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Evaluation of the availability of *Garcinia afzelii* Engl. (Clusiaceae) inside the Yapo-Abbé classified forest of, in Côte D'ivoire

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Abstract

The continuous exploitation of Non-Timber Forest Products (NTFP) inside the forests of Côte d'Ivoire still be of major preoccupation. The present study aims to evaluate the impact of intense exploitation of *Garcinia afzelii*, used for mouth and teeth care, on the population of this plant species inside the Yapo-Abbé classified forest.

The study of the availability of *G. afzelii* has been realized throughout an inventory of all adult individuals (dbh \geq 10 cm), inside 50 plots of 0.5 ha, using the area noting method. Potential of regeneration was evaluated by an inventory of younger individuals (dbh < 10 cm) in 4 sub-plots of 200 m² displayed randomly on the plots. A total of 7 adult individuals of *G. afzelii* have been inventoried inside the classified forest, either least than 1 ind.ha⁻¹, with an index of rarefaction \geq 80% in all biotopes. Fourteen (14) younger individuals represent the potential of regeneration of *G. afzelii*, either least than 11 ind.ha⁻¹. The comparison between the density of younger and adult individuals doesn't show a significance difference. The results of this study exhibited that *G. afzelii* is no more available inside the Yapo-Abbé classified forest, and its potential of regeneration is low. It is endangered to extincting. So, for its safeguard, its exploitation should be new.

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Introduction

The loss and the reduction of the quality of the flora, then the degradation of the forest ecosystems in Côte d'Ivoire, are of facts of intensive exploitation of timber and the practice of itinerant agriculture on burned soil spreading to unexploited forests (Kouamé, 1998; Bakayoko, 2005). From 16 million of hectares at the end of the 19th century, the Ivorian forest covers up, today, just 1.38 million of hectares (Koné, 2015).

The collecting of Non-Timber Forest Product (NTFP) defined as "biological goods other than timber, getting from forests, others wooded lands and trees developing outside the forest" (FAO, 2003), is considered to have less impact in the threat on species and on the floristic biodiversity (Aké-Assi, 1998).

However the quantity of plant's parts collected (stems, roots, barks and so on.), then the forms of collecting, as well as the pressing relating to continuous collecting of these products, on the availability of species sources of NTFP in the forests, are becoming real problems. The perennity of the forest ecosystems needs more attention in the management and efficient policy of protection against deforestation and forests damage. For protected areas, the safeguard of biodiversity is so necessary by now (Kouamé *et al.*, 1998 ; Mahamane, 2005). Many species are over-used in Côte d'Ivoire as sources of NTFP. Among them, appears *Garcinia afzelii* (FAO, 1996). That plant species is sought for its current use by Ivorian people like those of surrounding countries. For long time, it has been exploited, in the South-Eastern forest of Côte d'Ivoire without license. Today, although its vulnerability (FAO, 1996; UICN, 2012), its exploitation spreads to other forest regions of the country, particularly in the South-West (Kouassi *et al.*, 2015).

The main goal of this study is to evaluate the impact of the exploitation of *Garcinia afzelii* on the population of this plant species in the Yapo-Abbé

classified forest. The secondary goals are the following:

- evaluate the availability of adult individuals of *Garcinia afzelii* in the Yapo-Abbé classified forest;
- study the potential of the regeneration of this plant species in the biotopes of the classified forest.

Methodology

Study area

The Yapo-Abbé classified forest is located in the South Côte d'Ivoire, particularly in administrative region of Agnéby (Fig. 1), between the latitudes 5°40'02" and 5°47'32" North, then between the longitudes 3°57'02" and 4°11'37" West (SODEFOR, 1999).

That classified forest is composed of three forests blocks (Yapo, Mambo, Abbé) and covers up about 24 592 ha. At the beginning, these three blocks represented each a classified-forest. The block of Yapo is in majority a natural forest. This of Mambo is a mosaic of natural forest and enriched forest. As for the block of Abbé, it's a mosaic of enriched forest, re-wooded areas and fallows (SODEFOR, 1999). According to Beaufort (1972), the general aspect of that forest is like of a secondary oldened forest and almost as primary from side to sides. Located in a climax area of the rainy and dense forest, characterized by the rain sector of the Guinean domain (Guillaumet et Adjanohoun, 1971), and subordinated to a climate of Guinean type, the Yapo-Abbé classified forest of continues to have an annual mean rainfall of about 1400 mm, with an annual mean temperature of 27°C (SODEXAN, 2013) . The relief is less undulating. The native ethnical groups as the Abbey and Attié which have been joined by the foreigner populations from all regions of Côte d'Ivoire, and from the sub-regions of West Africa, constitute the border populations of that forest.

Generality relating to *Garcinia afzelii* Engl

Garcinia afzelii Engl. is a shrub from rainy and dense forest of 15 m high when adult, with a trunk's diameter from 10 to 13 cm. The lower part of the

trunk is cylindrical. The bark, apparently without rhytidome is pustular or warty. Its branches are horizontally spread. The leaves are simples, opposed and smooth. The limb possesses many secondary nervures, strong and parallel. Its greeny and unripe fruits become dark when ripening. As a species of the family of Clusiaceae or Guttiferae, its area of

distribution spreads from West Africa to Centre Africa. It belongs to the genus *Garcinia* Linn, which is composed of about 200 species. Two species are exploited in Côte d'Ivoire: *Garcinia kola* and *Garcinia afzelii*. *G. kola* has many uses in Ivorian traditional medicine.



Fig. 1. Geographical situation of the Yapo-Abbé classified forest of in the South Côte.

The boiling of the stem of that species is used as weakness remover (Adjanooun et Aké-Assi, 1979). Its seed, commonly called « little cola », in Côte d'Ivoire, is enough consummated. The seeds of that species is consummated freshly by its owners as stimulant or as aphrodisiac (N'Guessan, 1995; Yao, 2010) and is also, well sold in its production area and abroad. *G. afzelii* is particularly sought for mouth and dentary care. In fact, its stem, branches and roots are yielded, cut as small sticks which are used or commercialized all over Côte d'Ivoire, in the sub-region and in Saoudian Arabia (SODEFOR, 1999), for their use as tooth-pick. To money up its exploitation, every stem of that species is cut down and carefully stumped up. That species is exploited in classified forests too (Kouassi *et al.*, 2015). Over uses (alimentation, pharmacopaeia) of that species have been reported elsewhere in the world (Table 1).

Data relating to the exploitation of *G. afzelii* are not available because it is not listed as exploitable species in Côte d'Ivoire. Yet, according to SODEFOR (1999), 1 188 stems of *G. afzelii* have been irregularly collected, in the Yapo-Abbé classified forest between 1988 and 1993.

Data collecting

Availability of Garcinia afzelii inside the biotopes of the Yapo-Abbé classified forest

The area noting, currently used to evaluate the availability of specie sources of NTPF (Dossou *et al.*, 2012 ; Dro *et al.*, 2013), was the method used for the evaluation of the availability of *Garcinia afzelii* in the several biotopes (natural forest : NF ; arranged-forest : AF ; re-wooded forest: RF and fallow : F) which constitute the Yapo-Abbé classified forest. The inventory has been realized in plots of 0.5 ha (100 m x

50 m) inside which all individuals of dbh ≥ 10 cm (adult individuals or exploitable) were counted. The dendrometric measures were set up on the total height and the diameter of the stem at 1.30 m of the ground. The number of plots inventoried is

proportional to the area of each biotope. A total of 50 plots have been inventoried (Fig. 2) in this current study: 29 plots in the natural forest biotope, 10 in the arranged-forest biotope, 5 in the re-wooded-forest biotope and 6 others in the fallow biotope.

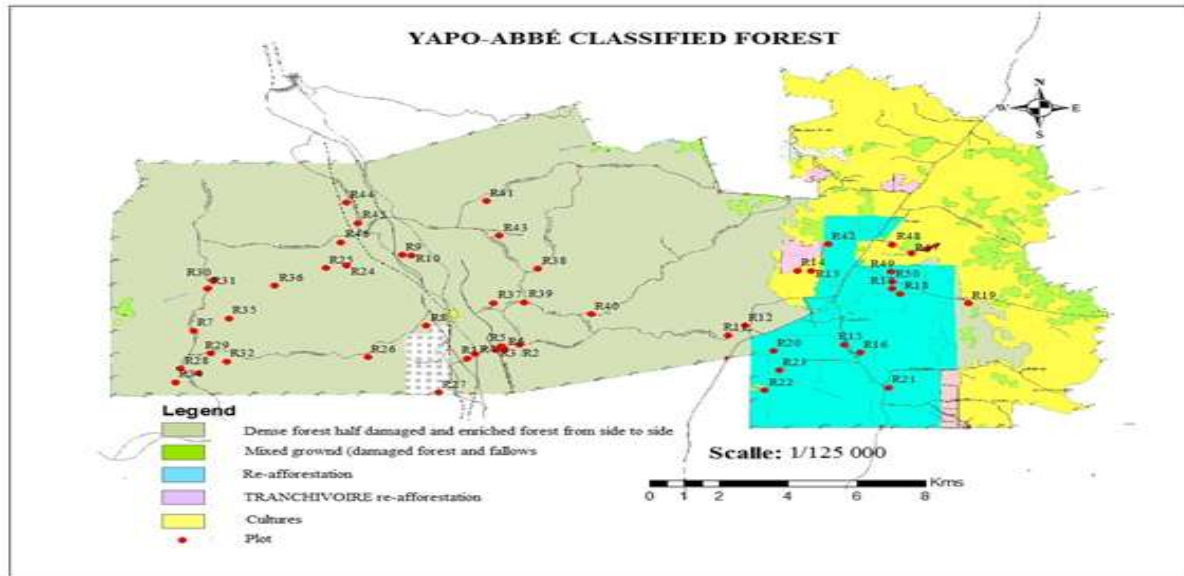


Fig. 2. Plots Distribution in the Yapo-Abbé classified forest.

Potential of regeneration of Garcinia afzelii in the biotopes of the Yapo-Abbé classified forest

The noting area was the method used to study the potential of regeneration of *Garcinia afzelii* in the biotopes of the Yapo-Abbé classified forest. During this study, 4 sub-plots of 100 m² have been set randomly inside each plot of 0.5 ha. In those sub-plots, all individuals with a diameter inferior to 10 cm (younger individuals) have been counted and the dendrometric parameters were noted. A total of 200 sub-plots were inventoried in this current study.

Data analysis

Availability of Garcinia afzelii in the biotopes of the Yapo-Abbé classified forest

Informations from the noting were entered in the computer using the Software Excel. The number of individuals in the several biotopes of the Yapo-Abbé classified forest was determined. Two parameters (the density and the index of rarefaction) were evaluated in this study. Analysis of variances served to mark differences between the densities (number of

individuals per hectare) of adult individuals within several biotopes. The test of comparison of means (TCM) was used to determine significance differences nearby 5% ($\alpha < 0.05$; indicates by letters a, b, c, d, e) between the means of density. Analyses were performed using the Software XLSTAT Pro 7.0.

Rarefaction index

The Rarefaction index (Ri) helps to determine the abundance or the rarity of a plant species. That index served to determine the status of *Garcinia afzelii* in the several biotopes then in the classified forest using the formula of Géhu et Géhu (1980):

$$R_i = (1 - n_i / N) \times 100$$

With:

- R_i : Rarefaction index of the species
- N_i : Number of plots where the species i is found
- N: Total number of plots set in the area .

The status of a species in an area is defined as follow:

- R_i $\geq 80\%$: the species is rare

- $50\% < Ri < 80$: the species is preferential, abundant in the area
- $Ri \leq 50\%$: the species is very preferential, more abundant in the area.

A rarefaction index equal to 100% means that the species is observed nowhere in the studied area, though that species is strongly endangered to extincting.

Potential of regeneration of Garcinia afzelii in the biotopes of the Yapo-Abbé classified forest

The potential of regeneration of *Garcinia afzelii* in the biotopes of the Yapo-Abbé classified forest was evaluated throughout the number and the density of younger individuals (ind.ha⁻¹). The analysis of variances of the density of younger individuals inside the biotopes was realized. The same analysis has been done between the younger and adult individuals too. The distribution by diameter classes of all numbered individuals allowed to understanding the stability of *G. afzelii* inside the several biotopes. Three diameter classes have been defined [1-5 cm] ;]5-10 cm[; [10-

15 cm]). According to Vermeulen *et al.* (2009), the stability of a species in a considered area is materialized by a decreasing structure corresponding to a higher number of younger individuals and the missing of problem of regeneration.

Results

Availability of Garcinia afzelii in the biotopes of the Yapo-Abbé classified forest

The noting area realized for the evaluation of the disponibility of *Garcinia afzelii* in the biotopes of the Yapo-Abbé classified forest displayed 7 adult individuals within 50 inventoried plots. In the biotope named natural forest, 5 adult individuals were inventoried, while 2 individuals were found in the arranged-forest biotope. No individual has been inventoried in both following biotopes such as the re-wooded forest and the fallow. The mean density of adult obtained varies from 0 to 0.4 ind.ha⁻¹ (Table 2). It is inferior to 1ind.ha⁻¹ whatever the biotope and does not vary significantly. Regarding these results, *G. afzelii* is no more available in the Yapo-Abbé classified forest.

Table 1. Several domains of uses of *Garcinia afzelii*.

Parts used	Utilizations
Stems	Tooth-pick, mouth and dentary care (FAO, 1996 ; Tra Bi, 1997 ; SODEFOR, 1999 ; Peprah <i>et al.</i> , 2009 ; Kouassi <i>et al.</i> , 2015)
Roots	Pharmacopaeia (N'Guessan <i>et al.</i> , 2014) Tooth-pick, mouth and dentary care (Kouassi <i>et al.</i> , 2015 ; N'Guessan <i>et al.</i> , 2014) Alimentation (Guedje <i>et al.</i> , 2000)
Boughs	Tooth-pick, mouth and dentary care (Peprah <i>et al.</i> , 2009 ; Guedje <i>et al.</i> , 2000 ; N'Guessan <i>et al.</i> , 2014 ; Kouassi <i>et al.</i> , 2015)
Barks	Pharmacopaeia (Peprah <i>et al.</i> , 2009 ; N'Guessan <i>et al.</i> , 2014)

The evaluation of the rarefaction index exhibited a value above 80% inside all the biotopes of the classified forest (Fig. 3). The biotopes like the re-wooded forest and the fallow had rarefaction index equal to 100%. Thus, *G. afzelii* is missing in theses biotopes as re-wooded forest and fallow. That plant species is rare in the natural forest and arranged forest biotopes. Regarding this result, *G. afzelii* is endangered to extincting in the Yapo-Abbé classified

forest.

Potential of regeneration of Garcinia afzelii in the biotopes of the Yapo-Abbé classified forest

The study of the potential of regeneration for *Garcinia afzelii* exhibited that the plant species has a lower number of younger individuals in the Yapo-Abbé classified forest.

Table 2. Number of adult individuals and mean density of *Garcinia afzelii* inside the biotopes of the Yapo-Abbé classified forest.

Biotopes			Statistical parameters		
		Number of individuals	Density (ind.ha ⁻¹)	F	P
Adults	Natural forest	5	0,34 ± 1,07 ^a	1,007	0,4268
	Arranged forest	2	0,4 ± 0,84 ^a		
	Re-wooded forest	0	0,00 ^a		
	Fallow	0	0,00 ^a		

A total, of 14 younger individuals have been inventoried within the 200 sub-plots set in the several biotopes of that forest: there are composed of 9 younger individuals in the natural forest biotope, 4 in the arranged forest biotope and 1 in the fallow biotope. The density of younger individuals ranged in

the decreasing order as follow; the arranged forest biotope (10 ± 30.38 ind.ha⁻¹), the natural forest biotope (7.76 ± 42.01 ind.ha⁻¹) and the fallow biotope (4.16 ± 20.41 ind.ha⁻¹). It's null in the re-wooded forest biotope (0,00 ind.ha⁻¹) (Table 3).

Table 3. Number of younger individuals and mean density of *Garcinia afzelii* inside the biotopes of the Yapo-Abbé classified forest.

Biotopes			Statistical parameters		
		Number of individuals	Density (ind.ha ⁻¹)	F	P
Youngers	Natural forest	9	7,76 ± 42,01 ^a	1,023	0,3882
	Arranged forest	4	10 ± 30,38 ^a		
	Re-wooded forest	0	0,00 ^a		
	Fallow	1	4,16 ± 20,41 ^a		

According to this result, the density of younger individuals of *G. afzelii* is very low inside the several biotopes of the classified forest. The comparative study of the density of adult and younger individuals

showed that it is the same case in the classified forest (Table 4). This result confirms the lower potential of regeneration of *G. afzelii* in the Yapo-Abbé classified forest.

Table 4. Comparison of the mean density of youngers and adults of *Garcinia afzelii* inside the biotopes of the Yapo-Abbé classified forest.

Biotopes	Density (ind.ha ⁻¹)		Statistical parameters	
	Youngers	Adults	F	P
Natural forest	7,76 ± 42,01 ^a	0,34 ± 1,07 ^a	3,602	0,06
Arranged forest	10 ± 30,38 ^a	0,4 ± 0,84 ^a	3,981	0,053
Re-wooded forest	0,00	0,00	-	-
Fallow	4,16 ± 20,41 ^a	0,00 ^a	1	0,33

The study of the distribution of diameter classes of *G. afzelii* inside the several biotopes (Fig. 4) displays a decreasing diameter structure for the natural forest and arranged forest biotopes. That structure is not decreasing inside the re-wooded and fallow biotopes.

Regarding this result, the regeneration of *G. afzelii* appears stable is the natural forest and the arranged forest biotopes, then compromise in the re-wooded and fallow biotopes.

Discussion

Availability of Garcinia afzelii in the biotopes of the Yapo-Abbé classified forest

The study of the availability of *Garcinia afzelii* inside the biotopes of the Yapo-Abbé classified forest exhibited that this plant species is missing within the re-wooded forest and the fallow biotopes. Contrary to the Haute Dodo classified forest, where that plant species still be abundant (Kouassi *et al.*, 2015), *G. afzelii* is no more available in the Yapo-Abbé classified forest as its density is largely below the exploitability limit, that is considered to be less than 7 individuals per hectare for species usually commercialized (SODEFOR, 1999). So *G. afzelii* can be considered as a plant species endangered to extincting in the Yapo-Abbé classified forest. The continuous clandestine and uncontrollable exploitation of *G. afzelii* led to the decrease of its individuals number, taking it as not available, inside the several biotopes of the forest.

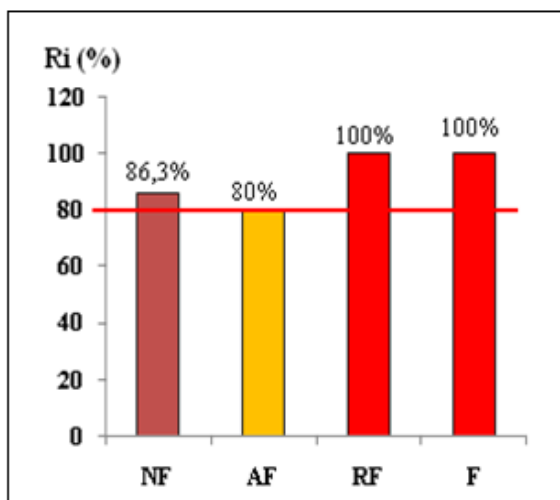


Fig. 3. Rarefaction index of *Garcinia afzelii* inside the biotopes of the Yapo-Abbé classified forest (NF: Natural forest; AF : Arranged forest ; RF : Re-wooded forest ; F : Fallow).

Some individuals still be present in the natural forest and arranged-forest biotopes. In both areas, individuals of *G. afzelii* met there, have probably been preserved. The unavailability of *G. afzelii* inside the Yapo-Abbé classified forest is probably due to the combinaison of many factors. Firstly, all individuals met, even seeds providers, are systematically cut

down. That doesn't guaranties durably a natural regeneration of the species by sexual way. Secondly, the form of exploitation respects no rule of preservation of a plant species. In such condition, no vital timber organ escapes to exploitation. Stems with their ramifications and roots are taken out. That doesn't guaranties regeneration through vegetative way either by slip, either by layer. According to Bassirou (2008), the method of collecting of parts or organs of a plant is always a problem for the perennity of basis resources as it leads to the death of the individuals. N'Guessan *et al.* (2014) reported that although the height of cutting or the stool used for that purpose, the sectioned stem no more live except in a partial shady area. The stumps' shoots fade and die one year after their apparition, that not allows the survival of the species.

Among these factors, we can notice the total missing of re-afforestation of the species after exploitation. In fact, in usual practice from the border populations of the classified-forests of Côte d'Ivoire, no cutting of trees inside the forest is followed by re-afforestation. In the same case, *G. afzelii* is not listed as an industrial exploitable species in Côte d'Ivoire. No program of re-afforestation is realized, neither as a perceptive, nor by the SODEFOR which is the structure in charge of the management of the classified forests. For farmers, the only objective is the drawing of sough organs. For Siebert and Belsky (1985), then Peters (1997), the action of man is the main reason of the rarefaction and disappearance of a lot of plant and animal specie.

Thus, numerous medicinal plants like *Prunus africana*, *Garcinia kola*, *Garcinia lucida*, *Siphonochilus aethiopicus*, and so on, are facing to intensive exploitation; they are endangered to extincting all over the world (Diederichs *et al.*, 2002 ; Cunningham et Mbenkum, 1993), as it is the case for *G. afzelii* in the Yapo-Abbé classified forest.

Potential of regeneration for Garcinia afzelii in the biotopes of the Yapo-Abbé classified forest

The study of the potential of regeneration for *Garcinia afzelii* in the biotopes of the Yapo-Abbé classified forest exhibited a lower potential of regeneration for that species. This lower potential can be attributed to the method of exploitation used which is safeless for all seed providers. The systematical destruction of seed providers led to a decrease of seeds production and the potential of regeneration of that species. In addition, the natural regeneration of that species is difficult because of problems, less or more important, relating to the growing of its seeds (N'Guessan *et al.*, 2014). According to Adou (2003), the rate of growing for *G. afzelii* is estimated to 55% and the dormancy delay for the seeds is about 8 months. N'Guessan *et al.*, (2014)

obtained a rate of 63% and a delay of growing of 4 months. All these constraints are not favourable for a massive growing of seeds from seed providers of this species which were let out during exploitation. For Clark et Clark (1992), only few trees in age of production, out of a ten thousands of seeds produced each season, survive and become adult. For Baraloto (2003), the most vulnerable step of natural regeneration consists in the growing of the seed and the survival of the young plant. Moreover, even though the regeneration is strong, the growth of youngs ones doesn't happen always in better conditions; as consequence, the impact of uncontrolled plant competition appears like a delay of growing and death (Bergeroo-campagne, 1958).

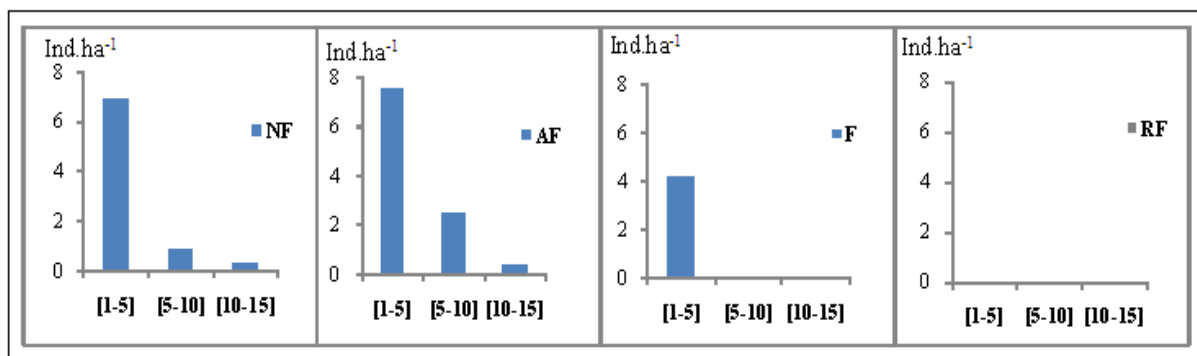


Fig. 4. Distribution, by diameter classes, of individuals of *Garcinia afzelii* inside the several biotopes of the Yapo-Abbé classified forest (NF: Natural forest; AF: Arranged forest; RF: Re-wooded forest; F: Fallow).

This natural selection, in the case of *G. afzelii*, reduces more its potential of regeneration inside the Yapo-Abbé classified forest. Furthermore this current study has also exhibited that the perennity of *G. afzelii* is affected by the damage of its natural area, which is the forest. In fact, the exploitation of the Yapo-Abbé classified forest for the production of timber, cabinet-work and itinerant agriculture on burned soil, led to the damage of that forest materialized by the building of large ways and fallows. These practices have probably destroyed seed providers and young plants of that species. The perennity of *G. afzelii* is so compromised within the Yapo-Abbé classified forest.

If regarding declaration from Guedje *et al.*, (2010),

the threats and the directives of the Convention on Biological Diversity (CBD), a commercial exploitation of NTFP representing an acceptable, equitable, economically viable, ecological sustainable and compatible with forest parcelling, has become an emergency. A safe collecting is needed in order to get a sustainable exploitation of *G. afzelii* within the others classified-forests of Côte d'Ivoire. Important reports on the production of young trees of *G. afzelii* have been presented by (N'Guessan *et al.*, 2014) for the Haute Dodo classified forest in the South-West Côte d'Ivoire. This study had produced wildings pricked out under shade with a success rate of 100%. Such result is observable for *G. afzelii* for which the assisted regeneration seems to be the better way in the Yapo-Abbé classified forest.

Conclusion

The evaluation of the availability and the potential of regeneration of *Garcinia afzelii* inside the Yapo-Abbé classified forest showed that the years of intensive exploitation through systematically cutting down of individuals from this species has deeply modified its status in the forest clump. Today, that species is no more present as it is endangered and in way of extinction.

For its safeguard inside de classified-forest, the exploitation of *G. afzelii* should be new and controlled.

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