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Exploring Barriers to Agroforestry Adoption by Cocoa Farmers in South-Western Côte d'Ivoire

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Abstract: Agroforestry is part of the package of good agricultural practices (GAPs) referred to as a reference to basic environmental and operational conditions necessary for the safe, healthy, and sustainable production of cocoa. Furthermore, cocoa agroforestry is one of the most effective nature-based solutions to address global change including land degradation, nutrient depletion, climate change, biodiversity loss, food and nutrition insecurity, and rural poverty and current cocoa supply chain issues. This study was carried out in South-Western Côte d'Ivoire through a household survey to assess the willingness of cocoa farmers to adopt cocoa agroforestry, a key step towards achieving sustainability in the cocoa supply chain markedly threatened by all types of biophysical and socio-economic challenges. In total, 910 cocoa households were randomly selected and individually interviewed using a structured questionnaire. Findings revealed that from the overwhelming proportion of farmers practicing full-sun cocoa farming with little or no companion trees associated, 50.2 to 82.1% were willing to plant and to keep fewer than 20 trees per ha in their farms for more than 20 years after planting. The most preferred trees provide a range of ecosystem services, including timber and food production, as well as shade regulation. More than half of the interviewed households considered keeping in their trees in their plantations for more than 20 years subject to the existence of a formal contract to protect their rights and tree ownership. This opinion is significantly affected by age, gender, access to seedlings of companion trees and financial resources. A bold step forward towards transitioning to cocoa agroforestry and thereby agroecological intensification lies in (i) solving the issue of land tenure and tree ownership by raising awareness about the new forest code and, particularly, the understanding of cocoa agroforestry, (ii) highlighting the added value of trees in cocoa lands, and (iii) facilitating access to improved cocoa companion tree materials and incentives. Trends emerged from this six-year-old study about potential obstacles likely to impede the adoption of agroforestry by cocoa farmers meet the conclusions of several studies recently rolled out in the same region for a sustainable cocoa sector, thereby confirming that not only the relevance of this work but also its contribution to paving the way for the promotion of agroecological transition in cocoa farming.

Keywords: cocoa farming; farmer's preferences; rural livelihoods; agroecological intensification; tree-based solutions

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Citation: Kouassi, J.-L.; Kouassi, A.; Bene, Y.; Konan, D.; Tondoh, E.J.; Kouame, C. Exploring Barriers to Agroforestry Adoption by Cocoa Farmers in South-Western Côte d'Ivoire. *Sustainability* **2021**, *13*, 13075. https://doi.org/10.3390/su132313075

Academic Editor: Roberto Mancinelli

Received: 15 August 2021
Accepted: 5 October 2021
Published: 25 November 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

Cocoa (*Theobroma cacao* L.) is a major cash crop predominating land-use systems in forest landscapes of Côte d'Ivoire [1,2]. It occupies roughly 40% of the areas covered by export crops, provides about 40% of export income, and contributes to about 14% of the gross domestic product [3,4]. From a social viewpoint, the cocoa sector (i) employs two-thirds of the country's active population composed at least of 843,798 smallholders and (ii) supports directly or indirectly 6 million people [3–5]. These smallholder farmers are responsible for the production of 95% of cocoa from monoculture farms whose average size is mostly in the range from 2 to 5 hectares [6].

Over the past four decades, the dynamics in cocoa production and harvesting areas in the country is noteworthy [2,7]. Indeed, between 1990 and 2015, the total production more than doubled, from 0.807 to 1.796 million tonnes, while harvested areas expanded proportionally by 44%, with the current area estimated at 3.52 million hectares [7]. The upward trend of cocoa production has been driven by the intensification of cocoa plantations, including full sun growing and fertiliser application, and the expansion of new cocoa fronts into forested and protected areas. As a result, several cocoa-forest landscapes emerged in the last forest reserves of the country which transitioned into major cocoa-growing areas [8]. These major degradations have caused an unprecedented decline in forest cover [9–11].

Together with cocoa-led deforestation, forest encroachment is responsible for forest degradation and biodiversity loss [10–12], and soil quality degradation and nutrient depletion [13,14], all things likely to be amplified by climate change, which, in turn, will endanger land suitability for cocoa in the long run [15,16]. The short-term impact of these unsustainable farming practices has resulted in the emergence of degradation-prone areas most likely unsuitable for growing through replantation [17,18]. Moreover, the ageing of cocoa orchards coupled with low soil fertility and high pest and disease pressures have severely decreased cocoa yield, with an average between 400 and 631 kg ha^{-1} [19], thereby threatening the supply chain and the well-being of smallholder cocoa growers.

To limit the devastative foreseen impacts of such an unsustainable cocoa cropping practice, it is imperative to make a deep shift leading to the build-up of resilient socio-ecological, productive, and profitable cocoa landscapes well fitted to address current and future environmental challenges. As one of the most effective nature-based solutions to address global change issues, including climate change, biodiversity loss, food and nutrition insecurity, and rural poverty, cocoa agroforestry seems the best-fit cropping practice capable of addressing the multiple challenges the current cocoa supply chain is facing. Agroforestry is also part of the package of good agricultural practices (GAPs) referred to as a reference to basic environmental and operational conditions necessary for the safe, healthy, and sustainable production of cocoa [20]. As a result, it can be used as a proxy for sustainable cropping practices in the cocoa sector. Cocoa agroforestry has successfully been used to restore degraded cocoa landscapes and sustainably stabilise cocoa production in Cameroon [21–23] and Costa Rica [24,25] by (i) providing shade to young seedlings to improve their survival rates, and (ii) improving chemical and physical properties of soils, as well as enhancing biodiversity in soils. Past studies have shown that cocoa agroforestry can enhance the efficiency of cocoa farms through pests and diseases reduction [26,27], soil fertility improvement [28,29], and yield and profit increase [30,31]. Moreover, shaded cocoa plays an important role in promoting biodiversity conservation, landscape connectivity, and restoration of abandoned or degraded land [24,32].

In Côte d'Ivoire, although full-sun cocoa is the widespread cocoa farming practice as the degree of shade in cocoa stands ranges from 24.5 to 48.1% [1], some areas in the east and the west are becoming favourable to its adoption. Some farmers planned to bring more trees on their farms for the expected benefits of shade trees to cocoa yields, additional income and pest and disease pressure management [33,34]. Furthermore, several initiatives and projects, including payments for ecosystem services and certification schemes, have been promoted to manage cocoa under mild to heavy shade in the prospect to reverse deforestation and restore forest cover [35].

Despite the positive trend stressed earlier, it is crucial to find out ways to devise more effective outreaching approaches to expand the presence of trees in cocoa farms at a wider scale. For that to happen, several factors driving adoption should be pinpointed and considered in scaling-up strategies. This study sought to investigate the factors that limit the adoption of cocoa agroforestry in southwestern Côte d'Ivoire, a region badly hit by the degradation of cocoa landscapes. Indeed, this current top cocoa-growing area is characterised by a very low adoption of cocoa agroforestry despite its marked vulnerability to climate change, depletion in soil fertility, and high prevalence in Cocoa Swollen Shoot Virus Disease (CSSVD).

The underlying assumption tested in this work stipulates that more sensitisation about the environmental services of trees together with an enabling environment should ease the take-up of tree planting by cocoa growers.

2. Materials and Methods

2.1. Study Area

The study was conducted in the Nawa region located in southwestern Côte d'Ivoire, where more than a third of the national cocoa production is produced [36]. Administratively, the Nawa region is divided into four departments (Soubre, Buyo, Meagui, and Gueyo), which are subdivided into 11 subprefectures (Figure 1). Covering about 9643 km^2, this region is home to 1,053,084 people, comprising 41.6% of foreign migrants and about 85% of rural inhabitants [37]. This region has one of the highest population densities of the country mainly due to the expansion of cocoa farming, which has attracted both national and foreign migrants [38].

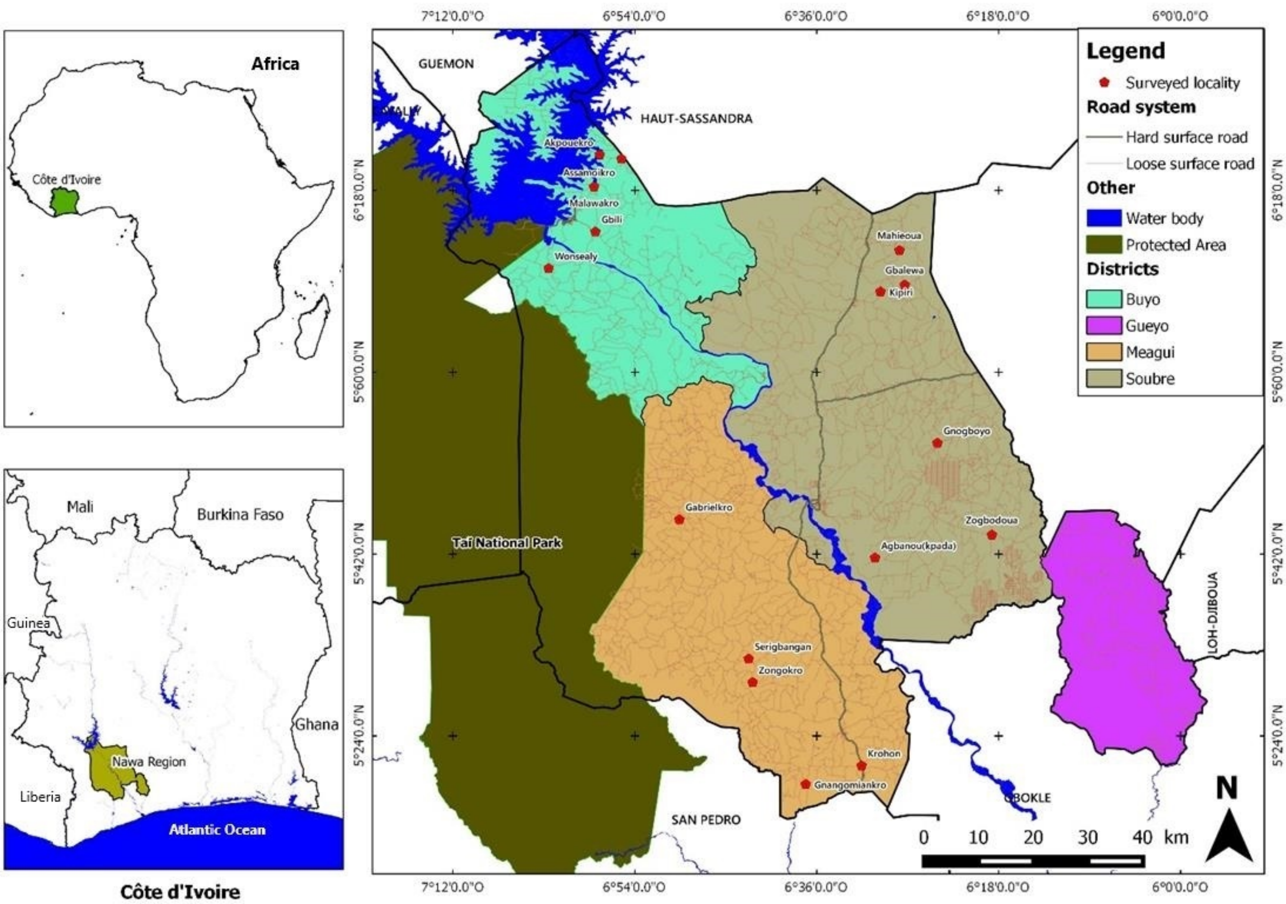

Figure 1. Location of the Nawa region and the surveyed localities.

The region is under a dominant subequatorial climate, with a bimodal regime, alternating between two rainy and two dry seasons. The annual rainfall varies between 1600 and 2000 mm and the average temperatures oscillate between 24 and 27 °C [39]. The relative humidity is permanently high throughout the year.

As an indicator of land use intensification, most of the vegetation of the region consists of manmade landscapes, including cocoa, coffee and rubber plantations and some fallow lands [40]. Farmers practicing extensive full-sun cocoa monocropping coupled with illegal logging are found to be the drivers of land degradation [41]. Presently, the Tai National Park, World Heritage Site and Biosphere Reserve remains the main natural and undisturbed forest in the area [42,43]. This protected area remains the main biodiversity hotspot of the region.

In general, soils of the region belong to the highly desaturated ferrallitic soils, which are generally fertile, suited to the cultivation of most tropical crops, e.g., cocoa, coffee, oil palm, rubber, banana, cassava and maize [44].

As the largest cocoa-producing area of Côte d'Ivoire, the region's economy is driven by cocoa, which employs 95% of agricultural households (about 72,051 households) and mainly contributes to households' source of income [3]. Agriculture and fishing are the main economic activities in the area.

2.2. Data Collection

The current study used a combination of interviews of local farmers and statistical analysis to gather local farmers' perceptions about introducing more tree species in their cocoa farms and to identify the conditions and determinants of this tree adoption as part of a future reforestation project. For this, 910 households (862 agroforestry and 48 non-agroforestry) were randomly selected using structured face-to-face interviews.

Between 53 and 61 households in 16 localities of the Nawa region, having more than 1200 inhabitants, were purposively selected, and surveyed (Figure 1). The sample size was calculated at the 95% confidence interval and a $\pm$3.23% level of precision.

Thirteen enumerators were hired and trained on survey instruments and ethical considerations to conduct the household interviews. Conducted in January 2015, the interviews lasted eight days and were held with household heads. These interviews were preceded by a pilot survey that enabled the identification and revision of unclear questions, thereby ensuring the suitability of the data collection tools and allowing enumerators to familiarise themselves with the data collection process and tools. The questionnaire was designed after a review of the literature about the farmers' perception of and determinants for agroforestry practices adoption and was made up of several semi-structured questions. Additional information included (i) household characteristics (age, nationality, ethnic group, level of education, income sources, etc.), (ii) agricultural practices (presence and type of spared trees in cocoa farms, etc.), and (iii) their needs and preferences (density and type of preferred tree species, duration of tree maintenance, type of contracts, etc.). The information was further gathered into the Open Data Kit (ODK) mobile data collection application, ready to be used.

2.3. Data Analysis

In this study, both descriptive statistics and regression analysis were used for data analysis. Basic descriptive statistics, such as mean, frequency and percentage, were used to provide insights into farmers' agricultural practices and intention to adopt agroforestry. The significance of differences between responses was assessed using the Kruskal–Wallis test for quantitative variables and Pearson's chi-squared test for qualitative variables at a 95% confidence interval.

The influence of collected variables on farmers' willingness to adopt cocoa agroforestry was tested by binomial logistic regression in the logit model. This approach consisted of finding variables (predictors) that could explain the opinion of surveyed farmers to adopt agroforestry. For this purpose, 15 independent variables such as the status of the respondent, gender, age, origin, household size, residence length, education, source of income, source of energy, access to market, land tenure status, cocoa farm and farmland size, presence of tree species on-farm and access to technical support were included in a stepwise regression. The best model was estimated on a backward elimination procedure based on minimising the Akaike Information Criterion (AIC). This binary logistic regression showed the probability of the effects of the independent variables on the dependent variables [45]:

$$logit(Y) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n \quad (1)$$

where:

i. Y is the dependent variable indicating the likelihood that $Y = 1$;
ii. α is the constant term (intercept);
iii. $\beta_1 \ldots \beta_n$ are the coefficients of associated independent variables;
iv. $X_1 \ldots X_n$ are the independent variables.

We thereafter computed the Average Marginal Effects (AME) [46], the pseudo R-squared value (Nagelkerke) and the Likelihood ratio test [45], in addition to model fit statistics. Only significant independent variables suggested having a substantial impact on farmers' intention to adopt agroforestry.

The overall analyses were carried out using the packages questionr [47], margins [46], and stats of R software [48].

3. Results

3.1. Sociodemographic Characteristics of Surveyed Households

Most respondents were men (91%) and had several children living in four-room mud housings (85.5%) with an almost equal distribution between agroforestry (AF) and non-agroforestry (NAF) farmers (Table 1). With an average age of 42.7 years, household heads were mostly migrants (80.1%) and settled in the region about 25 years ago. Up to 86.8% of respondents had a mobile phone with no signs of educational background (55.6%).

Table 1. Sociodemographic characteristics of surveyed households (n = 910).

Sociodemographic Attributes		NAF	AF	Nawa Region	χ^2 (*p*-Value)
Household	Proportion (%)	5.27	94.73	100.00	–
	Duration of residence (year)	22.96	24.87	24.78	0.915 (0.339)
	Men (no.)	3.54	4.15	4.12	4.001 (0.046)
	Women (no.)	3.67	3.94	3.93	1.019 (0.313)
	Size (no.)	6.98	7.98	7.92	3.672 (0.055)
	Living room (no.)	3.31	3.70	3.68	2.138 (0.144)
	Age of the head	41.77	42.79	42.73	0.319 (0.572)
Gender (%)	Female	8.33	9.05	9.01	2.5×10^{-30} (0.997)
	Male	91.67	90.95	90.99	
Age (%)	18–30 years old	16.67	19.49	19.34	0.270 (0.8738)
	30–60 years old	70.83	67.52	67.69	
	60–90 years old	12.50	12.99	12.97	
Migration status (%)	Non-native	27.08	42.69	41.87	8.003 (0.018)
	Native	33.33	18.33	19.12	
	Foreigner	39.58	38.98	39.01	
Marital status (%)	Single	8.33	5.80	5.93	1.083 (0.781)
	Married	87.50	90.26	90.11	
	Divorced	2.08	1.04	1.10	
	Widowed	2.08	2.90	2.86	
Education (%)	None	45.83	56.15	55.60	3.125 (0.537)
	Islamic school	6.25	5.45	5.49	
	Primary school	31.25	22.04	22.53	
	Secondary school	16.67	15.43	15.49	
	University	0.00	0.93	0.88	

AF: agroforestry farmers; NAF: non-agroforestry farmers.

3.2. Socioeconomic Characteristics of Surveyed Households

The studied households had agriculture (98.2%) as the main source of income and were engaged in growing several types of crops, including food crops and cash crops, as a diversification strategy to cope with uncertainties of the agricultural sector (Table 2). In addition, most of the respondents (86.9%) were the owner of their farmland covering, on average, 5 ha with a local agreement or contract (Table S3). They mostly used firewood (99%) as the principal source of energy for cooking (Table S2).

Table 2. Socioeconomic characteristics of surveyed cocoa households (*n* = 910).

Socioeconomic Attributes		NAF	AF	Nawa Region	χ^2 (*p*-Value)
Principal source of income (%)	Agriculture	97.92	98.26	98.24	4.992 (0.661)
	Trading	0.00	0.58	0.55	
	Breeding	0.00	0.35	0.33	
	Other	2.08	0.81	0.88	
Farm (%)	Cocoa	100.00	100.00	100.00	–
	Coffee	10.42	11.60	11.54	
	Rubber	31.25	22.62	23.08	
	Oil palm	2.08	4.64	4.51	
	Rice	0.00	0.23	0.22	
	Teak	0.00	0.35	0.33	
	Cola	0.00	0.12	0.11	
	Other	0.00	0.81	0.77	
Farm size (ha)	Cocoa	2.87	4.49	4.41	9.580 (0.002)
	Coffee	1.30	1.23	1.23	0.018 (0.894)
	Rubber	1.23	1.85	1.81	2.421 (0.120)
	Oil palm	2.00	2.33	2.32	0.017 (0.897)
	Other	–	1.50	1.50	–
	Total	3.423	5.18	5.08	6.131 (0.013)

AF: agroforestry farmers; NAF: non-agroforestry farmers.

3.3. Cocoa Agroforestry Practices

The findings of the study showed that 94.7% of the households grounded or retained trees on their cocoa farms as opposed to 5.3% who did not practise cocoa agroforestry. NAF farmers advanced space issues (45.8%), competition with cocoa trees (12.5%), tree felling during farm establishment, etc. as the main reasons why they did not plant or retain tree species in their farms (Figure 2).

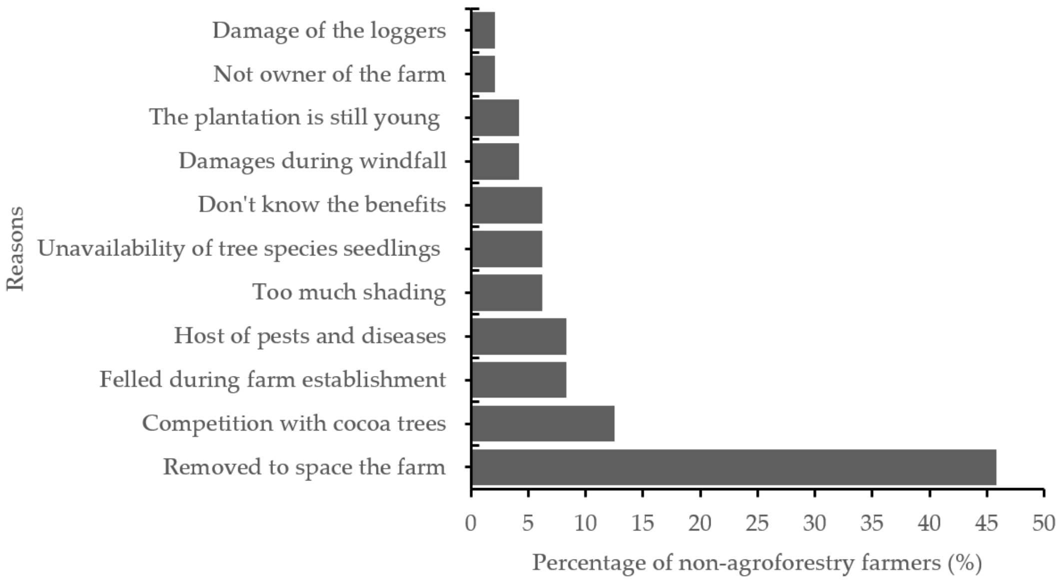

Figure 2. Reasons for not practising cocoa agroforestry in the region.

A significant proportion of the households (72.3%) expressed their willingness to plant more tree species on about 2.74 hectares of cocoa orchards, while 27.7% of respondents rejected tree planting in cocoa plantations (Table 3). Only 56.3% of NAF households accepted to adopt agroforestry practices in their cocoa farms. An overwhelming proportion of farmers (82.1%) committed to introduce fewer than 20 trees per hectare of their cocoa farms for various purposes, including food (42.1%), shade (40.4%), timber (38.9%) and medicinal (22.5%). However, farmers who were reluctant to adopt agroforestry (i) were motivated by the already sufficient density of tree species in their cocoa farms (53.6%), (ii) asserted the unavailability of space (26.2%), or (iii) did not give credit of the beneficial effect to the presence of trees in their farms.

On the other hand, significant associations were found between NAF and AF households' decision to adopt trees, the number of desired tree species to introduce and the size of farmland to manage under agroforestry.

Table 3. Tree species adoption and reasons for rejecting agroforestry practices.

Tree Species Adoption		NAF	AF	Nawa Region	χ^2 (*p*-Value)
Willingness to introduce tree species in cocoa farms	No	43.75	26.8	27.69	5.706 (0.017)
	Yes	56.25	73.2	72.31	
	Area (ha)	1.82	2.78	2.74	5.151 (0.023)
Desired type of tree species (%)	Food tree	31.25	42.69	42.09	–
	Shade tree	25.00	41.30	40.44	
	Medicinal tree	25.00	22.39	22.53	
	Fruit tree	10.42	21.58	20.99	
	Timber tree	33.33	39.21	38.90	
	Other	0.00	0.12	0.11	
Number of trees (%)	1–20 trees/ha	62.96	82.88	82.07	10.644 (0.014)
	21–40 trees/ha	33.33	13.15	13.98	
	41–80 trees/ha	0.00	2.69	2.58	
	More than 80 trees/ha	3.70	1.27	1.37	
Reasons for rejecting cocoa agroforestry practices (%)	Sufficient/excessive number of trees	28.57	55.84	53.57	-
	No space	14.29	27.27	26.19	
	Reduced cocoa production	19.05	7.36	8.33	
	Lack of knowledge about trees	0.00	6.06	5.56	
	Not beneficial	9.52	5.19	5.56	
	Damage of loggers	4.76	5.19	5.16	
	Not the owner of the farm	4.76	4.33	4.37	
	Stunting growth or death of crops	0.00	2.16	1.98	
	Pest shelters	4.76	1.30	1.59	
	Small size of the farm	4.76	0.43	0.79	
	Crop conversion	0.00	0.43	0.40	
	Source of black pod disease	0.00	0.43	0.40	
	Hard before getting benefits	0.00	0.43	0.40	
	Danger during tornado	4.76	0.00	0.40	
	Definitive leaving of the locality	4.76	0.00	0.40	

AF: agroforestry farmers; NAF: non-agroforestry farmers.

On average, 7.95 ± 6.56 trees per hectare were planted or retained in cocoa farms. These species were composed of exotic fruit tree, endogenous nut, and timber tree species, namely *Persea americana*, *Mangifera indica*, *Citrus sinensis*, *Citrus reticulata*, *Psidium guajava*, *Cola nitida*, *Ricinodendron heudelotii*, *Irvingia gabonensis*, *Ceiba pentandra*, *Milicia excelsa*, *Terminalia superba*, *Terminalia ivorensis*, *Pycnanthus angolense*, *Antiaris africana* and *Entandrophragma utile* (Figure 3).

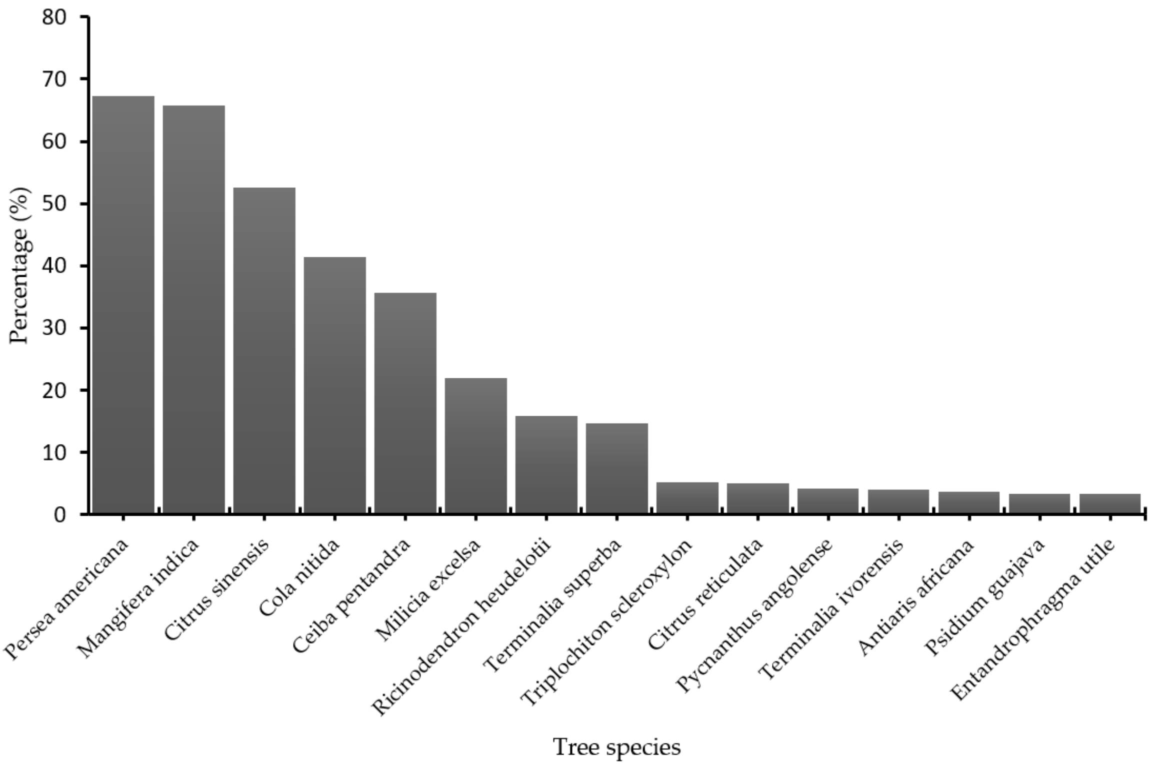

Figure 3. Most planted and spared trees species in cocoa landscapes.

More than half of the surveyed households pledged to adopt and maintain tree species for more than 20 years and requested a formal contract with agroforestry project promoters to protect their rights and their cocoa farms (Table 4).

Table 4. Duration of tree retention on-farm and necessary warranties.

Tree Retention and Warranty		NAF	AF	Nawa Region	χ^2 (*p*-Value)
Duration of tree retention on-farm	0–5 years	11.11	8.87	8.97	0.864 (0.834)
	5–10 years	11.11	16.80	16.57	
	10–20 years	22.22	24.41	24.32	
	More than 20 years	55.56	49.92	50.15	
Warranties to involve farmers	Sign formal contract	45.83	54.29	53.85	-
	Obtain the tree ownership	10.42	29.12	28.13	
	Assist in the sale of wood products	2.08	5.45	5.27	
	Other	6.25	1.62	1.87	

AF: agroforestry farmers; NAF: non-agroforestry farmers.

3.4. Determinants of Agroforestry Adoption

This study clearly revealed that the key drivers of cocoa agroforestry adoption are the age of farmers, the source of energy and the presence of spared tree species on-farm (Table 5).

For every increase in the age of farmers, the probability of agroforestry adoption significantly increased by 0.2%, respectively. Conversely, every discrete change in the number of male-headed and agroforestry households positively and significantly increased the probability of agroforestry adoption by 16.7% and 23.1%, respectively.

In addition, the supply of domestic energy for the households had a significant and positive effect on the adoption of tree species with a probability exceeding 72%. Furthermore, the origin of farmers is a contributing factor to adopt, or not cocoa agroforestry as foreign and native households were most likely to retain trees on the farm compared to nonnative Ivorian households.

Table 5. Socioeconomic determinants affecting respondents on agroforestry adoption.

Explanatory Variables	Model Summary			Marginal Effects		
	Estimate	Std Error	*p*-Value	AME	Std Error	*p*-Value
Constant	–19.970	1455	0.989			
Age	0.012 *	0.006	0.049	0.002 *	0.001	0.047
Gender (1—Male)	18.190	1455	0.990	0.167 **	0.054	0.002
Migration status						
1—Foreigner	31.950	1575	0.984	0.112 ***	0.034	0.001
2—Native	32.150	1656	0.985	0.282 ***	0.033	0.000
Source of energy						
Firewood	0.543 **	0.165	0.001	0.723 ***	0.014	0.000
Charcoal	1.860 ***	0.298	0.000	1.000 ***	0.000	0.000
Butane gas	0.824 ***	0.250	0.001	1.000 ***	0.000	0.000
Farm characteristics						
Shade tree presence (1—Yes)	1.120 ***	0.333	0.001	0.231 **	0.072	0.001
Pseudo R^2 (Nagelkerke)	0.239					
Log-likelihood	–46.124					
Wald chi-square	92.248 ***					
Sample size	910					

AME = Average Marginal Effects, * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

4. Discussion

The findings of the current research revealed that 81% of surveyed households were Ivorian and foreign migrants who settled in the region three decades ago because of two major migration waves. The first wave was composed of Ivorian migrants in the 1970s and the second of non-Ivorian, including Burkinabés and Malians, in the 1980s [49–51]. These migrants were instrumental in the establishment and expansion of cocoa landscapes in southwestern Côte d'Ivoire, which led to the move of the cocoa belt in this region in the 1980s [52,53].

From a demographic profile viewpoint, most of the households involved in the cocoa sector were adults (30–60 years old), married, and without any formal education. In addition, they owned, on average, less than 6 ha. These findings are in line with previous observations about the typical profile of a smallholder cocoa farmer and the size of farms, even though the average value of 4.4 ha is a bit lower than the 6.3 ha obtained by Assiri et al. [19]. Nonetheless, this result is congruent with those of Ruf et al. [54] who reported that farmers had 4.6 hectares of cocoa farms in Côte d'Ivoire. In this study, Ruf et al. [54] revealed a very low average school enrolment rate among cocoa farmers. This low rate of education could affect their decision to adopt innovations. Agkpo et al. [55] revealed that the education level positively influences the probability of adopting new technology and improves the propensity to replace ancestral practices with more modern attitudes, such as replanting and agroforestry.

The small size of cocoa farms could be explained by the conversion of old cocoa plantations into other perennial crops such as rubber and oil palm, declining the size of cocoa plantations [56], a strategy meant to help farmers cope with the falling of cocoa farm-gate prices. Furthermore, other contributing factors to the reduction in the size of farms were the diversification of crops [57,58], the depletion of forest lands [9,43,59], the failure and the high cost of cocoa regeneration and replanting initiatives under non-forest lands [60,61].

On the other hand, our results revealed that most of the cocoa growers were keen to maintain about 8 tree individuals per hectare in their farms, a value above the range between 2.0 ± 1.1 [35] and 9.6 ± 4.6 [34] trees per farm. Findings in other supplying countries such as Ghana revealed 2.4 to 5.10 ± 0.38 tree individuals per farm [62,63]. Inconsistencies among authors in the number of trees in farmlands highlight the need to deeply dive into cocoa agroforestry studies to find out the appropriate tree density that could sustain cocoa production.

In addition, tree species retained by farmers in their cocoa farms were mainly composed of exotic and local fruit tree species, namely *Persea americana*, *Mangifera indica* and *Citrus* sp., confirming previous findings highlighting that fruit tree species were the major tree species in cocoa landscapes [18,29,35]. These species help cocoa farmers diversify their source of income and ensure their food security as fruits are either directly consumed or sold to local traders and farmers during the lean season [64,65]. Moreover, the association of fruit-tree species has the potential to enhance cocoa productivity, as shown in central Côte d'Ivoire through cocoa-avocado and cocoa-orange intercropping systems [18].

Despite this positive move towards an agroecological transition to sustainable cocoa farming, most households intended to keep fewer than 20 food and shade trees on half of the size of their farms. This is indicative of some of their reservations about the effect of shade trees on cocoa production due to uncertainties about land tenure despite the publication of a new forest code emphasising the central role of cocoa agroforestry in rebuilding degraded cocoa landscapes and asserting farmer ownership of planted trees [66]. In fact, the willingness of cocoa growers to plant fewer than 20 trees per hectare could have been the outcome of the awareness-raising campaigns of cooperatives which recommended at least 18 tree individuals per hectare from 3 and 5 species in cocoa farms to fulfil the sustainability requirements of certification schemes [67]. In the same way, cash or in-kind payments promoted by REDD+ and biodiversity projects in the region might have encouraged the adoption and the preservation of trees species [68]. Similarly, Kaba et al. [69] asserted that farmers of the Eastern Region of Ghana intended to introduce 15–18 shade trees in their cocoa farms with *Spathodea campanulata*, *Terminalia superba* and *Terminalia ivorensis* being the most desirable species due to their positive role in improving community livelihoods. Recent studies have shown that low-to-intermediate-shade cocoa agroforests create benefits for climate adaptation and mitigation, soil fertility, disease mitigation, and biodiversity enhancement and do not compromise cocoa production in West Africa [27,70] and Indonesia [71].

Farmers who are willing to invest in agroforestry practices subjected their final decision to the availability of a formal Memorandum of Agreement with the authorities in charge of the management of the forest. These observations are consistent with the findings of several surveys conducted in the region [66,68]. Indeed, the new forest code recognises tree ownership to someone who has the land or who planted the tree on the condition of owing a formal land title, giving credit to the above statement made by farmers. This is explained by the recurrent damageable logging activities in the rural domain resulting in no blame or no compensation by the Forestry Administration. The reservation to adopt cocoa agroforestry is reinforced by the fact that nonnational migrants known to be one of the key actors in the cocoa sector have no right to be a landowner or to be given an official land title. Most of them have customary title deeds, which are often called into question when one of the contracting parties demises. Identically, land ownership could enable farmers to plan for the long term and access credits to support and develop their agribusiness and adopt sustainable innovations. Moreover, it may allow migrant or native cocoa farmers to protect their rights and plantations against recurrent attempts to expropriate planted tree species and further land-related insecurities. Therefore, to improve the adoption of tree planting in cocoa plantations, sensitisation campaigns on the benefits of shade trees in cocoa farms must be intensified, particularly in NAF households where adoption intention is still low.

Driving factors for the adoption of cocoa agroforestry included gender of the household head, age, migration status, source of energy and existence of trees on-farm. In fact, male-headed households are more likely to work on cocoa farms and manage an additional workload resulting from the introduction of trees. Several studies conducted in the region highlighted that looking at things from a gender perspective is meant to positively promote agroforestry in cocoa farms [31,72]. Kossonou et al. [73] outlined that less physically demanding activities are carried out by women in cocoa agroforestry systems, including farm maintenance during the first year, the creation of nurseries, cocoa pods harvest and bean maintenance.

Furthermore, the age of the head of the household plays a key role in the intent to adopt agroforestry. Farmers above 40 years old are most likely willing to adopt innovative and sustainable initiatives that could enhance their livelihoods in the future, thereby planning for the long term. This finding is in line with observations made that the age of farmers could be a determining factor in the adoption of agroforestry practices in Nigeria [74].

In addition, the origin of the farmer appears to be an underlying factor of agroforestry adoption. A recent appraisal conducted in Côte d'Ivoire related on-farm tree retention to the origin of farmers and are meant to supply their daily need for food, fuelwood, and traditional medicine [64]. Similarly, Owusu and Frimpong [31] showed that cocoa agroforestry adoption is triggered by several factors, including age, gender, and migration status, in Ghana and Cameroon [75].

Securing the source of energy for the household is one of the key determinants of agroforestry adoption. This finding could be explained by the fact that households used firewood from their farms as the main source of energy in the field and at home. This practice significantly enhanced their likelihood to adopt agroforestry in the current study. Similar observations were carried out by Herzog [76] in Côte d'Ivoire. Traditionally, firewood was collected in the forests. However, due to forest scarcity, firewood is harvested preferentially on cocoa plantations, prohibiting women from going long distances [77]. The adoption of shade trees may enable farmers to collect fuelwood for their households directly from their cocoa farms and improve their livelihood.

Farmers who have already been exposed to agroforestry are aware of the contribution of tree species to cocoa production and livelihoods' improvement, as well as the workload that the maintenance of these trees could generate. This result confirmed the recent observation by Atangana et al. [35] that outlined that experience in tree planting and expected benefits significantly affected tree adoption in Côte d'Ivoire. It is therefore important to assess the economic and environmental contribution of cocoa agroforestry systems to household livelihood in the short and long term, based on the on-farm tree introduction period.

On the other hand, even though the survey was carried out six years ago, the findings are not outdated. They are rather in line with current initiatives on the ground giving ways for agroecological transition, such as the "Cut and Replant" program, which aims to restore degraded cocoa orchards by improving soil health, fighting against the CSSVD, and planting improved seedlings and cocoa companion trees [78]. Indeed, agroforestry systems with around 50% shade cover may be an optimal coping strategy to balance CSSVD symptom severity versus reduced cocoa yield until diseased cocoa is replaced with more resistant varieties [27]. Moreover, the outputs of this survey can feed into ongoing programs, including the supply chain sustainability initiatives (SSIs) and the Cocoa and Forest Initiative (CFI), which aim to achieve sustainability in the cocoa sector [20]. The concept of SSIs emerged as voluntary cocoa/chocolate company efforts to eliminate environmentally detrimental practices from supply chains. As for CFI, it stands for a joint public-private partnership between the cocoa industry and the government of Côte d'Ivoire and Ghana to establish zero-deforestation by promoting cocoa agroforestry among other sustainable initiatives. The fact that trends emerged from this six-year-old study about potential obstacles—farmer age and gender, technical knowledge and skill, land tenure and ownership, availability of financial resources and seedlings of companion trees—likely to impede the adoption of agroforestry by cocoa farmers meet the conclusions of several studies recently rolled out in the same region for a sustainable cocoa sector [20,79], confirmed not only the relevance of this work, but also its contribution to promoting agroecological transition in cocoa farming.

Despite the usefulness of this study that shed some light on the perception of farmers in the context of the agroecological intensification of cocoa cultivation, the major limitation is the absence of matters related to health and labour issues, key drivers of sustainability in cocoa landscapes, as recently pointed out in Indonesia [80] and Papua New Guinea [81]. Within the current context of the rapid spread of the Coronavirus disease 2019 (COVID-19) pandemic, which may be a plausible source of obstacles to sustainable cocoa supply, a one-health approach should be used to explore integrative and multidisciplinary options for achieving sustainability in the cocoa sector.

5. Conclusions

The current study revealed that cocoa agroforestry is likely to be adopted by cocoa growers of southwest Côte d'Ivoire. Cropping practices mostly consist of integrating exotic fruit trees, including *Persea americana*, *Mangifera indica*, *Citrus sinensis*, *Citrus reticulata* and *Psidium guajava*; endogenous nuts such as *Cola nitida*, *Ricinodendron heudelotii*, *Irvingia gabonensis* and *Ceiba pentandra*; and timber tree species, namely *Milicia excelsa*, *Terminalia superba*, *Terminalia ivorensis*, *Pycnanthus angolense*, *Antiaris africana* and *Entandrophragma utile.* However, the willingness to adopt is subjected to several conditions relying chiefly on the existence of a formal Memorandum of Agreement with the authorities in charge of the management of the forest, which will protect their right and ownership over the planted or protected trees in compliance of the new forest code. On the other hand, factors including gender, age, migration status, the use of wood energy, as well as the presence of on-farm tree species, are key to driving the adoption of agroforestry practices.

These results could be used as food for thought as time seems favourable for the agroecological transition owing to (i) the adoption of the new forest code emphasising the role of agroforestry in the restoration of degraded cocoa landscapes or the reclamation of degraded forests; (ii) the involvement of the Ivoirian government in ongoing initiatives such as the CFI, Reducing Emissions from Deforestation and Forest Degradation (REDD+) and Green Climate Funds. The findings of this study should be used as a basis and benchmark for ongoing and future agroforestry projects to improve their effectiveness and their sustainability for climate change mitigation, food security, and ecological improvement of the landscape.

A bold step forward lies in (i) addressing the issue of land tenure and tree ownership by raising awareness about the new forest code and, particularly, the understanding of cocoa agroforestry; (ii) emphasising the added value of trees in cocoa lands; (iii) facilitating access to improved cocoa companion tree materials.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su132313075/s1, Table S1: Multicollinearity detection in a multinomial logistic regression model; Table S2: Other socioeconomic characteristics of the household; Table S3: Land tenure status and farmer quality.

Author Contributions: Conceptualization, J.-L.K., A.K., D.K. and C.K.; methodology, J.-L.K., A.K. and D.K.; formal analysis, J.-L.K.; data curation, J.-L.K. and D.K.; writing—original draft preparation, J.-L.K.; writing—review and editing, A.K., Y.B., D.K., E.J.T. and C.K.; supervision, A.K. and Y.B.; funding acquisition, C.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was performed within the framework of the feasibility study of a project proposal submitted to Livelihoods Fund for the Livelihoods Family Farming program—L3F, and was sponsored by Barry Callebaut.

Institutional Review Board Statement: All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Telecommunications Regulatory Agency of Côte d'Ivoire-ARTCI (License Number 2017-0279).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The household dataset generated and analysed during the current study is archived at https://dx.doi.org/10.17632/vmshp7xpc2.2, accessed on 22 July 2021.

Acknowledgments: The authors are grateful to the team of enumerators involved in this study led by Roland Aka. Also, we gratefully acknowledge the constructive comments of the three anonymous reviewers.

Conflicts of Interest: The authors declare no conflict of interest.

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