

**CHARACTERIZATION OF ECOSYSTEM SERVICES OF CASHEW PLANTATIONS  
(*Anacardium occidentale* L.) IN THE PENDÉ AND NYA DEPARTMENTS  
(EXTREME-SOUTH, CHAD)**

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**Abstract**

*In order to enhance the value of edible fruit trees from the Sudanian zone, such as cashew, a study was carried out in the Logone Oriental province in Chad. Ethnobotanical and socio-economic surveys, through structured and semi-structured interviews, were carried out with 18 resource persons, who were the owners and/or managers. It appears that the cashew nut sector is relatively young in this region. Nevertheless, the price per kg of nuts has evolved positively over the last three years (2019 to 2021), ranging from 186±44.11 FCFA (2019) to 386±75.93 FCFA (2021). Maximum production is recorded in plantations over 15 years old in Pendé and Nya respectively with 600 kg/year and 617 kg/year (2019), 700 kg/year and 625 kg/year (2020), 550 kg/year and 668 kg/year (2021). Seven traces of anthropization were encountered and it appears that young plantations (less than 10 years old, 10 to 15 years old) are more anthropized, but also, the species *Anacardium occidentale* L. is highly anthropized in the study area than other species. The study revealed that, despite a favourable eco-geographical setting for cashew cultivation, local populations are not interested in the crop and do not have enough land for it. A development plan for these agrosystems should be envisaged.*

**Key Words:** *Anacardium occidentale*, ecosystem services, Chad, Sudanian zone

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**Introduction**

The world's forests cover around 31% of the planet's land, or just over 4 billion ha (FAO, 2016) and are important because they provide goods and services that are essential for populations, but above all a socio-economic interest for local populations around the world and in Africa (Badjare *et al.*, 2018). As plantations are included in the definition of forests (FAO, 2002), many non-timber

forest products (NTFPs) come from both natural forests and plantations. These products can be harvested in the wild, produced in forest plantations or by trees outside the forest. These are products used as food or food additives (nuts, mushrooms, wild fruits, herbs, fibre, flowers etc). These resources enable people to meet their basic needs, but they are also the basis for biodiversity conservation (N'Guessan *et al.*, 2020).

Forest ecosystems are extremely rich in plant and animal species, some of which are little known or poorly understood. However, the increasing rate of deforestation, especially in the tropics, is likely to lead to the erosion of some previously unknown forest species (FAO, 2001).

The annual deforestation rate of the Sudanian zone of Chad is 2.5%/ha/year (SIDRAT, 2013). Spontaneous plant resources ensure food and health security for rural populations; this exploitation is carried out with remarkable intuitive and/or empirical wisdom, without adequate techniques to guarantee species sustainability and conservation. Some non-cultivated species enjoy no protection whatsoever, especially when found outside protected areas (Nguinambaye *et al.*, 2015). However, the economic stagnation and poverty experienced in the Sudanian zone, as in Chad, have led to ever-increasing pressure on these forest resources. For the Province of Logone Oriental, the exploitation of oil in the environment of the savannah region has many consequences, such as the rural exodus in search of work, the expropriation of arable land for the infrastructures required for this exploitation and the management of the spin-offs of this project at regional level. (Madjigoto *et al.*, 2007).

Nowadays, agroforestry is seen as a land-use option that can resolve certain threats to the environment, particularly in tropical countries where forest destruction is a major issue (Torquebiau, 2002). *Anacardium occidentale* L. can be found in very harsh climatic conditions, hence its introduction into Africa for reforestation (Kantousan, 2019). Cashew have become a speculative activity in most sub-Saharan

African countries (Djaha *et al.*, 2012). Its cultivation and exploitation contribute to the socio-economic development of several countries around the world (Bezerra *et al.*, 2007). In Chad, the lack of sufficient scientific knowledge about *Anacardium occidentale*, particularly its regeneration, ecology and harvesting methods, is in fact a constraint to the development of appropriate management strategies. Given this lack, it is now important to determine its potential, as well as its ecosystem values, in order to contribute to sustainable resource management strategies.

The aim of the present work is to contribute to valorization of the cashew tree with a view to its sustainable exploitation in the departments of Pendé and Nya. More specifically, the aim is to assess the ecosystem services provided by western *Anacardium occidentale* plantations and to determine their exploitation characteristics by producers.

#### **Study Sites**

The present study was carried out in the extreme south of Chad, in the Logone Oriental Province, whose capital is Doba, an oil-producing area, more precisely in the departments of Pendé (8° 51' 0" N and 16° 49' 0" E) and Nya (8° 34' 0" N and 16° 33' 0" E), in the Logone Oriental Province. (Fig.1.). Doba covers an area of 130,000km<sup>2</sup>, with a population density of 33 inhabitants/km<sup>2</sup> (RGPH, 2009). The climate of Eastern Logone is tropical sub-humid, located in the Sudanian zone, with 800 to 1,200mm of rainfall per year (Sama, 2003). These conditions make the Eastern Logone a favourable zone for agro-pastoral activities, with an average temperature of 28.9°C. Depending on climatic and edaphic conditions, three types of vegetation can be distinguished in

the Eastern Logone: dense wooded forest savannah, grassy savannah, wooded savannah and gallery forest (Madjigoto, 2007). The main economic activities are based on agriculture. These include

traditional food crops and cash crops. Pastoral activities are dominated by the breeding of small ruminants (sheep, goats, pigs).

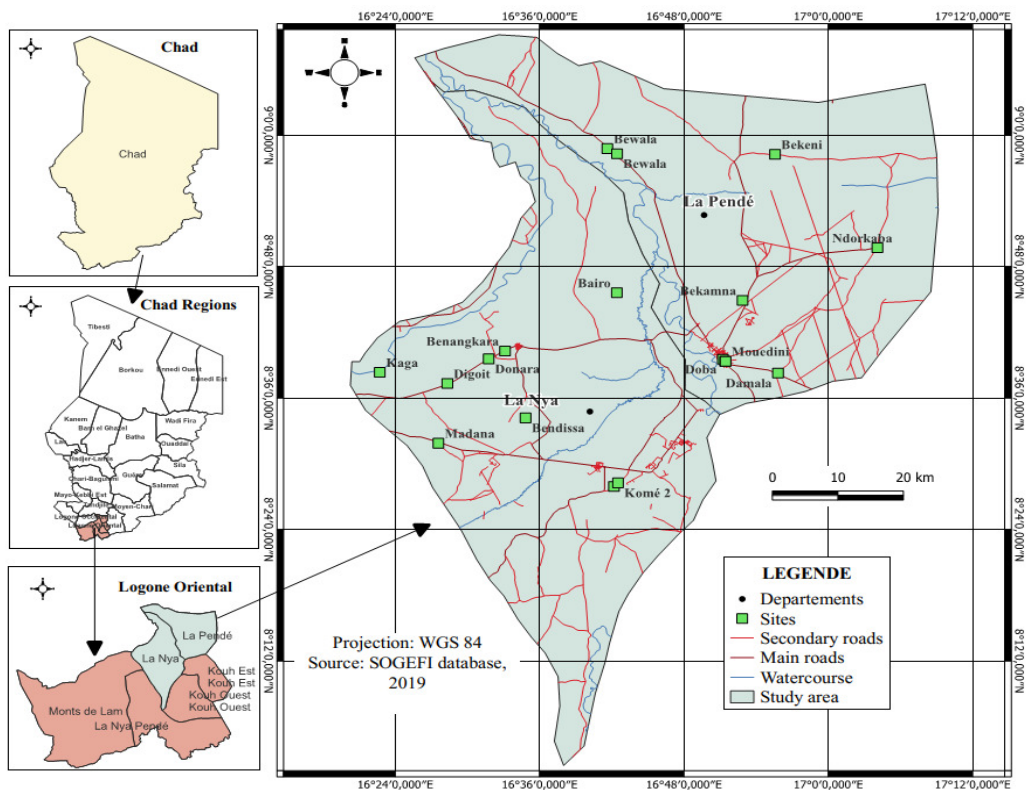


Fig. 1: Location map

## Methodology

### *Ethnobotanical Survey*

Using a structured and semi-structured questionnaire to gather quantitative and qualitative information, 18 plantation owners or managers were surveyed, and observations recorded on specially designed survey sheets. The aim was to obtain information on the plantations' socio-economic and operating characteristics. Observations were made on the various plots, which enabled us to assess plantation management and record the various traces of anthropization. The

questions concerned the socio-demographic characteristics of the respondents, the economic importance of cashew trees in the area and the revenues recorded over the last three years (2019, 2020, 2021), as well as the planters' cultivation practices in terms of plantation management.

### *Data Analysis*

Field data were recorded on Microsoft office Excel, then statistically analyzed and processed using SPSS Statistics 22 and XLSTAT. QGIS 3.22.3-1 software was used to design the location map of the

study area. Principal component analysis (PCA) and analysis of variance (ANOVA) were used. Mean values were then compared with each other using Duncan's test, and the smallest significant difference at the 5% threshold (probability level) was used to study the spatial variation of plant species identified during the study.

**Results and Discussion**  
**Socio-demographic Characteristics of Cashew Growers**

In terms of age, the study shows that the average age of growers is 48. This average masks disparities between growers, with a minimum age of under 23 and a maximum age of over 64. The analysis of variances shows a significant

overall difference between the different age groups of growers ( $P = 0.045 < 0.05$ ), but not between departments ( $P = 0.99 > 0.05$ ). The distribution of growers in the study area (Fig.2a) also shows that cashew cultivation is widespread among all age groups, with a predominance of people aged between 40 and 60 (61%), followed by the 20 to 40 age group (28%). Producers aged over 60 are in the minority (16%). In the two departments (Fig.2b), most producers are aged between 40 and 60 (Nya: 67% and Pendé: 56%), producers aged between 20 and 40 represent a small proportion (Pendé: 33% and Nya: 22%) and those aged over 60 are represented in a very small proportion (Nya: 11% and Pendé: 11%).

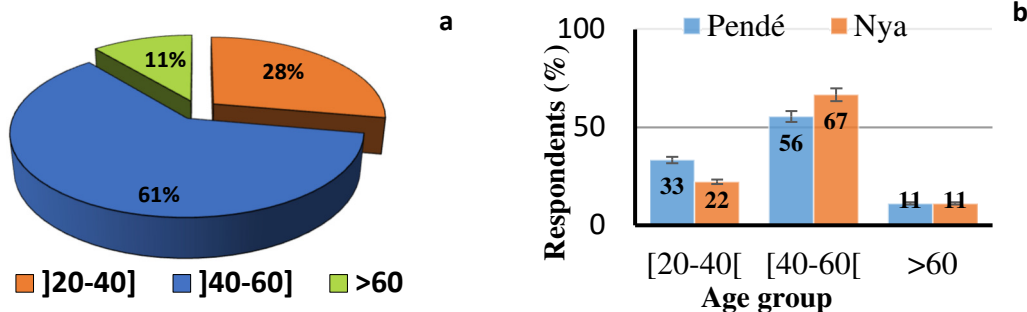


Fig. 2: Distribution of cashew growers by age (a: study area, b: departments)

Although the oldest producers are in the minority, the results show that young people are not very involved in the cashew nut sector, and that cashew cultivation is a matter for relatively old people. This could be explained by the way land is acquired, which is by inheritance, where land management is carried out by the head of the concession or by the eldest, but also by the lack of financial and material means among most young people. These results are similar to those of Dieng *et al.* (2019) in the major cashew-growing

regions of Senegal. The average age observed is close to that recorded by Mole (2000) in Mozambique and Balogoun *et al.* (2014) in Benin, who found 48, 51 and 49 years respectively, and similar to the age observed by Topper and Kasuga (2003) in Tanzania. Our results differ slightly from those of Lawal *et al.* (2010) in Nigeria, whose average age is 56. These results confirm the fact that cashew planting is an activity for relatively old farmers anxious to secure a source of

income for their periods of inactivity (retirement of civil servants).

**Socio-economic Characteristics of Cashew Plantations**  
**Nut Prices**

Table 1 shows the average price per kg of nuts over the last 3 years (2019, 2020, 2021) in the two departments. Over the last three years, these average prices conceal disparities, as the minimum prices

in Pendé and Nya are respectively 100 FCFA and 150 FCFA (2019); 150 FCFA and 225 FCFA (2020), 250 FCFA and 275 FCFA (2021). The maxima in Pendé and Nya are respectively 250 FCFA and 250 FCFA (2019); 350 FCFA and 325 (2020); 400 FCFA and 500 FCFA (2021). Analysis of variances shows that there is no significant difference in prices in the two departments ( $P = 0.68 > 0.05$ ).

Table 1 Average price per Kg of nuts over the last 3 years

Years	Average price of 1kg (FCFA)	
	Pende	Nya
2019	186±44.11	186±34.57
2020	253±38.33	269±38.27
2021	314±38.89	386±75.93

Based on the average nut prices for the three years, we can see that the price evolves positively each year in the two study sites (Fig.3). In Pendé, price growth is slightly higher than in Nya;

nevertheless, the cashew industry is developing in the study area. Interviews with producers revealed that the number of producers has increased in recent years, thanks to the yield and price of nuts.

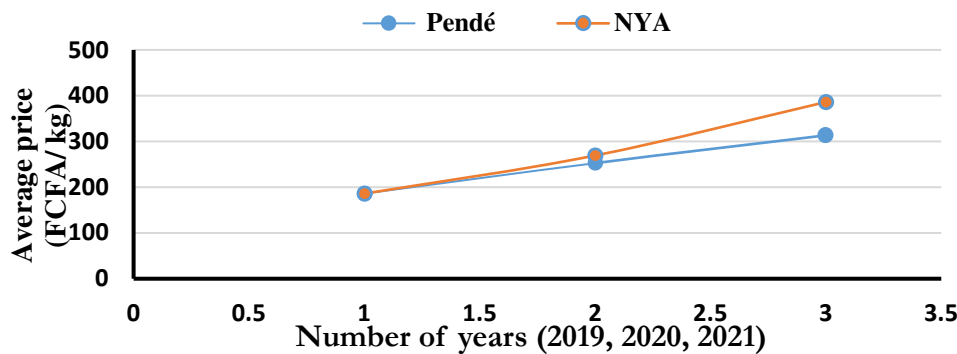


Fig. 3: Trends in nut prices by department (FCFA /kg)

These results are in line with those of Kantousan (2019), who showed that positive changes in orchards are accompanied by changes in cashew nut prices. According to Balogoun *et al.* (2014) in Benin, the area planted, the nut yield and the selling price of a kg of nuts are the most decisive factors in improving producers' incomes. Unlike in other

countries, the price of cashew nuts in the study area is very low. Indeed, Ndiaye (2020) has shown that the average price per kg of the nut around the years 2010, 2013, 2014, 2015 and 2017 in the commune of Diossong in Senegal increased on the market until reaching 1500, even 2000 FCFA.

**Annual Production by Plantation Age**

Cashew orchard production by age was assessed in the study area using estimates of the quantity of nuts produced in the last three years (2019, 2020 and 2021) (Fig.4). Thus, plantations less than 10 years old show low production, respectively in Pendé and Nya, of 208kg/year and

288kg/year (2019), 258kg/year and 356kg/year (2020), 342kg/year and 428kg/year. Maximum production is recorded in plantations over 15 years old: 600kg/year and 617kg/year (2019), 700kg/year and 625kg/year (2020) and 550kg/year and 668kg/year (2021).

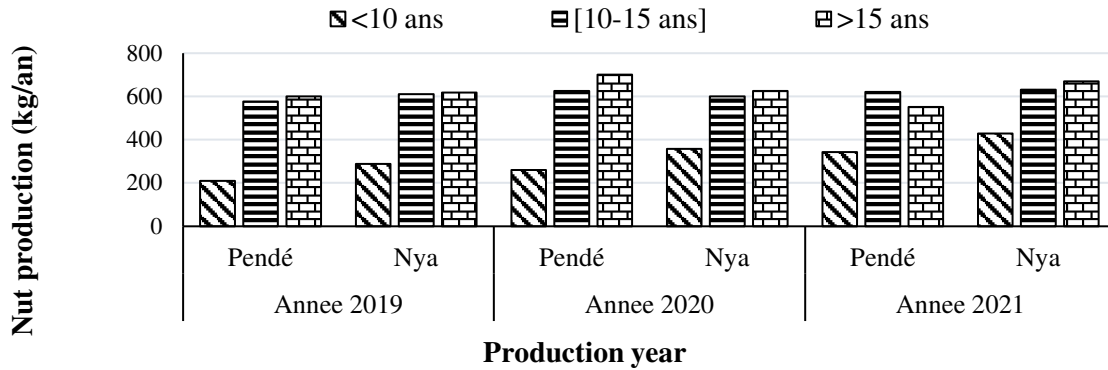


Fig. 4: Annual nut production by age group (2019, 2020, 2021)

These results show that production increases proportionally with orchard age. They confirm the work of Tandjiekpon (2005), who considers orchard age to be an influential factor in production. According to this author, the 10-20 year age class is considered to be the age of full production.

**Fruit Sales System (apple and nut)**

Cashew nuts from the study area are sold 44% in retail (calabashes), 39%

mixed (grouped and retail) and only 17% in grouped sales (several bags). Also, according to department, the most common types of sale are retail and mixed (Fig.5). Nuts are bought by traders who visit fields, farms and markets. It should also be noted that these traders export the nuts to neighbouring countries such as Nigeria. The cashew industry is marked by disorganization of the players and exploitation of producers by buyers.

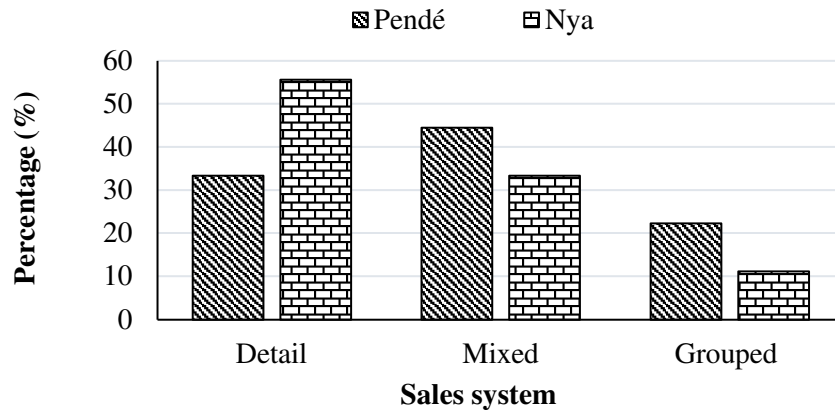


Fig. 5: Cashew fruit sales system (apple and nut)

These results show that the cashew nut sales circuit has not yet been mastered in the study area, with producers selling their products in retail outlets. This is not to their advantage, as prices fluctuate from time to time. These results are similar to those of Sali *et al.* (2020) in Cameroon. Market organization at producer level is very weak. This high level of retail sales is explained by growers' pressing need for money at harvest time and the degree of poverty in the region. Only a few growers prefer to wait for the right price before selling their grouped stocks of cashew nuts. This parameter indicates that there is

a need to train producers in group sales of their agricultural products.

**Different Types of Use**

The cashew tree can be exploited in a number of ways, depending on its various organs. Its wood is used to make objects, and its bark and leaves are said to have numerous medicinal properties. It also provides valuable food and industrial products. Figure 6 shows that commercial use predominates, with a proportion of 40% (Nya) and 43% (Pendé), followed by food use, which represents 40% (Nya) and 38% (Pendé). Medicinal and artisanal uses each account for 10% in both departments.

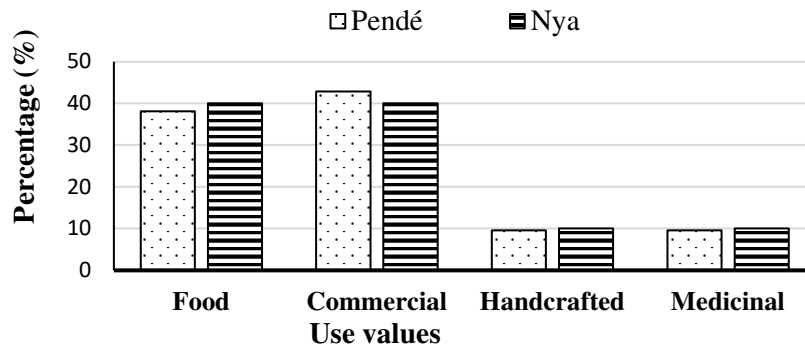


Fig. 6: Cashew tree use categories

These results show that cashew plantations make a major contribution to solving the food and economic problems of production. Similar results were obtained by Tebonou (2013) in Benin.

**Phytomedicine of *Anacardium occidentale***

In the study area, 100% of producers surveyed recognized at least one therapeutic virtue in the various cashew organs. All parts of the species are used. The bark and root are the parts most widely used for disease treatment (Table

2). The most frequently cited illnesses are: dental neuralgia (16.67%), dysenteric diarrhea (13.64%), malaria (12.12%), diabetes (9.09%), ringworm (9.09%), tooth decay (9.09%) and hypertension (6.06%). The proportions were slightly higher in Pendé than in Nya, with a highly significant difference ( $P = 0.0035 < 0.05$ ). Despite these results, respondents emphasized that the majority of the population is still unaware of cashew's many therapeutic virtues.

Table 2 Proportion of diseases cited by respondents

Use values	Pende (%)	Nya (%)	Study area (%)
Dysentery	17.24	10.81	13.64
Malaria	13.79	10.81	12.12
Diabete	10.34	8.11	9.09
Ulcer	6.90	2.70	4.55
Dental neuralgia	17.24	16.22	16.67
Stomach aches	6.90	2.70	4.55
Dental caries	6.90	10.81	9.09
Ringworm	6.90	10.81	9.09
Hypertension	3.45	8.11	6.06
Cough	3.45	8.11	6.06
Teething pains	3.45	5.41	4.55
Scorpion sting	0.00	5.41	3.03
Jaundice	3.45	0.00	1.52

These results show that the use of cashew products in the folk pharmacopoeia is another aspect of the plant's socio-economic importance in the lives of farming communities.

**Cashew Wood Harvesting**

The exploitation of cashew wood in the study area is categorized into fuelwood

(household energy), construction wood (enclosure, shed...), handicraft products (pestle, hoe, axe...) and charcoal production (Table 3). Firewood represents the highest proportion (46%), followed by timber (33%). Charcoal is poorly represented (13%), as are handicraft products.

Table 3 Proportion of cashew timber used

Use of wood	Pende (%)	Nya (%)	Study area (%)
Firewood	45	47	46
Construction	30	37	33
Handicraft products	10	5	8
charcoal	15	11	13

These results differ from those of Biao *et al.* (2012) in Benin. Cashew wood is also used as a source of energy (firewood), but the author explains that it burns very quickly and inefficiently, so people prefer to use other species that are more energetic and economical.

**Household Income from Plantations**

The cashew tree is a source of income for producers in the Pendé and Nya departments. This income contributes to

the family's food intake, health (hospital costs), rent, children's schooling and contingencies. Table 4 shows the proportions of household income. The highest proportion is food (28.13%), followed by health (23.44%) and schooling (21.88%). Contingencies (17.19%) and rent (9.38%) account for the lowest proportion of household income. According to surveys carried out among



growers, 100% confirm the usefulness of orchards in providing for their families.

Table 4 Proportions of household income participation

Types of needs	Pende (%)	Nya (%)	Study area (%)
Ration	30.00	26.47	28.13
Healthcare	23.33	23.53	23.44
Rent	10.00	8.82	9.38
Education	20.00	23.53	21.88
Unforeseen	16.67	17.65	17.19

**Cashew Plantation Management  
Structural Characteristics of Plantations**

Table 5 shows three structural characteristics of cashew plantations and their different significance levels. Thus, 44% of plantations in the study area are between 8 and 12 ha in size. The 0 to 8 ha range represents 39%, and only 17% of plantations are between 12 and 20 ha in size. In Pendé department, the average size of cashew plantations is 8.87±4.05 ha,

with a minimum size of 2 ha and a maximum size of 13 ha. In the Nya department, the average area is slightly higher (9.94±4.13 ha), with a minimum area of 3.5 ha and a maximum of 18 ha. In Nya, growers have the largest areas under cashew cultivation. The proportions are 44% (Pendé) and 33% (Nya) for areas of 0 to 8 ha; 33% (Pendé) and 56% (Nya) for areas of 8 to 12 ha; and 22% (Pendé) and 11% (Nya) for areas of 12 to 20 ha.

Table 5 Structural characteristics of cashew plantations.

Departments	Average age of orchards (year)	Average area (ha)	Average density (number of trees/ ha)
Pendé	13 ± 5.17 <sup>a</sup>	8.87 ± 4.05 <sup>a</sup>	99 ± 7.87 <sup>a</sup>
Nya	10 ± 5.98 <sup>b</sup>	9.94 ± 4.13 <sup>a</sup>	77 ± 14 <sup>b</sup>

Probability: P = 0,025, P = 0,38, P = 0,018

Plantation age and density showed significant differences between departments (P < 0.05), with the exception of area (P > 0.05). The average age of plantations in both departments is 11 years ±4.54, with a maximum age of 18 years and a minimum age of 3 years. The oldest plantations are found in Pendé (13 ± 5.17 years), with a maximum age of 18 years and a minimum age of 4 years. However, Nya records the youngest plantations (10 ± 5.98 years). Analysis of variance reveals a significant difference in density between

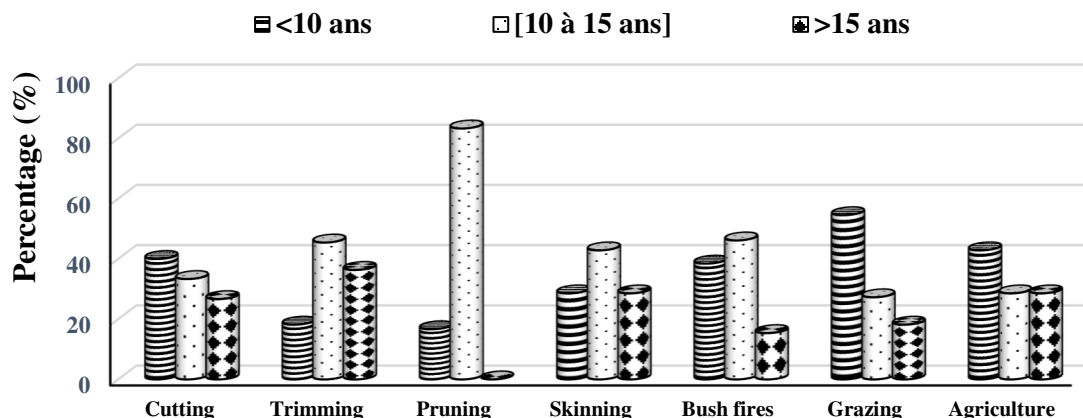
the two departments. Cashew plantations in Pendé are characterized by a higher density (99 ± 7.87 trees/ha) than those in Nya (77 ± 14 trees/ha).

**Indices of Anthropization**

The information gathered from growers, combined with observations made in the field, enabled us to record seven traces of anthropization in the various cashew plantations. Figure 7 shows the different traces encountered according to the age of the plantations. The intensity of the traces decreases with

the age of the cashew plantations. Trimming (45%), pruning (83%), skinning (43%) and bush fires (46%) are predominantly present in plantations in the 10-15 year age bracket; cutting (40%), grazing (55%) and agriculture (43%) are

frequent in plantations less than 10 years old. The analysis of variance shows that there is no significant difference between the different plantation age groups ( $P = 0,04 < 0,05$ ).



### Indices of anthropization

Fig. 7: Distribution of anthropization indices by age group

These results show that young plantations (less than 10 years old and 10 to 15 years old) experience more anthropization than old plantations. This may be due to the growth and production phase of young plantations, which are more exploited and treated by growers than old plantations.

Correspondence analysis including anthropization indices is illustrated in

Figure 8. Along the symmetrical axis, there is a positive correlation between the seven (7) traces of anthropization in the study area. The correlation between grazing and bushfire is very strong according to component 2. There is also a strong correlation between agriculture and pruning as a function of component 1. A high level of agricultural practice leads to a high level of pruning.

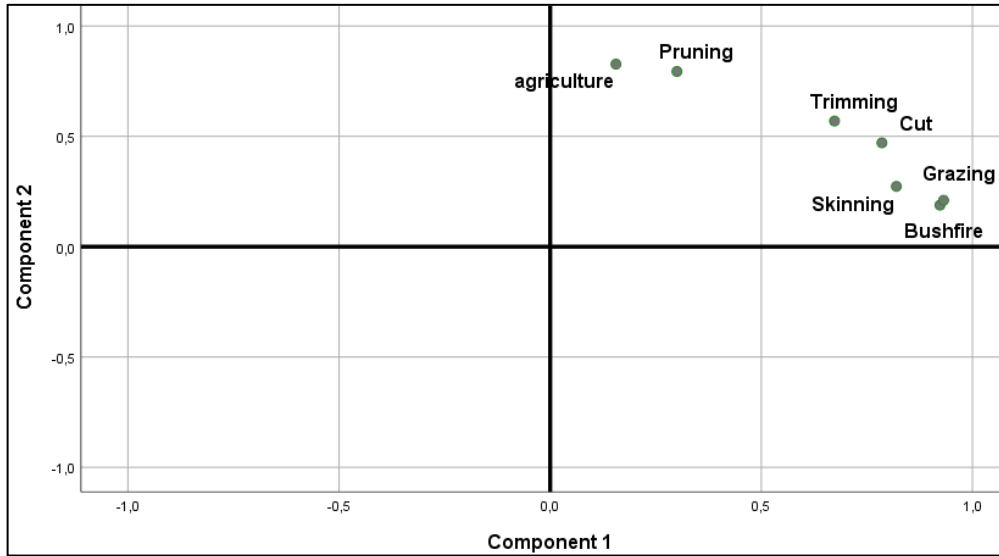


Fig. 8: Correlation between traces of anthropization

Figure 9 shows the species subjected to the various traces of anthropization. The distribution of these individuals has been established according to the correlation

between the traces of anthropization. Thus, *Anacardium occidentale* is very heavily anthropized, with 27% of the total rate of anthropization.

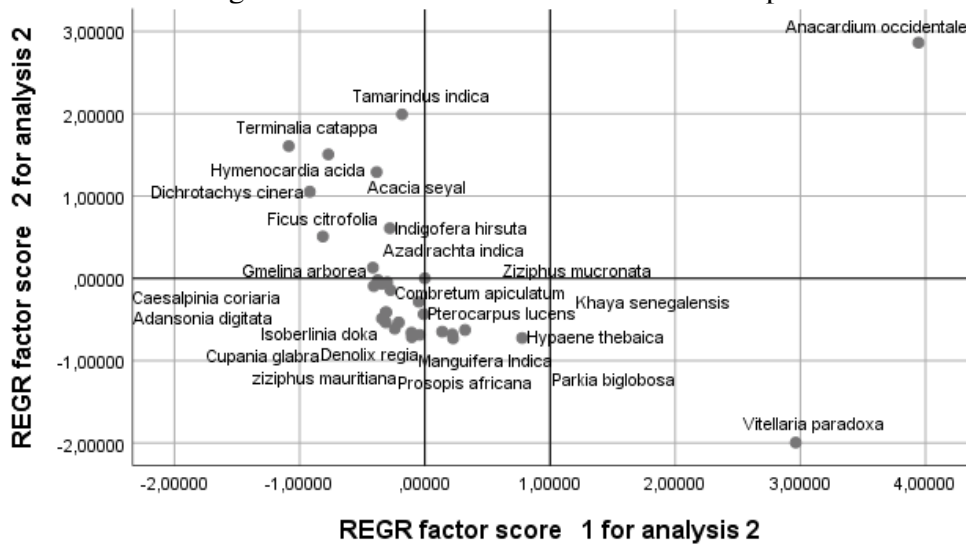


Fig. 9: Cloud of species subject to traces of anthropization

Traces of anthropization on this species are higher than on the other species, and are strongly represented by cutting, trimming and skinning. Six species are

moderately anthropized and 24 are only slightly or very slightly anthropized.

**Conclusion**

This study has shown that cashew tree products can be put to a wide variety of

uses, since most of the tree can be exploited for wood, fruit (apples and nuts), almonds and roots. There are many uses, depending on the part of the tree used. On the other hand, the cashew industry is still in its infancy in this region. The region has a favourable environment for cashew tree cultivation, and cashew fruit production is a genuine means of combating poverty, but the local populations do not have enough land for this crop. The services in charge of rural development need to sensitize the population to the emergence and better management of cashew plantations, in order to help reduce the socio-economic and environmental problems of this province and beyond.

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