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Availability and Traditional Uses of Some Plant Species in the Tanoe-Ehy swamp forest (FMTE), Southeastern Côte d'Ivoire

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ABSTRACT: The Tanoe-Ehy swamp forest (FMTE) has been identified as a high-priority site for primate conservation in West Africa. In addition to a lack of knowledge of the plant communities, the site is subject to pressure from local populations both on the periphery and in the interior. The aim of this ethnobotanical study is therefore to determine the uses made of the plant species collected by the local populations. To achieve this, ethnobotanical surveys were carried out in seven localities on the outskirts of the forest. Generally speaking, direct interviews with local people enabled us to identify the techniques and practices used to plant crops and the plants harvested in the study area. A total of 160 people were interviewed, most of them male farmers. The survey showed that most of the plantation land had been acquired by inheritance and had been established on forest land. Monocultural plantations are the most abundant in the study area. It is worth noting that the preferred place for collecting plants is within the FMTE. Most of the plant species collected are used for traditional medicine. They include *Landolphia membranacea, Tabernaemontana crassa, Combretum aphanopetalum, Parquetina nigrescens, Microdesmis keayana, Alchornea cordifolia,* and *Strophanthus hispidus* with a rarity index of less than 80%. Given the importance of the FMTE in terms of a particular ecosystem and biodiversity conservation, it is desirable and urgent that, in addition to awareness campaigns for local populations, the process of its definitive classification be accelerated to put an end.

KEYWORDS: Wetlands, swamp forest, ethnobotanical survey, Tanoe-Ehy swamp forest, Côte d'Ivoire.

1 INTRODUCTION

The Tanoe-Ehy Swamp Forest (FMTE) is a swamp forest covering an area of 12,000 hectares, in line with the dynamics of the creation of a voluntary nature reserve (RNV). Identified in 2004 by the Research and Actions for the Conservation of Primates in Côte d'Ivoire (RASAP-CI) program, it was recognized as a site of high conservation value [1]. It is one of the last refugee for three critically endangered monkey species on the IUCN Red List: the Roloway monkey (Cercopithecus diana roloway), the Diana monkey (Cercocebus atyslunulatus), and the Miss Waldron's red colobus (Piliocolobus badius waldronae) according to [2]. This wetland is one of the last remnants of its kind. In 2006, the process of declaring it a Voluntary Nature Reserve (VNR) began.

The FMTE is an important natural resource for the surrounding local population. However, demographic growth and a lack of arable land have led to increased deforestation around the FMTE, threatening biodiversity conservation and sustainable development in the region in the medium term. While awaiting its official designation as part of the rural domain, the FMTE faces numerous pressures from nearby communities, with the establishment of numerous perennial crops (oil palm, cocoa, rubber, etc.) and food crops (plantain, cassava, etc.), reducing its area. The result is the transformation of these forest ecosystems into large plantations of perennial crops, some of which are owned by villagers and others by the Industrial Palm Plantation of Côte d'Ivoire (PALMCI), an agro-industrial unit that produces palm oil [3]. All these threats threaten the sustainability of the habitats that make up the FMTE site. It is also subject to fishing activities during the rainy season.

In 2016, an agroforestry support project was launched to help protect and conserve the environment in the long term, primarily for the benefit of the rural population. The aim of this study is to master the management of the FMTE and its surrounding area, leading to the implementation of an integrated rural development project. Although difficult to access, the FMTE is in the process of being steadily degraded. Its plant resources are heavily exploited by neighbouring rural populations. As a result, research into the causes of this anarchic and continuous exploitation of the flora of the future RNV by rural populations is a priority in order to better safeguard its biodiversity through effective participatory management [4]. It is in this context that an ethnobotanical study was carried out in the FMTE area in order to identify the cultivation practices carried out and to determine the uses made of the plant species collected by the local populations.

2 METHODOLOGY

2.1 STUDY SITE

The climate in the Department of Tiapoum, where FMTE is located, is subequatorial or equatorial and is characterized by four seasons: a major dry season from December to February, a major rainy season from March to July, a minor dry season in August, and a minor rainy season from September to November. FMTE experiences abundant rainfall, generally with an average annual precipitation between 1400 mm and 1600 mm [5]. Temperatures vary between 22°C and 30°C. The average temperature is 26°C. Temperatures are highest in April and August. The soil of the Tanoe-Ehy swamp forest (FMTE) belongs to the subclass of highly denatured ferralitic soils of granitic or schistose type [6], with a high water-holding capacity [7]. The forest is covered with evergreen swamp vegetation on hydromorphic soils. The swamp forests are flooded most of the year. In the periphery, there are several perennial crops such as cocoa plantations, oil palm groves, coffee plantations, etc [8].

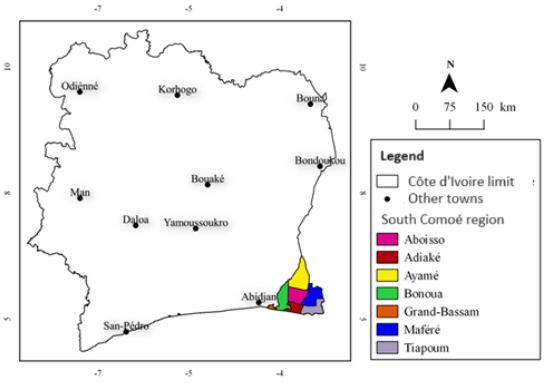

Fig. 1. Geographical location of the Sud-Comoé region in Côte d'Ivoire

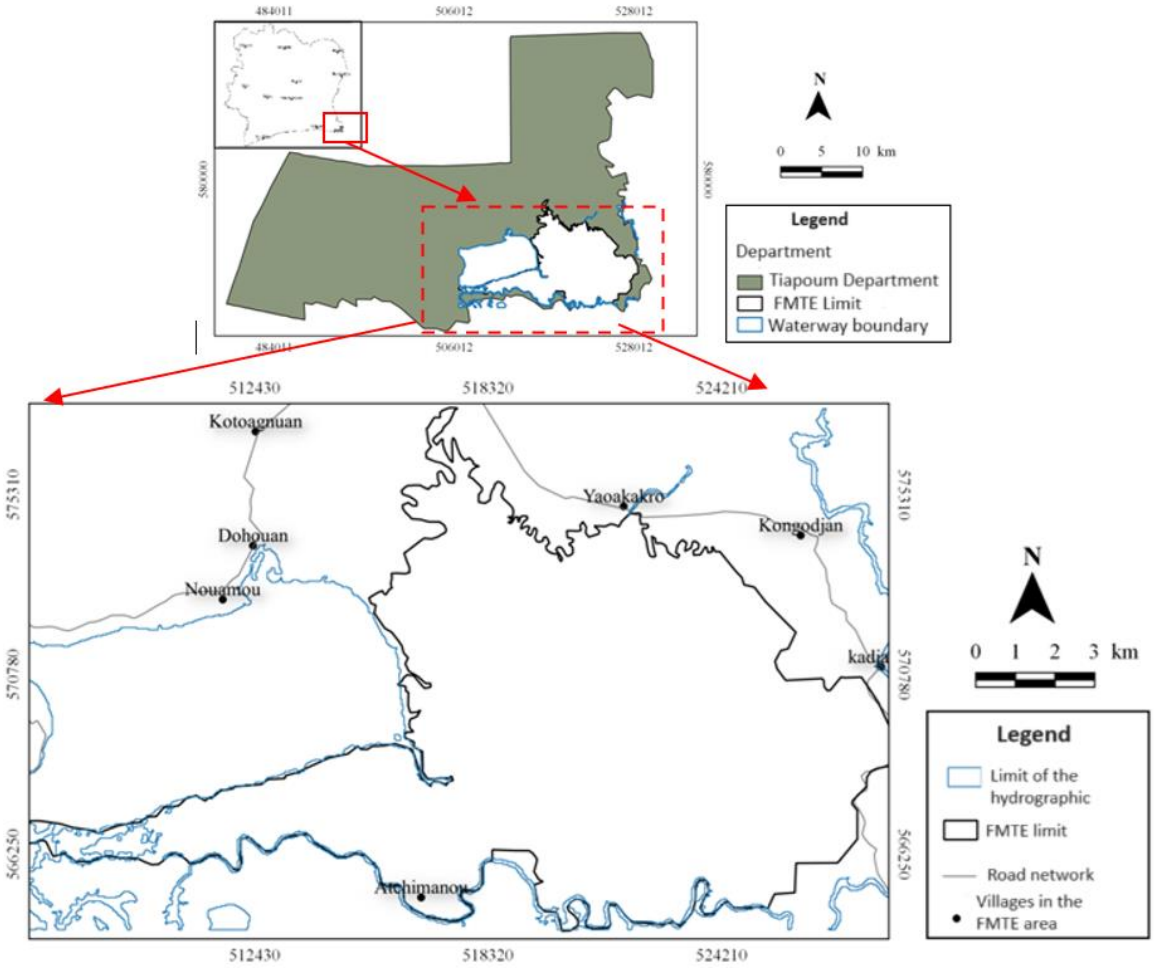

Fig. 2. Location Maps of the Tanoe-Ehy Swamp Forest (FMTE)

2.2 SURVEYS ON THE USE OF PLANT SPECIES BY LOCAL PEOPLE

Ethnobotanical surveys were conducted in seven localities located on the periphery of the FMTE: Atchimanou, Nouamou, Dohouan, Kotoagnuan, Yaoakakro, Kongodjan and Kadjakro. The selection of these sites was based on an assessment of the importance of the forest to the local population and the impact that these neighboring populations have on the dynamics of the FMTE. Direct interviews with the local population (Figure 3) helped to identify the agricultural practices used to establish crops. First, questions were asked about the profile of the farmers. To this end, a questionnaire was administered individually to farmers in the relevant localities of the study to describe various criteria, including origin, gender and age of farmers, level of education, modalities of access to land, and membership in a cooperative or support structure. Subsequent interviews focused on the plant species they harvest in the FMTE and the purposes for which they use them (Fig.3).Six main types of uses were considered in this study: food, medicinal, timber, shade, artisanal, and Building. For each species used, information on where preferred to harvest was collected. With regard to plantations, questions focused on parameters such as size, age, previous harvests, and crop varieties used by the farmers, among others. The age of the plantations was classified in 5-year intervals. For the size of the plantations, due to the relatively small proportion of plantations in this area, the classification was done with intervals of two hectares. The questionnaire was administered to 160 farmers. Five types of land use were identified in the study [8]: cultivated, fallow, upland forest, temporarily flooded forest, and permanently flooded forest.

Fig. 3. Photographic view of a discussion session on the traditional use of a plant

2.3 ANALYSIS OF SURVEY DATA

In this study, farmers' profiles were determined by analyzing survey data using statistical methods, including box plot analyses. The characterization of plantations around the FMTE was conducted through univariate and multivariate analyses. To achieve this, the relationships between various plantation parameters (plantation age, plantation size, previous crops, inputs, etc.) mentioned by the respondents and the localities were examined using Chi-square tests. This was done to ascertain whether these parameters constitute key determinants in the typology of these plantations.

Additionally, the availability of species for traditional use was assessed using the rarity index, calculated based on the equation proposed by [9]. This index is calculated according to the following formula:

$$Ri = [1 - (ni / N)] \times 100$$

In this equation, Ri is the rarity index of a species i, ni is the number of plots where it occurs, and N is the total number of inventoried plots. According to [10], species with a rarity index of less than 80% are considered preferred, very common, and abundant in the study areas. Species with a rarity index greater than 80% are considered rare and therefore highly endangered in the area. This index was used by [11] in Côte d'Ivoire, [10] and [12] in Togo.

2.4 STATISTICAL METHODS FOR DATA ANALYSIS

In some cases, one-way analysis of variance (ANOVA) was used to compare sample means and indices calculated for different groups of inventoried habitats. Whenever the calculated probability was significant, the Tukey test was used to compare pairwise means and assess significant differences between them. In other cases where the conditions for ANOVA were not met, the non-parametric Kruskal-Walli's test was used. In such cases, the Dunn test was used to compare pairwise means and to determine whether significant differences existed.

In this study, the chi-squared test was used to test the existence of relationships between data obtained from the surveys conducted (plantation size, age of plantations, method of land acquisition, previous crops, etc.) in different locations. The selected significance level for these analyses was set at 5% ($p = 0.05$).

The Mann-Whitney (U) test, a non-parametric test, was used to compare two independent samples with small sample sizes that do not meet the "normality" condition (the shape of the distribution does not follow a bell curve or Gaussian distribution). This test is primarily used for ordinal variables. In this study, it was used to compare the means of the "gender" and "level of supervision" variables across sites.

Box plots or box-and-whisker plots were used to summarize key characteristics of the variable under study (median, mean and standard deviation, quartiles, minimum and maximum). This graphical representation was primarily used to compare the same variable across populations of different sizes and locations.

Multiple Correspondence Analysis (MCA) was used to illustrate the distribution of different plantation groups based on survey data. MCA is a multivariate technique used to analyze relationships between categorical variables and to visualize patterns in the data.

These statistical methods provided a robust framework for analyzing and interpreting the diverse data collected in this study, allowing for a comprehensive understanding of the relationships and variations within the surveyed parameters across different locations and groups.

3 RESULTS

3.1 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE POPULATIONS SURVEYED AND CROPPING PRACTICES

3.1.1 RESPONDENT PROFILE

A total of 160 individuals were interviewed across seven villages, with varying distribution among them: Atchimanou (20 individuals), Dohouan (27 individuals), Kadjakro (24 individuals), Kongodjan (24 individuals), Kotoagnuan (24 individuals), Nouamou (23 individuals), and Yaoakakro (21 individuals). An analysis of the distribution of farmers based on their origin revealed differences among natives, allochthones, and allogenes. Natives were the most numerous, averaging 12.4 ± 5.3, while non-natives were the least numerous, with an average of 4.1 ± 4.4 individuals (Fig. 4). Of all respondents, 2.48% were female, and 97.52% were male, with an average of 22.3 ± 1.4 males per site (Figure 5). The mean age of respondents per site was 38.9 ± 10.4 years, predominantly falling between 31 and 44 years according to box plot analysis. The Mann-Whitney test confirmed significant differences between the number of women and men (Fig. 6). Education levels varied across localities, with 54% of farmers reporting attendance at school, and 46% being illiterate. Respondents who attended school up to secondary level were the least numerous, with an average of 3 ± 2 individuals per locality. Illiterates were the most numerous, averaging 10.4 ± 3.1 people per locality. The Kruskal-Wallis test indicated significant differences in education levels (Fig. 7). Married individuals were the majority in the visited localities, with an average of 21.1 ± 2.6 per site, while widows were the least numerous, with an average of 0.3 ± 0.5 per site. The Kruskal-Wallis test showed significant differences in the marital status of respondents (Fig. 8).

In terms of plantation establishment, the majority of respondents did not benefit from supervision. Unsupervised individuals were the most numerous in the localities, with an average of 21.6 ± 1.4 (Fig. 9).

3.1.2 CULTURAL PRACTICES

In the study area, four methods of land acquisition were identified: purchase, inheritance, donation, and sharecropping. Sharecropping involves sharing either the harvest or the cultivated area between the owner and the worker. The predominant method among these was inheritance (Fig. 10), ranging from 33.3% in Kotoagnuan to 85.7% in Kadjakro. Conversely, purchase was the least mentioned method, with proportions ranging from 4.3% in Nouamou to 16.7% in Kongodjan.

Additionally, three previous cultivation practices were mentioned by all the farmers surveyed in the study area (Fig. 11). Most plantations in the study area were established following clearing (62.5%). On the other hand, those originating from old plantations represented the lowest proportion (13.75%). Furthermore, forests in the study area served as the main previous cultivation practice in the localities of Kadjakro and Atchimanou, accounting for 81% and 80% of cases, respectively

Forests also served as previous cultivation practices in the localities of Kongodjan and Kotoagnuan, where they accounted for 45.8% of cases each. The Chi-square test revealed a relationship between the locality and the previous cultivation practice ($\chi 2 = 13.37$; $p < 0.05$). Two types of plantations were distinguished from the survey analysis: monocultures (cocoa, palm, rubber and coconut trees) and mixed cropping (cocoa-palm, cocoa-coconut, etc.). Among the respondents, 71.25% reported having plantations in monoculture, compared to 28.75% in polyculture, such as cocoa-coconut, palm-rubber, etc. (Fig.12). The age of the plantations of the owners interviewed ranged from 2 to 63 years, according to their statements. The distribution of plantations by age groups showed that plantations over 25 years old accounted for more than 32.5% of the plantations in the study area (Fig.13). The Chi-square test showed that there was a relationship between the distribution of plantations by age groups and the localities ($\chi 2 = 46.047$; $p < 0.05$). The areas of the plantations in the study area ranged from 0.5 to 24.5 ha. The area class between 0.5 and 2 ha included the largest number of plantations (38.13%), while the class over 8 ha included the smallest number of plantations, i.e. 3.13% (Fig.14).

In the different localities, the plantations with an area ranging from 0.5 to 2 hectares are the most significant. The Fisher's exact test on the contingency table indicates that there is a relationship between the localities and the sizes of the plantations ($\chi 2 = 53.15$; $p < 0.05$).

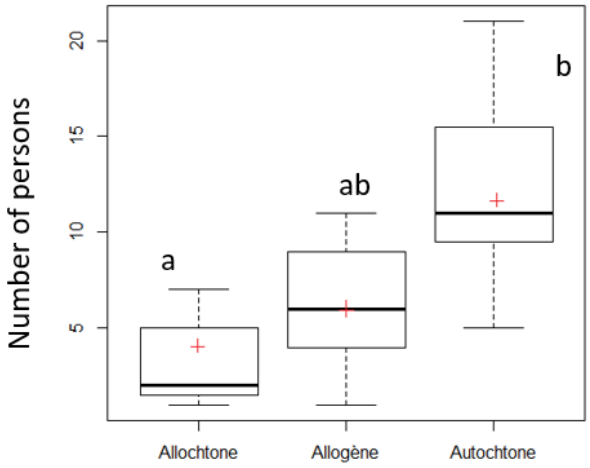

Fig. 4. Origin of farmers in the localities Kruskas Wallis test: K = 8, 33; p = 0.016

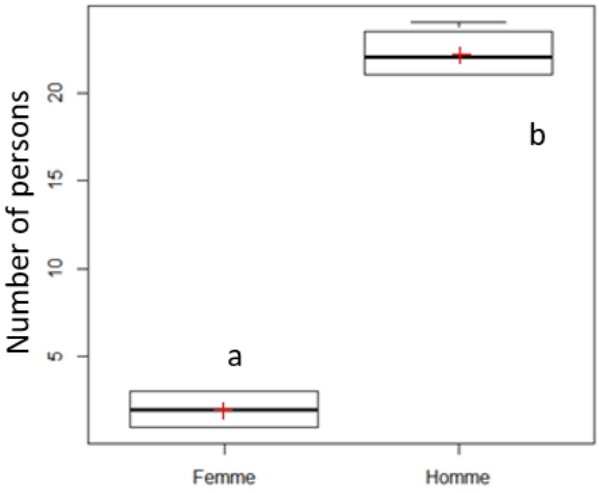

Fig. 5. Gender of farmer in localities Mann-Withney test: U = 14.5; p = 0.042

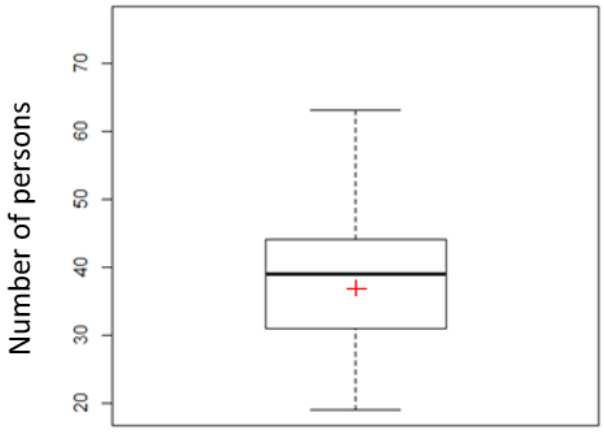

Fig. 6. Number of people of the age variable of farmers in localities

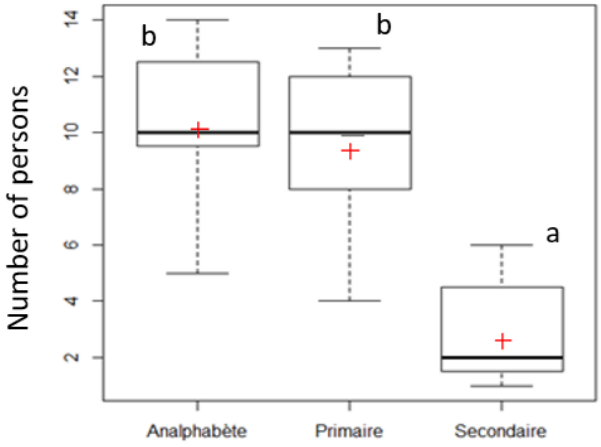

Fig. 7. Level of education of farmers in Kruskas Wallis test: (K = 11,59; p = 0,003)

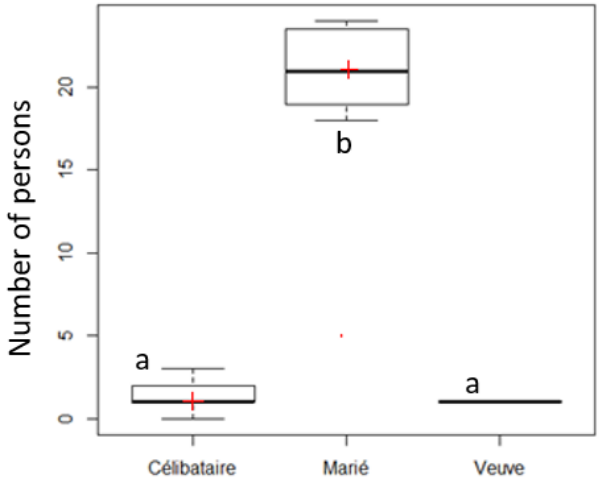

Fig. 8. Marital status of farmers in localities Kruskas Wallis test: (K = 11,62; p = 0,003)

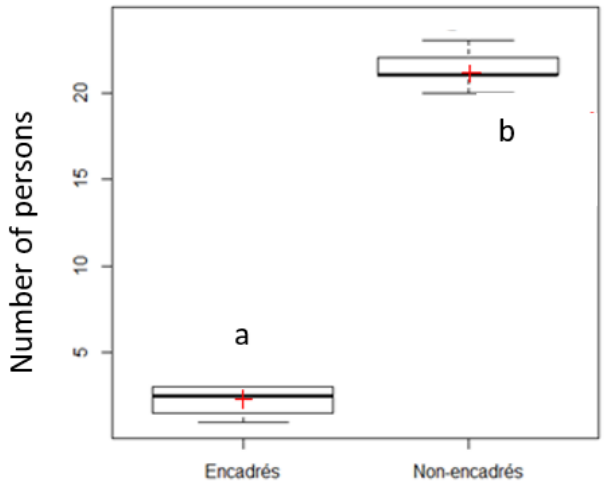

Fig. 9. Level of supervision of farmers in localities, Mann-Withney: U = 28,1; p = 0,009)

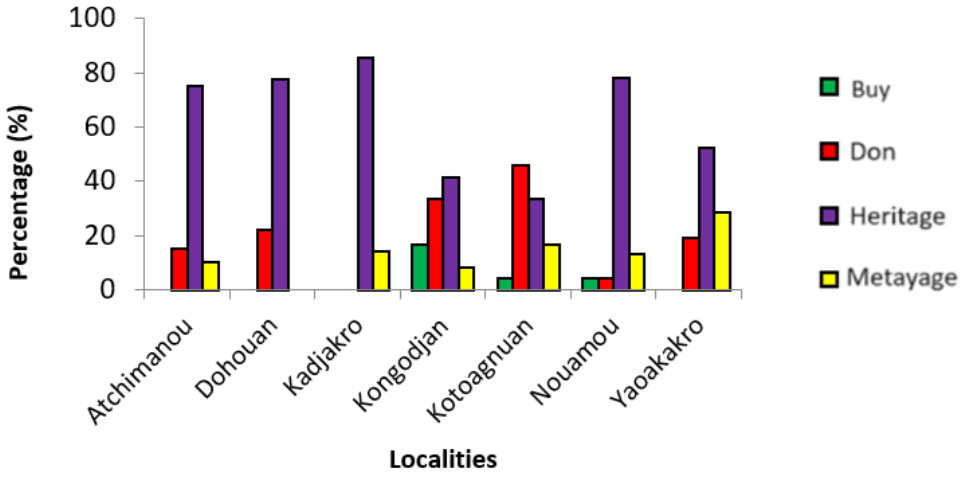

Fig. 10. Histograms of land acquisition methods in different localities

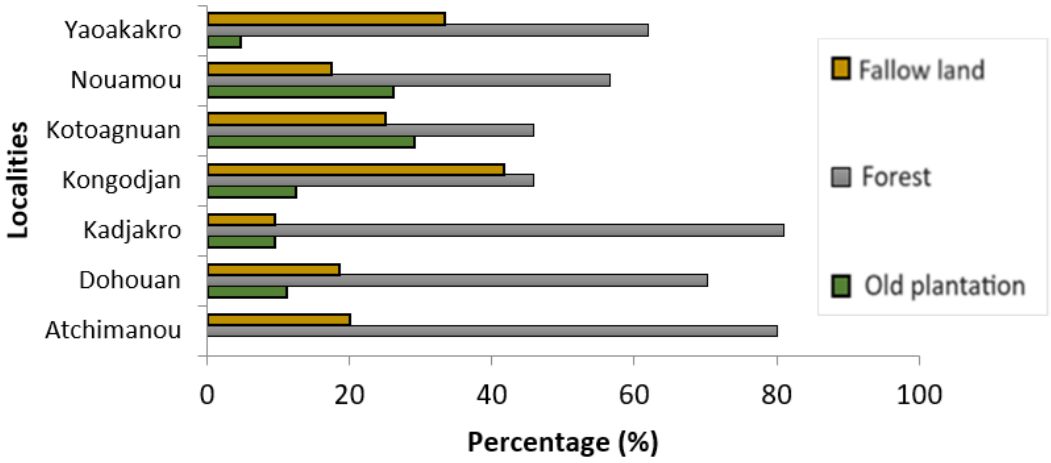

Fig. 11. Histograms of previous crops in different localities

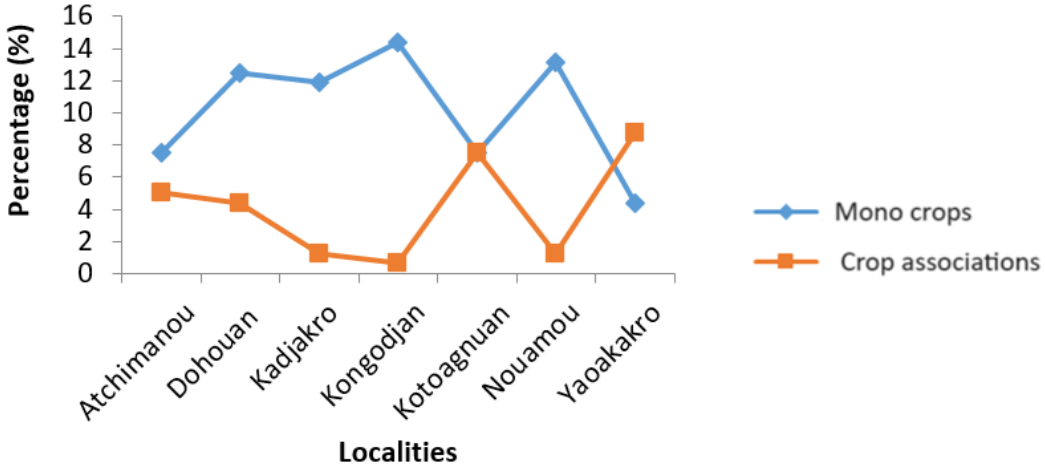

Fig. 12. Histograms of crop types in different localities

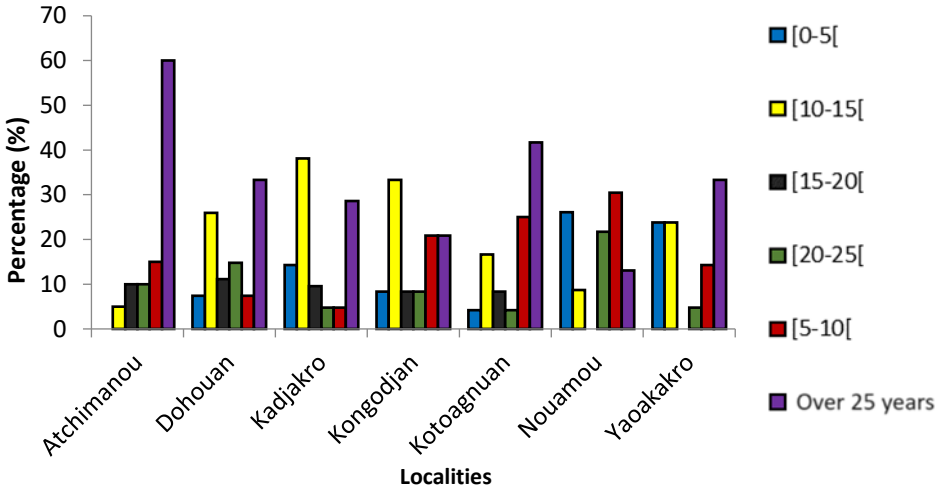

Fig. 13. Histograms of age classes of plantations in different localities

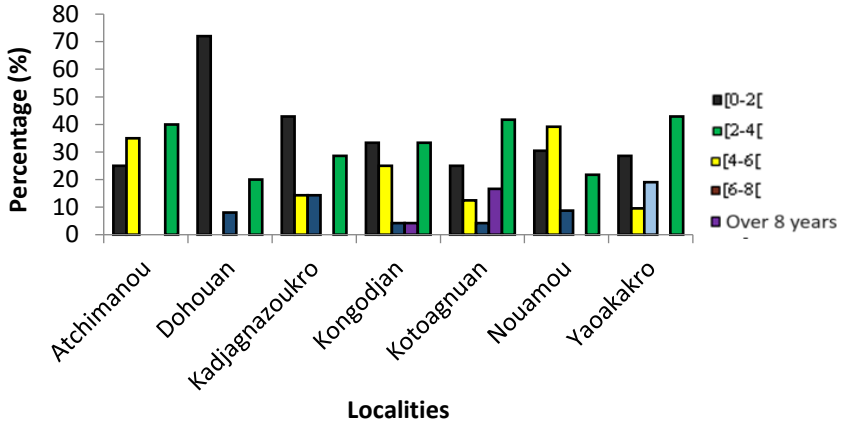

Fig. 14. Distribution of plantation areas in different localities

3.1.3 TYPOLOGY OF FMTE PLANTATIONS

The variables that distinguished the plantation groups were: previous crop, area, age of the crop, and type of crop. The first two axes of the Multiple Correspondence Analysis (MCA) explained 39.40% of the variance (Figure 17). Three groups of plantations emerged based on the distribution of these variables.

According to the analysis of the MCA factorial map, axis 1 differentiated plantations established in forest from those established in fallow land. On the positive side of axis 1, there were large-scale oil palm and coconut plantations, over 25 years old, usually installed on former plantations. The plantations in this group (P1), which had areas exceeding 8 hectares, were mainly located in the localities of Dohouan, Nouamou, and Kotoagnuan. On the negative side, there were cocoa plantations in the localities of Atchimanou and Kadjakro, representing group P2, as well as mixed crops such as (oil palm-coconut, cocoa-coconut) in the localities of Kongodjan and Yaoakakro.

Axis 2 contrasted monoculture plantations (cocoa, oil palm, and coconut) with mixed crops (cocoa-oil palm, cocoa-coconut, oil palm-coconut, and coffee-oil palm) present in the localities. On the positive side of the axis, the plantations in group P3 were generally composed of mixed crops such as oil palm-coconut, coffee-oil palm, and cocoa-coconut. These plantations had an age ranging from zero to five years, with fallow land as the previous crop. On the negative side of the axis, there were monoculture plantations of cocoa and oil palm.

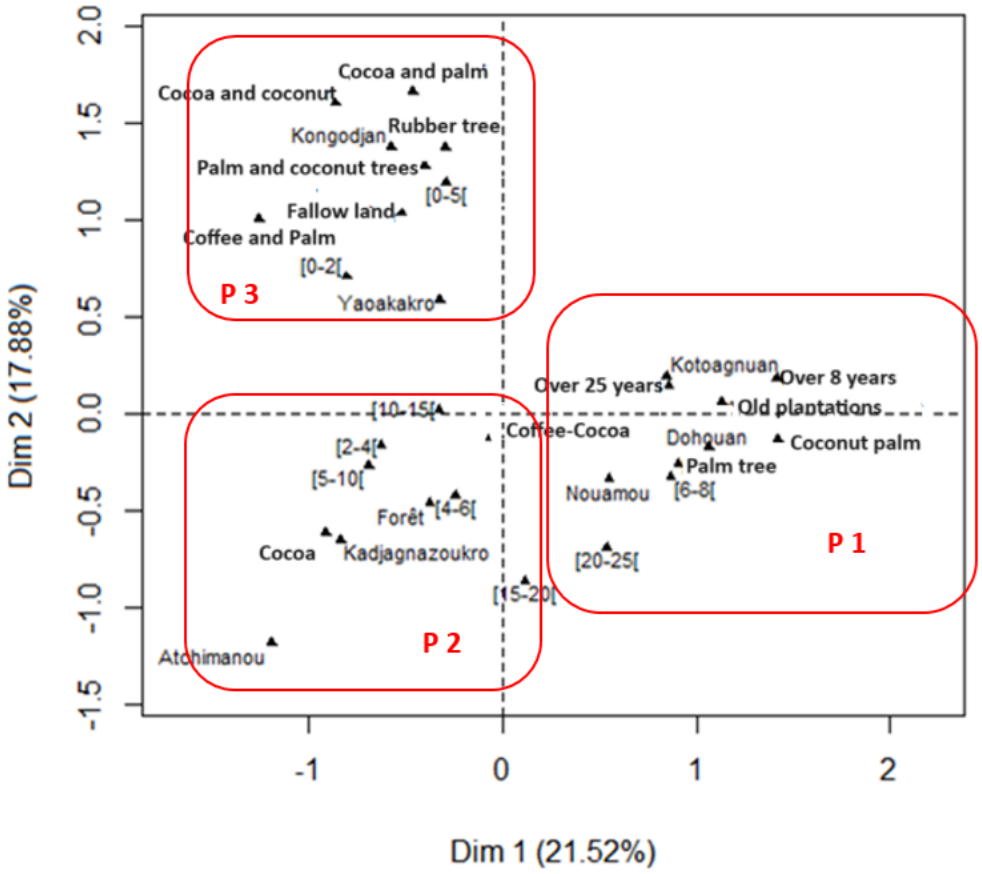

Fig. 15. Factor map of the order of plantation types in FMTE

3.2 Harvesting Sites Of Local Use Species

After analyzing the survey data, five sources of supply were reported by the respondents. The Tanoe-Ehy Swamp Forest remains the primary source of local species supply for the local population, with a citation frequency of 52.2% (Table 1). At this level, forests on firm ground were the most significant source of supply for the populations, with a citation frequency of 26.56%. Temporarily flooded forests followed firm ground forests with a citation rate of 18.75%. Permanently flooded forests were mentioned as the least cited source of supply for locally used species. The peripheral zone of the Tanoe-Ehy Swamp Forest was identified as a secondary supply source with a proportion of 46.87% (Table 1). Plantations and fallow lands adjacent to the Tanoe-Ehy Swamp Forest were considered other sources of supply for locally used species, with citation rates of 21% and 9%, respectively.

Table 1. Source of supply of species for traditional use in space

Area FMTE	Sample location	Number of species	Percentage (%)	Total percentage (%)
Peripheral area	Culture	22	34,37	47,8
	Fallow	11	17,18	
FMTE	Upland forest	17	26,56	52,2
	Temporarily flooded forest	12	18,75	
	Permanently flooded forest	7	10,93	
	General total	**64**		100

3.3 Species Use

The populations have utilized the species for six categories of use: food, craftsmanship, traditional medicine, Building, timber, and shading (Fig. 18). Traditional medicine constituted the primary use of species by the populations in the study area, with a citation frequency of 50%. The least practiced use was the utilization of species as timber, with a citation frequency of 3.1%.

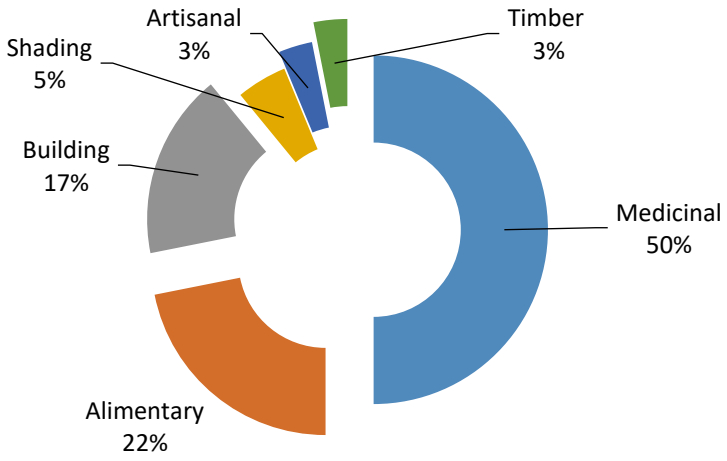

Fig. 16. Spectrum of different uses of species harvested by local populations

3.4 AVAILABILITY OF THE SPECIES CITED IN THE DIFFERENT INVENTORY SITES

The FMTE area is home to a variety of plant species, some very common and plentiful, and others scarcer. Out of the species recorded, 29 have a traditional medicinal use in the FMTE. Seven of these species (*Landolphia membranacea, Tabernaemontana crassa, Combretum aphanopetalum, Parquetina nigrescens, Microdesmis keayana, Alchornea cordifolia* and *Strophanthus hispidus*) have a rarity index below 80%. The rest of the species have a rarity index between 80 and 97.7%. For instance, Garcinia kola has a rarity index of 82.2% in the FMTE and 83.3% in the peripheral areas. The species used for food are eight, regardless of the area. *Irvingia gabonensis* is the only species that has a rarity index below 80% in the habitats of the FMTE (Figure 19). It is highly valued by the local populations for the quality of its fruit. However, it is not available in the peripheral areas of the FMTE, with a rarity index of 81.3%. *Ricinodendron heudelotii,* whose fruits are used as condiments, has a rarity index above 80% in both types of spaces. Regarding the timber and Building species, 15 species were identified. Among them, five (*Ficus trichopoda, Raphia hookeri, Elaeis guineensis, Hallea ledermanii* and *Borassus aethiopum*) are used in the Building of roofs, chairs, etc. These species have a rarity index below 80% in the FMTE. *Raphia hookeri* and *Elaeis guineensis* are highly sought after by the local populations, because their sap is used as an alcoholic drink, called "Bandji" for E. guineensis and "Doka" for R. hookeri. These species are nearly impossible to find in the peripheral areas, with rarity indices above 80%. The timber species are eight: *Piptadeniastrum africanum, Tarrietia utilis, Milicia regia, Milicia exelsa, Terminalia ivorensis, Tieghemella heckelii, Entandrophragma angolense* and *Triplochiton scleroxylon*. Only *Entandrophragma angolense* has a rarity index below 80%. The other species have rarity indices above 80%. In the field of handicraft, six species were cited by the populations. Alstonia boonei, whose trunk is used for sculpture, has a scarcity index above 80% in both spaces. *Ricinodendron heudelotii* is also used for sculpture, with scarcity indices below 80% in both types of spaces. The leaves of *Thaumatococcus daniellii* are used as packaging for local products. This species has a scarcity index below 80% in the FMTE. Elaeis guineensis is the only species that has a use in three domains: food, medicinal and handicraft. In the handicraft domain, its leaves are used to make brooms (Table 2).

Fig. 17. View of a woman breaking Irvingia gabonensis fruit from the FMTE space

Table 2. List of traditionally used species and their rarity index in the FMTE area

			Rarity index (%)	
Scientific name	**Use**	**Part used**	**FMTE**	**Peripheral area**
Alchornea cordifolia	Medicinal	Leaf	78,6	11,2
Alstonia boonei	Medicinal/ Artisanal	Leaf/ Trunk	89,2	88,2
Anchomanes difformis	Medicinal	Root	81,2	99,2
Bambusa vulgaris	Medicinal/ Building	Leaf/ Chaume	82,1	63,2
Baphia nitida	Medicinal/ Artisanal	Leaf/ Trunk	89,2	97,7
Borassus aethiopum	Building / Alimentary	Leaf/ Fruit	79,2	55,2
Calamus deërratus	Building	Leaf	84,6	97,7
Cecropia peltata	Shading	Leaf	96,2	42,3
Chromolaena odorata	Medicinal	Leaf	97,7	20,4
Cola nitida	Alimentary	Fruit	96,2	75,3
Combretum aphanopetalum	Medicinal	Leaf	54,6	98,5
Culcasia angolensis	Medicinal	Fruit	86,2	98,7
Dacryodes klaineana	Alimentary	Fruit	63,1	63,1
Elaeis guineensis	Alimentary/Medicinal/ Artisanal	Fruit, sap, seeds/ Roots/ Leaf	74,2	36,5
Entandrophragma angolense	Timber/ Medicinal	Trunk/ Bark	96,9	32,3
Ficus trichopoda	Building	Trunk	36,1	98,5
Garcinia kola	Medicinal	Fruit	82,2	87,3
Hallea ledermanii	Building	Trunk	73,1	92,3
Hypselodelphys violacea	Medicinal	Leaf	90,0	99,4
Irvingia gabonensis	Alimentary	Fruit	39,5	81,3
Khaya ivorensis	Medicinal	Bark	89,3	96,3
Landolphia membranacea	Medicinal	Leaf	36,1	83,2
Microdesmis keayana	Medicinal	Root	76,5	19,4
Milicia excelsa	Building	Trunk	93,1	94,6
Milicia regia	Building	Trunk	81,4	89,1
Morinda morindoides	Medicinal	Leaf	96,2	43,5
Nauclea diderrichii	Building	Trunk	86,2	90,8
Nauclea xanthoxylon	Medicinal	Bark	93,8	78,2
Parquetina nigrescens	Medicinal	Seed	74,4	25,4
Paullinia pinnata	Medicinal	Leaf	82,3	91,1
Piper guineense	Medicinal	Fruit	80,0	99,2
Piptadeniastrum africanum	Timber	Trunk	93,8	96,2
Psidium guajava	Alimentary	Fruit	82,7	99,2
Pterocarpus erinaceus	Medicinal	Bark	90,1	89,4
Pycnanthus angolensis	Shading	Leaf	94,6	23,4
Raphia hookeri	Building	Leaf	68,5	95,4
Rauvolfia vomitoria	Medicinal	Leaf	96,2	31,3
Ricinodendron heudelotii	Alimentary/ Artisanal	Fruit/ Trunk	93,8	86,9
Scleria depressa	Medicinal	Root	89	99,2
Spondias mombin	Alimentary	Fruit	63,1	65,4
Strophanthus hispidus	Medicinal	Root	79,3	96,3
Tabernaemontana crassa	Medicinal	Leaf	36,5	28,2
Tarrietia utilis	Building	Trunk	87,8	82,3
Terminalia ivorensis	Building	Trunk	95,2	93,1
Tetracera alnifolia	Medicinal	Stem	90,0	98,4
Thaumatococcus daniellii	Artisanal/ Medicinal	Leaf/ Fruit	82,0	23,2
Tieghemella heckelii	Building	Trunk	81,5	96,9
Tiliacora dinklagei	Medicinal	Stem	90,4	99,2

Tricalysia pallens	Artisanal	Stem	99,2	25,4
Triplochiton scleroxylon	Timber/ Medicinal	Trunk/ Bark	82,6	98,5
Xylopia aethiopica	Medicinal	Fruit	81,1	80,4

4 DISCUSSION

4.1 FARMING PRACTICES OF FMTE AREA POPULATIONS

Palm and cocoa are the main crops grown in the study area. The average age of farm managers is 39, and 97.52% of them are men. This may be explained by the customary land laws of the main peoples in the study area. These laws favour men's right of access to land, since women, as members of the family, tend to marry in other localities. As a result, when the family's land holdings are divided up, only adult male heads of household are entitled to the land or farms they already own. The latter are responsible for their younger brothers, whom they use as labourers to maintain the farms. When the head of the family dies, the deceased's land holdings are retained by the eldest member of the patrilineage. But this practice, inherited from a time when land was not a source of wealth, is becoming increasingly unacceptable to the children of the deceased, who have worked to expand the plantations. [13], in south-west Côte d'Ivoire, showed that young city dwellers returning to their villages, who had hoped to set up their own farms, were forced to live under the dependence of their parents. In this study, over 54% of the farmers interviewed in the various localities had attended school, which means that only 46% were illiterate. The high rate of school attendance recorded in the study area can be explained by the return to the land of young people who have dropped out of school. This return is often due to the death of the family member who provided the schooling. This is also the case in our study area. It also often happens that the pupil is obliged to look after the family farm if the father dies, especially when the father is the eldest in the family or the first male. The high proportion of literate people may also be linked to the return of some retired people to farming. This observation has already been made by [14] and [15]. They may also be civil servants (nurses, teachers, sub-prefects, etc.) assigned to rural areas who are interested in agriculture because of the additional foreign currency they can earn. However, even if the illiteracy rate in the study area is lower than the national average of 56.4%, as indicated by [15] in agricultural areas of Côte d'Ivoire, it is still negligible. This situation can be explained by the very isolated location of certain localities such as Atchimanou, Yaoakakro... Most of the people surveyed had dropped out of primary school either because of a lack of funds or because their parents refused to allow them to continue. This situation, which prevails in certain localities in the study area (Atchimanou, Kadjakro, Kongodjan, etc.), seems to be the cause of a crucial lack of schools, or those that do exist are not functional. As a result, only farmers with a stable financial situation send their children to the nearest schools for education. Those whose parents do not have the necessary financial means are content with agricultural activities. Our observations are in line with those of [16] Grand-Bassam. For these authors, the low literacy rate is linked to parents' insufficient financial resources. The same observation was made by [3] in the same study area, who explain that the high illiteracy rate is due to the isolated location of certain localities.

To sum up, the people surveyed in the FMTE area are generally of indigenous origin. They are mostly men, with an average age of 39, and are generally educated. In fact, the return to the land of young people who have been to school, as well as retired people, is thought to be behind the high level of schooling in this area.

4.2 ACCESS TO LAND AND PLANTATION CHARACTERISTICS

Inheritance is the main method of access to land for the indigenous people in the study area. This method of accessing land is governed by a number of rules laid down by customary law. This can be explained by the fact that when the head of the family dies, the family plantation is divided between the members of the family. The question of rights of access to land cannot therefore be dealt with separately from that of access to labour. In the current context of competition for land and economic crisis (reducing farmers' financial capacities), the product-sharing contract is proving to be particularly flexible and suitable for arbitrating the allocation of labour and land use rights [17]. Irrespective of the crop type and locality, plantations are established from nurseries. When oil palm crops are planted, nurseries are purchased from research structures such as the National Center for Agronomic Research (CNRA) or PALM-CI. The establishment of these crops therefore requires a certain amount of knowledge on the part of farmers from organisations such as ANADER. In fact, several training programmes have been initiated by ANADER, but access to certain production sites remains closed. Moreover, even if these training courses are received, they remain difficult to put into practice by the producers because of the multitude of phyto-chemical treatments which do not take into account the level of impoverishment present in the villages. Our results differ from those obtained by [13]. In addition, illiteracy and the low level of income of producers are thought to be the cause of the failure to apply the advice of agricultural supervisors. The establishment of crops in the FMTE area is linked to the availability and size of the land and involves preparing the plot. Generally, once a plot has been cleared, it is developed to maximise yields in the first few years. As cocoa cannot generally produce from the first year, cocoa is planted in association with food crops (yam, taro, plantain banana, etc.).

Three groups of plantations emerge according to the distribution of these variables from the Correspondence Factorial Analysis. The typology based on the farms highlighted the fact that they do not have the same configuration. This underlines the fact that production systems may vary according to the biophysical, climatic and human characteristics of the forest zone [18]. For example, the conversion of forests to cocoa plantations in Atchimanou and Kadjakro, although in the form of a traditional full-sun agroforestry system, is leading to the erosion of local biodiversity ([19]; [20]. Oil palm plantations in the localities of Dohouan, Nouamou and Kotoagnuan highlight the sandy texture of the soil, which is ideal for this type of crop. Palm and coconut trees need a favourable climate and soil, and a regular supply of water throughout the year to ensure good yields. On the

other hand, the presence of crop associations such as cocoa-palm, palm-coconut, etc. in the Yaoakakro areas shows a diversity of crops. Farmers are keen to constantly increase their production, and are striving to develop specialised cropping systems in order to benefit from maximum savings and recoup expenses as quickly as possible. Farmers generally prefer to combine crops because of the shortage of arable land, high demand and rapid production.

In FMTE, the main crops are palm and cocoa. This practice is passed down from father to son, and the land is bequeathed to the eldest son on the death of the head of the family, but this practice is becoming increasingly unacceptable. The majority of farmers have attended school. This situation can be explained either by the fact that it is former civil servants who are returning to the land, or by the fact that the head of the family dies and the student son is obliged to return to the land in order to look after the plantations, or by the fact that civil servants have been posted to rural areas.

4.3 USE OF SPECIES BY LOCAL POPULATIONS

The use of natural resources for medicinal purposes is the most widespread form, not least because of the enormous difficulties of access to modern medical care and its relatively high cost. The abundance of species used for medicinal purposes shows that farmers are well aware of their virtues. Their importance in the plantations could be justified by the fact that, faced with poverty, farmers are turning to traditional medicine to cover their health needs. Conventional facilities (health centres) are still relatively expensive in relation to their purchasing power, and are rare in the various localities. The local people gather medicinal plants from their fields, which are known to relieve certain ailments. This is the case with *Alstonia boonei* (Apocynaceae), known locally as Emien, which is recognised for its effectiveness in treating malaria. Our results corroborate those of [11], who worked in the locality of Agbaou. These authors confirm that most of the local population use species such as *Alstonia boonei, Xylopia aethiopica,* etc., collected in this area, for medicinal purposes due to the distance from health centres. The second type of product used by local people, particularly those in the south-east of FMTE, is food. Their wide variety in FMTE areas could enable people to ensure their food security and additional income, particularly women and children. [21], [22] and [23] had already shown this in their work. The staple diet of the Akan people, who live in the study area, is based on starchy foods (cassava, yam and banana), vegetables (cheese leaves), fruit eaten raw (avocado) and beverages (palm wine). According to [21], the nutritional value of certain species, including *Elaeis guineensis* and *Ricinodendron heudelotii* (Euphorbiaceae), known locally as Akpi, enabled people to cover their energy and vitamin requirements. The local population's interest in certain plants, mainly *Tieghemella heckelii,* Piper guineense and *Ricinodendron heudelotii,* was also observed in the study area. Akpi fruit is used to make sauce, and pepper (*Piper guineense*) fruit is used as a spice to season food. It is reported as a food plant in other regions of Côte d'Ivoire [24], and in Congo [25]. Other forms of resource use, such as building and handicrafts, are also cited by people in the study area. In these localities, the majority of houses are covered with raffia leaves (Raphia spp). Most of these building and craft materials come from FMTE. This situation has already been observed by [3], who emphasised that FMTE is still the only source of building materials in the area. Rattan palms are used to make furniture, generally in the localities of Dohouan, Atchimanou and kadjakro. The palm nuts are also used as bait in traps to capture animals, especially primates, rodents and birds, sold as bushmeat. According to [26], rattan palms are used by local people in the Haute-Dodo classified forest to make furniture and various objects.

4.4 FMTE AREA: PLACE WHERE SPECIES ARE HARVESTED FOR VARIOUS TRADITIONAL USES

The survey shows that 11.39% of species are cited by local people as being used in their diet, pharmacopoeia, handicrafts or Timber production. In fact, this proportion is lower than that obtained by [11] in the locality of Agbaou, who obtained 17.3%. It can therefore be said that several species for traditional use are still poorly known or insufficiently exploited despite their virtues. According to [27], knowledge and effective use of plant species seem to be closely linked to three main factors: the distribution of the species concerned, their availability over time and the uses that people make of them. The proportion of species that can be used traditionally is higher in the forest on the site of the future reserve and in the plantations in the farming areas. The spontaneous species for traditional use that we have encountered grow on their own and do not require any particular maintenance. They are only found in plantations when they are spared by farmers. As a result, their numbers are higher in forests and lower in plantations and fallow land. As pointed out by [28] in Benin, tropical forests, because of their high biodiversity, are teeming with various species whose virtues are well known to the people who depend on them. According to [24], the best-known used species of spontaneous flora in the Department of Gagnoa are found mainly in the forests. However, in the outlying areas of the FMTE, the study shows that the proportion of these species with various traditional uses is higher in plantations than in fallow. This fact shows that when crops are planted and during the maintenance phases, particular importance is attached to conserving species that can be used because of their virtues. Different forms of exploitation appear to be more severe in FMTE forest habitats than in peripheral areas. [29] defined four (4) criteria for a "priority" or "key" forest product for local populations: significant commercial or economic value, products for which demand exceeds supply capacity, multiple-use species or species with many parts used, or species classified as vulnerable according to the International Union for Conservation of Nature or national laws. On the basis of the rarefaction indices, and taking account of these "priority" species criteria, we divided up the various taxa cited by the farming communities during the survey of the species cited for the quality of their wood, *Entandrophragma angolense, Triplochyton scleroxylon, Milicia regia* and *Milicia excelsa* are among those recognised as such in Côte d'Ivoire by the "Société de Développement des Forêts". Among them, *Milicia excelsa, Entandrophragma angolense* and *Triplochyton scleroxylon* are classified as top-quality Timber species and are all on the Red List of Vulnerable Species of Ivorian Flora [30]. Our remarks corroborate those of [31]. For this author, the plant species mentioned above are considered to have a high commercial value and are much used by local populations living in forest areas. They may therefore be among the "priority" or "key" species for local populations in the FMTE area. *Elaeis guineensis* and *Raphia hookeri* are used for their saps, roots, leaves and seeds. The sap from these

species (palm wine) is highly prized and extensively extracted in all regions of Côte d'Ivoire. These observations are similar to those of [31] in a study of three agro-ecological zones in Côte d'Ivoire: the savannah, the savannah-forest transition zone and the forest zone. The author claims that palm wine accounts for more than 10% of the calorific needs of the rural population of Côte d'Ivoire. The pulp of *Elaeis guineensis* is used to extract edible red palm oil. From the kernel, black oil is obtained, which is used in pharmacopoeia and to make soap. Leafs are also used for building roofs and making brooms and baskets. Their roots and young leaves are used for medicinal purposes. Given all these uses, Elaeis guineensis and Raphia hookeri can be classed as "priority" or "key" species for riparian populations in the FMTE area. The rarity index for *Elaeis guineensis* shows that this species is still available in all FMTE areas. This can be explained by the widespread domestication of the species in all tropical forest areas. *Garcinia Kola* has a rarefaction index which shows that this species is rare in FMTE areas. This rarity is linked to the massive harvesting and sale of the seeds of this species, commonly known as "petit cola". In several regions of Côte d'Ivoire, these seeds are known for their aphrodisiac and fortifying properties in the fight against erectile dysfunction. Our results are in line with those of [32]. These authors showed in their work in the Department of Adzopé that the use of *Caesalpinia benthamiana* and *Garcinia Kola* contributes significantly to primary health care for the treatment of erectile dysfunction. The rarity of this species in the locality is a general fact in Côte d'Ivoire. Its unavailability in the FMTE area may be linked to even greater instability in its ecological niche. Various other species do not meet the four criteria indicated by [29], although they are important for rural populations in the FMTE area. Their rarefaction index remains above 80% either in rural areas or in FMTE. Their rarefaction is most often linked to their ecology and/or the way they are harvested. Among the species in the latter category is *Ricinodendron heudelotii,* known locally as 'Akpi' for its seeds, which are used in the preparation of sauces. It is one of the species best known to people in several localities. Seeds of this species can be stored and sold all year round. Our observations corroborate those of [33] in his work in the Department of Divo, who states that several species such as Akpi are highly prized by the people of this area. In fact, this author showed that these populations use these species for sale on the various markets and for self-consumption. Another species, *Thaumatococcus danielii,* whose leaves are used as packaging, is not only grown by people in the study area. In fact, this species, commonly known as the "Attiéké Leaf" in reference to Attiéké, a cassava semolina highly prized by Ivorians, whose leaves are used in traditional packaging, is exploited by all the local populations in the forest areas. In short, the use of plants for medicinal purposes remains the most widespread form of use in the WFI region, given the difficulties of access to modern medicine. Several species in the WFI region are still available to local populations. However, others are rare and/or vulnerable due to misuse by local populations or the degradation of their ecological niche.

5 CONCLUSION

A large proportion of Côte d'Ivoire's wetland forests are still disappearing, mainly as a result of human activities such as hunting, farming, fishing and logging. An initiative for the conservation, protection and management of Ivorian forests is envisaged with the advent of Voluntary Nature Reserves (RNV) or community forests. The FMTE, which is the subject of this study, is part of this dynamic, as it is under constant threat of pressure from local populations. Faced with this problem, one question is increasingly being asked. It is a question of carrying out studies into the rational use of the plant species of the FMTE by the populations living in the surrounding area. To achieve this, it has been necessary to determine the uses made by local populations of the plant species harvested in this area. The forest of the Tanoé-Ehy marshes remains the main source of harvested plant resources for the local population. The main uses are traditional medicine and food. All these activities could constitute a major threat to the sustainability of biodiversity in the future RNV that is FMTE.

Ultimately, it is time to reconcile the well-being of local populations with biodiversity conservation in the FMTE area. Environmental management and conservation programmes through plantation reforestation (agroforestry) must be initiated in the localities closest to FMTE. Given the attachment of the communities to this site, the FMTE management rules should take into account their conception, their know-how and their perception in terms of conservation and protection of biological diversity. Given the great importance of the Forêt des Marais Tanoé-Ehy (FMTE) in terms of a particular ecosystem and biodiversity conservation, it is desirable and urgent that, in addition to awareness-raising campaigns for the local populations, the process of its definitive classification be accelerated to put an end to its degradation.

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