Floristic Diversity of Residual Forest Fragments Of The Dassioko Classified Forest (South-West Of Côte d'Ivoire)

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1.Abstract

Background and Objectives: Scientific data on the floristic diversity of the residual forest fragments of the classified forest of Dassioko are lacking in Côte d'Ivoire. This study was conducted to improve knowledge of residual forest fragments in the classified forests of Côte d'Ivoire.
Materials and methods: In order to characterize the different types of land use in the Dassioko classified forest, a raster image of the study area was downloaded and image processing was performed. Plots were set up, and floristic inventories were conducted in the plots. The analyses were carried out through the richness, floristic composition, and structural diversity of the vegetation
Main results: This study identified 5 land use classes in the Dassioko Classified Forest. These are natural forests, forest plantations, crops, bare soil/new clearings, and water bodies. The residual forest fragments of the Dassioko Classified Forest contain 119 plant species divided into 46 families and 110 genera. The dense forests contain a large number of species. In the area, we note the presence of 12 vulnerable species according to the IUCN red list. The distribution of stems by diameter classes presents an inverted J shape.
Conclusion: The floristic diversity in each of the zones is significant with a number of special status species that justify the importance that the Dassioko forest could have in conservation if a rehabilitation plan is put in place before the destruction of the entire forest.

Keywords: Forest fragments, Sustainable management of protected areas, Dassioko classified forest of Côte d'Ivoire.

2. Introduction

Classified forests, elements of biodiversity conservation, are experiencing strong anthropogenic pressures in Côte d'Ivoire. Despite conservation measures, the scarcity of arable land leads to the illegal occupation and the degradation of state lands, including classified forests. These illegal anthropogenic activities are carried out in violation of regulations on the management of classified forests. The interventions of loggers are most often followed by illegal activities of the local population (Miabangana & Malaisse, 2020). Legal commercial activities in the classified forest lead to the loss of areas and often to the fragmentation of mature forest habitat (Andrén, 1994). Habitat loss greatly threatens species richness than forest fragmentation (Betts, et al., 2006). Habitat loss is therefore currently recognized as the main factor in the fluctuation or loss of biological diversity (Wiegand, et al., 2004). In these forest fragments, we witness the disappearance and depletion of certain plant and animal species.

In Côte d'Ivoire, the classified forest of Dassioko is known for its richness in terms of flora and fauna diversity. However, the region of this classified forest is subject to numerous movements of populations who occupy the land with extensive agriculture (Kassi, et al., 2010). The Dassioko classified forest, the subject of this study, is the first forest to have been classified among the vast network of Ivorian classified forests. It was the very first forest massif placed under protection in 1923 by the colonial authorities (N'Guessan, et al., 2014). With the increase in population in the region and the depletion of agricultural land, this classified forest, like all the others, is constantly under attack.

Unfortunately, updated data on the state of forest fragmentation of the classified forest of Dassioko are non-existent. This makes it difficult to measure its recent momentum. To overcome this insufficiency, the present study was initiated with the objective of determining the floristic diversity of the classified forest of Dassioko. This specifically involves characterizing the different types of land use in the Dassioko classified forest and then evaluating the floristic diversity of the different residual fragments in the Dassioko classified forest.

2.1. Purpose of the study:

The main objective of the study is to contribute to a better knowledge of the floristic diversity of the classified forest of Dassioko. Specifically, this involved: (1) Characterizing the types of land use in the classified forest of Dassioko, (2) Evaluating the floristic diversity of the different residual fragments in the classified forest of Dassioko.

2.2. Research questions:

In this study, we address the following questions: What types of land use are present in the Dassioko classified forest? (2) What is the floristic potential of the residual fragments in the Dassioko classified forest?

3. Materials and methodology

3.1. Geographic location

Dassioko Classified Forest, named after a nearby village, is located in the southern coastal area of Côte d'Ivoire. It lies between 5° 00'06" and 5° 07 23" North latitude and 5° 49 48" and 5° 56 57° West longitude (Figure 1). It covers the departments of Fresco and Sassandra with an area of 12,538 hectares. This forest has direct contact with the Atlantic Ocean, constituting its southern limit. The eastern and western parts of the said forest are delimited by artificial lines that run along the roads connecting respectively the locality of Dassioko at the ancient site of Dassioko on the coast and the village of Akakro in Dagbégo.

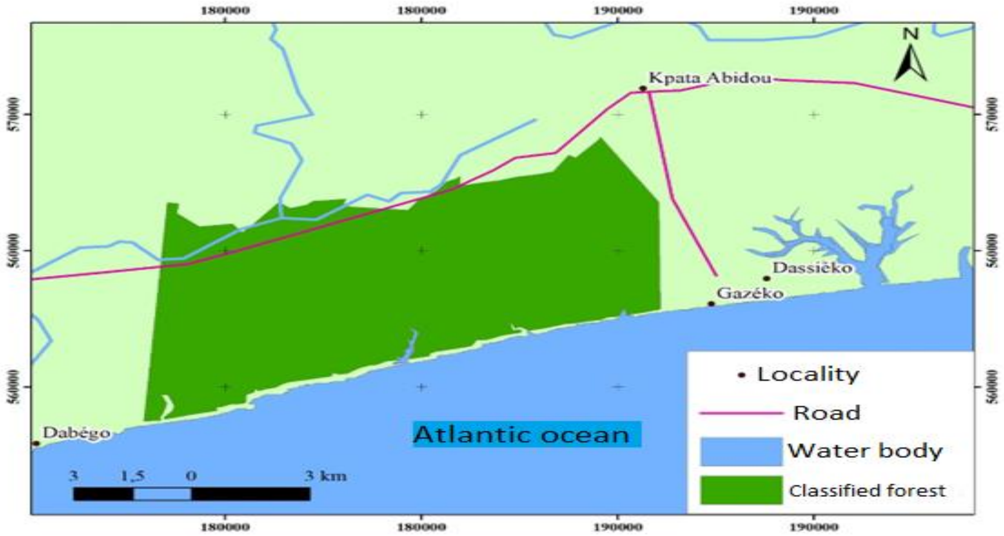

Fig 1: Location of the Dassioko classified forest in Côte d'Ivoire

3.2. Methodology for data collection

Data gathering: A raster image of the study area, taken in the dry season on 01/08/2020, was uploaded to https://earthexplorer.usgs.gov/ . From this image, the study area was extracted from a shapefile of the classified forest of Dassioko (Kpan, et al., 2014). Georeferencing is a technique for the spatial positioning of an entity in a unique setting and a well-defined geographical location in a system of specific coordinates and references (N'Guessan, 2004). The georeferencing of the spectral bands of the Sentinel 2 image was not essential. Their correction was automatically carried out by the data provider. In the present study, 42 square plots of 20 m sides were installed in the various residual fragments of the Dassioko classified forest, ie an inventory area of 1.68 hectares. These plots were placed in the forest fragments on the basis of cartographic processing. Within these plots, all tree species have been identified. Individuals of tree species with a diameter at breast height greater than or equal to 2.5 cm were counted. This minimum size of dbh makes it possible to maximize the diversity of tree species in the different habitats (Vroh, et al., 2013). For individuals with buttresses and stilt roots over 1.30 m high, the diameter was measured just above these buttresses and stilt roots. At the level of branched individuals less than 1.30 m above the ground, each stem was considered a plant, and circumference measurements were made on each of them. For each inventory plot, the geographical coordinates were recorded using a GPS.

Processing of satellite images: The downloaded image did not require any specific pre-processing. An unsupervised classification was made. The color classes obtained were confronted with the reality on the ground with 200 control points collected during the missions in the Dassioko classified forest. A match was made with the control plots to assess the overall performance level of the classification. This procedure allowed the elaboration and analysis of the confusion matrix from which the Kappa coefficient and the global precision were calculated (Congalton, 1991). These treatments were carried out on the ENVI 5.3 software.

3.3. Methodology for data analysis

The species diversity index considered in this study is the one most commonly used in vegetation studies. This is that of Shannon et Weaver (1948). It combines the number of species and their relative abundance and makes it possible to quantify the floristic diversity of a site (Felfili, et al., 2004). This index noted (H') is given by the following mathematical expression: Pi is the proportional abundance or percentage of the abundance of a species present (pi = ni/N). The formula is therefore formulated according to the equation: **H' = -∑ Pi x ln Pi.**

Piélou equitability index (E), also called the regularity or equipartition index, translates the way in which individuals are distributed across species (Adjakpa, et al., 2013). It makes it possible to know the dominance of an environment in a number of species (Huston, 1994). In its formula, E designates the Piélou equitability index, H' is the Shannon index and S represents the total number of species in the plot or space concerned. The formula is therefore formulated according to the equation: **E = H' / ln S.**

The structural diversity of the vegetation was evaluated from the density and the basal area. The density corresponds to the number of individuals for a given surface. The density of stems (D) is the ratio of the number of stems (N) in the plots of the medium under consideration to the total area of the plots (S) in hectares. Density is a good criterion for assessing forest dynamics and local formation potential (Rollet, 1974). In its mathematical expression (D), N designates the number of individuals and S the total area expressed in hectares. The formula is therefore formulated according to the equation: $\boldsymbol{D = \frac{N}{S}}$. The basal area (A) of a plant formation is the sum of the cross sections of this formation's trees, shrubs, and woody lianas. It can therefore be calculated, for the entire stand, by species or by groups of species. This parameter is characteristic of the stability of a biotope (Rollet, 1974). In its formula, A is expressed in m²/ha, d represents the diameter of the tree, and Π = 3.14. The distribution of stems by diameter class is often called "total structure" by foresters (Bouko, et al., 2007). The formula is therefore formulated according to the equation: $\boldsymbol{A = d^2 \times \frac{\pi}{4}}$. The distribution of individuals by diameter class makes it possible to account for the demographic structure of woody populations and to assess the state of the plant formation to be able to develop naturally in different environments through histograms of stem distribution by class. of diameter.

To determine the most important or predominant species in each type of space, the Species Importance Value Index (IVI), developed by Cottam & Curtis (1956), was calculated. The most important families were determined by calculating the Family Importance Index (VIF). The data from the floristic surveys made it possible to calculate the ecological parameters such as the relative frequency, the relative dominance, and the relative density of each species. The sum of the values of these parameters made it possible to obtain the importance of each species compared to the other species of the site through the IVI (Index Value Importance) (Kent & Coker, 2003). This index is frequently used in tropical forests to describe the ecological importance of species (Gonmadjé, et al., 2011; Agbodjogbe, 2011). The importance value of families (VIF) of Cottam & Curtis (1956) taken up by several authors (Gonmadjé, et al., 2011) was also used to assess the role of each family in the structuring of the plant population. The Importance Value Index (IVI) gives each species information on the number of individuals, their distributions as well as on the importance according to the basal area (Nusbaumer, et al., 2005). This is a characteristic index of the importance of each species within a biotope. The IVI is the sum of the relative frequency (FR), dominance (DoR), and relative density of each species (DeR). The formula is therefore formulated according to the equation: **IVI = FR + Do R + De R.**

4. RESULTS

4.1. Land use type

The Dassioko classified forest covers an area of 12.540 hectares. The field visits and the cartographic processing made it possible to identify and describe five main classes of land use (Figure 2 et 3). A land cover map was produced with a Kappa coefficient value of 0.80 and an overall accuracy of 92.17%. In the classified forest of Dassioko, the natural forests are relics of dense forests still intact. The undergrowth is open with the presence of plant species such as *Baphia nitida* and *Ochthocosmus africanus*. The flora is dominated by megaphanerophytes such as *Berlinia confusa*, *Aningeria robusta*, and *Gilbertiodendron pressi*. Forest plantations represent forest formations resulting from reforestation. The main species used are *Gmelina arborea*, *Terminalia superba*, *Tarrietia utilis*, *Ceiba sp.*, and *Tieghemela heukeli*. Two types of reforestation have been observed in the Dassioko classified forest. The first reforestations were carried out in 1995 from *Gmelina arborea*. The structure of these forest plantations today resembles a natural forest. Two other types of reforestation were carried out in 2000 and 2005 respectively. These latter plantations are much more like fallow land. In cultivated areas, a distinction is made between food crops and perennial crops. Food crops are represented by rice in the lowlands, yams, and corn. In terms of perennial crops, these are cocoa, coffee, and rubber.

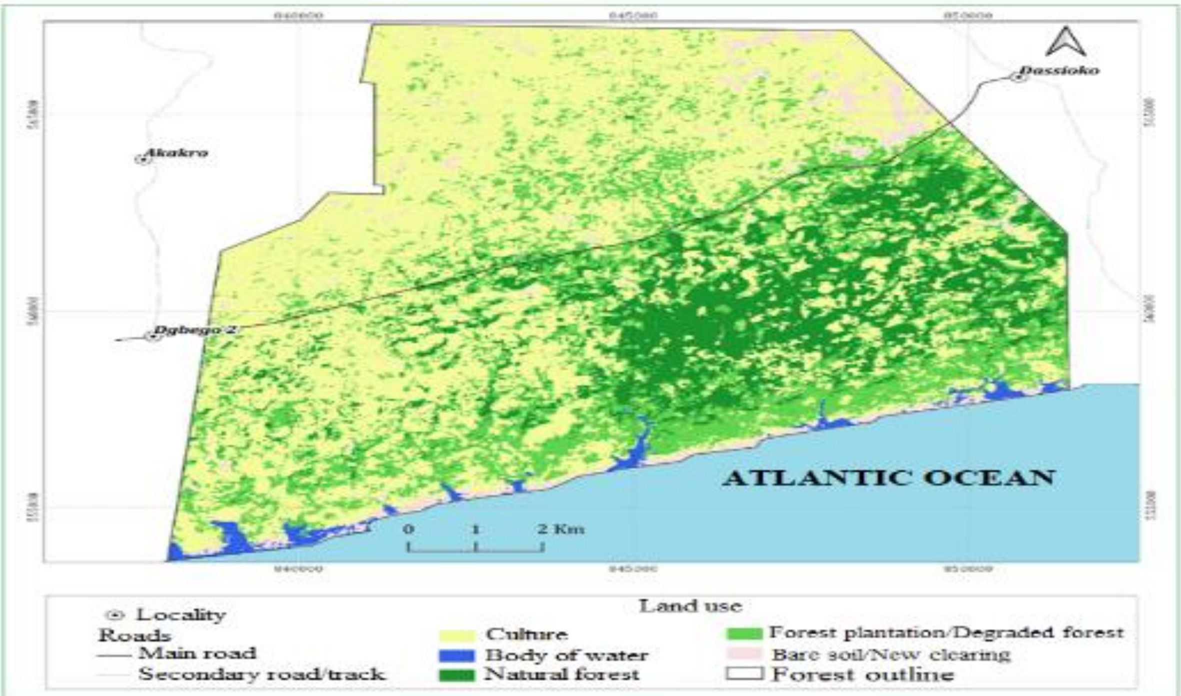

Fig 2: Land cover of the Dassioko classified forest

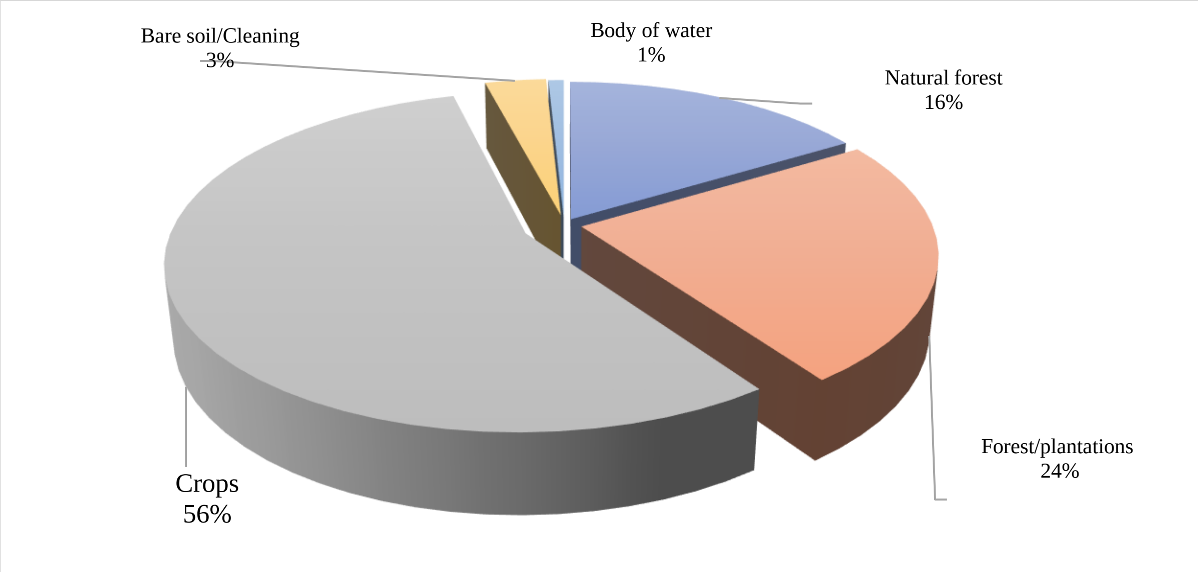

Fig 2**:** Land use in the Dassioko classified forest

4.2. Diversity and Floristic Composition

A total of 119 species belonging to 46 families and 110 genera were recorded from the Dassioko classified forest. Dense forests include 101 species divided between 93 genera and 40 families. As for the forest plantations, they present 50 plant species distributed among 47 genera and 28 families. The families most represented in species are Fabaceae, Apocynaceae, and Sterculiaceae (Figure 4).

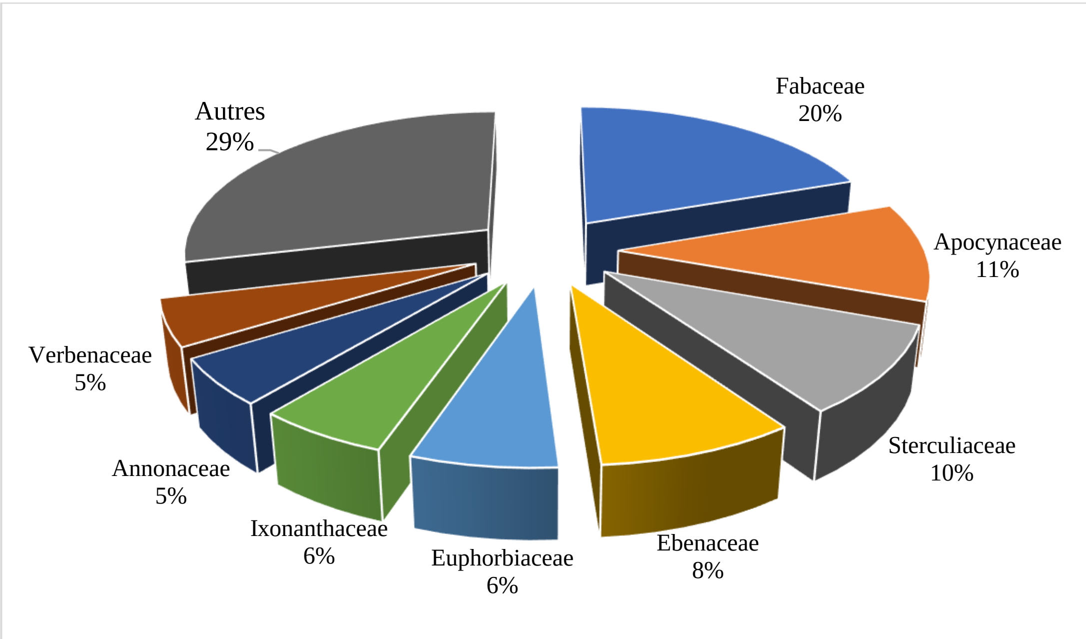

Fig 3: Most families in the Dassioko classified forest

Concerning the morphological types (Figure 5), the microphanerophytes are the most abundant with about 50% of the taxa collected. The mesophanerophytes follow with 38% of the taxa. The megaphanerophytes represent 11% as well as the nanophanerophytes which constitute approximately 1% of the taxa observed. Dense forests are dominated by microphanerophytes with 382 species while forest plantations are dominated by mesophanerophytes (292 species). Guinean-Congolese (GC) species are the majority in the Dassioko forest and constitute 64% of the taxa identified.

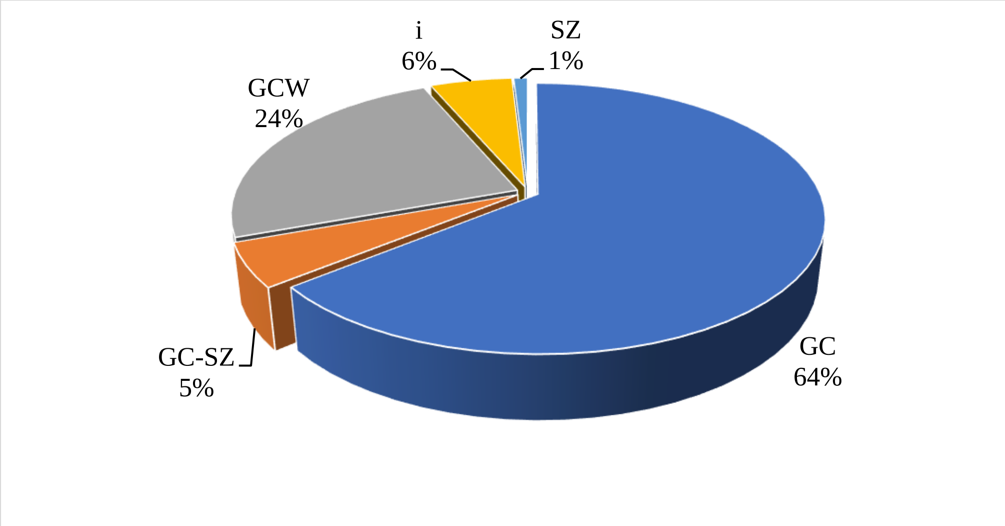

Fig 5: Chronological types of species encountered in the Dassioko classified forest

Legend: GC: Guinean-Congolese Species; GC-SZ: Guineo-Congolese and Sudano-Zambezian species; GCW: Species of the West African forest block; SZ: Sudano-Zambezian species; i: Introduced species

Only *Garcinia afzelii has* been found in forest plantations as a vulnerable species. The highest value of the diversity index according to Shannon (5.13) is obtained in natural forests. Conversely, forest plantations are the least diversified with a value of the diversity index according to Shannon equal to 3.65. The value of Piélou 's equitability for the entire forest is 0.83. It varies according to the different biotopes. The natural forest registers the greatest value of the equitability of Piélou (0.83) compared to the value obtained in forest plantations (0.72). The similarity coefficient shows that 51.4% of the species encountered are common to natural forests as well as forest plantations.

4.3. Structural diversity

The overall basal area in the Dassioko Classified Forest is estimated at 42.5 m²/ha. According to the different biotopes, the highest value was recorded in the dense forest at 37.41 m²/ha while in forest plantations, the basal area is the lowest with a value of 5.09 m²/ha. Twelve (12) diameter classes have been determined in the Dassioko classified forest. The greatest number of stems is found in two classes (]0 cm to 10 cm [and]10 cm to 20 cm [) with 200 and 256 stems respectively. Moreover, from the interval (]20 cm to 30 cm [and] 30 cm to 40 cm [), we observe the variation in the number of diameter classes. The histogram of the overall distribution of stems by diameter class shows that there are many trees with small diameters compared to those with larger diameters. The distribution of stems by diameter class shows an inverted J shape. (Figure 6 et 7).

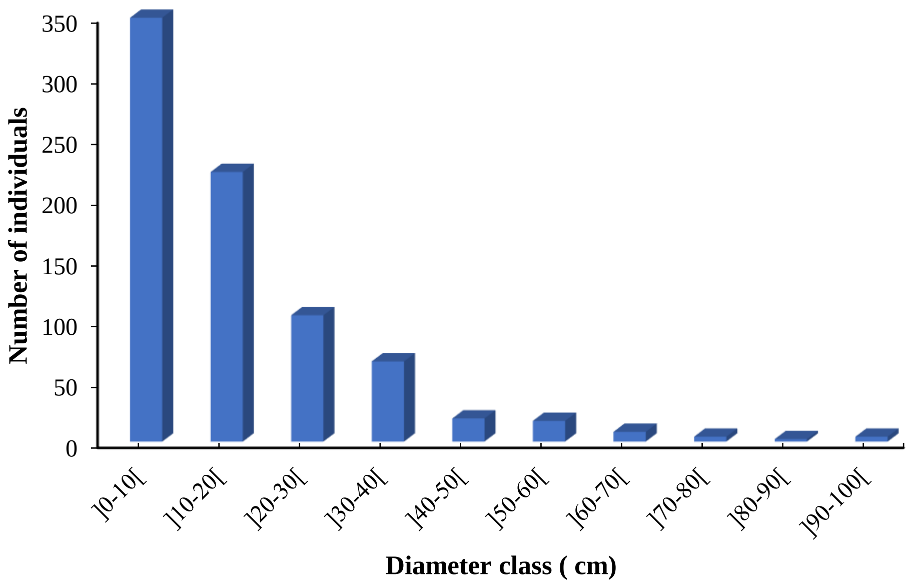

Figure 4: Number of stems in the Dassioko forest

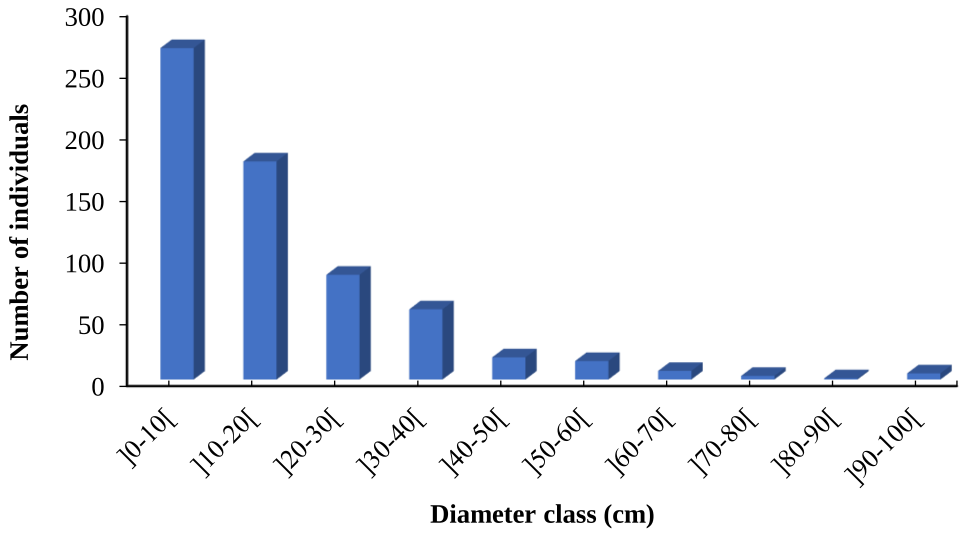

Fig 5: Number Of Stems In The Dense Forest

4.4. Importance of the species

Of all the collections, 12 species were identified as vulnerable according to the UICN red list. Eleven of these species are found in natural forests. These are *Afzelia africana*, *Anthonotha vignei*, *Berlinia occidentalis*, *Copaifera salikounda*, *Entandrophragma angolense*, *Gilbertiodendron bilineatum*, *Gilbertiodendron splendidum*, *Khaya ivorensis*, *Nauclea diderrichii*, *Nesogordonia papaverifera* and *Hallea Lerdzermanii*.

In the dense forest, the predominant species are in descending order of their Importance Value Index (IVI): *Gilbertiodendron preussii*, *Ochthocosmus africanus*, *Funtumia africana*, *Diospyros gabunensis*, and *Hymenostegia afzelii*. These species are preponderant regardless of the dbh considered. In the forest plantation, we have in descending order their Importance Value Index (IVI), *Gmelina* *arborea*, *Funtumia africana*, *Macaranga barteri*, *Terminalia ivorensis*, and *Ficus capensis* (Table 1 and 2).

Table 1: Index Of Importance Values Of Predominant Species In The Natural Forest

Species	Golden	Fr	Last	IVI
Gilbertiodendron preussii (Harms)	19.81	56.66	15.09	91.57
Ochthocosmus africanus Hook.f	5.94	70	6.31	82.26
Funtumia africana (Benth.) Stapf	6.41	50	8.48	64.90
Diospyros gabunensis gurke	5.12	43.33	6.13	54.59
Scaphopetalum amoenum A. Chev.	5.16	30	10.46	45.63
Hymenostegia afzelii (Oliv.) Harms	3.43	46.66	3.97	54.07
Diospyros canaliculata DeWild.	2.88	30	3.61	36.49
Berlinia confused HoyIe	2.32	25.33	2.80	30.45
Anthocleista nobilis G.Don	2.04	23.33	1.80	27.17
Xylopia staudtii En. & Diels	1.30	23.33	2.34	26.98
Pycnanthus angolensis (Welw .)	1.25	23.33	2.34	26.93
Cleistopholis patens (Benth .)	1.21	23.33	1.62	26.17
Strombosia pustulata Oliver. var	2.34	20	2.16	24.51
Isomacrolobium vignei (Hoyle)	1.92	20	1.44	23.36
Chrysophyllum pruniform Eng.	1.69	20	1.26	22.96
Anthonotha fragrans (Bak.f.) Exell	2.21	7	1.08	10.29

Legend: IVI values in bold are those of the predominant species; FR: Relative Frequency; From R: Relative Density; Do R: Relative Dominance I IVI: Importance Value Index

Table I: Index Of Importance Values Of Predominant Species In The Forest Plantation

Species	Golden	FR	Last	IVI
Gmelina arboreal roxb	0.14	88.77	22.73	111.64
Funtumia africana (Benth.) Stapf	0.3	54.44	42.92	97.66
Macaranga barteri Mull. Arg.	0.01	44.44	3.43	47.88
Terminalia ivorensis A. Chev.	0.14	23.22	4.26	27.62
Rauvolfia vomitoria Afzel.	0.01	22.22	2.43	24.66
Ochthocosmus africanus Hook. f	0.01	22.22	1.82	24.05
Ficus capensis Thunb.	0.01	22.22	1.82	24.04
Chrysophyllum pruniform Eng.	0.02	22.22	1.21	23.45
Anthocleista nobilis G.Don	0.01	22.22	1.21	23.44
Maesopsis eminii Eng.	0.01	22.22	1.21	23.44
Trema guineensis (Schum. & Thonn .)	0.03	11.11	5.48	16.62
Ficus mucus Ficalho	0.02	11.11	2.43	13.56

Legend: The IVI values in bold are those of the preponderant species, FR: Relative Frequency; From R: Relative Density; Do R: Relative Dominance

5. DISCUSSION

The floristic inventories highlighted a preponderance of microphanerophytes as well as mesophanerophytes. This configuration augurs vegetation in reconstitution. The high number of plant species is linked to the degradation of forest formations with a preponderance of heliophyte species. Competition between juvenile species is favored by human activities that have led to the degradation of the forest. The work of Kpan (2014) carried out in this same classified forest of Dassioko reports a higher number of plant species. Fabaceae and Apocynaceae have the largest number of species. This could be explained by the fact that the classified forest of Dassioko is located in a zone of dense humid forest in the Guineo-Congolese region dominated by Fabaceae and Apocynaceae (Aké-Assi, 2002). The dominance of Guinean Congolese species in the different environments could also indicate a fairly good composition of the vegetation. According to Vroh (2013), a high proportion of species from the Guineo-Congolese region in an environment could be a sign of good vegetation recovery.

The abundance of microphanerophytes and the low proportion of megaphanerophytes are linked to the logging of commercial ligneous species. The different indices of species importance values indicate that dense forests have a better level of cover. This could be explained by the fact that these dense forests are dominated by species such as *Gilbertiodendron preussii* which have very high significance value indices. (Gonmadje, et al., 2012) show that the zone block reveals that the Caesalpiniaceae have the highest family importance index values in the Guinean Congolese phytogeographical zone. This family is also considered as the one characterizing ancient forests. The evenness index of dense forests is greater than that of forest plantations, thus suggesting that individuals are better distributed among the species recorded in dense forests compared to forest plantations. Environments under disturbed pressures are likely to be specifically richer than those that show no signs of aggression (Adou Yao et N'Guessan, 2006). The low diversity in the forest plantation compared to other parts of the forest is due to the fact that this area has been reforested.

According to the work of Wala *et al.* (2012), the distribution of classes and heights obtained on the plant groups at the study site is typical of environments undergoing reconstitution. According to this author, in the natural environment, the shape of the curve is generally attributed to a regeneration of species, which creates a high concentration of individuals in small and medium diameters. This is the case at the level of forest plantations which are regenerating since they have been cultivated according to our SODEFOR interlocutors. *Gilbertiodendron preussii* is preponderant in the dense forest, while it is almost absent in the reforested environment. This species certainly develops preferably in dense forest environments, little or not disturbed as for Zeb et al. (2016). It is a species that never reaches large diameters in secondary formation, even in 40-year-old fallows. The high-importance values of species like *Funtumia africana*, *Macaranga barteri*, and *Gmelina arboreal* in the reforested area are linked to the many disturbances suffered by this forest due to exploitation and infiltration by the villagers. These are the destructive actions that can lead to favorable openings for the installation of such typical species of secondary formation (Senterre, 2005). The preponderance of *Ceiba pentandra* and *Macaranga barteri*, in the dense forest, is linked to the heliophilous character, typical of the species of secondary formations (Van Steenis, 1958). On the whole of the forest, even *Diospyros gabunensis* and *Ochthocosmus africanus* are important, the strong preponderance of *Gilbertiodendron preussii* for all diameters is so remarkable that one could characterize this forest as a "forest with *Gilbertiodendron preussii*.

6. Conclusion

The flora of the Dassioko classified forest is rich in 119 species which are divided between 110 genera and 46 families. It is essentially composed of microphanerophytes with a significant proportion. From the quantitative point of view, this forest is floristically rich in Euphorbiaceae and Fabaceae. But, it appears that the Ivorian socio-political crises have caused a massive infiltration of illegal immigrants in the classified forest of Dassioko for the cultivation of cocoa trees which has thus contributed to the scarcity of certain plant species and resulted in the various forest fragments. Despite this situation, this area abounds with a large number of special-status plant species. Among these, there are 16 endemic species including 10 West African block species, 10 Upper Guinea species, 15 flora species threatened with extinction, and 12 considered Vulnerable in Côte d'Ivoire. This abundance of species with special status confirms the fact that the natural forest part remains, like the other coastal forests, a center of endemism. This high number of commercial forest species in this forest exposes it to intense clandestine exploitation. In addition, the interior of the classified is strongly subjected to anthropogenic pressures as the edge was reforested by SODEFOR. The reforested part abounds with enough young species of trees for the reconstitution. The floristic diversity in each of the zones is significant with a number of species with special status which justifies the importance that the Dssioko forest could have in conservation if a rehabilitation plan is put in place before the destruction of all of it. the forest.

This work made it possible to know the floristic diversity of the residual forest fragments of the classified forest of Dassioko. Thus, for proper planning of the conservation and sustainable management of the biodiversity of the Dassioko forest, it would be useful to carry out ecological monitoring studies in the Dassioko classified forest.

6. Conflict of Interest

The authors declare that they have no competing interests regarding the publication of this paper.

7. Reference

1. Adjakpa J.B., Yedomonhan H., Ahoton L. E., Weesie P.D., Akpo L.E., Structure et diversité floristique des îlots de forêts riveraines communautaires de la Basse vallée de la Sô au Sud-Est du Bénin. Journal of Applied Biosciences, 2013, 65 :4902 – 4913
2. Adou Yao C.Y., N'Guessan E.K., Diversité floristique spontanée des plantations de café et de cacao dans la forêt classée de Monogaga, Côte d'Ivoire| Spontaneous floristic diversity of cocoa and coffee plantations in the classified forest of Monogaga, Côte d'Ivoire (reviewed paper). Schweizerische Zeitschrift fur Forstwesen, 2006, 157 (2), 31-36.
3. Agbodjogbe G.J., Analyse de la Structure des Galeries Forestières de la Réserve Totale de Faune de Tamou (RTFT) en République du Niger. Thèse de Master international, Muséum national d'histoire naturelle, Paris, IRD, Sud expert plantes, Université de Dschang, Université Abdou Moumouni, 2011, 59 p.
4. Andrén H., Effect of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: à review. Oikos, 1994, 71 : 335-366.
5. Betts M.G., Forbes G.J., Diamond A.W., Taylor P.D., Independent effects of fragmentation on forest songbirds: an organism-based approach. Ecological Applications, 2006, 16 (3), 1076-1089.
6. Aké-Assi L., Flore de la Côte d'Ivoire 2, catalogue, systématique, biogéographie et écologie. Genève, Suisse : Conservatoire et Jardin Botanique de Genève, Boisseria, 2002, 58 : 441.

7. Bouko S.B., Sinsin B., Soulé G.B., Effets de la dynamique d'occupation du sol sur la structure et la diversité des forêts claires et savanes du Bénin. *Tropicultura*, 2007, 25 (4), 221- 227.
8. Congalton R.G., A review of assessing the accuracy of classifications of remotely sensed data. Remote sensing of environment,1991, 37 (1), 35-46.
9. Cottam G., Curtis J.T., The use of distance measures in phytosociological sampling. Ecology, 1956, 37, 451-460.
10. Felfili J.M., da Silva Júnior M.C., Sevilha A.C., Fagg C.W., Teles Walter B.M., Nogueira P.E., Rezende A.V., Diversity, floristic and structural patterns of cerrado vegetation in Central Brazil. Plant Ecology, 2004, 175(1), 37-46.
11. Gonmadje F., Doumenge C., Mckey D., Tchouto G.P.M., Sunderland T.C.H., Balinga M.P.B., Sonké B., Tree diversity and conservation value of Ngovayang's owland forests, Cameroon. Biodiversity and Conservation, 2011, 20, (12) : 2627-2648.
12. Huston M.A., Biological diversity: the coexistence of species on changing landscapes. Cambridge University Press, 1994, Cambridge, UK.
13. Kent M., Coker P., Vegetation Description and Analysis - a Practical Approach. John Wiley & Son Eds: UK; 2003, 354p.
14. Kpan T.F., Adeba P.J., Koné I., Kouassi K.P., Roedel M.O., The anuran fauna of a Volunteer Nature Reserve: the Tanoé-Ehy Swamp Forests, south-eastern Ivory Coast, West Africa. Zoosystematics and Evolution, 2014, 90(2), 261-270.
15. Miabangana E.S., Malaisse F., Structure, composition et diversité floristiques de l'île forestière Loufézou dans le Plateau des Cataractes (République du Congo), Geo-Eco-Trop, 2020, 44(2), 1-16.
16. N'Guessan K.E., Utilisation des données satellitaires à haute résolution pour l'étude des ressources végétales en Côte d'Ivoire : Cas des forêts classées de Badenou et du Haut Sassandra. Thèse de Doctorat, Université Paul Sabatier (Toulouse, France), 2004, 219 p.
17. N'Guessan K.F., Konan K.E., Kouadio K., Adjé A.O., « Le réseau d'aires protégées » in Zones d'importance écologique particulière et valorisation de la biodiversité, 2014, 273-279.
18. Nusbaumer L., Gautier L., Chatelain C., Structure et composition de la Forêt Classée du Scio (Côte d'Ivoire) Etude descriptive et comparative. Candollea, 2005, 60 (2), 393-443.
19. Rollet B., L'architecture des forêts denses humides sempervirentes de plaines, Paris, France. Centre Technique Forestier Tropical, 1974, 298 p.
20. Senterre B., Recherches méthodologiques pour la typologie de la végétation et la phytogéographie des forêts denses d'Afrique tropicale. Acta botanica gallica, 2005, 152 (3), 409-419.
21. Shannon C.E., A mathematical theory of communication. Bell System Technical Journal, 1948, 27, 379-423.
22. Sørensen T., A method of establishing groups of equal amplitude in plant sociology based on similitary of species content. Det Kongelige Danske Videnskabernes Selskab. Biologiske Skrifter, 1948, 5 (4), 1-34.
23. van Steenis C.G.G.J., Condition and cause in ecological interpretation. Blumea. Supplement, 1958, 4 (1), 93-95.
24. Vroh B.T.A., Evaluation de la dynamique de la végétation dans les zones agricoles d'Azaguié (Sud-est Côte d'Ivoire). Université Félix-Houphouët-Boigny, UFR Biosciences, Thèse Unique de Botanique, 2013, 131 p.

25. Zeb U., Khan H., Gul B., Khan W.M. Floristic composition and phytosociological studies of Hazar Nao hills, District Malakand, Khyber Pakhtunkhwa, Pakistan. Pakistan Journal of Weed Science Research, 2016, 22(2), 295-315.
26. Wala K., Woegan A.Y., Borozi W., Dourma M., Atato A., Batawila K., Akpagana K.,. Assessment of vegetation structure and human impacts in the protected area of A ledjo (Togo). African Journal of Ecology, 2012, 50 (3), 355-366. (Cameroun). Plant Ecology and Evolution, 2012, 145 (2), 152-164.
27. Wiegand T., Revilla E., Knauer F., Dealing with uncertainty in spatially explicit population models, Biodiversity and Conservation, 2004, 13, 53–78