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Technical Efficiency of Farms, and Fight Against Poverty: Case of the Cashew Sector in Côte d'Ivoire

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Abstract

Cashew was introduced in the north of Côte d'Ivoire to support the economy in the region. This study was conducted to evaluate the technical efficiency of cashew farms in Côte d'Ivoire. The technical efficiency of producers was measured using the Data Envelopment Analysis approach, and the determinants of this efficiency were identified using a TOBIT model. Data were collected in 4 regions: GBEKE, HAMBOL, PORO and WORODOUGOU. In the four regions studied, the average technical efficiency is 49.2% in Variable Scale Efficiency (VRS) and 38.3% in Constant Return to Scale (CRS). Based on our results, the producers in the study area were not efficient. The producers who follow the good practices, have a technical coefficient estimated at 74.2%, and superior to those who follow the good practices, of which, the coefficient is estimated at 70.2%, in Variable Scale Efficiency (VRS). The technical efficiency of farms was positively influenced by the age of farms and agricultural advisory services, and negatively influenced by the pruning practice. Income from cashew farming in the study area (21,816 to 37,987 CFAF/person/year according to region) is below extreme poverty line (CFA F 122,385/year/person), leading to deteriorating cashew/food terms of trade. Cashew farming is often used as a means of land appropriation and of getting credit. Its rapid expansion has dramatically reduced land for subsistence agriculture, raising an accute food security issue. Cashew farming has helped improve poverty indicators through macroeconomic policy. However, this impetus from the agricultural sector economy remains insufficient to boost the modernization of the agricultural sector. The country still has all assets (research institutes, schools of agronomy, skills etc.) to reverse this situation. Hence the he study recommends that producers capitalize on exogenous variables which can improve agricultural efficiency. It also recommends coaching organizations to use technical efficiency measurement and identification of effectiveness determinants to better guide their coaching. As for the Government, it should redouble efforts to implement the recommended solutions in order to avoid producer impoverishment, a barrier to harmonious development in this region of Côte d'Ivoire.

Keywords: cashew farming, poverty reduction, data envelopment analysis, Côte d'Ivoire

1. Introduction

Since independence, Côte d'Ivoire has built its economic development on agriculture. Cashew was introduced for ecological functions (fight against bush fires, land degradation due to deforestation, and the advancing desert) in the northern region of the country in the 1970s. Since 1994, it has played an economic function with an international economic climate conducive to cashew marketing. This new cash crop, first used as a means of diversifying the incomes of northern people in order to fight against poverty, gradually became a substitute for cotton, which was doubly affected by the disintegration of the sector nationwide and by the steady decline in production prices. Production strategy arbitrage between the two cash crops gradually turned in favour of cashew. Today, cashew farming covers just over two-thirds of the country. Production rose from 500 t in 1980 to 711,000 t in 2018, making Côte d'Ivoire the world's leading producer and exporter of raw nuts ahead of India and

Vietnam. This increase in cashew nuts production was not without difficulties. Cashew is mainly produced from family farms. The majority of producers usually operate small farms of 2 to 3 ha. Yields are low at 300-350 kg/ha vs 1000 kg/ha in India (and Guinea Bissau) and up to 2 tonnes in Vietnam. The quality of ivorian nuts is poor. Producers complain not only about poor sale and failure by buyers to comply with the producer price set by the Government, but also about the steady decline in producer prices. However, today the cashew economy is approx 250,000 to 300,000 producers, and 1.5 million direct and indirect jobs. It supports 246 cooperatives, 71 exporting companies, 73 commercial companies and 5 industrialists. Farming income to producers is estimated at 380.650 billion CFAF/year (FIRCA, 2018). All producers living on cashew are hoping for better incomes. The incomes are certainly dependent on the purchase price, but also on farm productivity. A vibrant agricultural sector must necessarily involve maintaining efficient farms, according to Churchill (1979), Wampach (1983), Parsons (1994) and Soegbe Sewade (2010).

Following this performance logic, the Cotton and Cashew Board set up a strategy to disseminate Good Agricultural Practices (GAPs) in order to improve farm yields. Despite the efforts made since 2013, yields are slowly evolving (300 to 500 kg/ha). Producer incomes are still low (CFAF 180,000/farm/year on average) compared to the poverty line of CFAF 269,075/person/year. And this situation has led to a deterioration of cashew/food terms of trade (Kouakou et al., 2017). According to the same author, in 1999, one kilogram of cashew was needed to buy two kilograms of rice. However, in 2013, seven (7) kg of cashew were traded for one kilogram of low quality rice sold at CFAF 350. According to Leibenstein (1978), in economics, the measurement of an entity's performance should take into account the criterion of technical efficiency, which relates the production to the factors of production used. From a scientific perspective, productive or technical efficiency analysis concerns are doubly justified. At the microeconomic level, technical efficiency measurement helps better understand productivity analyses. The same levels of individual efficiency determine collective effectiveness. Achieving efficiency in the economy as a whole therefore requires eliminating individual inefficiencies. The results of efficiency comparisons support decision-making. The position of each producer relative to the most efficient producer in the study provides an insight into the growth potential of productivity. In addition, this analysis provides useful information about the characteristics of production processes. Finally, the analysis helps identify the drivers of performance (Soegbe Sewade, 2010). Technical or productive efficiency growth is the foundation for improving producers' incomes. In fact, producers want to achieve productive efficiency, that is, to produce more without wasting production factors in order to ensure sufficient income for their families.

With a view to enhancing technical efficiency on cashew farms in Côte d'Ivoire, the Coton and Cashew Board (CCB) commissioned this study in four (4) regions: GBEKE, HAMBOL, PORO, and WORODOUGOU. The overall objective of the study was to assess the impact of the CCB on cashew producers. Specifically, it was to measure and compare the technical efficiency of producers who follow good practice and those who do not, identify the drivers of technical efficiency, and analyze the poverty situation of such producers in order to make recommendations to improve their technical efficiency.

2. Literature Review

2.1 Adoption of Technological Innovations and Socio-Economic Impact of Cashew Farming on Producers

Several studies were conducted on the analysis of farm efficiency, the adoption of technological innovations and the socio-economic impact of cashew farming on producers. Benido (2017) affirmed that there are several models to analyze the determinants of adopting good agricultural practices in cashew farming. And that the most widespread are: Tobit, Logit and Probit. However, he chose the Probit model, which is better suited to dichotomous and qualitative dependent variables. He pointed out that the determinants of adopting good practices are: the level of education of householders, the price earned from the sale of nuts, and membership of a functional producer organization. Balogoun et al. (2014) used the COBB-DOUGLAS economic profitability model to identify determinants of the annual income earned from the sale of cashew nuts. According to the author, this income is significantly influenced by the area planted, the total cost of labor, the yield of nuts, the selling price per kilogram of nuts, the producer's marital status, and access to credit. The income generated by this crop helps producers meet their needs, improve their living conditions and environment, and especially increase schooling rate. However, the development of cashew farming leads to many farmer/pastoralist conflicts and land conflicts that threaten social cohesion in the northern area of the country. Kouakou et al. (2017) confirm the predominance of cashew farming in the northern area (Bondoukou department). The emergence of cashew farming raises a serious food security problem because of scarcity of land and labor for subsistence agriculture. For this author, even though cashew farming provides income for producers, this is very low and cannot buy food to meet needs.

To understand all these failures, Stessens (2002) argues that for an innovation or production technique to be successfully adopted, it is essential to study the production system in the area. This would help better understand producer constraints (land pressure, priority, availability of labor, lack of financial resources or credit etc.) and accurately assess the conditions for adopting new technologies. To the same author, most of the agricultural development projects that operated in northern Côte d'Ivoire targeted a specific crop or aspect of the farm, neglecting the entierety and specificity of the farm and its socio-economic environment. These projects often failed to address the real and critical problems of the target groups. According to Roca (1987), the list of failed projects in sub-Saharan Africa is much longer than that of successful projects. Fresco (1986) in his "Cassava in Shifting Cultivation" reached a similar conclusion. Apart from cotton farming and the localized adoption of animal traction, no other innovation was really successful in northern Côte d'Ivoire from 1962 to 1980 (Bigot, 1981). Surveys of the adoption of new varieties of maize, sorghum and millet in the regions of Ferkessédougou and Sinématiali in northern Côte d'Ivoire reveal similar results. Beets (1990) confirms this with special emphasis on the need for a thorough analysis of the farming practices, the socio-cultural system and the economics of farming systems before any intervention. Without comprehensive information on farming systems, it is highly doubtful that new techniques will be adopted by farmers because they are faced with a myriad of factors that they need to consider when making any production decision. Population density, and market access and economic profitability of farms are, *inter alia*, the main factors determining the evolution of production systems and, consequently, the adoption of agricultural innovations. According to Boserup (1965), until certain conditions for these two factors are unmet, production systems are likely to remain unchanged. Finally, the low rate of adoption of new varieties or crops and the improved techniques developed at research stations have reinforced the conviction that an in-depth study of the technical efficiency of farms and of the determinants of their effectiveness is essential before any intervention. This study would therefore provide answers for the profitability of cashew farms and their impact in the fight against poverty, based on the mathematical optimization tools coupled with the econometric model presented in the section below.

2.2 Technical Efficiency

The concept of technical efficiency has its origin in fundamental theoretical work on the behavior of firms by Debreu (1951), Koopmans (1951), and Farrell (1957). Efficiency is intended to gauge the ability of a production system to produce "at best" through the implementation of all means of production (capital, land and labor) (Coelli et al., 1998). Berger Allen and Humphrey David (1997) show that there are two main families of competing methods in the way of constructing the frontier and therefore in calculating the technical efficiencies: parametric methods and non-parametric methods. The choice between the two methods is purely optional and depends on the researcher. In the nonparametric approach, no particular analytical form is specified for the boundary, but rather the formal properties that the whole of production is supposed to respect. The non-convex non-parametric approach was proposed by Deprins et al. (1984) with the only assumption being the free disposal of productions and inputs. The convex non-parametric frontier approach was introduced by Farrell (1957) through the Data Envelopment Analysis (DEA) method. This data wrapping method was first developed by Charnes, Cooper, and Rhodes (1978) who generated the CCR model (Constant Return to Scale Model), and then by Banker, Charnes, and Cooper (1984), who produced the BCC model (Variable return to scale model). This method involves the use of linear programming techniques. The Data Envelopment Analysis (DEA) method, according to Huguenin (2013), makes it possible to evaluate the performance of organizations that turn resources (inputs) into services (outputs), and more easily takes into account multi-production technology. It helps consider several outputs and inputs at the same time, and then determines the frontier at the top of observations rather than a regression plan at their center. Calculating an efficiency score indicates whether an organization has room for improvement. By identifying the return to scale type, whether variable (BCC or Variable Return to Scale model) or constant (CCR or Constant Return to Scale model), it indicates whether an organization should increase or reduce its size to minimize its average cost of production. By setting target values (input or output orientation), it indicates by how much the inputs need to be reduced and the outputs increased for an organization to become efficient. By identifying reference pairs, the Data Envelopment Analysis (DEA) method indicates which organizations have "best practices" to be analyzed. For our part, we are interested in the BCC model. In the model developed by Banker et al. (1984), the amount of outputs produced can be maximised without the need to increase inputs. The BCC model uses the following mathematical program:

$$\text{Max } h(k) = \sum_{r=1}^{s} U_r \cdot Y_r \cdot k + C_k \text{ under constraint,}$$

$$\begin{cases} \sum_{i=1}^{m} V_i \cdot X_i \cdot k = 1 \\ \sum_{r=1}^{s} U_r \cdot Y_r \cdot j - \sum_{i=1}^{m} V_i \cdot X_i \cdot k - C_0 \leq 0 \\ U_r, U_i \geq \varepsilon \end{cases} \quad (1)$$

Where, s = number of outputs; U_r = weighting coefficient for output r; Y_r = amount of output r produced by the firm; m = number of inputs; U_i = weighting coefficient for inputs i; X_i = amount of input i used by the firm.

In short, the nonparametric method has the characteristics of being more flexible and makes it possible to avoid errors due to the poor choice of the function. However, it attributes all the inefficiency to the producer without taking into account other random factors beyond the control of the operator, which may be sources of inefficiency. Several studies have been conducted on technical efficiency.

Kane (2010) used the nonparametric Data Envelopment Analysis (DEA) method to measure the effectiveness of family farms in the Zoetelé, and a censored TOBIT to generate and identify the efficiency factors of family farms. The results show that the technical efficiency levels of family farms are estimated at 44.6% in constant returns to scale and at 67.8% in variable returns to scale. In addition, the area under cultivation and the destination of the production negatively affect the technical efficiency while membership of a peasant organization and age improve it. Djimasra (2010) measured the technical efficiency of 38 cotton-producing countries over a period from 1990 to 2008, or 1026 observations in total, using the Data Envelopment Analysis (DEA) method of the non-parametric model. The efficiency scores obtained under the Constant Return to Scale (CRS) and Variable Return to Scale (VRS) technologies are 51.9% and 73.7% respectively on average. Koné (2015) also used the non-parametric Data Envelopment Analysis (DEA) method for his analysis of the poverty and technical efficiency of cocoa producers of the Méné agricultural cooperative company. His results show that the technical efficiency for cooperative members is 33% compared with 82% for non-cooperative members. The cooperative members are therefore less efficient.

2.3 Analysis of Determinants of Technical Efficiency

Determinants are factors that have a positive or negative impact on a phenomenon to be studied. An analysis of the determinants of effectiveness uses several methods: correlation analysis, average-to-average method, variance analysis, and regression analysis, on which we will focus. Regression analysis is a method of performing regressions of efficiency indices on a number of technical or socio-economic variables. A two-step approach has been suggested (Tobin, 1958). It determines efficiency indices through discretionary variables in the production function firstly, and secondly, uses non-discretionary variables to explain efficiency. Here, two estimation methods are used: the ordinary least squares method (OLS) and the double truncation TOBIT method. Initiated by Tobin (1958), the Tobit model originated from his work modeling the relationship between a household's income and spending on durable goods. It generally refers to regression models in which the definition domain of the dependent variable is constrained in one form or another. It is a limited dependent variable model, that is, a model for which the dependent variable is continuous, but is only observable over a certain interval. It lies midway between the linear regression models where the endogenous variable is continuous and observable, and the qualitative models. To estimate the Tobit, the ordinary least squares method or the maximum likelihood method can be used. The Tobit model is as follows:

$$E_i = g(\chi_i) = \beta_0 + \sum_{i=1}^{n} \beta_i \chi_i + \lambda_i \quad (2)$$

Where, E_i is the technical efficiency index; χ_i are the technical and socioeconomic characteristics of producers; λ_i is the random term; β is the weight associated with each technical or socio-economic variable.

The model will be estimated using the maximum likelihood method, given the specificity of the dependent variable:

$$Y_i^* = \beta\chi_i + \lambda_i \quad (3)$$

Where, Y_i^* is the efficiency score for each producer; i = {1, n} is the producer index.

The use of the TOBIT model for the analysis of determinants has shown that cocoa farming as main activity, acquiring land by inheritance or gift, marital status, producer age, and farm age impact technical efficiency positively. Ndiaye (2018) analyzed the technical efficiency of family farms in Mauritius. The nonparametric Data Envelopment Analysis (DEA) approach and the TOBIT model were used to measure effectiveness and identify its determinants. The results showed that the average technical efficiency under the variable scale yield is 72.6% and that 46.5% of the sample are technically efficient under variable scale yield. As for productivity, it is significantly influenced by farmer sex, cultivated area, and salary.

2.4 Poverty Analysis

According to Eddy (2017), the farming income represents what the farm provides to the producer for his work, his land and his management. It is the result from the difference between the gross product in value (GP) and the actual costs (AC) consisting of fixed costs (CF) and average variable costs (VC). The farming income is therefore: FI (CFA F) = GP – AC = GP – (VC + FC). If the farming income is positive, then it can be concluded that the activity is economically profitable. However, if the result is negative, then the activity is said to be not economically profitable. This happens when the total costs are too high and the gross product is too low to cover them. According to Paraïso et al. (2010), very high fixed costs may make the farming income negative in the case of large investments. This indicator is also used to measure business performance, called value added. The farming income will be compared to the poverty line to assess the farmer's poverty level.

3. Methodology

3.1 Study Area and Sampling

The data were collected in four (4) regions of the country, the characteristics of which are summarized in Table 1: Poro in the north; Worodougou in the north-west; and GBêkê and Hambole in the center. The data in our study were from the 2017-2018 season. The four regions have a wet tropical climate as a whole. Rainfall is low in this area; soils are rich but very fragile. Poverty remains high (over 50%). The economy is mainly agricultural and pastoral.

Table 1. The characteristics of the four regions

Characteristics/Regions		PORO	WORODOUGOU	GBEKE	HAMBOL
Bio-physical	Relief	High plateaus at 360 m altitude	Hight plateaus at 350 m altitude	Altitude 339 metres	Altitude 326 metres
	Rainfall	1,200 and 1,400 mm	1,286 mm/year	1,139 mm/year	1,087 mm/year
	Soil	Medium or poorly desaturated ferralitic soils	Poorly desaturated ferralitic soils. Tropical brown soils. Good farmlands	Medium or poorly desaturated ferralitic soils	Ferruginous soil over ferrallitic material
	Climate	Humid tropical climate type	Sudanese type climate	Tropical type climate	Sudanese type climate
	Vegetation	Grassy savannah with trees and gallery forests and clear forests	Wooded savannah and dry clear forests	Grassy savannah and some gallery forests	Grassy savannah and some gallery forests
	Area	12,621 Km^2	11,492 Km^2	8,930 Km^2	19,497 Km^2
Human	Ethnicities	Sénoufo, Dioula, Malinké	Mandé, Sénoufo, Gouro	Baoulé, Malinké	Tagbana, Djimini
	Population	763,852	272,334	940,623	430,000
	Religion	-Muslim (54%) -Animist (16%) -Christian (9%) -No religion (20%)	-Muslim (72%) -Animist (10%) -Christian (5%) -No religion (12%)	-Muslim (37%) -Animist (23%) -Christian (21%) -No religion (15%)	-Muslim (24%) -Animist (26%) -Christian (30%) -No religion (20%)
Economic	Activities	Cereals, yam, cassava, market gardening, cotton, cashew, livestock farming, tourism	Sweet potato, cereals, coffee & cocoa, cashew, cotton, cassava, banana, livestock farming, trade, mining	Yam, banana, market gardening, cashew, trade, mangoe, citrus fruit, industry	Yam, cereals, cashew, livestock farming, trade, honey, pottery
	Poverty rate	54.0%	54.5%	54.9%	56.1%

Source: Ministère du Plan et Dévelppement, Rep. Côte d'Ivoire, 2015.

To determine the sample, we used the following Bernoulli formula:

$$n = t^2 \times p \times (1 - p)/m^2 \quad (4)$$

Where, n: Minimum sample size to get significant results for an event and a set risk level; t: Confidence level (the standard value for the confidence level of 95% will be 1.96); p: The estimated share of population presenting the characteristic estimated at 11.8%, resulting from the producers in study area/number of national cashew producers ratio (35415/300000); m: Error margin (usually set at 5%).

The size of our sample was estimated at 160 farms. The farms were selected randomly in the area concerned by the snowball approach, taking into account farmer availability and farm accessibility. A correlation test was performed to analyze the endogeneity. The distribution of our sample is shown in the Table 2.

Table 2. Distribution of our sample

Regions	Towns	Size	Total
PORO	Korhogo	20	40
	Napié	20	
WORODOUDOU	Séguéla	20	40
	Djibrosso	10	
	Sifié - Worofla	10	
GBEKE	Bouaké	15	40
	Béoumi	15	
	Bottro	10	
HAMBOL	Dabakala	8	40
	Niakara	8	
	Katiola	24	
Total			**160**

3.2 Tools and Method

3.2.1 Classification of Producers

The producers in our sample were classified into three (3) groups (low, medium and high) according to the intensity of implementation of Good Agricultural Practices (GAPs), depending on the farmer coaching organization. The practices include cleaning, fireguard, pruning, thinning, insecticide use and on-farm herbicide use. The score method is used here:

(i) We start by assigning a coefficient (1 = yes, 0 = no) of implementation to each GAP because we expect an impact on the one who implements the GAPs.

(ii) Then, we calculate the average score obtained by each producer based on the formula:

$$\text{Average Score} = \frac{\sum \text{score i}}{\text{N}} \tag{5}$$

Where, N is the number of practices considered.

(iii) Thereafter, we calculate a producer implementation rate, based on the following formula:

$$\text{ProdRate} = \frac{\sum_{i}^{n} \text{score i}}{\text{maximum total score}} \tag{6}$$

(iv) And, we calculate the average rate (AvRate) and the deviation for the rates obtained.

At the end of these stages, producers are ranked according to the rate obtained based on the following criterion:

Weak implementation: ProdRate ≤ (AvRate – Standard Deviation).

Average implementation: (AvRate – Standard Deviation) ≤ ProdRate < AvRate.

Strong implementation: ProdRate ≥ AvRate.

It was after this classification that the statistics for the different classes were extracted, and the efficiency calculated depending on classes.

3.2.2 Measuring Technical Efficiency

As part of this study, we chose Data Envelopment Analysis (DEA) in output-oriented variable return of scale (VRS-model) as a tool for measuring technical efficiency. This non-parametric convex method seems to us to be better suited for reasons of flexibility and the most widely used tool for calculating efficiency frontier and determining efficiency scores. The dependent variable or output is the Production (P) expressed in kilograms (Kg). The explanatory variables or inputs are as follows:

Land (T): This is cashew farmed area. It is expressed in hectare (ha).

Capital (K): These are the annual quantities of inputs, fixed costs and variable costs. The inputs taken into account are fertilizers, insecticides and herbicides. Fixed costs consist of equipment amortization. Variable costs consist of small agricultural equipment, transport costs, ancillary expenses (fuel, string), bags purchased and casual labor. Capital is expressed in value (CFA Francs).

Work (W): It consists of hired labor and family labor. It is expressed in man day (m-d).

(i) The Constant Return to Scale Model (CCR Model) is as follows:

Developed by Charnes et al. (1978), this model is input-oriented and assumes constant returns to scale. Thus, for each unit k, the equation amounts to maximizing the "efficiency ratio" in the presence of "s" outputs and "m" inputs. This equation can be reduced to a simplified expression of linear programming, as follows:

$$\text{Max } h(k) = \sum_{r=1}^{s} U_r \cdot Y_r \cdot k + C_k$$

Under constraint,

$$\begin{cases} \sum_{i=1}^{m} V_i \cdot X_i \cdot k = 1, \\ \sum_{r=1}^{s} U_r \cdot Y_r \cdot j - \sum_{i=1}^{m} V_i \cdot X_i \cdot k - C_0 \leq 0 \\ U_r,\ U_i \geq \varepsilon \end{cases} \quad (7)$$

Reciprocally, the CCR model may be estimated as a minimisation of the cost function. We would obtain:

$$\text{Min } f(k) = \frac{\sum_{i=1}^{m} U_i \cdot X_r \cdot k}{\sum_{r=1}^{s} U_r \cdot Y_r \cdot k}, \text{ under constraints, } \begin{cases} \frac{\sum_{i=1}^{m} U_i \cdot X_r \cdot k}{\sum_{r=1}^{s} U_r \cdot Y_r \cdot k} \leq j = \ldots n \text{ (number of units)} \\ V_r,\ U_i \geq 0 \end{cases} \quad (8)$$

(ii) Variable return to scale model (BCC):

The BCC model by Banker et al. (1984) relates to variable returns to scale. It introduces new variables into the CCR model, which distinguishes between scale efficiency and technical efficiency. The formulation of the model is as follows:

$$\text{Max } h(k) = \sum_{r=1}^{s} U_r \cdot Y_r \cdot k + C_k$$

Under constraint,

$$\begin{cases} \sum_{i=1}^{m} V_i \cdot X_i \cdot k = 1 \\ \sum_{r=1}^{s} U_r \cdot Y_r \cdot j - \sum_{i=1}^{m} V_i \cdot X_i \cdot k - C_0 \leq 0 \\ U_r,\ U_i \geq \varepsilon \end{cases} \quad (9)$$

Technical efficiency will be measured by region and by class of producers.

3.2.3 Analysis of Determinants of Technical Efficiency

The analysis of the determinants of producer technical efficiency was made by the TOBIT model. We chose this model as it is better suited for discrete dependent variables in qualitative determinants analysis. Efficiency is considered a limited dependent variable with values between 0 and 1. The model's explanatory variables are compiled in Table 3.

Table 3. Explanatory variables for the analysis of determinants of the TOBIT model

Variables	Explanation, Type of variable, and Codification	Sign expected
Area *(Area)*	Producers with a small acreage are more efficient than those with a larger acreage.	+/-
Farm age *(Farm_Age)*	Farm age will affect productivity at two levels: firstly, a young (-3 years old) or old (+25 years old) farm will have a low yield, unlike a farm that falls within this interval if the producer follows good farming practices. To take into account the age effect, we used the square shape of age. Indeed, Miyata et al., quoted by Eddy (2017), state that the relation between farmer's age and technical efficiency is U-shaped. We think it is the same for the age of the farm.	+/-
Creation and maintenance of fireguard *(Fireguard)*	Fireguard helps protect the farm from bushfires that destroy the hard work of producers. This has a positive impact on efficiency. **Codification: 1 = Yes; 0 = No**	+
Thinning *(Thinning)*	It helps respect the 10m space recommended as distance between the trees and fosters sound development of the crown. Which improves its productivity and positively impacts its efficiency. **Codification: 1 = Yes; 0 = No**	+
Pruning *(Pruning)*	Pruning involves cutting large branches that are cumbersome, diseased or dead to improve productivity. This has a positive impact on efficiency. **Codification: 1 = Yes; 0 = No**	+
Clearing *(Clearing)*	Proper maintenance of the farm by clearing (weeding) it frequently provides a better production. Clearing positively affects producer efficiency. **Codification: 1 = Yes; 0 = No**	+
Educational level *(Educ_Level)*	The more educated the producer, the better he understands training and is able to implement modern production techniques. He also has the opportunity to get necessary information on market prices and buy his inputs at a lower price. This has a positive impact on efficiency. **Codification: 1 = Yes; 0 = No**	+
Dedicated agricultural advisory service *(Agri Advisory)*	Dedicated agricultural advisory service includes several activities including training and awareness. It aims to improve producers' income and yields. This has a positive impact on efficiency. **Codification: 1 = Yes; 0 = No**	+
Sex *(Sex)*	Men have more physical strength to endure cultivation work. This has a positive impact on their effectiveness. **Codification: 1 = Yes; 0 = No**	+
Experience *(Experience)*	Technical efficiency is U shaped. The yound and oldest producers are supposed to be less efficient whilst those in the interval are more efficient.	+/-

The model is as follows:

$$Y^* = a1 \cdot Area + a2 \cdot Farm\_Age + a3 \cdot Thinning + a4 \cdot Fireguard + a5 \cdot Pruning + a6 \cdot Educ\_Level + a7 \cdot Sex + a8 \cdot Agri\_Advisory + a9 \cdot Clearing + a10 \cdot Experience + e \quad (10)$$

Where, Y^*: explained variable *i.e.*, producer efficiency index; ai: estimated coefficients whose sign indicates the meaning of the correlation between the explanatory variable and the explained variable, with i = {1, 10}; e: error term.

3.2.4 Analysis of Poverty

Farm incomes by region will be estimated, and compared with poverty benchmark in Côte d'Ivoire. The indicator used is as follows:

$$FI\ (CFA\ F) = GP - AC = GP - (VC + FC) \quad (11)$$

Where, FI is farming income; GP is gross product in value; AC is actual costs; CF is fixed costs; and VC is variable costs.

4. Results and Discussions

4.1 Characterisation of the Study Area

The population is 60% young (under 25 years old), and women—49.6% of the population—are predominantly in the vegetable and food crop trade. Cashew farming is a householder and male-dominated business. However, it involves 13% of women. Family size is 8 people on average in the Poro and Worodougou, and 6 people in Gbêkê and Hambol. The illiteracy rate among adults is 56.8% in Gbêkê and Hambol; 78.8% in Poro; and 72% in Worodougou. Funding and agricultural supervision are almost non-existent in the study area.

4.2 Measurement of Producer Technical Efficiency by Region

Data compiled in Table 4 show that the annual production per farm ranges from 50 to 9,200 kg; farm area ranges from 0.50 ha to 32 ha; annual capital from 12,000 to 1,981,500 CFA Francs; and annual work from 10 to 1,500 m-d.

Table 4. General statistics of DEA variables by region

Regions/Varibles		Production (kg)	Land (ha)	Capital (CFAF)	Work (m-d)
GBEKE (N = 40)	Minimum	50	0.50	14 500	10
	Average	1 609	3.42	261 935	298
	Maximum	6 000	12.00	1 270 667	1 320
	Standard Deviation	1 299	2.73	246 251	232
HAMBOL (N = 40)	Minimum	50	1.00	12 000	36
	Average	1 781	5.87	255 765	249
	Maximum	7 000	22.00	910 000	659
	Standard Deviation	1 521	4.83	209 744	144
PORO (N = 40)	Minimum	150	0.50	28 300	78
	Average	1 991	5.79	268 269	402
	Maximum	7 000	26.00	1 981 500	1 505
	Standard Deviation	1 631	6.00	340 928	276
WORODOUGOU (N = 40)	Minimum	150	1.00	30 000	22
	Average	2 053	6.28	269 836	211
	Maximum	9 200	32.00	1 671 667	894
	Standard Deviation	1 879	7.10	346 250	223

Over the entire study area (Table 5), the analysis shows that, on average, farmers produce 1,859 Kg; the average farming area is 5.34 ha; producers' capital is 263,951 CFA Francs; working time is 290 m-d. The standard deviations are high, illustrating a great variability of farm models.

Table 5. Statistics of DEA variables

		Production (kg)	Land (ha)	Capital (CFAF)	Work (m-d)
Total Sample N = 160	**Minimum**	50	0.50	12 000	10
	Average	1 859	**5.34**	**263 951**	290
	Maximum	9 200	32.00	1 981 500	1 505
	Standard Deviation	1 591	5.48	289 158	233

To understand the endogeneity, a correlation test was run, and the results are presented in Table 6.

Table 6. Correlation matrix (Pearson)

Variables	Production	Land	Capital	Work
Production	1	0.523	0.262	0.277
Land	0.523	1	0.481	0.245
Capital	0.262	0.481	1	0.211
Work	0.277	0.245	0.211	1

The Pearson correlation test shows that the correlation coefficients observed between variables are very different from 1. The variables are therefore not correlated with each other, and there is no endogeneity between the variables of our DEA model. Selection biases were treated by randomization. People surveyed were selected randomly in the area concerned by the snowball approach, taking into account their availability, accessibility and willingness to contribute to the study. And the results are shown in Table 7.

Table 7. General statistics of DEA variables over total sample

NUM	Codprod	REGION	CRSTE	VRSTE	NUM	Codprod	REGION	CRSTE	VRSTE
1	Prod1	GBEKE	0.305	0.487	81	Prod81	PORO	0.500	0.469
2	Prod2	GBEKE	0.416	0.421	82	Prod82	PORO	0.386	0.469
3	Prod3	GBEKE	0.386	0.445	83	Prod83	PORO	0.386	0.468
4	Prod4	GBEKE	0.386	0.923	84	Prod84	PORO	0.500	0.468
5	Prod5	GBEKE	0.500	0.857	85	Prod85	PORO	0.386	0.467
6	Prod6	GBEKE	0.072	0.762	86	Prod86	PORO	0.316	0.467
7	Prod7	GBEKE	0.386	0.745	87	Prod87	PORO	0.236	0.467
8	Prod8	GBEKE	0.386	0.723	88	Prod88	PORO	0.500	0.467
9	Prod9	GBEKE	0.386	0.721	89	Prod89	PORO	0.386	0.465
10	Prod10	GBEKE	0.386	0.859	90	Prod90	PORO	0.386	0.465
11	Prod11	GBEKE	0.386	0.843	91	Prod91	PORO	0.386	0.463
12	Prod12	GBEKE	0.386	0.843	92	Prod92	PORO	0.386	0.462
13	Prod13	GBEKE	0.386	0.843	93	Prod93	PORO	0.386	0.462
14	Prod14	GBEKE	0.100	0.578	94	Prod94	PORO	0.386	0.459
15	Prod15	GBEKE	0.386	0.663	95	Prod95	PORO	0.386	0.459
16	Prod16	GBEKE	0.500	0.659	96	Prod96	PORO	0.386	0.459
17	Prod17	GBEKE	0.386	0.659	97	Prod97	PORO	0.386	0.459
18	Prod18	GBEKE	0.386	0.656	98	Prod98	PORO	0.386	0.457
19	Prod19	GBEKE	0.386	0.520	99	Prod99	PORO	0.386	0.457
20	Prod20	GBEKE	0.200	0.519	100	Prod100	PORO	0.386	0.455
21	Prod21	GBEKE	0.500	0.510	101	Prod101	PORO	0.386	0.454
22	Prod22	GBEKE	0.386	0.495	102	Prod102	PORO	0.386	0.452
23	Prod23	GBEKE	0.167	0.492	103	Prod103	PORO	0.386	0.449
24	Prod24	GBEKE	0.386	0.493	104	Prod104	PORO	0.416	0.443
25	Prod25	GBEKE	0.200	0.492	105	Prod105	PORO	0.386	0.439
26	Prod26	GBEKE	0.386	0.496	106	Prod106	PORO	0.312	0.438
27	Prod27	GBEKE	0.386	0.495	107	Prod107	PORO	0.386	0.437
28	Prod28	GBEKE	0.100	0.495	108	Prod108	PORO	0.386	0.436
29	Prod29	GBEKE	0.500	0.492	109	Prod109	PORO	0.386	0.435
30	Prod30	GBEKE	0.500	0.492	110	Prod110	PORO	0.386	0.433
31	Prod31	GBEKE	0.386	0.491	111	Prod111	PORO	0.386	0.432
32	Prod32	GBEKE	0.386	0.491	112	Prod112	PORO	0.386	0.432
33	Prod33	GBEKE	0.500	0.490	113	Prod113	PORO	0.386	0.431
34	Prod34	GBEKE	0.386	0.489	114	Prod114	PORO	0.386	0.429
35	Prod35	GBEKE	0.416	0.489	115	Prod115	PORO	0.386	0.427
36	Prod36	GBEKE	0.386	0.489	116	Prod116	PORO	0.500	0.425
37	Prod37	GBEKE	0.386	0.489	117	Prod117	PORO	0.500	0.425
38	Prod38	GBEKE	0.386	0.489	118	Prod118	PORO	0.308	0.425
39	Prod39	GBEKE	0.386	0.489	119	Prod119	PORO	0.386	0.424
40	Prod40	GBEKE	0.298	0.489	120	Prod120	PORO	0.386	0.424
41	Prod41	HAMBOL	0.386	0.489	121	Prod121	WORODOUGOU	0.386	0.418
42	Prod42	HAMBOL	0.500	0.489	122	Prod122	WORODOUGOU	0.386	0.414
43	Prod43	HAMBOL	0.386	0.488	123	Prod123	WORODOUGOU	0.386	0.408
44	Prod44	HAMBOL	0.386	0.488	124	Prod124	WORODOUGOU	0.386	0.402
45	Prod45	HAMBOL	0.386	0.488	125	Prod125	WORODOUGOU	0.386	0.499
46	Prod46	HAMBOL	0.386	0.488	126	Prod126	WORODOUGOU	0.416	0.499
47	Prod47	HAMBOL	0.386	0.488	127	Prod127	WORODOUGOU	0.500	0.498
48	Prod48	HAMBOL	0.386	0.487	128	Prod128	WORODOUGOU	0.501	0.497
49	Prod49	HAMBOL	0.386	0.486	129	Prod129	WORODOUGOU	0.500	0.494
50	Prod50	HAMBOL	0.386	0.486	130	Prod130	WORODOUGOU	0.386	0.493

51	Prod51	HAMBOL	0.500	0.486	131	Prod131	WORODOUGOU	0.386	0.489
52	Prod52	HAMBOL	0.386	0.486	132	Prod132	WORODOUGOU	0.386	0.487
53	Prod53	HAMBOL	0.310	0.486	133	Prod133	WORODOUGOU	0.386	0.487
54	Prod54	HAMBOL	0.386	0.486	134	Prod134	WORODOUGOU	0.386	0.478
55	Prod55	HAMBOL	0.386	0.485	135	Prod135	WORODOUGOU	0.500	0.475
56	Prod56	HAMBOL	0.410	0.485	136	Prod136	WORODOUGOU	0.386	0.462
57	Prod57	HAMBOL	0.416	0.485	137	Prod137	WORODOUGOU	0.386	0.459
58	Prod58	HAMBOL	0.386	0.485	138	Prod138	WORODOUGOU	0.500	0.459
59	Prod59	HAMBOL	0.400	0.484	139	Prod139	WORODOUGOU	0.386	0.456
60	Prod60	HAMBOL	0.127	0.484	140	Prod140	WORODOUGOU	0.386	0.456
61	Prod61	HAMBOL	0.386	0.483	141	Prod141	WORODOUGOU	0.386	0.452
62	Prod62	HAMBOL	0.386	0.482	142	Prod142	WORODOUGOU	0.227	0.452
63	Prod63	HAMBOL	0.386	0.482	143	Prod143	WORODOUGOU	0.386	0.449
64	Prod64	HAMBOL	0.416	0.482	144	Prod144	WORODOUGOU	0.386	0.447
65	Prod65	HAMBOL	0.386	0.481	145	Prod145	WORODOUGOU	0.386	0.445
66	Prod66	HAMBOL	0.279	0.479	146	Prod146	WORODOUGOU	0.386	0.443
67	Prod67	HAMBOL	0.500	0.479	147	Prod147	WORODOUGOU	0.416	0.443
68	Prod68	HAMBOL	0.501	0.478	148	Prod148	WORODOUGOU	0.386	0.429
69	Prod69	HAMBOL	0.386	0.478	149	Prod149	WORODOUGOU	0.386	0.429
70	Prod70	HAMBOL	0.386	0.478	150	Prod150	WORODOUGOU	0.386	0.425
71	Prod71	HAMBOL	0.386	0.478	151	Prod151	WORODOUGOU	0.386	0.417
72	Prod72	HAMBOL	0.361	0.478	152	Prod152	WORODOUGOU	0.072	0.415
73	Prod73	HAMBOL	0.386	0.476	153	Prod153	WORODOUGOU	0.386	0.404
74	Prod74	HAMBOL	0.500	0.475	154	Prod154	WORODOUGOU	0.386	0.457
75	Prod75	HAMBOL	0.386	0.475	155	Prod155	WORODOUGOU	0.500	0.456
76	Prod76	HAMBOL	0.386	0.475	156	Prod156	WORODOUGOU	0.386	0.455
77	Prod77	HAMBOL	0.167	0.475	157	Prod157	WORODOUGOU	0.386	0.454
78	Prod78	HAMBOL	0.386	0.474	158	Prod158	WORODOUGOU	0.386	0.354
79	Prod79	HAMBOL	0.386	0.472	159	Prod159	WORODOUGOU	0.400	0.354
80	Prod80	HAMBOL	0.386	0.472	160	Prod160	WORODOUGOU	0.386	0.404

The distribution of technical efficiencies from our estimations shows that they are centred around 0.4 (Figure 1) and 0.4-0.5 (Figure 2) as variable return to scale and constant return to scale respectively.

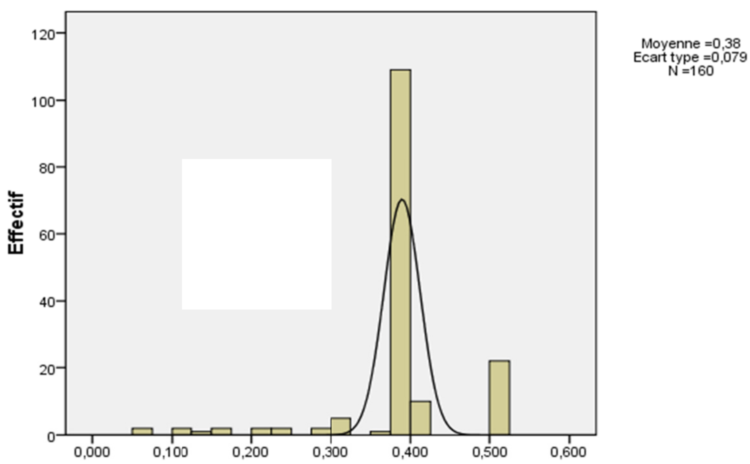

Figure 1. Kernel density of technical efficiency in constant return to scale

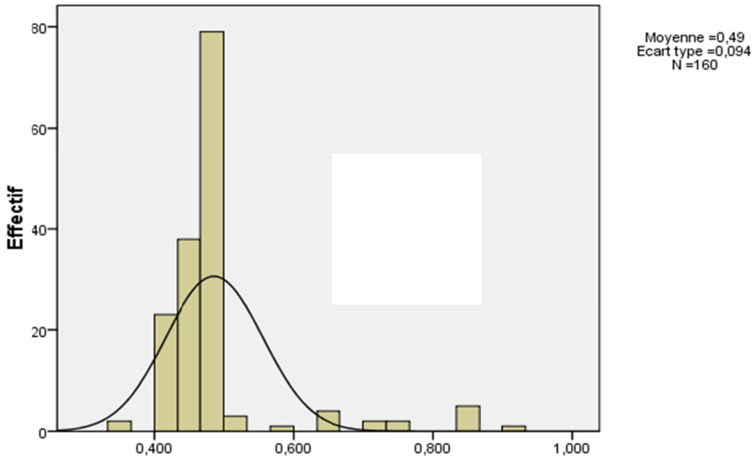

Figure 2. Kernel density of technical efficiency in variable return to scale

To measure the technical efficiency of farms, in practice, two linear programming models are used: The first one measures the overall technical efficiency by estimating a production frontier in constant return to scale. This is known as Overall Technical Efficiency (OTE). The second one measures Pure Technical Efficiency (PTE), considering the variable return to scale assumption. The transition from one assumption to another requires a scale of change called Scale Technical Efficiency (STE), which is obtained in a residual way using the ratio of the overall technical efficiency score to that of pure technical efficiency.

Ultimately, overall technical efficiency (Constant Return to Scale assumption) combines two components, *i.e.*, pure efficiency (Variable Return to Scale) and Scale Technical Efficiency, as follows:

$$OTE = PTE \times STE \quad (12)$$

A company is said to perform well and is considered as "best practice" for others when its efficiency score is equal to one. Table 8 presents the results of the DEA model by region assuming Variable Return to Scale (VRS), Constant Return to Scale (CRS) and Scale Technical Efficiency (STE). This table contains the average efficiency scores assuming constant returns to scale (OTE), which is also overall efficiency. The total efficiency consits of pure efficiency (efficiency assuming variable return to scale (PTE) and Scale Technical Efficiency (STE).

Table 8. Producer efficiency scores by region in percentage terms

Regions	Technical efficiency in CRS (OTE)	Technical efficiency in VRS (PTE)	Scale efficiency (STE)
GBEKE	58.9%	64.6%	91.7%
HAMBOL	34.4%	47.6%	73.5%
PORO	53.9%	65.0%	83.8%
WORODOUGOU	58.5%	72.1%	82.5%
Total	38.3%	49.2%	80.2%

In all four regions surveyed, the average technical efficiency is 49.2% VRS and 38.3% CRS, with a Scale Technical Efficiency (STE) of approx. 80.2%. Based on our results, farms in the four regions are technically inefficient. The comparative analysis shows that two regions are always well ranked regardless of the yield assumptions used. These are Worodougou—ranking 2nd in Constant Return to Scale (CRS) and 1st in Variable Return to Scale (72.1%), and Gbêkê—ranking 1st in Constant Return to Scale (58.9%) and 3rd in Variable Return to Scale (VRS). Whatever the yield assumption, the Hambol region remains the last of the four regions in terms of efficiency. The observed inefficiency could be explained by the mismanagement of inputs by producers. This input wastage also leads to additional production costs. However, the Worodougou region's technical efficiency advantage over the other regions may be due to good rainfall in the area because of the forest in the region.

4.3 Measurement of Producer Technical Efficiency by Class

Based on good practice criteria according to coaching organizations, *i.e.*, cleaning, fireguard, pruning, thinning, and on-farm use of insecticide and herbicide, farms can be categorised into three (3) classes: the best (40 farms), the average ones (40 farms) and the small ones (35 farms). Technical efficiency for these farms was measured according to this categorization. The results obtained are compiled in Table 9. Our results show that in Variable Return to Scale (VRS), low-class producers have a higher efficiency index than high-class producers. In Constant Return to Scale (CRS), the weakest rank second behind the class of farms that are said to be the best or strong.

Table 9. Producer efficiency scores by class in percentage terms

Regions	Technical efficiency in CRS (OTE)	Technical efficiency in VRS (PTE)	Scale technical efficiency (STE)
WEAK (35 farms)	52.6%	74.2%	71.9%
AVERAGE (40 farms)	39.1%	50.3%	78.7%
STRONG (40 farms)	61.2%	70.2%	85.2%
Total	38.3%	49.2%	80.2%

We believe that the better efficiency in the weak farms class is due to the rationality of producers in this class, who waste less inputs. Producer coaching organizations favor productivity over rational input management and farm surface control. These results show that the higher the size of the farm, expressed in hectare of planted area, the less efficient the management. Especially as farms operate in a hostile environment (climate, lack of proven technological progress, lack of funding, difficult access to roads, poor supervision, etc.). These results also reflect perhaps a limitation of the Data Envelopment Analysis (DEA) compared to financial measures that incorporate the market price of inputs and outputs. The Data Envelopment Analysis (DEA) or technical efficiency measurement reflects the managerial efficiency of the production system. These results also reflect the competing objectives between the coaching organization pursuing farm capitalization, and a destitute farm manager or producer who wants to maximize his profit. Productivity is a simple-looking indicator that measures the relationship between production and the factors required to achieve it. This is the primary indicator of the farmer's or farm manager's dashboard. For a destitute producer, local agricultural productivity is one of the drivers of economic growth; and the analysis of agricultural performance helps identify priorities to be defined in terms of agricultural strategies, accompanying measures, and support required. This leads them to be more rational in the use of production factors. We supplement our analysis with regression studies to incorporate exogenous factors—at least some of them—which may explain the observed efficiencies.

4.4 Analysis of Determinants of Producer Technical Efficiency

The TOBIT model yielded the results reported in Table 10. They show significant correlation at different levels of significance, and signs between efficiency indices and some factors. Our results show that the determinants of producer technical efficiency are "farm age", "dedicated agricultural advisory service" and "Pruning". The other factors are not significant but affect producers' technical efficiency positively or negatively.

Table 10. TOBIT results

Variables	Coefficient	Std error	z	Critical p.
Consistency	0.453123***	0.170338	2.6601	0.00781
Educational level	-0.0456175	0.0485794	-0.9390	0.34771
Experience	0.00181162	0.00415628	0.4359	0.66293
Agricultural advisory service	**0.13508*****	**0.0519841**	**2.5985**	**0.00936**
Sex	0.0630268	0.0778211	0.8099	0.41800
Farmer age	**0.0052757***	**0.00313513**	**1.6828**	**0.09242**
Clearing	0.0101493	0.120204	0.0844	0.93271
Fireguard	-0.020125	0.0775157	-0.2596	0.79515
Thinning	0.0407037	0.0560915	0.7257	0.46804
Pruning	**-0.108553****	**0.0523708**	**-2.0728**	**0.03819**
Area	-0.00436376	0.00486784	-0.8964	0.37001

Note. Level of significance: * = 10%; ** = 5%; *** = 1%.

The "Agricultural Advisory Service" variable is significant at 1%, and positively impacts efficiencies. This is in line with our expectations because producers who are provided with agricultural advisory service receive more information and more pragmatic guidelines to improve their production. This positive correlation is explained by the fact that good practices improve agronomic conditions for good production. But unfortunately, these good practices generate additional costs, which the additional production in value, can not support. This is why producers who follow good practices are not technically efficient, as our results above show. The "Farm Age" variable is significant at 10%, and has a positive impact on efficiencies. This means that the oldest farms (more than 25 years old) produce less than the youngest ones, according to a study by the *Initiative Cajou Africain* (ICA—African Cashew Initiative) and GIZ, which shows that production reaches its maximum between 15 and 20 years, and decreases from the age of 20. Eddy (2017) obtained this result. Kane (2010) and Koné (2015) also found that farm age improved efficiency. The ''Pruning'' variable is significant at 5%, and adversely impacts efficiencies. Such result is counter-intuitive because this practice eliminates poorly growing, diseased or dead branches to improve productivity. However, the result can be explained by poor implementation of related advice. Indeed, if producers do not sort branches properly, it is normal to achieve poor performance. In addition, the negative impact is short term because a few months later, the cut branches will resume producing. In view of our results, we recommend that cashew producers take literacy classes regardless of their age in order to better understand training and benefit from new technologies in the field; they should join peasant professional organizations to receive training, avoid input wastage as this leads to additional production costs and makes the farms less efficient. They should properly implement maintenance practices, especially pruning, to avoid any counter-effect. As for coaching organizations, we recommend that they use this approach for measuring the technical efficiency and/or financial productivity of farms, and Tobit-type regression models to guide the accompanying strategies. We suggest they capitalize on factors that are exogenous to farms and can improve their efficiency.

4.5 Analysis of Poverty

Poverty is defined as a situation where a person does not have sufficient income to meet their basic needs (food, housing, clothing, health care, and schooling). Poverty line is the indicator of poverty measurement, while the Gini index (or coefficient) is a synthetic indicator of wage inequalities (income, living standards, etc.). It varies between 0 and 1. It is 0 in a situation of perfect equality where all wages, incomes, standards of life are equal. It is 1 in the most unequal situation possible one where all wages (income, living standards, etc.) except one are zero. Between 0 and 1, the inequality is stronger when the Gini index is high. To understand poverty in the study area, we estimated farming income. The enrichment of farms, and the income per person per year and per day were estimated. This data tabulated below will be compared to the poverty and extreme poverty indicators shown in the table 11.

Table 11. Evolution of poverty lines in current francs during the surveys

Year	1985	1993	1995	1998	2002	2008	2015
Poverty line (in F/year)	75 000	101 340	144 800	162 800	183 450	241 145	269 075
Extreme poverty line (in F/year)		63 375	86 760	95 700	94 280	101 826	122 385

Source: Ministère du Plan et du Développement, INS-ENV (2015) and previous years.

National poverty line in the global economy is estimated at CFA F 269,075/year/person, or CFA F 737/day/person. Extreme poverty line is estimated at CFA F 122,385/year/person, or CFA F 340/day/person (Ducroquet, H., 2017). This indicator in the cashew sector, based on the income procured, is estimated at 380.650 billion CFA F in 2018; the income/person/year is estimated at CFAF 158.604 or CFA F 441/day/person. This shows that cashew farmers nationwide have an income below poverty line and can be considered as poor.

The income in CFA F/person/year for producers in the study area is estimated at 37,987 in the Gbêkê region; 21,816 in the Hambol region; 36,630 in the Poro region; and 37,476 in the Worodougou region (Table 12). These incomes are all below the extreme poverty line estimated at 122,385 CFAF/person/year. With such a level of income (less than 1 dollar/day/person), the producer only survives, and cannot capitalise on his farm. This low financial profitability of cashew farms is due to the low producer price, which is indexed to the international market price, to the small size and the low yield of farms. Knowing that he does not have enough financial resources, the producer does not seek to be a good applicator of good practices that require resources. He rather wants to be rational, and therefore a good manager. This is why smallholders, and those who are not good practitioners, are the most financially efficient in our study. In this sense, it is easy to understand why producers do not follow the coaching organizations' guidelines for good farming practices.

Table 12. Producer farming income by region

	Regions			
	GBEKE	**HAMBOL**	**PORO**	**WORODOUGOU**
Average farm area in Ha	3	3	3	3
GROSS PRODUCT (PBA) IN CFAF	**592 200**	**374 850**	**558 600**	**455 700**
Yield in Kg	564	357	532	434
Average selling price in Kg	350	350	350	350
VARIABLE COSTS IN CFAF	276 725	185 235	252 000	144 120
Insecticide in CFAF	2450	7 560	19 650	9 330
Herbicide in CFAF	35 955	26 850	32 160	37 500
Fertiliser in CFAF	1 500	825	2 250	3 450
Other expenses (fuel, transport, bag, string) in CFAF	30 075	15 660	28 290	10 245
Small farm equipment in CFAF	25 080	16 035	38 085	16 515
Casual labour in CFAF	211 740	118 305	131 565	67 080
FIXED COSTS IN CFAF	11 580	15 090	13 560	11 775
Depreciation allowance	11 580	15 090	13 560	11 775
FARMING INCOME IN CFAF/YEAR/FARM	303 895	174 525	293 040	299 805
Average size of households	8	8	8	8
Farming income/year/person in CFAF	**37 987**	**21 816**	**36 630**	**37 476**
Farming income/day/person in CFAF	**105**	**61**	**102**	**104**

Source: Survey data, 2018.

The financial inefficiency of good practitioners is due to the more than proportional rise in input prices relative to the physical productivity of farms. These realities are very often poorly taken into account by coaching organizations in developing agricultural technical itineraries. At the macro-economic level, poverty rate dropped from 48.9% in 2008 to 46.3% in 2015 because of the economic recovery combined with the efforts made by the Government to improve living conditions. The poverty rate dropped from 62.5% to 56.8% in rural areas, while in urban areas, it dropped from 29.5% to 35.9% because of rural exodus. This shows that poverty is essentially rural. Also, the spatial distribution of poverty reveals that it is higher in northern regions (high cashew producing area) and lower in southern regions (cocoa producing area). In our study area, poverty ranges from 51.5 to 59.9% and is above the national average (46.3%) according to FMI (2016). The Gini index shows that inequalities are gradually being reduced in Côte d'Ivoire. It was 0.405 in 2015 vs 0.420 in 2008 and 0.500 in 2002 (UNDP, 2017). In all regions of the project area, this indicator is estimated at 0.398 and is close to the national benchmark (0.380) according to FMI (2016).

Cashew farming also raises an acute problem of food security in terms of non-availability of land for subsistence agriculture and of deteriorating cashew/food terms of trade, as confirmed by Kouakou et al. (2017). According to this author, in 1999, 1 kilogram of cashew nut was needed to buy two kilograms of rice. However, in 2013, 7 kg of cashew were traded for 1 kilogram of low quality rice sold at 350 CFAF. Beyond monetary gains, cashew production involves other underlying interests. The determinants of cashew farming are also psychological. According to Kouakou et al. (2017), some people own large areas of orchards and take pride in them not for monetary profitability, but rather to appear as big farmers. Because of this activity, they have easy access to credit in their community when in need. Also, the cashew tree, a perennial crop, allows people to own land permanently. It is an opportunity to acquire land ownership rights because no one can snatch a plot on which trees have been planted. Cashew thereby becomes legal proof of land ownership. So, very often, improving yield to increase farming income is not a priority, compared to land race. It can therefore be argued that cashew farming seems to be a virtuous circle of poverty. And when a cashew producer does not get enough income to live on, he is forced to engage in other activities such as food crops, vegetable crops, trade etc. All the activities conducted by a producer to get income in order to live determine his production system. To innovate in our environment, we should deepen our knowledge of our environment, our land and labour constraints, and our priorities, etc. or our production system in order to minimize the risk of failure. This justifies, as Stessen (2002) and Boserup (1965) argued, that it is necessary to always study production systems in order to avoid technical innovation adoption failures.

5. Conclusion

The study reveals that with regard to efficiency, whether in terms of constant or variable return to scale, the farms in the study area as a whole are not technically efficient (49.2% in Variable Return to Scale and 38.3% in Constant Return to Scale). However, comparatively, the Worodougou region is doing better at 72.1% in VRS, and the region with the lowest efficiency is Hambol with 47.6% in VRS. Regarding the three classes' efficiency in terms of good practice, it should be remembered that the farm group with low application of good agricultural practices has the best rate of technical efficiency (74.2% in Variable Return to Scale).

The "Agricultural advisory service" variable is significant at 1% and positively impacts efficiencies. This positive correlation is explained by the fact that, good practices improve agronomic conditions for good production. But unfortunately, these good practices generate additional costs, which the additional production in value, can not support. This is why producers who follow good practices are not technically efficient, as our results above show. The "Farm Age" variable is significant at 10% and has a positive impact on efficiencies. This means that the oldest farms (more than 25 years old) produce less than the youngest ones, according to a study by the *Initiative Cajou Africain* (ICA—African Cashew Initiative) and GIZ, which shows that production reaches its maximum between 15 and 20 years, and decreases from the age of 20. Eddy (2017) got such a result. Kane (2010) and Koné (2015) also found that farm age improved efficiency. The ‘‘Pruning’’ variable is significant at 5% and adversely impacts efficiencies.

The poverty analysis has shown that, at the national level, the cashew sector provides agricultural producers with an income of CFA F 158,604/person/year, or CFA F 441/day/person. This income is below the poverty line estimated at CFAF 269,075/year/person, or CFA F 737/day/person. The income in CFA F/person/year for producers in the study area is estimated at 37,987 in the Gbêkê region; 21,816 in the Hambol region; 36,630 in the Poro region; and 37,476 in the Worodougou region. All these incomes are below the extreme poverty line estimated at CFA F 122,385/person/year. With such a level of income (less than a dollar/day/person), the producer only survives, and cannot capitalise on his farm. Knowing that he does not have enough financial resources, the producer does not seek to be a good applicator of good practices that require resources. He rather wants to be rational, and therefore a good manager. This is why smallholders and those who are not good practitioners are the most financially efficient in our study. In this sense, it is easy to understand the reasons why producers do not follow coaching organizations' guidelines for good farming practices. Cashew farming also raises an acute issue of food security in terms of non-availability of land for subsistence agriculture and of deteriorating cashew/food terms of trade. It is used not necessarily to get income, but to acquire land ownership rights, to be held in esteem in society and to get financial credit. It can therefore be argued that cashew farming seems to be a virtuous circle of poverty. This is why we believe, like Etessen (2002) and Boserup (1965), that for a technological innovation to be successfully adopted, it is essential to carry out an in-depth analysis of the producer's production system in terms of its efficiency and of the determinants for its proper functioning.

In view of the foregoing, it can be argued that cashew farming is not financially profitable for the majority of producers, but economically profitable because it provides income for many people and businesses. Cashew farming has helped improve poverty indicators through macroeconomic policy. However, this impetus from the agricultural sector economy remains insufficient to boost the modernization of the agricultural sector. The country still has all assets (research institutes, schools of agronomy, skills, etc.) to reverse this situation.

The study recommends that producers capitalize on exogenous variables which can improve farm efficiency, such as farm age, agricultural advisory services, and good pruning practice. It recommends that coaching organizations use technical efficiency measurement, and efficiency determinants identification to better guide their support. Cashew has been introduced in these four regions to revive and support their economies. The low profitability of cashew farms illustrated in this study requires that the Government redouble its efforts to address the identified failures and to implement the recommended solutions, in order to avoid a pauperization of producers, resulting in rural exodus, thereby undermining the harmonious development of the Ivorian economy.

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