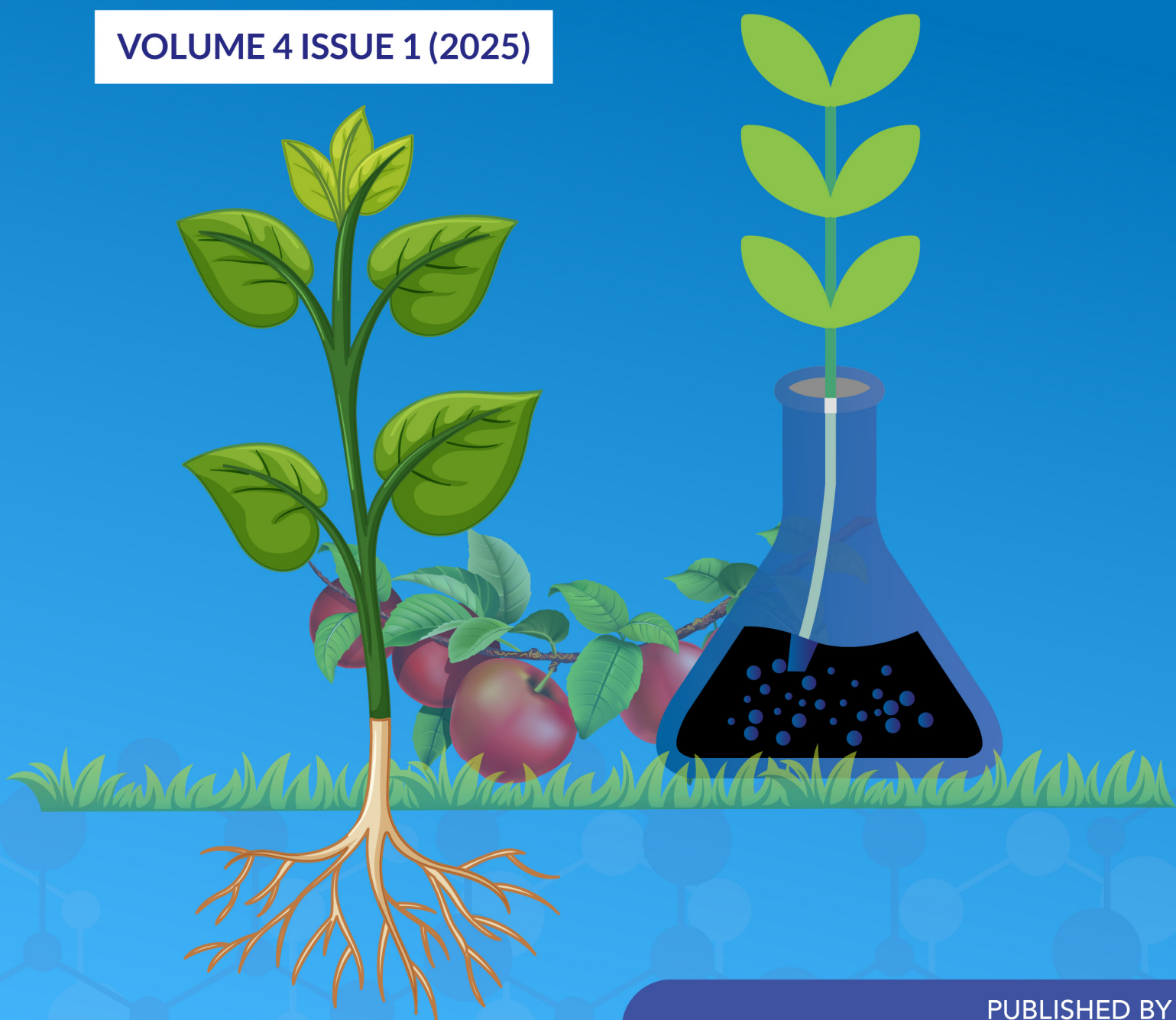




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Understanding Farmers' Perceptions and Factors Determining the Adoption of Good Agricultural Practices: Evidence from the Cashew Nut Production in Côte d'Ivoire

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ABSTRACT

Côte d'Ivoire, the world's leading cashew nut producer with 1,200,000 tons in 2022, faces low productivity of raw cashew nuts (350-500 kg/ha) due to limited adoption of Good Agricultural Practices (GAP). The objectives of this study are to examine the relationship between producers' perceptions and the decision to adopt good agricultural practices, and to determine the determinants of the intensity of adoption of good agricultural practices. Probit and Poisson regression models were applied to data collected from 845 cashew producers in Côte d'Ivoire. The results show that training and access to extension services influences the adoption of good agricultural practices. The average adoption scores showed that the most widely adopted good agricultural practices were plot preparation, direct seeding, formation pruning, firebreak strips, thinning, and pruning. Estimates from the probit model show that producer training on cashew technical itineraries, producer supervision by extension services, and producer perceptions are the main factors that determine the adoption of good agricultural practices. The estimates of the negative binomial model show that gender, level of education, social origin, training, and access to extension services favor the adoption of several good agricultural practices. Policies should prioritize expanding training programs and strengthening extension services to enhance the adoption of Good Agricultural Practices among cashew-nut producers and improve cashew production yield.

INTRODUCTION

The global agricultural sector is facing increasing pressure to enhance productivity while ensuring environmental sustainability and resilience to climate change. In this context, the adoption of good agricultural practices (GAPs) plays a crucial role in optimizing agricultural output and mitigating adverse environmental impacts. GAPs encompass various techniques and strategies aimed at improving soil health, water management, pest control, and farm management.

In contemporary agricultural discourse, the adoption of Good Agricultural Practices (GAPs) represents a pivotal strategy for enhancing productivity, sustainability, and socio-economic outcomes within the global agricultural sector. GAPs encompass a spectrum of techniques, technologies, and management practices designed to optimize crop yields, minimize environmental impacts, and improve farmers' livelihoods (FAO, 2019). The successful uptake of GAPs among farmers is not only crucial for achieving food security goals but also for mitigating the challenges posed by climate change and fluctuating market demands (Ferraro *et al.*, 2020).

Among various agricultural commodities, cashew nut (*Anacardium occidentale* L.) production has strategic significance for many developing countries, including Côte d'Ivoire, where it plays a pivotal role in national economic development and rural livelihoods (WFP, 2018). As one of the world's largest producers of cashew nuts, Côte d'Ivoire faces significant challenges such as fluctuating market prices, climate variability, and evolving

consumer preferences. In this context, the adoption of GAPs in cashew nut production has emerged as a critical factor influencing both the economic viability of farmers and the sustainable management of natural resources (PNUD, 2021).

In recent years, global cashew nut production has witnessed substantial growth, positioning Côte d'Ivoire as its leading producer. The first cashew plantations in Côte d'Ivoire were established in the early 1959-1960s by the Société d'Assistance Technique pour la Modernization de l'Agriculture en Côte d'Ivoire (SATMACI) and Société de Développement des Forêts (SODEFOR) as part of a program to protect the environment and combat erosion and deforestation (Ducroquet *et al.*, 2017). A decade later, the embellishment of raw cashew nut prices led to a craze among producers for the production of raw cashew nuts to the detriment of forestry (Gouma, 2003), with the creation of the first plantations since 1972 (Conseil Coton Anacarde, 2017). The cashew nut production zone will gradually expand from the savannah zone (Kone, 2014) southward around the 2000s, in cocoa-growing areas of forest-savannah contact, cocoa loops (M'Bahiakro & Bouaflé), and around 2010 in some cocoa-growing areas (Bayota, Gagnoa) (Ruf *et al.*, 2019). However, massive adoption of this crop has been carried out by the producers themselves, without any substantial technical or financial support from the state (Ruf *et al.*, 2019).

Understanding farmers' perceptions of GAPs and the determinants influencing their adoption are essential

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for designing effective agricultural policies, extension services, and capacity-building initiatives tailored to local contexts (Gómez-Limón *et al.*, 2022). Despite the recognized benefits of GAPs, adoption rates vary widely across regions and farming communities and are influenced by a complex interplay of socioeconomic, institutional, and environmental factors.

This study sought to provide empirical insights into the factors shaping farmers' adoption of GAPs in cashew nut production in Côte d'Ivoire. By exploring farmers' perceptions, motivations, barriers, and enabling factors related to GAP adoption, this study aimed to inform strategies that promote sustainable agricultural practices, enhance farmers' resilience, and foster inclusive economic growth in the region.

The literature on Good Agricultural Practices (GAPs) often discusses their benefits for enhancing agricultural productivity and sustainability, yet there remains a notable gap regarding the specific determinants influencing farmers' adoption of GAPs in cashew nut production, particularly in the context of Côte d'Ivoire. Existing studies have predominantly focused on staple crops or broader agricultural contexts, overlooking the unique challenges and opportunities within cashew nut farming, a crucial sector of the Ivorian economy. This study aims to fill this gap by empirically examining the factors influencing GAP adoption among cashew nut farmers in Côte d'Ivoire, thereby contributing to a nuanced understanding of how socioeconomic, institutional, and environmental factors interact in shaping adoption decisions. By elucidating farmers' perceptions, motivations, and barriers related to GAP adoption, this study seeks to provide actionable insights for policymakers and development practitioners aiming to promote sustainable agricultural practices and enhance the resilience of cashew nut farmers in the region.

Using a mixed-methods approach that combines qualitative interviews and quantitative surveys, this study endeavors to provide a nuanced understanding of how GAP adoption can be effectively promoted among cashew nut farmers in Côte d'Ivoire. By identifying the key determinants and stakeholders involved in the adoption process, this study aims to offer actionable recommendations for policymakers, development practitioners, and agricultural stakeholders striving to enhance the sustainability and competitiveness of cashew nut production in the global market.

There is abundant literature on the factors that determine producers' adoption of agricultural innovations. Several studies based on economic theories indicate that the determinants of technology and innovation adoption are of various kinds: socio-economic (education, income, age, attitude to risk, experience in agriculture), demographic (number of people in the household, number of assets), institutional (information, training, membership of a producer organization), and technical, economic, and environmental (Adégbola & Gardebroek, 2007). Moreover, among the most widely recognized

determinants of the adoption of agricultural innovations, farmers' perception of the characteristics of innovation proposed by extension services is of prime importance (Adesina & Baidu-Forson, 1995). Indeed, several studies have demonstrated the influence of producers' perceptions of the attributes of proposed technologies (nutritional quality, yield, price, availability of inputs, etc.) on their decision to adopt them (Adégbola & Gardebroek, 2007).

The objectives of this study were to examine the relative effects of producers' perceptions on the decision to adopt good agricultural practices and to determine the main factors in the adoption and intensity of the adoption of good agricultural practices.

LITERATURE REVIEW

Concept of good agricultural practices

Coulibaly *et al.* (2019) stated that Good Agricultural Practices are an expression used by various organizations linked to agriculture, and that this term refers to a set of rules to be respected (good practices) for establishing and developing crops to optimize agricultural production while reducing as far as possible the risks associated with such practices, both with regard to man and the environment. In its run-up to the World Summit on Sustainable Development, the UN (2002) stressed the importance of sustainable agriculture for food security and resource management. FAO (2002) defines good agricultural practices as a set of sustainable agricultural production systems that are socially viable, economically profitable, and productive, while protecting human and animal health and welfare and the environment. In this context, Good Agricultural Practices can be seen as those that contribute to sustainable agriculture.

According to the FAO, Good Agricultural Practices are based on 11 guiding principles. These principles apply to both the entire production and value chain of a plant or animal product on a given farm, and to the various sub-components of agriculture.

In Côte d'Ivoire, several agricultural innovations, including good farming practices for various crops (e.g., cocoa, cashew nuts), are being disseminated to producers by several extension organizations. As far as cashew nuts are concerned, twelve (12) themes (Table 1) that bring together all environmentally-friendly agricultural practices and ethical values in cashew nut production zones have been retained as part of the framework agreement (2014-2017) between the "Conseil du Coton et de l'anacarde" and ANADER. These practices involve both good production and post-harvest practices. The adoption and application of these practices aims to improve cashew nut productivity and quality.

These themes were disseminated by ANADER through an agricultural advisory service dedicated to cashew nut growers, which provided information and training in villages, school fields, demonstration units, and plot visits. The dissemination of these themes involves an "agricultural advisor's extension agent as a channel of

Table 1: Good production practices in cashew nut cultivation

N°	Themes
1	Plot preparation
2	Plant material acquisition when creating a new orchard
3	Staking when creating a new orchard
4	Digging and filling in when creating a new orchard
5	Direct seeding when creating a new orchard
6	Planting when creating a new orchard
7	Fertilization during the planting stage
8	Creation of firebreaks around your orchard
9	Replanting when creating a new orchard
10	Shaping pruning
11	Thinning
12	Pruning

Source: ANADER

dissemination, and a producer as the “advised agent” advised agent. Local radio stations are also used to broadcast information in the local languages.

Determinants of the adoption of agricultural innovations Among the definitions proposed by several authors on innovation adoption, Rogers (1983) appears most frequently. He defines innovation as “an idea, practice, or object perceived as new by a person or unit of adoption”. For him, one of the characteristics of technological innovations is that they are not automatically adopted once they appear, even if they have superior qualities compared with older technologies. Rogers (2003) considered that the degree of adoption is linked to the level of diffusion, which is the process by which an innovation is communicated to members of a social system through certain channels over time. Thus, adopting agricultural innovation means that it offers something more than the current practices.

Roussy *et al.* (2015) reveal that many works on innovation adoption behavior are based on the hypothesis that the overall perceived utility of an innovation corresponds to the sum of the utilities of the characteristics making up that innovation, referring in this to the work of Lancaster (1966).

In addition, several theoretical models have been developed for technology adoption and choice since the work of Rogers (1983) to explain the behavior of actors. These include i) the diffusion of innovation model (Rogers, 1983), ii) the technology acceptance model (Davis, 1989), iii) the theory of interpersonal behavior (Triandis, 1980), and iv) the neoclassical theory of rational expectations (Muth, 1961). Studies based on these theories indicate that the determinants of technology and innovation adoption are of various types: social, technical, economic and environmental.

Recent empirical studies have examined the adoption of good agricultural practices for cashew cultivation in Côte

d'Ivoire. Ouattara (2017) identified the determinants of the adoption of good pre-harvest cultivation practices for cashews. Using an unordered multinomial logit model, she shows that social variables, such as location and level of education, favor the adoption of good pre-harvest cashew production practices. Conversely, variables such as the age of the farm manager and household size had a negative impact on the adoption of certain good cashew-growing practices.

Coulibaly *et al.* (2019) examine the financial profitability of adopting good production practices. They used the score method and budget. Analyses show that 54.7% of growers apply good production practices, which positively impact yield and income. However, their application is financially less profitable because it incurs higher costs.

Perceptions and adoption of agricultural innovations

Since the seminal work of Kivlin and Fliegel (1966a, b, 1967), many studies in agricultural economics have been conducted on the factors that influence producers' perceptions and adoption of new agricultural technologies. Perceptions are psychological factors that can influence an individual's behavior. Sheth and Mittal (2004) stated that this is a process by which individuals select, organize, and interpret information. Their perceptions were subjective. Economists (Jones, 1989; Lin & Milon, 1993) who have worked on consumer demand have corroborated that consumers have subjective preferences for product characteristics and that their demand for products is significantly affected by their perception of product attributes. In the context of agriculture, the key attributes described in the literature include: i) compatibility, ii) complexity, iii) observability, transferability, iv) cost, profitability, v) risk and uncertainty, vi) trialability, and vii) relative advantage (Barroga, 2019).

Empirically, according to Rogers' model (2003), the particular characteristics of the technology and the way potential users perceive its value can explain between 50% and 90% of the variation in adoption rates. Similarly, Adesina and Baidu-Forson (1995) show that technology adoption by farmers reflects rational decision making based on farmers' perception of the relevance of the characteristics of the technologies studied through their work on adoption decisions of improved rice varieties by Sierra Leonean farmers. Indeed, they showed that farmers' adoption decisions depended mainly on their perceptions of these new varieties. Specifically, factors such as cooking, yield, ease of dehulling, and milling play decisive roles in the decision to adopt these rice varieties.

MATERIALS AND METHODS

Study area and sampling

The present study was conducted from October to November 2017 in the cashew nut production basin in Côte d'Ivoire, which covers 19 regions in the northern half of the country (Figure 1).

This methodological approach was based on a survey of raw cashew nut producers in various zones. The sample

targeted 1020 raw cashew nut producers in the cashew production zone, representing a sampling rate of 15% compared to the parent population of 149,600 producers. The final database covered 845 cashew nut growers throughout the production zone, regardless of whether they were included in the training and monitoring project

for good agricultural practices.

Data were collected using a questionnaire intended for cashew-nut growers. They covered sociodemographic information on growers, plot characteristics, growers' perceptions of good agricultural practices, and economic data.

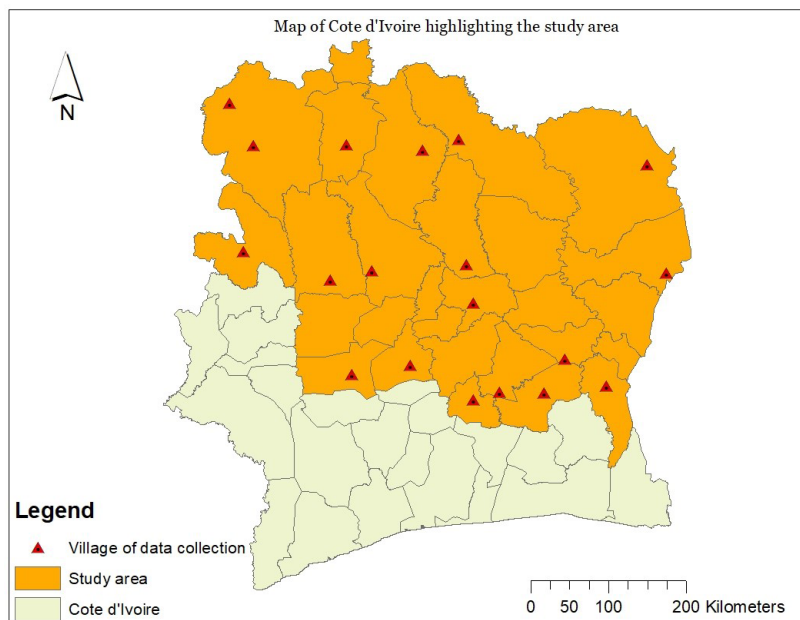


Figure 1: Study survey areas

Source: Author based on survey data

Data analysis

Data were processed using STATA software and focused on the socioeconomic and demographic characteristics of producers, technical characteristics of cashew nut plots, producers' perceptions, and institutional factors. Data analysis was performed using descriptive statistics (mean, standard deviation, percentile, etc.), correlation coefficients, score method, and two regression models. Two regression models were used: probit and Poisson.

The score method

The score method was used to assess attitudes towards adopting good farming practices. This method was implemented as follows: For each good practice, the farmer was asked to choose the level of appreciation or application. Four modalities (not at all, little, moderately, and strongly) were submitted according to the manufacturer's judgment. The ratings were as follows: not at all, 1; somewhat = 2, moderately = 3, and strongly, 4. The average score for each good practice was obtained by averaging the scores assigned to the theme by each producer. The average score was calculated as follows:

$$\text{means score} = (\sum \text{score}_i) / N \quad \text{.....(1)}$$

where i is the responding producer and N is the total number of responding producers.

The average score for good practice was between 1 and 3. The more a theme was adopted, the higher the adoption score, which tended to be 4. A theme with a score of one implies that it has not been adopted.

Probit model

Let U_{ij} be the utility that producer i hopes to obtain using technique j , and let $i = \{1, 2, \dots, n\}$. The producer's decision involves two mutually exclusive alternatives. The i th producer will use technique j if $U_{i1} > U_{i0}$ (1 for good farming practices and 0 for peasant practices). Anticipated profit (U^*) is an unobserved latent variable that depends on alternative choices and the farmer's socioeconomic, demographic, and institutional characteristics (X_{ij}). According to the probit model, if the producer considers good farming practices to be more profitable, $U_i^* > 0$; otherwise, he continues with the technique he was using and $U_i^* \leq 0$. With U_i^* the unobservable latent variable associated with the adoption decision; Where X_{ij} constitute a vector of explanatory variables, β_i the parameter vector and ϵ_i the error term.

$$U_i = \sum_{j=1}^n \beta_i X_{ij} + \epsilon_i; i=1, \dots, n; j=1, \dots, n \quad \text{.....(2)}$$

$\begin{cases} U_i = 1 & \text{adoption of good agricultural practice} \\ U_i = 0 & \text{non-adoption of good agricultural practice} \end{cases}$

The probability of adopting a good practice is then equal to:

$$P_i = \text{prob}(a=1) = \sum_{j=1}^n \beta_i X_{ij} + \epsilon_i > 0 \quad \text{.....(3)}$$

$$P_i = F(\sum_{j=1}^n \beta_i X_{ij}; i=1, \dots, n; j=1, \dots, n) \quad \text{.....(4)}$$

Where F is the normal distribution function.

$$F(x) = \int_{-\infty}^x (1/(\sqrt{2\pi})) e^{-t^2/2} dt \quad \text{.....(5)}$$

The distribution function F follows a normal distribution, and The Z statistic is used to estimate various coefficients and parameters of the equation.

Poisson model

Poisson regression is estimated by considering the total number of Good Agricultural Practices that can be adopted by a producer. Poisson regression is usually employed when the dependent variable is a count variable, which in this case is the sum of the good agricultural practices adopted. The Poisson probability distribution is more appropriate than the normal distribution used in the probit model, or the logistic distribution used in the logit model. The probability density function is expressed as follows:

$$F(y_i/x_i) = P(Y_i/y_i) = (e^{-\lambda} \lambda^y) / y!, y = 0, 1, 2, 3, 4, 5, \dots \dots (6)$$

Where y_i is the total number of good agricultural practices adopted by the farmer and x_i is the variables influencing the adoption process. The expected mean parameter (λ) of the probability function is defined as

$$E(y_i/x_i) = \lambda_i = \exp(x_i' \beta) = \exp(\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_k x_{ik} + \varepsilon_i) \dots (7)$$

This equation can be estimated using the maximum likelihood approach.

RESULTS AND DISCUSSION

Socio-demographic characteristics of cashew nut growers and farm techniques

The descriptive statistics for the continuous and discrete categorical variables used in this study are presented in Table 2. The results showed that cashew-nut growers were mainly men (95%), with a marginal proportion of women (5%). The average age of producers was 47 years, with a standard deviation of 11 years. The predominance of men over women in cashew nut cultivation can be explained by the difficult access of women to land, as noted by Koné (2011), who affirmed that traditionally, women rarely receive or inherit valuable land definitively

with exclusivity and are excluded from the management rights of lineage land heritage. Indeed, given its occupation of space over several years and its economic interest, the cultivation of cashew trees constitutes a cash crop owned mainly by men.

The average size of cashew-growing households was 10 members who could participate in the fieldwork. With regard to the education level of cashew nut growers, the results showed that more than a majority of growers (63%) were illiterate. In terms of social status, the results showed that the majority of cashew nut growers were natives (82%), with a small proportion being non-natives (8%) and allochtones (10%). The most likely explanation is that non-native and non-native faces, in the same way as women, have difficult access to land capital. Indeed, the majority of non-natives and non-natives had access to land for the establishment of cashew plots through purchase or rental. In terms of marital status, the majority of cashew growers lived as couples (64%), either cohabiting or being married. The results of the study showed that the majority of cashew growers acquired their plots by inheritance (54%), compared with 21% of growers who created their own farms and owned their plots. On average, producers own around 1.5 plots per farming household. The average size of cashew plots was 4.2 ha. These plots were 17 years old on average; therefore, cashew orchards tended to age. These plots were located approximately 4 km from producers' homes. Within the framework of the training program dedicated to producers, the study revealed that 79% of producers have been trained, sensitized, or informed about good cashew-growing practices, compared to 56% who have received advisory support from supervisory services.

Table 2: Producer socio-economic characteristics and cashew nut farm techniques

Variables	Obs	Mean	Std. Dev.
Socio-demographics			
Sex (Female=0; Male=1)	845	0.948	0.222
Producer age (year)	845	46.807	11.182
Household size	845	10.372	5.499
Literate	845	0.370	0.483
Social status (0=native; 1=native;)	845	0.820	0.384
Marital status (1=in couple; 0=not in couple)	845	0.645	0.479
Cashew nut plot			
Inheritance mode (1=inheritance; 0=other)	845	0.544	0.498
Ownership mode (1=owner; 0=other)	845	0.214	0.411
Purchase mode	845	0.044	0.205
Rental of plot	845	0.031	0.173
Number of plots	845	1.498	0.667
Plot age (year)	845	16.843	6.805
Production area (ha)	845	4.172	3.205
Plot distance (km)	845	3.507	2.597
Institutional			

GAP training	845	0.796	0.403
Contact with extension agent	845	0.563	0.496

Source: Author based on survey data

Cashew nut growers' perception of good agricultural practices

The mean rank of growers' perceptions of each good agricultural practice was calculated and the rank was determined using Kendall's coefficient of agreement (Table 3). Among the various good agricultural practices,

Kendall's test revealed that pruning is the first and most important in terms of growers' perceptions, which promotes improved yield and nut quality. This was followed by thinning and fire banding around the orchards. Practices such as fertilization, digging, and relining are in the last position.

Table 3: Kendal's w test on farmers' perception of good agricultural practices

Good agricultural practices	Mean rank	Rank
Pruning	5,40	1
Thinning	5,57	2
Making firebreaks around your orchard	5,89	3
Plot preparation	6,15	4
Acquiring plant material when creating a new orchard	6,58	5
Training pruning	6,59	6
Direct seeding when creating a new orchard	6,81	7
Staking when creating a new orchard	6,81	8
Planting when creating a new orchard	6,93	9
Fertilization during the planting stage	6,95	10
Digging and filling when creating a new orchard	7,03	11
Regarnishing when creating a new orchard	7,29	12
W de Kendalla	0,076 ***	
Khi-deux	705,706	
ddl	11	

Source: Author based on survey data

Frequency of adoption of good agricultural practices by producers

The level of adoption of each good agricultural practice, based on the average score, is presented in Table 5. This study revealed that growers preferentially adopted tree branch pruning, thinning, and firebreak creation to protect their orchards, soil preparation, semi-direct seeding, and formation pruning, for which the level of adoption is high. However, they had a low level of

adoption for the acquisition of planting materials, staking, digging, planting, fertilization, and replanting.

Although descriptive, these analyses have the advantage of being easy to understand. Moreover, they constitute a first step towards a more in-depth study of the implications of agricultural practices and socio-economic characteristics on the perception of the adoption of good cashew production practices.

Table 4: Level of adoption of good farming practices by producers

Good agricultural practices	Not at all	Little	Moderately	Very much	Mean score
Plot preparation	411	78	114	242	2,221
Acquiring plant material when creating a new orchard	517	102	122	104	1,779
Staking when creating a new orchard	559	48	100	138	1,783
Digging and filling in when creating a new orchard	578	59	90	118	1,702
Direct seeding when creating a new orchard	473	57	127	188	2,036
Planting when creating a new orchard	567	62	103	113	1,718
Fertilization during the planting stage	621	55	64	105	1,589
Laying firebreaks around your orchard	398	42	79	326	2,394

Replanting when creating a new orchard	532	91	94	128	1,785
Shaping pruning	422	104	129	190	2,103
Thinning	326	99	135	285	2,449
Pruning	325	81	130	309	2,501

Note: Average weight = 2.005

Multi-collinearity test results

Multicollinearity tests were performed for all econometric models. For each model, the partial correlation test indicated a correlation between explanatory and dependent variables. Similarly, a correlation exists between the model's explanatory variables. This led to multicollinearity. To solve this problem (Nana & Thiombiano, 2018) cite several authors such as Asfaw *et al.* (2012); Cahuzac and Bontemps (2008), who recommend calculating the variance inflation factor (VIF). According to Chatterjee *et al.* (2000), a multicollinearity problem is identified when the VIF has a value greater than or equal to 10 and/or when the mean of the VIFs is greater than or equal to 2. Conversely, some authors (Allison) indicated VIF values of 4, 5, and 10 before raising concerns. On the other hand, if none of these two values is reached, the impact of multicollinearity is not, according to these authors, cause for concern, and all the explanatory variables can therefore be retained for the analysis, the latter not being redhibitory "distorted" by the existing level of multicollinearity. The VIF calculation in this study shows that multicollinearity for each model is not a problem in the estimation. In fact, all VIFs are less than five, the inverse of the VIFs of each variable is less than one, and the mean of the VIFs is less than two. Consequently, we conclude that there is no multicollinearity between explanatory variables.

Presentation and interpretation of probit estimation results

The results of the maximum likelihood and marginal effects probit estimations are presented in Tables 6, 7, 8, and 9. The critical probabilities associated with the various likelihood ratio statistics are 0.000 significant at the 1% level. The various models are, therefore, highly significant overall, and the variables considered as a whole are also significant. Relationships exist between the explanatory variables and the variables that explain the adoption of each good farming practice. In dichotomous models, coefficients cannot be interpreted directly. We can only suggest that a positive coefficient increases the probability, and vice versa for a negative coefficient.

Statistical interpretation of estimated parameters

Tables 5 on the estimated parameters of the probit model for each good agricultural practice show that all (independent) explanatory variables sometimes show statistically significant differences for some good practices and not for others. Similarly, the coefficients of the same variable have positive signs for some good farming practices, and negative signs for others. However, certain variables, such as farmers' training in good agricultural practices, farmers' access to extension services, and all the variables relating to farmers' perceptions of good agricultural practices, showed statistically significant and positive differences in the adoption of the 12 good agricultural practices.

Table 5: Estimation of probit model parameters on factors determining adoption of each good production practice

Variables	Plot preparation	Plant material	Staking	Digging & filling	Direct seeding	Planting
Sex	0.264 (0.232)	0.268 (0.254)	0.798*** (0.297)	0.689** (0.297)	0.251 (0.240)	1.042*** (0.321)
Producer age	0.009* (0.005)	0.005 (0.005)	0.013** (0.005)	0.011** (0.005)	0.007 (0.005)	0.015*** (0.005)
Household size	-0.017* (0.010)	-0.005 (0.011)	0.005 (0.010)	0.006 (0.010)	-0.004 (0.010)	-0.002 (0.010)
Literate	0.029 (0.107)	0.181 (0.110)	0.113 (0.110)	0.021 (0.110)	0.151 (0.108)	0.111 (0.108)
Social status	0.001 (0.146)	0.013 (0.152)	0.130 (0.149)	0.042 (0.152)	0.153 (0.147)	0.064 (0.150)
Marital status	-0.004 (0.108)	-0.132 (0.115)	0.119 (0.116)	0.024 (0.116)	-0.039 (0.113)	-0.141 (0.114)
Inheritance mode	-0.112 (0.145)	-0.178 (0.146)	-0.438*** (0.145)	-0.540*** (0.142)	-0.204 (0.145)	-0.375*** (0.143)

Ownership mode	-0.767*** (0.168)	-0.744*** (0.175)	-0.744*** (0.173)	-0.779*** (0.171)	-0.967*** (0.173)	-0.745*** (0.171)
Purchase mode	-0.385 (0.289)	-0.097 (0.302)	-0.460 (0.305)	-0.608** (0.303)	-0.514* (0.289)	-0.395 (0.292)
Rental of plot	-0.305 (0.364)	-0.994** (0.479)	-1.022** (0.478)	-1.015** (0.465)	-0.995** (0.478)	-0.915** (0.465)
Number of plots	-0.070 (0.082)	-0.028 (0.084)	-0.067 (0.085)	0.011 (0.083)	0.002 (0.083)	-0.099 (0.083)
Plot age	-0.011 (0.008)	-0.020** (0.009)	-0.039*** (0.009)	-0.028*** (0.008)	-0.018** (0.008)	-0.024*** (0.008)
Production area	0.020 (0.018)	0.042** (0.019)	0.042** (0.018)	0.022 (0.018)	0.025 (0.018)	0.005 (0.018)
Plot distance	-0.020 (0.020)	-0.046** (0.022)	-0.016 (0.021)	-0.013 (0.021)	-0.030 (0.021)	-0.039* (0.021)
GAP training	0.708*** (0.160)	0.479** (0.187)	0.508** (0.199)	0.445** (0.198)	0.758*** (0.176)	0.683*** (0.198)
Contact with extension agent	0.679*** (0.116)	0.890*** (0.123)	0.892*** (0.126)	0.840*** (0.129)	0.582*** (0.118)	0.686*** (0.122)
Perception of plot preparation	1.126*** (0.114)	NA	NA	NA	NA	NA
Perception of plant material	NA	1.292*** (0.120)	NA	NA	NA	NA
Perception of staking	NA	NA	1.093*** (0.122)	NA	NA	NA
Perception of digging	NA	NA	NA	1.042*** (0.120)	NA	NA
Perception of direct sowing	NA	NA	NA	NA	1.239*** (0.114)	NA
Perception of planting	NA	NA	NA	NA	NA	0.991*** (0.116)
Constant	-1.642*** (0.402)	-1.883*** (0.433)	-2.747*** (0.472)	-2.475*** (0.467)	-1.936*** (0.416)	-2.743*** (0.487)

NA: Not applicable

Source: Author, based on survey data.

*** significant at 1%; ** significant at 5%; *significant at 10%.

Regarding the determinants affecting the adoption of all GAPs, the results of the probit model showed that the variables training, coaching, and producers' perceptions had positive and significant relationships with the adoption of all (12) GAPs, with marginal effects ranging from 11.3% to 33.6%. With regard to the training and coaching of producers on good agricultural practices, the results show that the majority of producers (80%) were informed, sensitized, or trained on good production practices, and 56% were coached by agricultural advisory services.

As part of the implementation of the agricultural advisory program dedicated to cashew nut growers, the many information dissemination channels used (supervisory structures, NGOs, CCA, radio, etc.) have

made it possible to inform many growers on cashew nut-related topics. Similarly, ANADER's training courses on good production practices through farmers' field schools and visits to plots by agricultural advisors have enhanced growers' knowledge and interest in these practices. These results are similar to those of Roussy *et al.* (2015), who argue in their work that the informational context, both formal (advisor visits) and informal (producer networks), affects the adoption of innovations. These results suggest that information campaigns and producers' technical and cognitive capacities must be further strengthened to better support them in the process of adopting and appropriating good production practices. Regarding producers' perceptions, the results suggest that the more cashew producers believe that good agricultural practices

improve tree yield and nut quality, the more willing they are to adopt these practices.

Indeed, Djaha *et al.* (2012) noted that high plantation densities are among the constraints at the root of low yields observed in cashew production zones. Indeed, all good practices have been indicated to sustainably increase yields. This result confirms our basic hypothesis that a producer's perception of a good production practice improves its probability of adoption. Our results concur with those of Adesina and Zinnah (1993), who showed that Sierra Leonean farmers' decisions to adopt improved rice varieties largely depend on their perceptions of new varieties. The assumption that farmers' perceptions of their own capacity to adapt and change are a determining factor in the choice of agricultural practices (Hyland *et al.* 2016; Talanow *et al.*, 2021; Topp *et al.*, 2023). Consequently, to facilitate the adoption of good production practices, emphasis should be placed on the benefits. To this end, practical demonstration sessions in farmers' school fields between demonstration plots and farmers' plots can be organized to assess the yield and quality of raw cashew nuts. This study is also in line with the findings of Niambe *et al.* (2024), who provide insights into the socioeconomic factors affecting the adoption of sustainable practices in Nigeria.

Factors determining the intensity of adoption of good farming practices

Frequency of intensity of adoption of Good Agricultural Practices

Among the 12 GAP, cashew nut growers can adopt different sums of good agricultural practices, referred to here as adoption intensity, ranging from 0 to 12 (Table 10). This study revealed that producers adopt an average of five GAP at a time. In terms of proportion, the study shows that 28% of cashew growers have not adopted any of the 12 Good Agricultural Practices, preferring traditional farming practices. On the other hand, approximately 19% of growers have adopted all twelve (12) recommended agricultural practices for the better management of cashew plots. Between these extremes, the proportion of growers with adoption intensities ranging from 1 to 11 fluctuated between 3.2% and 6.86%. The results also show that more than half of the growers (53%) did not adopt the entire technological package of good agricultural practices, but rather made partial or sequential choices of the package of good agricultural practices they applied to the plots. Similar results were reported by Roussy *et al.* (2015). Indeed, several factors can explain producers' sequential adoption behavior of technological packages, including fixed costs, credit constraints, risk, and uncertainty (Aldana *et al.*, 2011).

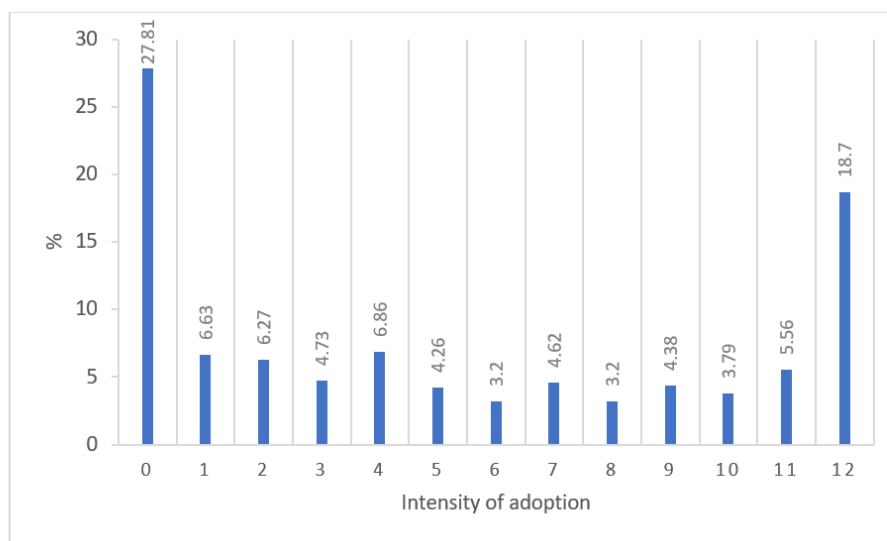


Figure 2: Intensity of adoption of good farming practices

Source: Author based on survey data

Test for normality of independent variable

The Skewness and kurtosis test shows that the "Intensity_Adopt" dependent variable does not follow a normal distribution. The Skewness p-value was less than 0.05; therefore, we rejected the H0 hypothesis, and the data did not have a normal distribution.

Multicollinearity test between variables

Before proceeding with multivariate analysis, it is essential to examine the correlations of the explanatory variables to detect any multicollinearity that may bias the conclusions

of the analysis.

Examination of the correlation matrix shows that there is no strongly elevated level of correlation that requires corrective actions. The correlation coefficients ranged from -0.571 to a maximum of 0.509 . All these correlation coefficients are below the 0.8 threshold and therefore, do not reveal the presence of a serious multicollinearity problem.

Detecting over-dispersion

The fish model is the most widely used probabilistic

framework for the analysis of count data; however, this model is only appropriate if the mean of the count variable is equal to its variance $E(y) = \text{Var}(y)$. If this hypothesis is not verified, the parameters estimated using the maximum likelihood method will be biased. In this case, an alternative counting model that considers overdispersion (negative binomial model) is indispensable. The ratio of the variance to the mean of the dependent variable estimated for the 845 producers in the sample, with a value of 4.24, favored an over-dispersion of observations in relation to the Poisson distribution hypothesis.

Model estimation using poisson and negative binomial regression

The over-dispersion test performed after estimating the regression of the Poisson model (Table 6) shows a highly significant over-dispersion ($p\text{-value} < 0.05$), allowing us to reject the null hypothesis of equality of the mean and variance of the “Intensity Adop” variable. Therefore, it is necessary to use a negative binomial model.

The estimates of the Poisson and negative binomial models (Table 6) confirm the superiority of the negative binomial model. The likelihood ratio test ($\text{Prob} \geq \chi^2_{1,0.000} = 0.000$) led to the choice of a negative binomial model. The Poisson model is a nonlinear model, and Incidence Rate Ratios (IRR) were used to interpret the coefficients obtained after regression. An incidence rate ratio of less than 1 ($\text{IRR} < 1$) means that an adopter is less likely to adopt several good agricultural practices, while an incidence rate ratio of greater than or equal to 1 ($\text{IRR} \geq 1$) means that an adopter is more likely to adopt several good agricultural practices.

The results of the Poisson regression model show that the gender of the producer, level of education, social status, marital status, and training and supervision of producers in good agricultural practices have positive effects on the intensity of adoption of good agricultural practices within the population studied. On the other hand, the mode of acquisition of cashew plots (inheritance, ownership, rental) and the number of cashew plots owned by the producer had a reducing effect on the intensity of adoption of good agricultural practices.

The marital status of couples positively influenced the intensity of the adoption of good farming practices. This result is similar to that of Sale *et al.* (2014), who noted that married farmers have children who serve as their labor force for various agricultural tasks. This marital status determines the farmer's needs and expenses, and conditions his decisions to improve agricultural productivity.

The incidence rate ratio associated with the sex variable was greater than 1 ($1.439 > 1$) and was statistically significant at the 1% threshold. This means that the intensity of the adoption of good agricultural practices among men was 1.439 times higher than that among women. The incidence rate ratio associated with the literacy variable was greater than 1 ($1.206 > 1$) and was statistically significant at the 1% threshold. This means

that the intensity of the adoption of good farming practices among literate farmers is 1.206 times higher than that among non-literate farmers. This result confirms the importance of producers' level of education in the adoption of good farming practices. Male producers, who comprise 95% of cashew nut growers, have a higher adoption intensity than female producers. This result is consistent with several studies that have shown a positive correlation between decisions to adopt innovation and education level in sub-Saharan Africa (Kebede *et al.*, 1990). Indeed, a high level of education influences the attitudes and thoughts of producers, making them more open, rational, and able to analyze the benefits of good production practices. Education facilitates critical thinking and the effective use of information received by producers (Dissanayake *et al.*, 2022). Thus, literate producers understand their interest in adopting the entire technological package of good agricultural practices, which impacts the yield and quality of raw cashew nuts. This implies that actions to strengthen the capacities of current cashew producers in functional literacy will have to be carried out to improve their level of education and to make them aware of educating future generations of producers, with the aim of improving their decision to adopt good production practices.

The incidence rate ratio associated with the social status variable was greater than 1 ($1.233 > 1$) and statistically significant at the 1% threshold. This means that the intensity of adoption of good farming practices among indigenous producers is 1.233 times higher than that of allogeneic or allochthonous producers. This result shows that origin has a positive influence on producers' adoption behavior. This result can be explained by the fact that indigenous producers are more likely to take part in training courses (75%) on good farming practices and receive coaching (80%) from extension agents, as well as by their access to land (Nkamleu & Coulibaly, 2000).

The incidence rate ratio associated with the training variable was greater than 1 ($3.813 > 1$) and statistically significant at the 1% threshold. This means that the intensity of the adoption of good farming practices among producers who have been trained in good farming practices is 3.813 times higher than that among producers who have not been trained. The incidence rate ratio associated with access to advisory support from extension services is greater than 1 ($3.813 > 1$) and is statistically significant at the 1% threshold. This means that the intensity of adoption of good farming practices among producers who receive support from extension services on good farming practices is 3.813 times higher than that of producers who receive no support.

Conversely, the incidence rate ratios associated with the plot acquisition mode variable are less than 1 and statistically significant at the 1% threshold for the owner and lease modes, and 10% for the inheritance mode. These results show that these modes of access to plots by producers have a reducing effect on the intensity of adoption of good farming practices.

Table 6: Parameter estimates for Poisson and negative binomial models of intensity of adoption of good farming practices

VARIABLES	Poisson regression		Negative binomial regression	
	IRR	dydx	IRR	dydx
Sex	1.586*** (0.150)	2.408*** (0.496)	1.439** (0.251)	1.923* (0.924)
Producer age	1.002 (0.001)	0.010 (0.008)	1.001 (0.003)	0.003 (0.017)
Household size	1.004 (0.003)	0.023 (0.016)	1.004 (0.007)	0.019 (0.036)
Literate	1.136*** (0.036)	0.664*** (0.166)	1.206** (0.085)	0.991** (0.378)
Social status	1.198*** (0.055)	0.942*** (0.241)	1.233** (0.118)	1.108* (0.511)
Marital status	1.062* (0.036)	0.316 (0.177)	1.143* (0.085)	0.707 (0.396)
Inheritance mode	0.844*** (0.033)	-0.882*** (0.205)	0.854* (0.079)	-0.833 (0.494)
Ownership mode	0.647*** (0.032)	-2.269*** (0.262)	0.697*** (0.078)	-1.904** (0.596)
Purchase mode	0.935 (0.082)	-0.352 (0.459)	1.029 (0.199)	0.149 (1.019)
Rental of plot	0.276*** (0.053)	-6.717*** (1.006)	0.232*** (0.067)	-7.716*** (1.579)
Number of plots	0.96* (0.023)	-0.210 (0.127)	0.904* (0.049)	-0.531 (0.291)
Plot age	0.991*** (0.002)	-0.048*** (0.013)	0.995 (0.005)	-0.026 (0.028)
Production area	1.001 (0.005)	0.006 (0.028)	0.996 (0.012)	-0.022 (0.061)
Plot distance	0.992 (0.006)	-0.043 (0.033)	0.998 (0.014)	-0.013 (0.073)
GAP training	3.416*** (0.281)	6.412*** (0.440)	3.813*** (0.443)	7.069*** (0.695)
Contact with extension agent	2.073*** (0.083)	3.805*** (0.217)	2.107*** (0.163)	3.935*** (0.462)
Constant	0.715** (0.107)		0.69 (0.195)	
Observations	845		845	
Prob > chi2 =	0.000		0.000	
Chi-square =	1593.600		355.338	
Pseudo R2 =	0.240		0.077	

Source: Author based on survey data

CONCLUSION

The objectives of this study were to examine the relationships between producers' perceptions and the decision to adopt good agricultural practices and to determine the main factors in the intensity of adoption of good agricultural practices in the context of improving

cashew nut farm productivity. To this end, a probit model and negative binomial regression model were implemented using data collected from 845 producers. The results showed that in terms of growers' perceptions, certain good agricultural practices, such as pruning, thinning, and firebreaks, were the most important for

improving the yield and quality of raw cashew nuts. Good agricultural practices are among those with a high level of adoption. This link is confirmed by the results of the probit model, which showed that training, coaching, and producers' perceptions were the main factors determining the probability of all (12) good farming practices. An important finding of this study is that more than half of cashew growers adopt among some growers do not adopt the entire technological package of good agricultural practices, but rather make partial or sequential choices. On the other hand, the mode of acquisition of cashew nut plots (inheritance, ownership, rental) and the number of cashew nut plots owned by the producer reduced the intensity of the adoption of good agricultural practices. These results suggest that industry management actors should initiate programs to strengthen producers' technical capacities and provide incentives for the adoption of good agricultural practices to raise cashew nut plot productivity. In practice, this can be achieved through information campaigns and practical demonstration sessions in farmers' school fields (technical and cognitive capacity-building). In-situ demonstration sessions will help improve cashew-nut growers' perceptions.

Policy Implication

Based on the findings that highlight the significant factors influencing the adoption of Good Agricultural Practices (GAPs) in cashew nut production in Côte d'Ivoire, several policy recommendations can be formulated to enhance adoption rates and promote sustainable agricultural practices. First, it is crucial to prioritize and expand training programs tailored to the cashew technical itinerary to ensure that producers have access to comprehensive knowledge and skills necessary for the effective implementation of GAPs, such as plot preparation, direct seeding, and pruning techniques. Second, strengthening and expanding extension services, focusing on regular supervision and advisory support for farmers, is imperative. This can enhance technical assistance and guidance, which are pivotal in overcoming the barriers to adoption identified in this study, particularly for practices such as formation pruning and firebreak strips. Additionally, addressing socioeconomic factors, such as sex disparities, educational levels, and social backgrounds, through targeted interventions and incentives can further incentivize adoption. Policy efforts should also aim to improve access to the resources and inputs necessary for GAP implementation, thereby fostering a conducive environment for sustainable agricultural development in the cashew sector in Côte d'Ivoire.

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