowest number of mortars (61) and pestles (82) were produced in 2007-2012 and mortars (35) and pestles (54) were produced in 2001-2006 in the Kekubesem (Figs. 4 and 5).

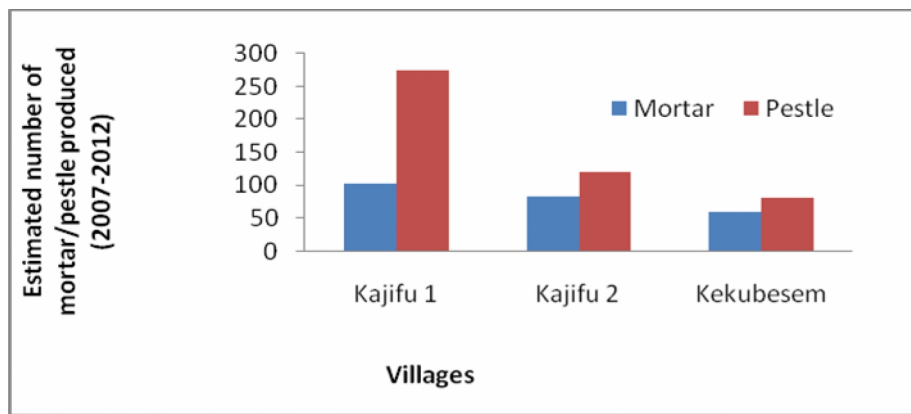


Fig. 4. Number of mortars and pestles produced in the three communities

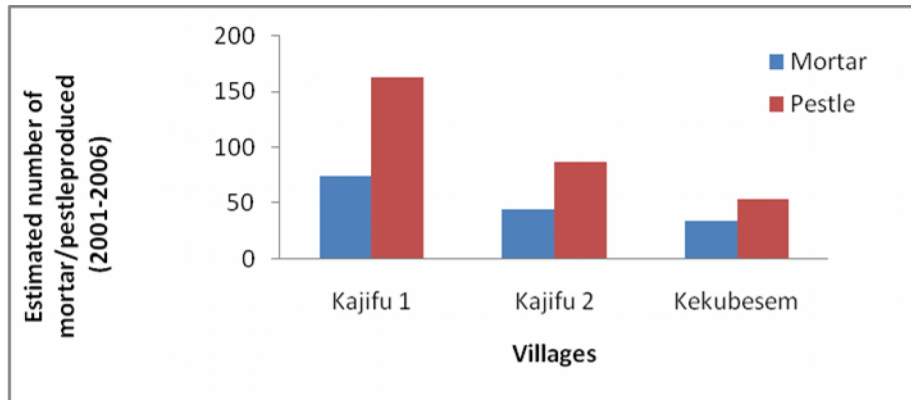


Fig. 5. Number of mortars and pestles produced in three communities

Table 2. Number of trees per hectare and important value index (IVI) in the protected and unprotected forest

Family	Species	Unprotected forest		Protected forest	
		Density ha ⁻¹	IVI	Density ha ⁻¹	IVI
Annonaceae	<i>Annickia chlorantha</i> (Oliv.) Setten & Maas	14.1±22.13	20.8±26.88	30.9±8.41	40.8±10.11
Fabaceae	<i>Baphia nitida</i> Lodd.	142.2±22.13	177.5±26.88	54.4±8.41	60.1±10.11
Irvingiaceae	<i>Irvingia gabonensis</i> (Aubry-Lecomte ex O' Rorke) Baill	6.38±22.13	16.1±26.88	6.6±8.41	10.3±10.11
Fabaceae	<i>Pterocarpus soyauxii</i> Taub	31.3±22.13	65.3±26.88	14.7±8.41	54.6±10.11
Combretaceae	<i>Terminalia ivorensis</i> A. Chev	4.7±22.13	11.4±26.88	5.1±8.41	17.6±10.11
Meliaceae	<i>Melicia excelsa</i> Welw.C.C Berg	3.1±22.13	8.9±26.88	-	-

4. DISCUSSION

According to [2,21,9,12,13] such types of patterns indicate the exploitation of older individuals and greater mortality among the young individuals. On the basis of the population structure of the different tree species of the different forest sites following five general patterns are recognizable.

Generally greater population of individuals in the seedling size class (0.0-4.9cm) as compared with the sapling size class (5.0-10cm) and slightly higher percentage of individuals in the third and fourth size classes and sometimes decline or increase the higher size class (>20) as exemplified by *Annickia chlorantha*, *Baphia nitida* and *Pterocarpus soyauxii*. This situation may be attributed to rapid conversion of the seedlings to saplings and that of saplings into trees. A greater population of individuals in the lower size classes compared to the large classes as exemplified by *Irvingia gabonensis*. This represents frequent reproduction [22,23,21,9,13]. A lesser population of individuals in the lower size classes compared to the larger size classes as exemplified by *Pterocarpus soyauxii*. This population has produced abundant population in the past with better conversion from one size class to another but at moment the seedlings are not coming up frequently, though the species might have produced the seeds, but environmental factors are not supporting proper establishment. *Terminalia ivorensis* individuals are present only in the older size class and no seedlings or sapling size classes were represented. This might be due to environmental factors that influence flowers and seed production.

4.1 Variation in Number if Wooden Mortar and Pestle Produced

The number of wooden mortars and pestles produced over the years varied from one community to another. The number of mortar and pestles produced from 2007-2012 were higher, compared to the production of 2001-2006. The high production of wooden mortar and pestles over the years could be linked to the increase in population in which new families established and needed their own wooden mortars and pestles. Kajifu 1 followed by Kajifu 2 recorded the highest number of wooden mortar and pestles produced over the years. This could be due to the high population and the proximity of the two villages to the unprotected forest for harvesting of tree species. Kajifu 1 and 2 are accessible and movement of these products to neighbouring villages, towns and major markets is easy. The village Kekubesem recorded the least number of wooden mortar and pestles produced over the years. Probably, series of patrol carried out by eco-guards reduced the harvesting of these species.

5. CONCLUSION

This study concluded that all the six targeted tree species used for the making of wooden mortars and pestles were found selectively harvested in the forest stands. This anthropogenic phenomenon needs a quick conservation and management strategy implemented; because if this situation is ignored it will lead to structural imbalances, habitat destruction and local extinction of species. Nevertheless, tree species density for *Annickia chlorantha*, *Baphia nitida* and *Pterocarpus soyauxii* were not heavily disturbed and thus have the ability of recovering if management strategies for these species are considered. *Melicia excelsa*, *Terminalia ivorensis* and *Irvingia gabonensis* showed poor or no regeneration and a fragmented population due to over harvesting of these tree species many years ago and there may be minimal possibility for recovering.

6. RECOMMENDATION

This study recommends a regular patrol by the authorities concern to check illegal harvesting and punish defaulters. This study also recommends that there should be enrichment planting of the targeted tree species in primary forest, secondary forest and farm land to reduce pressure on these species and save the trees from extinction. This study also recommended the establishment of community nursery and a seed bank for all the targeted tree species.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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