

# Socio-Economic Importance of Certain Development Indicators Linked to Farmers in Cocoa-Based Agroforestry Systems in the Central Region of Cameroon

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**How to cite this paper:** Nadege, M.T., Marlène, N.T., Clotèxe, T.V. and Carole, T.M. (2025) Socio-Economic Importance of Certain Development Indicators Linked to Farmers in Cocoa-Based Agroforestry Systems in the Central Region of Cameroon. *Open Journal of Ecology*, 15, 865-882. <https://doi.org/10.4236/oje.2025.1512048>

**Received:** October 10, 2025

**Accepted:** December 1, 2025

**Published:** December 4, 2025

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## Abstract

Agroforestry Systems (AFS) in Cameroon have considerable socio-economic potential and their composition is essentially determined by the type of producers and their strategies. This study was conducted in the cocoa AFS of the localities of Yambassa and Talba in the Central Region of Cameroon. The characterization and socio-economic development indicators related to farmers were done using semi-structured survey forms sent to producers. Sampling was done in the 25 m × 25 m (625 m<sup>2</sup>) quadrats of the cocoa AFS to determine their floristic composition and in addition to cocoa trees, all trees with a diameter at breast height (dbh) ≥ 5 cm were inventoried. A total of 180 cocoa farmers were surveyed and 122 quadrats were carried out in the study area. For producers of Traditional, SODECAO and Innovative cocoa AFS, the money from cocoa sales contributes a priori to nutrition at 47%, 32% and 32% respectively. A total of 8734 individuals belonging to 44 species and 24 families were collected in the cocoa AFS of the study area. No significant difference was found (ANOVA, p = 0.053) between the number of cocoa trees per hectare by type of cocoa AFS. The density of woody plants/ha is higher in Traditional and SODECAO AFS (respectively 84 ± 51.8 and 77 ± 36.0 individuals/ha) than in Innovative AFS (21 ± 20.8 individuals/ha). The species present in cocoa plantations produce goods and services to producers and the environment such as traditional medicine (*Voacanga africana*, *Anthocleista schweinfurthii*), timber and crafts (*Podocarpus milanjianus*, *Milicia excelsa*, *Triplochytton scleroxylon*, *Ceiba pentandra* *Terminalia superba*) and fruit trees such as *Persea*

*americana*, *Citrus* sp. and Non-Timber Forest Products (NTFPs) such as *Cola accuminata*. For sustainable agroforestry systems, it would be essential to combine agroecological performance and sustainability of cocoa AFS.

## Keywords

AFS Cocoa, Farmers, Floristic Composition, Socioeconomic, Structure

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## 1. Introduction

The cacao trees were introduced in Africa during the 19th century in response to a growing demand for cocoa [1]. Present in West and Central Africa for over a century, cacao cultivation now occupies significant areas of forest land [2]. In the main producing countries of West and Central Africa, the area under cocoa cultivation increased from approximately 3 to 5 million hectares between 1961 and 2000 [3]. After the Second World War, the agricultural challenge was to feed the world (mass production), which was achieved through the mechanization of agriculture, but at the expense of the environment [4]. Today, global agricultural production must therefore face new challenges: on one hand, achieving sustained production targets to meet the needs of a constantly growing population. On the other hand, reducing negative environmental impacts so as not to compromise resource availability for future generations: “sustainable agriculture”. To this end, Cameroon has been undertaking agro-system models for some years now in order to find the one that can maximize profitability and ensure the protection of the environment [5]. Agroforestry represents agricultural practices defined as the development of the soil with a simultaneous or sequential association of trees and crops or animals, in order to obtain products and services useful to man [6] [7]. Agroforestry systems consist of optimizing positive interactions in order to obtain, from available resources and under existing ecological, technological and socio-economic conditions, a higher, more diversified and more sustained total production [8] [9]. This involves the management of cocoa plantations in association with other species capable of providing goods and services to cocoa trees and producers [10] [11]. Given that agroforestry has a positive effect on improving crop yields [12], it would be credible to say that agroforestry improves the socio-economic life of farmers. This improvement would be valid, among other things, through the stabilization of farms, the settlement of farmers and the establishment of perennial crops. In Africa, more than 70% of the population lives in rural areas [13] and practice of agriculture as a source of food and income generation.

In Cameroon, cocoa farming is the main source of income for more than 40,000 families living in rural and urban areas of the country [14] [15]. Moreover, it contributes to more than 2% for the national gross domestic product (GDP) and 6% to the primary sector of GDP [16] [17]. Compared to systems with a complex structure (strong shade and multi-layered structures), cocoa plantations in Cam-

eroon are most often made up of several components (food crops, fruit plants and woody plants) [18]. Cultivated plants mainly in the forest area of the country (South-Central Cameroon), there is a varied range of cocoa-based agroforests where floristic composition and structure vary from one ecological zone to another [18] [19]. Following the interest shown by the population in this crop, the expansion of cocoa cultivation leads to the improvement of the plant material used, which is increasingly advanced and adapted to ecosystems other than the forest ecosystem [20] [21]. We therefore distinguish between the Traditional systems which are the oldest and where the cocoa trees grow under the cover of forest species. The semi-improved systems or SODECAO were implemented by the Cocoa Development Company in Cameroon (SODECAO). These systems represent methods of managing cocoa plantations in association with other woody species under managed forest. The development of research in the field of cocoa cultivation has involved a so-called “Innovative” system, in full sun, in the form of an agroforest, where the cocoa trees are associated at their young age with either fruit species, or the oil palm, or the coconut trees. The objective of these technological advances is to raise the level of production of areas already developed in order to increase the goods and services provided by cocoa cultivation. However, the rural agricultural environment of developing countries still has a connotation of a disadvantaged environment. Therefore, actions, including the introduction of new farm management technologies, are primarily aimed at improving the standard of living of farmers. The impact assessment of these actions cannot be limited to the sole assessment of technical benefits such as improved crop yields [22]. It also addresses the socio-economic aspects that are the expression of the improved well-being of these farmers [23]. A socio-economic assessment in rural areas therefore requires taking into account the pillars of rural life in general, with adaptations to the realities of the environment concerned. It therefore calls for consideration of development indicators (ethnic groups, level of education, cocoa varieties, producers’ adaptation mode, etc.) that link a producer to a type of cocoa AFS. Therefore, this study aims to assess the socioeconomic importance and the development of indicators linked to farmers facing the resilience of cocoa cultivation and the floristic composition of three cocoa AFS in the Central Region of Cameroon.

## 2. Materials and Methods

### 2.1. Study Site

This study took place in the Central Region of Cameroon, especially in the localities of Talba and Yambassa. Talba village, which is approximately at 120 km from the city of Yaoundé, is located in the Mbangassina subdivision, Mbam-et-Kim Division [20]. The village of Yambassa or Boyambassa is located at 112 km in the northern periphery of the capital Yaoundé in the Bokito District of the Mbam-et-Inoubou Division. It is located between the village of Balamba and the town of Ombessa, precisely on National Road N° 4 (Yaoundé-Obala-Bafoussam). Talba

belongs to the forest agro-ecological zone with a bimodal rainfall regime. The climate there is of the Guinean equatorial type, characterized by four seasons of unequal distribution. Annual average temperatures range between 22°C and 32°C, with a thermal amplitude varying between 8°C and 13°C, rainfall is between 1300 and 1500 mm of water per year [24]. Yambassa has a subequatorial climate of the Guinean type with 4 seasons including 2 dry seasons and 2 rainy seasons. The annual average rainfall is between 1000 mm and 1500 mm, the climate is of interest to the farmer because it allows to have a good knowledge of the crops production due to the climatic conditions and soil productivity. The equatorial climate has a rather favourable impact on agricultural activity because it allows two crop cycles per year [16]. The village of Talba is located in the southern Cameroonian plateau, its landscape is a morphological unit surrounded by a succession of hills whose altitude varies between 670 and 882 m. Yambassa is located in a plain whose altitude varies between 200 and 500 m. The topography is relatively flat, interrupted by very gentle slopes which generally end in marshy lowlands [17]. The soils of Talba are mostly ferralitic, acidic, clayed, red, black, yellow and sometimes sandy in colour; the soils of this locality are fertile and suitable for cocoa cultivation and diversified agriculture [16].

The soil types found in Yambassa are essentially lateritic and ferralitic. With a particular plant cover, the village of Yambassa and Talba are located in the vast peri-forest savannah zone with Sterculiaceae and Ulmaceae. This is in fact the transitional zone between the dense semi-deciduous forest and the shrub and tree savannahs of the Adamawa plateau. The Ossananga ethnic group, also called Sanaga, is the one native of Mbangassina municipality, while in the village of Talba, we found all three tribes (Tsinga, Bonjo, Kombé) originating from this municipality, four other tribes of this same ethnic group have dispersed into neighbouring municipalities, which are Ngorro, Baveuk, Mvellé and Batsenga [23] [24]. Cocoa farming is the most widely practiced activity in Talba and Yambassa, and therefore occupies very large areas.

## 2.2. Sampling

### 2.2.1. Data Collection Relating to the Typology of Agricultural Operators

This study was conducted in the cocoa AFS of the localities of Yambassa and Talba in the Central Region of Cameroon. The major cocoa production areas in Cameroon are the Central and Southern Regions of the country. The choice of these localities is explained by the fact that they essentially have similar ecological and geographical characteristics (located in the forest-savannah transition zone) and the choice of the study area was also due to the presence of different Agroforestry System types present in the study site. In addition, Traditional cocoa AFS are well practiced in Yambassa, unlike in Talba where SODECAO and Innovative cocoa AFS are found.

The characterization of cocoa AFS was done by means of semi-structured interviews addressed to producers through a survey questionnaire including socio-economic development indicators related to farmers (ethnic groups, mode of ac-

quisition of AFS, destination of incomes, plant material used, etc.). To ensure that the farmers met in the districts of Mbangassina and Bokito were in a position to provide relevant answers to the questionnaires administered to them, the non-random sampling method [25] [26] was applied, and the selection criteria for cocoa farmers were based on agronomic criteria (cocoa variety, cultivation practices, mode of acquisition of AFS, associated species, etc.) and socioeconomic criteria (level of education, income, relationships between cocoa farmers, mode of adaptation of cocoa farmers, etc.). This method was used to identify them, to obtain information on the cultivation operations carried out in their plots and for each type of cocoa AFS. Also, socio-economic information from the different cocoa farmers was collected. Individual interviews and focus groups (discussion groups composed of 20 - 30 people) were thus conducted in both sites of the study area. An in-depth survey of cocoa plantations was also carried out in the plantations to better identify the variables to be taken into account. These variables help to differentiate different cocoa AFS and also to discuss with producers about the management of their plantations, their structure and composition. For this, a plot survey framework was associated with socio-economic surveys to carry out visits to the cocoa AFS and to obtain information on the implementing strategies of cocoa AFS. A total of 180 cocoa farmers were surveyed in the study area, *i.e.* 60 cocoa farmers with Traditional type AFS, 60 cocoa farmers with Innovative type AFS and 60 cocoa farmers with SODECAO type AFS.

### 2.2.2. Characterization and Floristic Inventory in Cocoa Agroforestry Systems

Sampling was done in quadrats of 25 m × 25 m (625 m<sup>2</sup>), the inventory of woody plants consisted of walking along the quadrats counting and measuring the circumference of all associated woody plants (≥5 cm) at 1.30 m from the ground and 30 cm above the buttresses for trees that had them as recommended by [4]. The plant species were identified by assigning scientific, local and sometimes commercial names. The correspondence between local, commercial and scientific names was established using botanical lexicons. All species samples identified or not in the field were collected, pressed and later confirmed to the National Herbarium of Cameroon. The nomenclature follows that of Angiosperm Polygenetic Group (APG IV).

### 2.2.3. Data Analysis

#### 1) Analysis of socio-economic data

For each important indicator (Ethnic groups, Level of education of producers, mode of acquisition by type of cocoa AFS, contribution of cocoa to the income of populations, etc.), the number of people and the frequency of citations were determined in order to show the different actors encountered and the place of cocoa cultivation in the farm incomes. The frequency is given by the following formula:

$$F = (n/N) \times 100$$

With  $n$ : the number of citations and  $N$  the total number of citations.

## 2) Analysis of characterization data of cocoa agroforestry systems

Data processing and analysis were carried out by type of cocoa AFS. Analysis of variance (ANOVA) was applied to the different densities obtained and comparisons of means between the different cocoa AFS in the study area were carried out by the Tukey HSD test with a 5% confidence interval using R 3.1.3 software.

### Density of associated trees and cocoa trees

The number of associated trees and cocoa trees was inventoried at the scale of the sampling quadrat, considering all individuals with a diameter greater than or equal to 5 cm. The densities obtained were extrapolated to the hectare for all sampled plots. The density of the sampling unit is given by the following formula:

$$Di = \frac{Di}{N}$$

With  $Di$ : density of a plot;  $N$ : number of plots.

The density values obtained in each 625 m<sup>2</sup> were extrapolated to the hectare using an expansion factor (EF)

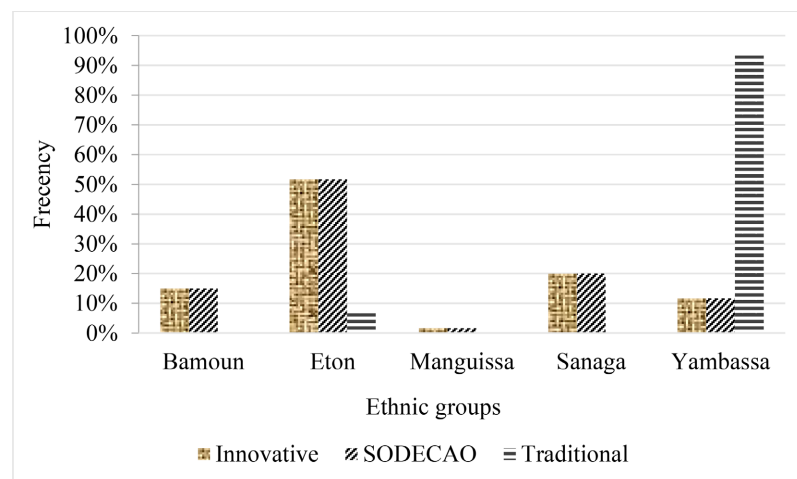
$$EF = 10,000 \text{ m}^2/\text{Plot area (m}^2\text{)} [27].$$

## 3. Results

### 3.1. Socio-Economic Profiles of Farmers

#### 3.1.1. Ethnic Groups and Types of Cocoa Agroforestry Systems Practiced

The grouping of producers made it possible to identify, according to the type of cocoa AFS, the ethnic diversity of the population present in the study area. Also, it appears from the households interviewed in the Yambassa village that Traditional cocoa AFS are practiced by 93% of the population of the “Yambassa” ethnic groups and 7% of the population of the “Eton” ethnic groups. Interviews conducted with households in the Talba village showed that SODECAO and Innovative cocoa AFS are practiced respectively by 52% of “Eton”, 20% of “Sanaga”, 15% of “Bamoun”, 12% of “Yambassa” and 2% of “Manguissa” (Figure 1).



**Figure 1.** Distribution of producers according to their ethnic groups and by type of system practiced.

### 3.1.2. Level of Education of Producers

The results obtained show that Traditional cocoa AFS are practiced by 85% of producers with primary education level, 15% with secondary education level. SODECAO-type cocoa AFS are respectively practiced by 80% of producers with secondary education level, 12% with higher education level and 8% with primary education level. Similarly, it is noted that Innovative cocoa AFS are practiced by 87% of producers with secondary education level and 13% with a higher education level (Figure 2).

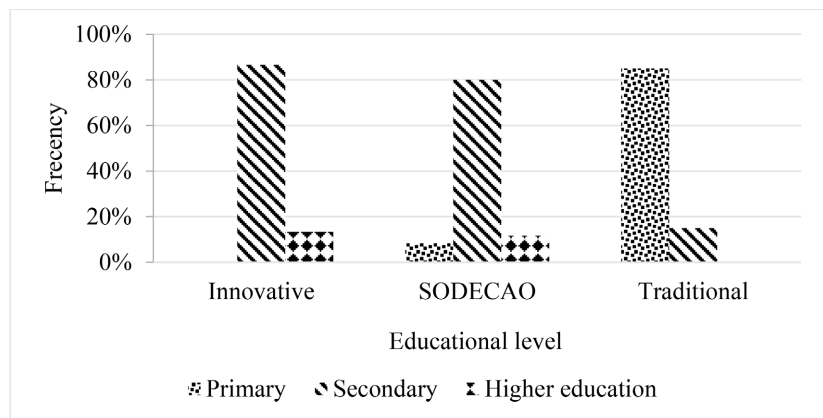


Figure 2. Education level of producers.

### 3.1.3. Acquisition Method by Type of Cocoa Agroforestry Systems

The method of acquisition of cocoa AFS is an indicator that helps to show the choice of the illustrative variable of the typology of producers. Figure 3 presents 3 methods of acquisition of cocoa AFS (creation, inheritance, and purchase). For Innovative cocoa AFS and SODECAO type, the most dominant method of acquisition is creation (63%) followed by inheritance (20%) and purchase (17%) while for Traditional cocoa AFS, the most dominant method of acquisition is inheritance (50%), followed respectively by creation (33%) and purchase (17%).

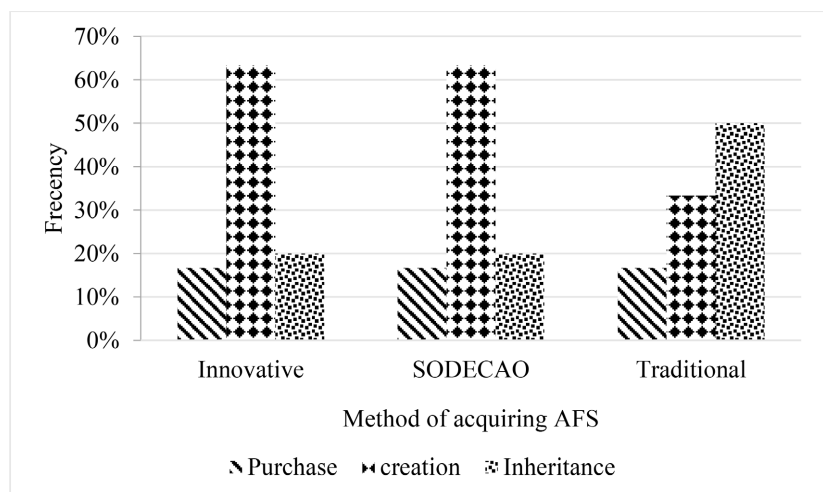


Figure 3. Acquisition methods of cocoa agroforestry systems.

### 3.1.4. Contribution of Cocoa to the Population Incomes in the Study Area

The distribution of cocoa income according to the importance, necessity, and priority of family financial concerns is shown below (Figure 4). It shows that for producers of the Traditional, SODECAO, and Innovative cocoa AFS, the cocoa incomes contribute to the nutrition of 47%, 32%, and 32% respectively, to improve and expand the activity (cocoa farming) in the village with 12%, 23%, and 23%, respectively. This money also contributes to children's schooling (20%, 13%, and 13% for each of these systems), health (13% each), and savings or investments in other activities (8% each) of the families concerned.

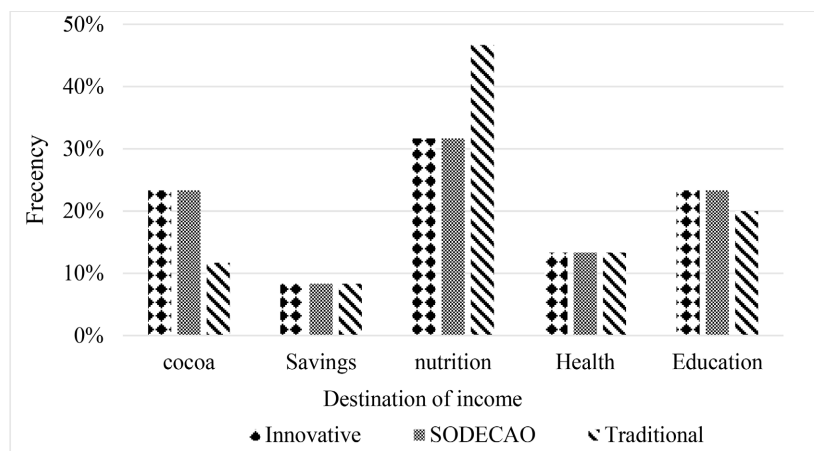


Figure 4. Contribution of cocoa income to other population activities.

### 3.1.5. Cocoa Varieties by Type of Cocoa Agroforestry Systems

The results in Table 1 show the average percentage of the different types of varieties used in the study area for each type of cocoa AFS. It appears that the Innovative cocoa AFS were planted with 100% hybrid planting material (improved variety). On the other hand, those established in the Traditional and SODECAO AFS were planted with 10% and 62% hybrid planting material respectively, with 90% and 38% of the variety mixture respectively.

Table 1. Cocoa varieties by type of cocoa agroforestry systems.

Seed type	system type		
	Innovative	SODECAO	Traditional
Hybrid	100%	62%	10%
Mix of variety	0%	38%	90%

### 3.1.6. Adaptation Methods of Producers According to the Types of Cocoa Agroforestry Systems

Different adaptation methods were mentioned by producers to cope with fluctuations in cocoa prices and production instability (Table 2). It appears that producers opted for an expansion of cocoa areas whether for Innovative, SODECAO or Traditional cocoa AFS at 100%, 67% and 55% respectively. On the other hand,

only producers of Traditional and SODECAO AFS also opted for diversification in the agricultural sector with 35% and 20% respectively and then for improvement with 10% and 13%.

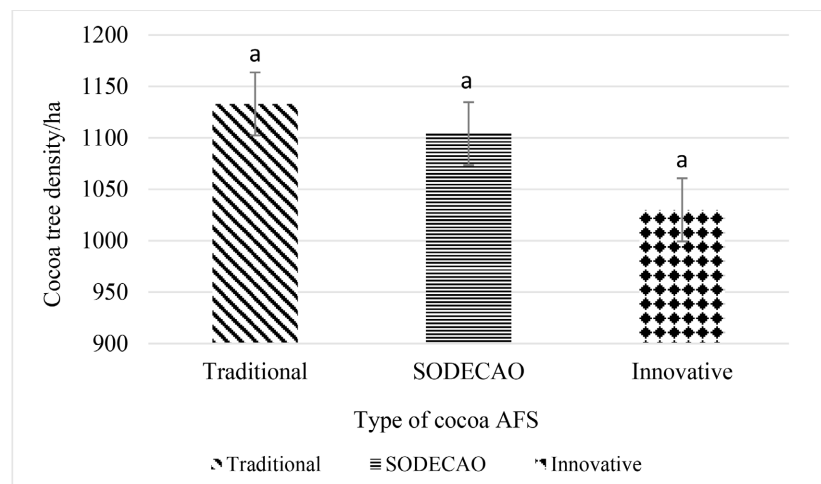
**Table 2.** Adaptation methods of producers in the study area.

Type of adaptation	Type of cocoa AFS			
	Innovative	SODECAO	Traditional	Grant total
Improvement	0%	13%	10%	8%
Diversification	0%	20%	18%	18%
Expansion of areas	100%	67%	74%	74%

### 3.2. Structure and Composition of Cocoa Agroforestry Systems in the Study Area

#### 3.2.1. Density of Cocoa Trees by Type of Cocoa Agroforestry Systems

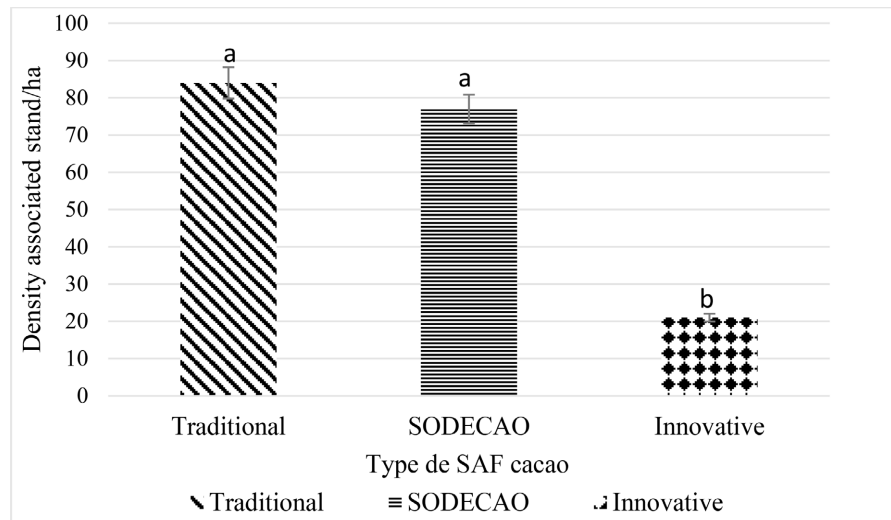
The density of cocoa trees per hectare by type of cocoa AFS is presented in **Figure 5**. No significant difference was found (ANOVA,  $p = 0.053$ ) between the number of cocoa trees per hectare by type of cocoa AFS. The density of cocoa trees/ha is on average  $1133 \pm 322$  trees/ha in Traditional cocoa AFS,  $1030 \pm 309$  trees/ha in Innovative AFS and  $1104 \pm 220$  trees/ha in SODECAO AFS.



**Figure 5.** Density of cocoa trees by type of cocoa agroforestry systems.

#### 3.2.2. Density of Associated Species by Type of Cocoa Agroforestry Systems

The results of the density of associated individuals show that there is a significant difference (ANOVA,  $p = 0.002$ ) between the number of individuals associated with the hectare in the Traditional AFS ( $84 \pm 51.8$  individuals/ha) and that of the Innovative AFS ( $21 \pm 20.8$  individuals/ha). On the other hand, this difference is not observed between the Traditional AFS and the SODECAO AFS ( $77 \pm 36.0$  individuals/ha) (**Figure 6**).



**Figure 6.** Density of associated stand by type of cocoa agroforestry systems.

### 3.2.3. Importance of the Associated Population in Cocoa Agroforestry Systems

The floristic inventory carried out in the Traditional, SODECAO and Innovative cocoa AFS of the Central Region of Cameroon made it possible to identify 49 species, 44 of which were identified, divided into 24 families (**Table 3**). The species present in cocoa plantations produce goods and services to producers and the environment such as traditional medicine (*Voacanga africana*, *Anthocleista schweinfurthii*), timber and crafts (*Podocarpus milanjianus*, *Milicia excelsa*, *Triplochytton scleroxylon*, *Ceiba pentandra*, *Terminalia superba*). In the species associated with the cocoa tree, we also find fruit trees such as *Persea americana*, *Citrus* sp. and Non-Timber Forest Products (NTFPs) such as *Cola acuminata*, *Ricinodendron heudelotii* and many others as listed in **Table 3**.

**Table 3.** Species associated with cocoa trees and their uses. The local names are Eton (1) and Yambassa (2).

Families	Scientific names	Local names	Local use
Anacardiaceae	<i>Mangifera indica</i>	Boulondo	sc, sa
	<i>Spondias cytherea</i>	Atanga (Ewondo)	sc, sa
Apocynaceae	<i>Alstonia bonei</i>	Akouk (1)	me, bw, sh
	<i>Voacanga africana</i>	Boukougni (2)	Me
Bombacaceae	<i>Bombax buonopozense</i>	Essodoum (1) Guélégoum (2)	ti, bw, sh
	<i>Ceiba pentandra</i>	Douma (1) Bougoumé (2)	ti, bw, sh, sf
Burseraceae	<i>Canarium schweinfurthii</i>	Boumpet (2)	bw, sc, sa, me
	<i>Dacryodes edulis</i>	Assa (1) Bouboua (2)	sc, sa, me
Caricaceae	<i>Carica papaya</i>	Boupôpô (2)	sc, sa
Cecropiaceae	<i>Musanga cecropiodes</i>	Esseng (1) Guésingua (2)	bw, sh

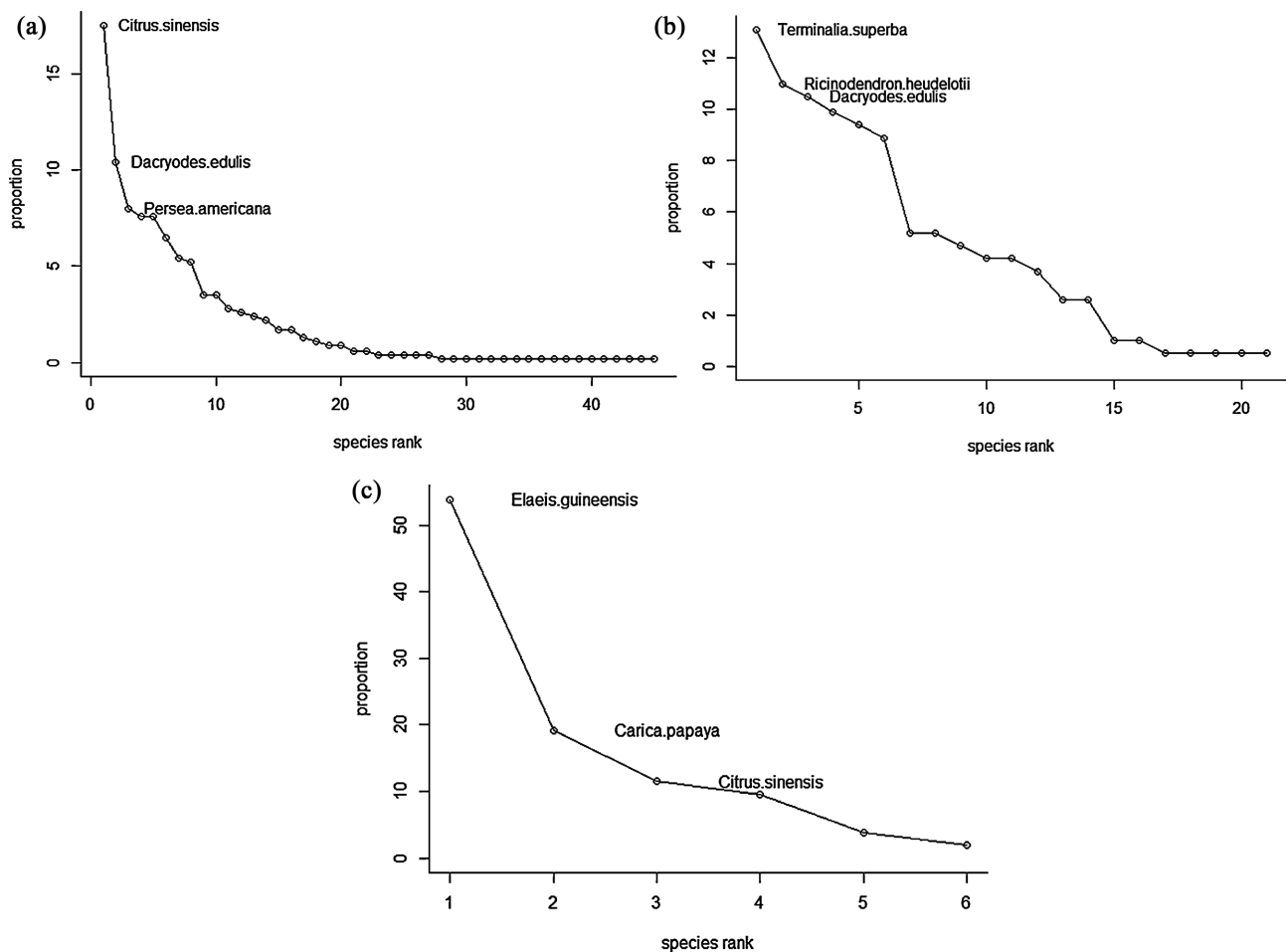
**Continued**

Cesalpiniaceae	<i>Azelia africana</i>	Handlebar (2)	ti, bw, sh
Combretaceae	<i>Terminalia superba</i>	Akom (1) Nounko (2)	ti, bw, sh, sf, me
Connaraceae	<i>Cnestis grisea</i>		me, so
Euphorbiaceae	<i>Hevea brasiliensis</i>	Ndanda ebouma (1) Keume (2)	sa, sh
	<i>Macaranga cordifolia</i>	Alambiaga (2)	Sh
	<i>Phyllanthus discoideus</i>	Ebebeng (1)	bw, me
	<i>Ricinodendron heudelotii</i>	Essessang (1) Guéyiéna (2)	sc, sa, me
	<i>Uapaca vanhouttei</i>		Ti
Clusiaceae	<i>Garcinia kola</i>		sc, sa
	<i>Mammea africana</i>	Abotzok (1)	ti, sa, me, sc
	<i>Harungana madagascariensis</i>		ti, me, sf, so
Irvingiaceae	<i>Irvingia gabonensis</i>	Adogntangani (1) Do'oh (2)	sc, sa, sh
Lauraceae	<i>Persea americana</i>	Pia (1) Boufia (2)	sc, sa, me
Loganiaceae	<i>Anthocleista schweinfurthii</i>		Me
Mimosaceae	<i>Acacia</i> sp.		bw, ti
	<i>Albizia zygia</i>		me, sf
Moraceae	<i>Ficus exasperata</i>	Guisacsac (2)	ti, bw, me
	<i>Ficus mucoso</i>	Toll (1) Guébotso (2)	ti, bw, me, sf
	<i>Milicia excelsa</i>	Abang (1) Tchônou (2)	ti, bw, sf, me
	<i>Myrianthus arboreus</i>	Engokom (1)	Me
Myrtaceae	<i>Psidium guajava</i>		sc, sa
Arecaceae	<i>Elaeis guineensis</i>	Ibile (2)	sc, sa
Podocarpaceae	<i>Podocarpus melanjianus</i>		bw, ti, me
Rutaceae	<i>Citrus reticulata</i>	Mandalia'a (2)	sc, sa, me
	<i>Citrus sinensis</i>	Boukomgou (2)	sc, sa, me
Sapindaceae	<i>Allophylus cobbe</i>		sc, sa, me
Malvaceae	<i>Cola acuminata</i>	Buhen (2)	sc, sa, me
	<i>Cola pachycarpa</i>		sc, sa, me
	<i>Cola</i> sp.		sc, sa
	<i>Unknown 1</i>		sf, sa
	<i>Mansonia altissima</i>	Nkoul (1)	ti, bw
	<i>Triplochyton scleroxylon</i>	Oukolo (2)	ti, bw, sh, sf
Verbenaceae	<i>Tectona grandis</i>	Guilôbio (2)	ti
Viloiaceae	<i>Rinorea paviflora</i>		ti
Undetermined 1	Undetermined 1		bw
Undetermined 2	Undetermined 2		bw, me

Notes: sc = self-consumption; ti = timber; me = medicinal; sh = shade; bw = burn-wood; sa = sale; so = social; sf = soil fertility.

### 3.2.4. Rank Proportion Curve (%) of Different Cocoa Agroforestry Systems in the Study Site

The Rank proportion (%) curve is obtained from the abundance of species of each type of cocoa AFS. It appears that the flora of Traditional cocoa AFS (A) is respectively represented by *Citrus sinensis* (30.1%), *Dacryodes edulis* (12.8%), *Persea americana* (8%) and *Azelia bipidensis* (5.3%). That of SODECAO cocoa AFS (B) is dominated respectively by *Terminalia superba* (13.1%), *Ricinodendron heudelotii* (11%) and *Dacryodes edulis* (10.5%). The flora of Innovative cocoa AFS (C) is however dominated by *Elaeis guineensis* (53.8%), *Carica papaya* (19.2%) and *Citrus sinensis* (11.5%) (Figure 7).



**Figure 7.** Rank proportion curve (%) of Traditional (a), SODECAO (b) and Innovative (c) cocoa agroforestry systems in the study area.

## 4. Discussion

### 4.1. Socio-Economic Profile of Farmers

The analysis of data on ethnic groups and types of cocoa agroforestry systems practiced shows that in the Yambassa village, Traditional AFS is most practiced by the Yambassa tribe, which predominates over the other tribes. The Talba village, on the other hand, presents a mix ethnic group, but much more dominated

by the Eton, who are in fact non-natives of this village, practicing mostly SODECAO and Innovative AFS. These results corroborate with those of [28] and those of [29], who worked on lands in the Central Region of Cameroon and confirmed that the large farmers in the locality of Talba are mainly non-natives belonging to the Eton and Manguissa ethnic groups, who have ancient genealogical links with the Sanaga ethnic group, who are the natives of the locality of Talba.

Farmers in SODECAO and Innovative AFS are more receptive to innovations than those in Traditional AFS. This shows that the educational level of farmers is a central element for understanding the methods integrated into new cocoa farming practices and technical itineraries. This education allows producers to better develop strategies for diversifying plantations and improving their life standard [30].

In the Innovative AFS and the SODECAO type, the most dominant acquisition method is creation with 63% each, followed by 20% of inherited cocoa AFS and 17% of purchase of cocoa AFS each, which underlines the pioneering front side of the Talba locality. While for Traditional cocoa AFS, the most dominant mode of acquisition is inheritance with 50%, followed respectively by 33% of AFS creation and 17% of cocoa AFS purchase. This shows the unavailability of spaces to be exploited for the establishment of new cocoa AFS in the Yambassa village and moreover, most of the available cocoa AFS belong to heads of families. These results are contrary to the results found by [31] who worked on the management and conservation of forest resources in South Cameroon showed that more than 70% of cocoa plantations are acquired by inheritance against 30% which were created by the producers.

The main activity in the study area is cocoa farming [32] [33]. For producers of SODECAO and Innovative AFS, the money from cocoa sales contributes to the nutrition (32% each) and to improving and expanding the activity (cocoa farming) respectively 32% each, while for Traditional AFS, this money is much more intended for nutrition (47%). Money from each of these three systems also contributes to children's schooling, health and savings or investments in other family activities. This shows that, the cocoa incomes are therefore intended to solve the long- and short-term problems of producers.

The Innovative cocoa AFS were planted with 100% hybrid variety (improved variety). On the other hand, those of the Traditional and SODECAO AFS were planted respectively with 10% and 62% hybrid variety and the remainder corresponding to the all-comer plant material (mainly from traditional plots) with respectively 90% and 38%. This can be explained by the fact that the plant material used can be decisive in the choice of the structure of the AFS set up by the different cocoa producers. These results corroborate with those of [14] and [30] who showed that the simplification of AFS is consistent with the diffusion of new cocoa plant material. However, [30] specifies that when cocoa cultivation is carried out in full sun, the decline in yield is progressive, because the plant weakens quickly, thus causing a drop in the production rate and the shortening of its life cycle.

Faced with fluctuations in cocoa prices and unstable production, producers in the study area have adopted several adaptative methods such as expanding cocoa areas, improving existing areas and diversifying into other crops. It is noted that producers in Innovative, SODECAO and Traditional AFS opted much more for expansion at 100%, 67% and 55% respectively. Moreover, only producers in Traditional and SODECAO AFS have also opted for diversification in the agricultural sector with 35% and 20% respectively; then for improvement with 10% and 13%. This mode of adaptation practiced mainly by producers in Innovative cocoa AFS jeopardizes the conservation of natural resources and the sustainability of existing systems. They also corroborate with those of [31] who state that following a drop in production due to the cocoa AFS age and the high costs of rehabilitation products, producers most often opted for extensions or new creations to benefit from the humus inputs from new forest clearings.

#### **4.2. Structure and Composition of the Cocoa Trees and Associated Stand in the Study Area**

The density of cocoa trees, 1133 plants per hectare, 1104 plants per hectare and 1030 plants per hectare respectively recorded in the Traditional, SODECAO and Innovative AFS are similar to the 1111 cocoa stems/ha which is higher than the agronomic standard [20]. These values are lower than the 2400 stems/ha obtained by [31] in the cocoa AFS exposed to the sun in Ivory Coast. These results also show that during establishment, it is profitable for producers to plant at high density to avoid possible replacements in the cocoa AFS, so the more mature a plantation is, the more the producer has had time to regulate a certain number of aspects in his plantation, namely the cocoa density and the associated population.

The average density of associated trees in Traditional AFS (84 individuals/ha) and SODECAO (77 individuals/ha) are higher than those in Innovative AFS (21 individuals/ha). Indeed, Traditional AFS and SODECAO are similar in terms of density of associated species, but this density remains higher in Traditional AFS. In Innovative or open-air AFS, the intensification of cocoa cultivation is one of the major concerns for farmers who aim to increase their yields of commercial cocoa. These results confirm the work of [33] who showed that Traditional or complex AFS are in Africa the best examples of permanent agriculture that preserves the forest environment and its biodiversity.

##### **Importance of associated population in cocoa AFS**

The floristic inventory carried out in the Traditional, SODECAO and Innovative cocoa AFS of the Central Region of Cameroon revealed that these cocoa AFS have a diversified plant potential with a specific richness of 49 species, 44 of which were identified, divided into 24 families. This shows that the cocoa AFS in the study area is diversified and therefore more stable. These results confirm those of [34] who showed that the most diversified ecosystem is the most stable. These different species identified in the different cocoa AFS of the study area show the

willingness of the farmer to introduce fruit trees for the most part when setting up his cocoa plantation for nutritional (*Dacryodes edulis*, *Persea americana*, *Mangifera indica*, *Citrus* sp.), medicinal (*Alstonia boonei*, *Cola acuminata*, etc.) and microclimatic virtues because they provide a sufficient quantity of shade to the cocoa trees [34]. The marketing of products from these trees would allow producers to better maintain their plantations [1]. Thus, according to the farmers, the fruit species as they are found there, isolate the cocoa trees from infection with the swollen shoot virus [34]. However, these changes bring fruit tree species back to the same stratum as cocoa, raising fears that competition between species will increase rather than decrease [4]. The Rank proportion (%) curve obtained from the abundance of species in each type of cocoa AFS confirms the willingness of farmers to introduce species according to their objectives.

Similarly, these producers, faced with the vagaries of production and the selling prices of cocoa, which are often very unstable, make various choices to adapt to them. Similarly, the alternative to better overcome these vagaries would be to support a selective introduction of high-value trees such as *Dacryodes edulis*, *Ricinodendron heudelotii*, *Persea americana*, *Citrus* sp. in the cocoa AFS which are not harmful to the cocoa trees. The decrease in the associated population observed in the Innovative AFS can also be explained by the new varieties which are adapted to savannah ecosystems which remains a strategy to increase cocoa production [4] [5].

## 5. Conclusion

Determination of socioeconomic indices related to farmers and the floristic composition of cocoa agroforestry systems which was carried out thanks to socio-economic surveys made it possible to identify the three types of cocoa AFS (Traditional, SODECAO or semi-improved and Innovative) practiced in the Central Region of Cameroon and to determine the contribution of cocoa to producers' income. Ethnic groups, the level of education of producers, the methods of acquiring cocoa AFS, cocoa varieties by type of cocoa AFS, the adaptation mode of producers and the enthusiasm for making a profit are the socioeconomic indicators that link a producer to a type of AFS. The fact that a producer has some of these characteristics and not others would lead him towards one type of AFS rather than another. The structure of AFS can vary from one locality to another depending on the techniques and cultural practices applied there. Given the importance of these cocoa AFS in the daily lives of the populations of the Central region of Cameroon, it is imperative to ensure the sustainability of these production systems through the quality of seeds and new cultural methods and techniques.

## Acknowledgements

We thank the farmers of the Central Region of Cameroon and the Botanic, Systematics and Climate Change laboratories of the University of Yaoundé I respectively for their availability and for the data analysis.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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