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MODELLING PERCEPTION AND ECONOMIC PERFORMANCE OF TEAK (*TECTONA GRANDIS*) PRODUCTION IN RURAL PLANT NURSERIES OF BENIN REPUBLIC

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Abstract

In Benin Republic, teak sector is the most active among the wood markets with a strong national demand. It is therefore necessary to improve its efficiency. This study aimed at modelling the perception and economic performance of teak plant production in some rural nurseries. To this end, a survey was conducted among 140 teak nurseries in northern, central and southern regions of Benin using the "snowball" sampling method. Interviews organized with plant nurserymen served to gather data on their demographic and socio-economic characteristics, plant production techniques, production costs and output, and teak production perception. The perception of producers and the performance of teak plant production were modeled respectively from a logistic regression model and then from a linear regression model. The analysis of the results showed that the age of the nurseryman, unlike variables such as gender and seniority in production, negatively influences the economic performance of teak plant production. Household size also influences the economic performance of teak plant production and the perception of the nurseryman, but with a negative effect on the last variable. Nevertheless, the number of years of schooling and the nurseryman's assessment of the distance between the plant nursery and his home has a positive influence on his perception. Policies development aimed at improving the production of teak plants in Benin would therefore require particular attention to these different determinants.

Key words**:** *Benin, economic performance, modelling, perception, teak*

INTRODUCTION

Forest plantations are particularly important for economic and social development of rural areas in Benin. They also play a crucial role in maintaining environmental functions [13, 19,20]. Teak (*Tectona grandis Lf*) is a tropical tree species with a significant economic potential [29, 32]. Globally, teak occupies about 5.7 million hectares, of which about 250,000 are in Africa [6]. Native to Southeast Asia, its wood is prized for centuries and it is not uncommon to find old carved works, doors and vaults entire in Indian and Persian temples [24]. In West Africa, teak is the forest species most used [2, 31]. It was introduced there about a century in Nigeria (1889), Tanzania (1898), Ghana (1905), Cameroon and Togo (1907-1912) [43]. In Benin, a West African country, forest formations were valued at 4.311 million hectares [18] on a total of 19,000 hectares of forest plantations [5, 17]. According to [7], domanial plantations are teak alone covering about 15,000 ha. In Benin, the importance of teak in the economic area as well as environmentally is also highlighted [3]. Several studies have shown the importance of the revenue generated by the production of teak) [36]. These benefits also involve job creation, added value and revenue generated through downstream processing and distribution of the product [37].

However, forest cover decrease for about 50,000 ha per year, being 1.06% of the total forest cover per year [17]. This loss affecting

the overall Beninese forest cover could threaten teak wood production in general, affecting the economy of production particularly. Therefore, reforestation policies are conducted by the Beninese Government to encourage local authorities to invest in teak plantations (*Tectona grandis Lf*) [42]. Thus, in order to fill this deficit and meet the high demand for wood in the domestic market, it appears imperative to improve teak production. This study aimed at modelling perception and economic performance of the production of teak in the rural nurseries of Benin.

MATERIALS AND METHODS

Study Area

The study was conducted in the Republic of Benin, a tropical country in West Africa. It was carried out from the north to south of the country. To this end, nine (9) Research sites were identified, Tori-Bossito, Toffo and Agbomey Calavi in the South; Savè, Dassa and Glazoué in the Center; Parakou, Bembèrèkè and Malanville in northern Benin. These areas were selected because of the large number of plant nurseries existing in each of them, and the important contribution of these different areas of Benin teak production. According to [37], the southern area of Benin like the other two areas alone contributes to 69.2% of the domestic wood. By adding the contribution of the Center region, this estimate could be around 85% of total production. South and Center teak plantations benefits from a sub-equatorial type of climate in transition to tropical climates (Sudanian or Sudan Guinea) characterized by an average annual rainfall varying from 1,100 mm/year to 1,200 mm/year [30]. They are all characterized by four seasons: two rainy seasons alternating with two dry seasons. The average temperature ranges from 27°C to 28°C [30]. The North area meanwhile have a Sudanese type of climate that varies between 1,100 and 1,200 mm/year with alternating two (02) seasons: A (01) rainy season extends from May to October and a (01) dry season from November to April [16].

Sampling and database

The study population represents teak producers. Surveyed are nurserymen ensuring the management and control of production operations and maintenance of teak plants in nurseries. To this end, the sample is composed of both North, Center and South nurserymen. In total 140 nurseries spread over 9 research sites were investigated. The research sites are located in the municipalities of Tori-Bossito, Toffo and Agbomey Calavi in the South; Savè, Dassa and Glazoué in the Center; and Parakou, Bembèrèkè and Malanville in Northern Benin.

Table 1 shows the structure of the formed sample. The said sample was prepared from the snowball method (snowball sampling).

Table 1. Distribution of teak nurseries surveyed by area and municipalities

Areas	Municipalities	Number of nurseries surveyed	Percentage of the total sample (%)
South	Abomey	8	5.7
	Tori-Bossito	18	12.9
	Toffo	9	6.4
Center	Dassa	13	9.3
	Glazoué	14	10.0
	Savè	8	5.7
North	Bembèrèkè	20	14.3
	Parakou	35	25.0
	Malanville	15	10.7
Total		140	100.0

Source: Results of investigation (2018).

The data collected from the sampled nurserymen were related to demographics and socio-economic (gender, age, affiliation or not to a Peasant Organization, years of schooling, household size, access to extension service, seniority in the production of teak), expenses and production costs recorded by the nursery and their perception of the production of teak nursery plants. Note that all these data were collected during surveys (structured interviews) based on a questionnaire containing both open and closed questions. The veracity of this information was evaluated by triangulation through focus groups.

Constitution, processing and analysis of performance data

Analysis of economic performance

In this study, the economic performance of the production of teak plant nurseries was evaluated from several economic performance indicators on the basis of expenses and production costs recorded by the nursery. This study is inspired by the work of [8, 10, 16, 33, 37]. Some profitability indicators such as Product Gross Value (PBV), the Gross Income (RB) and Net Income (RN) have been calculated.

The Gross Product Value (PBV) is designated by the multiplication of the number (Q) of teak plants by the selling Price Unit (PU). Thus, the Gross Product Value (PBV) is given by:

PBV = Q * PU ..... (1)

The Gross Income (RB) in turn corresponds to the difference between the Gross Product Value and Variables charges (CV). The Variable Charges represent costs directly related to production inputs acquisition (teak seeds, polyethylene bags, fungicides, insecticides, fertilizers and casual labor work). The Gross Revenue is calculated by deducting from PBV all expenses directly related to production. Note that the Gross Income is the wealth created by the teak nursery. Its formula is given:

RB = PBV- CV .....(2)

It is expressed in FCFA/1,000 plants. If RB> 0, then it is concluded that the Gross Product Value arrives to cover the costs Variables. The production of teak plant in nurseries is economically profitable from the perspective of Revenue Gross operating the nursery.

Net Income (RN) of output is obtained by subtracting from the Gross Product Value (PBV), the total cost (CT) or by deducting from Gross Income (RB), fixed costs (CF). It is given by the following formula:

RN = PBV - CT = PBV - CV - CF = RB - CF .....(3)

It is expressed in FCFA/1,000 plants. If RN> 0, then it is concluded that the Gross Product Value manages to cover both Fixed and Variable Costs. The production of nursery teak plants is economically profitable. By cons, if RN <0, then the Gross Product Value cannot cover all the costs of production. In this case, the production is not economically profitable. Note that Fixed Costs (FC), correspond to expenses incurred by the operation but not related to the output level. These charges are related to depreciation of agricultural equipment, membership fees and finance charges. Charges related to depreciation are determined by applying a linear damping rate to the total value of acquisition of the equipment for the nursery for the execution of production activities. This rate corresponds to the inverse of the life of the equipment [44]. The life and cost vary from one tool to another. The tools used in the various sites are: hoe, rake, watering can, wheelbarrow, etc.

Identification and analysis of the determinants of economic performance

One of the objectives of this study is to analyze the determinants of economic performance in the production of teak nurseries. The research methodology was made based on the work of [4, 26, 41]. In order to analyze the determinants of economic performance, a multiple linear regression model was developed on the basis of 140 nurserymen. The equation of the regression model can be written as follows:

$$y = \alpha 0 + + \alpha 1 xi\ Ɛi \quad \text{.....(4)}$$

where: y is the dependent variable, the explanatory variables xi, α is a constant called "intercept" and Ɛi the error term of the model.

The explanatory variables included in the model are: age of the nurseryman, gender, household size, membership of a Peasant Organization, seniority in the activity, the ease of access to water, access to extension services. From the existing literature and observations in the field, various reasons to justify the inclusion of these variables in the regression model. Thus, age, a variable

expressed in years, is a parameter determining the economic performance of agricultural production. Indeed, the more the nurseryman is aged, the more he is gaining experience to improve the economic performance of his activities. Age could positively influence the economic performance of production. It is a dichotomous variable coded by the value 0 if the producer is a woman; and 1 if he is a man. Certain factors are likely to prevent women from devoting themselves full time to the maintenance of their plants. Household size is a source of labor power for any farm. Therefore, it could positively influence the net income of the teak nursery. Whether or not to belong to a cooperative of nursery farmers (OPA) could also have a positive effect on the economic performance of production. Indeed, nurseries belonging to a group receive training and various forms of support to help them improve the economic performance of their operations. It is a binary variable taking the values 1 if the nurseryman is a member of an OPA or 0 if not. In addition to these variables, the experience of the nurseryman positively influence the net income from operations. The more the nurseryman has experience in planting teak, the more he has strengths and knowledge that will enable him to improve his teak production; which production could be done without other essential factors among such water. Indeed, water is an indispensable factor in teak production. Although, all nurseries have access to water, some easier to that resource than others. This variable could have a positive or negative effect on the economic performance of nursery. So this is a dichotomous variable that takes the value 1 when the nurseryman has easy access to water and 0 if not. Some nurserymen benefit from the support of agricultural services and certain development projects in order to improve the performance of their production. Access by nurserymen to agricultural services is therefore an important variable; it is a binary variable taking the value 1 if the nurseryman has access to the various extension services or 0 otherwise. This variable could positively influence the economic performance of production. Tables 2 and 3 show a summary of all the variables included in the model with their expected sign.

Table 2. Summary of model variables and the expected signs for Net Income

Variables	Variable Types	Descriptions	
Variables explained			
Net Income (RN)	Quantitative	Dependent Variable: Net Income Value of operating the nursery	
Explanatory variables			Expected sign
Age	Quantitative	Age nurseryman	+
Sex	Qualitative	Gender nurseryman 0 = Female, 1 = Male	+
Household size	Quantitative	Number of people forming the household	+
Belonging to a OPA	Qualitative	Whether or not a takeover 0 = No, 1 = Yes.	+
Seniority	Quantitative	Years of experience in nursery	+
Ease of access to water	Qualitative	Ease of access to water 0 = No, 1 = Yes	±
Access to extension services	Qualitative	Access or not to extension services 0 = No, 1 = Yes.	+

Source: Results of investigation and documentary research (2018).

Table 3. Summary of model variables and the expected signs for nurseryman perception

Variables	Variable Types	Descriptions	
Variables explained			
Nurseryman perception	Quantitative	Dependent: Perception Nursery	
Explanatory variables			Expected sign
Household size	Quantitative	Number of people forming the household	+
Belonging to a OPA	Qualitative	Whether or not a takeover 0 = No, 1 = Yes.	+
Seniority	Quantitative	Years of experience in nursery	+
Years of schooling	Qquantitative	Number of years of schooling	+
Distance from home to nursery	Qualitative	Distance between home and the nursery nursery 0 = Close, 1 = Far.	+

Source: Results of investigation and documentary research (2018).

Constitution, processing and analysis of data on perception

Mobilized Data

The evaluation of the perception of teak production by nurserymen can be developed on several fronts. In this study, it was focused on their perception of technical and economic performance of the production of nursery teak plants. The technical performance measures the ability of the farm to get the maximum outputs from a combination of inputs and or its ability to achieve a given level of output from smaller quantities of inputs [23]. The production will be economically efficient when the nursery is making profit from his operations [27]. To this end, a series of questions was asked to each nurseryman forming the sample to set the variable "perception of technical and economic performance of the production." Chronologically, the questions were: 1) Do you think the production of teak plants is economically viable? 2) By combining all production inputs, do you think you achieve maximum profit? 3) From the combination of your resources, are you satisfied with your production of teak plants? 4) What do you consider the parameters that influence both economic performance and technical teak production in nursery.

Processing and data analysis

In this study, the approach used to analyze the technical and economic performance perception of nurserymen has been designed into a model. The model was based on demographic and socioeconomic characteristics of nurserymen. These are: household size of the nursery, membership of a cooperative, experience in production, the number of years of schooling, and the appreciation of the distance between home and the nursery (Table 3). Based on the literature review, two main types of models are commonly used to analyze the perception of producers. These are mainly logit regression model and Probit model. Here, as developed by [28] we adopt the logit model to specify the relationship between the probability of perceiving the technical and economic performance of the production and its determinants. Logit models have been introduced for decades by [12, 25, 35, 39] to explain the choice of a profession in its different perspectives [28]. This model is often used in the case studies of perception based on an econometric model for the convenience. In addition, the Logit model maintains the estimated probability between 0 and 1 [38].

[1] present the model by the following equation:

$$E(Y) = P(Y) = \frac{e^{\alpha+\beta Xi}}{1+e^{\alpha+\beta Xi}} \quad \text{.....(5)}$$

When the producer does not perceive the technical and economic performance of the production of teak plants, the probability becomes for this purpose:

$$P(\text{non-perceived}) = 1 - P(Y) = \frac{1}{1+e^{\alpha+\beta Xi}} \quad \text{.....(6)}$$

where:

P (Y): The probability of a nurseryman i to perceive the technical and economic performance of the production; P (Y) = 1 if the nurseryman perceives and 0 if not.

e: The exponential function

Yi: the dependent variable; perception of technical and economic performance of the production of teak,

β: The vector of parameters to be estimated whose sign allows the interpretation of results

α: Constant

Xi: i characteristic of the nurseryman; it represents the vector of variables

with

$$X = \beta 0 + + \beta 1 TailM\ \beta 2 AppOPA\ \beta 3 Exp + + + \beta 4 AnSco\ \beta 5 Dist \quad \text{.....(7)}$$

where: TAilM = Household size of nursery,

AppOPA = Belonging to a OPA,

Epx = Seniority in the production ANSCO = the number of years of schooling,

Dist = Evaluation of the distance between home and the nursery the nursery.

RESULTS AND DISCUSSIONS

Techniques of teak plant production

The information collected in the field and the comments made, provided a record of the technical route followed by nurseries for the production of teak plants in Benin. Four main phases have been identified. These are: the acquisition of teak seeds, triggering pre-germination, planting itself and for the maintenance of seedlings. These different plant production steps are similar to that identified by [37] in the Atlantic region in southern Benin. Two main sources of seed supply have been identified. The collection of teak seeds at the foot of mature trees in the dry season is the first form of acquisition and is used by nearly 65% of nurserymen who have been investigated. The second approach is supply by purchasing or support of the governmental structures. There is two different varieties of seeds. The local variety and the variety of Tanzania. However, the variety of Tanzania remains the most requested by producers.

Indeed, the latter compared to the local variety showed better growth performance [22]. It is a variety of seeds tested and introduced by the National Office of Wood in order to improve national level production. As was mentioned above, the seed is obtained after the outbreak of the pre-germination of the seed and sowing. Thereby, Seeds are exposed to sun and watered until the release of rootlets. This operation is conducted by all nurseries because of the physical dormancy of teak seeds [14]. It follows by the maintenance of seedlings. Nurserymen maintain seedlings through watering and regular weeding and by providing the necessary minerals.

Economic performance production plants

The costs and expenses indicated by nurserymen have been utilized to assess the economic performance of the production of teak plants in Benin. Indeed, nurserymen in the production plants are facing different forms of production costs. The analysis of the results allowed us to distinguish fixed costs and variable costs of production.

Table 4. Costs and revenue for 1,000 teak plants in CFA

Elements	Average	Standard Deviation
Seeds	323.67	65.32
Polyethylene bag	2,881.42	482.77
Soil	108.03	91.31
Fertilizers	269.69	40.12
Fongicides-Insecticides	441.32	50.56
Casual labor	8,617.85	2,540.92
Variable costs	12,642.01	2,584.39
Amortization	3,453.57	1,694.14
Various Charges	401.03	97.11
Fixed costs	3,854.60	1,698.46
Total costs	16,496.62	7,668.34
Revenue generation	74,464.28	32,755.34
RNE	**57,967.66**	**32,790.46**

Source: Results of estimates made with SPSS.

Table 4 presents costs and revenue for 1,000 teak plants in CFA.

These identified charges are identical to those highlighted by [15].

Thus, for a production of 1,000 teak plants, with higher variable costs as fixed, nurseries on average perform an expenditure of 16,496.62 CFA (± 7,668.34) and realize an average revenue of 7,668.34 CFA (± 32,755.34) (Table 4).

According to [9, 40], net income from operations of nurseries being positive, we can conclude that the production of teak plants is profitable in Benin. These results are consistent with those of [37] whose economic evaluation led to the conclusion that the production of teak production is profitable in Southern Benin.

Modeling the perception of producers and production performance

The perception of producers and the teak plants production performance were modeled respectively from a logistic regression model and a linear regression model (Table 5). Estimated models are generally significant at the 1% level (probability <0.01). Thus, unlike to the age of the nurseryman, variables such as gender and experience in production

negatively affect the economic performance of the production of teak plants. Household size influences both the perception of nurseries that economic performance teak production. But unlike the economic performance of the production, it has a negative effect on the perception of producers producing teak plants.

Table 5. Estimation results of the econometric models

	Performance Model			Perception model		
Variables	***Coefficient***	***t***	***prob***	***Coefficient***	***z***	***prob***
Constant	8,431.434	0.55	0.580	-0.487	-0.79	0.427
Age	-527.575 **	-2.06	0.041	-	-	-
Sex	11,814.270 *	1.96	0.052	-	-	-
Belonging to a takeover	3,988.615	0.89	0.372	0.536	1.24	0.212
Household size	1,770.793 **	3.11	0.002	-0.089 *	-1.76	0.079
Ease of access to water	6,644.879	0.69	0.494	-	-	-
Access to the extension service	17,955.180	1.89	0.61	-	-	-
Seniority	1,332.023 **	3.00	0.03	0.062	1.46	0,144
Number of years of schooling	-	-	-	0.100 **	2.18	0,029
Distance from home to nursery	-	-	-	1,830 ***	4.06	0.000
Abstract models	Number of observation = 140 F (7, 132) = 6.78 Prob> F = 0.0000 *** R-squared = 0.4268 Adj R-squared = 0.3964			Number of observation = 140 LR chi^2 (5) = 30.13 Prob> chi^2 = 0.0000 *** Log pseudolikelihood = -67.760437 Pseudo R^2 = 0.1819		

***: significant at the 1% (P _ 0.01); **: significant at 5% (0.01 <P _ 0.05); *: Significant at 10% (0.05 <p _ 0.10).
Source: Results of estimates made with STATA.

The age and sex

Age has a negative and significant effect at the 5% level on the economic performance of teak production. We therefore conclude that the more nurseryman is aged, the less he took advantage of his operation. Indeed, becoming older nurseryman is less involved in his operations. An old nurseryman is not really open to new technologies that are proposed to improve his production and indirectly the income of his operations. As age of the nurseryman, sex has a negative and significant effect at the 10% probability level on the economic performance of the production. From these results, it is concluded that male perform better than female producers. Male are heads of their households and have to deal with the different needs of their households which are food and health-care. To this end, they are involved as much as possible in their operation in order to get the most profit from their exploitation. Moreover, women in the study area, unlike men, by their mother nurturing function they play in their household [34] devote little time to their operations so as not to miss their obligation.

Seniority in production

The seniority of the nurseryman defines his years of experience in the production of teak plants. This variable has a positive and significant effect at the 5% level of economic performance production. Indeed, the nurseryman, gain experience from the previous challenges he used to face before. Thus, the more experienced he is, the more he has assets that will enable him to better

produce and maximize the output. This is what justifies the positive effect of the seniority of the nurseryman on the economic performance of the production.

The household size

Household size is a potential source of labor and allows producers to increase production. This variable has a positive and significant effect on the level of 1% of economic performance production. Thus, the bigger nurseryman household, the higher he gets to benefit from his operations. Indeed, the members forming the nursery household (spouse (s), child (ren) and relatives) represent a potential workforce source; a workforce that can be called "free" [21] because it does not require any payment. He performs by cons an indirect payment in the sense that he has to meet the needs of the household from income of the production. However, this payment qualified as indirect has a negative influence on the perception that the nurseryman have on the technical and economic performance of the production. Indeed, household size has a negative and significant effect at the 10% level on the perception of the nurseryman. According to him, the larger the household, the less he takes advantage of its operations.

The number of years of schooling

In a context of development, education has always been a key parameter. The number of years of schooling has a positive and significant effect at the 5% level on nurserymen perception. According to these, the more the nurseryman is educated, the better he benefits from its operation. The educated nurseryman is able to read, write and have a minimum master of basic operations management tools. According to [15], Education is a factor of crucial importance because it enables producers to understand and establish the account of his operations. To this end, the most educated nurserymen have the facility to apply the guidance received during the training and information sessions within groups. The combination of these assets allows teak producers to improve their production and income in turn.

The distance between home and the nursery

The distance between home and the nursery also influences the perception of nurserymen. This parameter has a positive and significant effect at the 5% level on the latter. According to nurserymen, when the nursery is close to their home, they easily go there and make the longest possible maintenance operations. Nurserymen whose nursery is near the farm, get to perform on average 7 to 8 hours of working time per day; unlike those whose nursery is far who have only 3 to 4 hours daily working time. The production of teak plants, like any other agricultural production requires important maintenance [11].

CONCLUSIONS

This study aimed to modelling perception and economic performance of the production of teak in rural plant nurseries of Benin. According to the analysis, teak production is economically profitable and technically efficient as perceived nurserymen. The analysis of the determinants of perception and economic performance of the production identified and highlight all of the parameters that will enhance the production of teak plants in Benin. Thus, Age of the nurseryman unlike variables such as gender and seniority in production negatively affect the economic performance of the production of teak. Household size affects both the perception and economic performance of teak production, but with a positive effect on the latter. Nevertheless, the number of years of schooling and the appreciation of the nursery of the distance between the operation and home positively influences the perception. Policy development for improving the production of teak production in Benin must therefore pay special attention to these determinants. This will not only boost the national economy in terms of wealth creation, but also participate in the fight against drought and climate changes that threaten local populations. The support of extension services, Non Governmental Organizations and relevant international institutions will also facilitate attending this goal.

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