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Thème :

Adaptation au changement climatique : un défi pour une agriculture durable, la sécurité alimentaire et la paix au Sahel

Theme:

Adaptation to Climate Change : A Challenge for Sustainable Agriculture, Food Security and Peace in the Sahel

Volume 1

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Farm size effect on rice production in the office of Niger in Mali

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Abstract: This study aims to determine the effect of farm size on rice production from collected data from 105 rice producers in the Office of Niger zone. The augmented Cobb Douglass production function was used to estimate effects of the rice farm size and socio-economic characteristics of farmers on the rice farm production. The results show a high level of correlation between the farm size and rice production in the study area. The coefficient of determination (R2) is found to be 82.21%. This shows that the farm size alone is explaining up to 82,21% of the rice production in the Office of Niger area. The overall F test indicates that the used model explains about 64% expected result at 1% significant level. The sum of variables' coefficients is 0.89 which is less than 1. This result means that rice farmers in ON zone are working at decreasing rate of scale meaning that if all production factors (farm size and labor) are increased by 1%, total production will increase by 0.89%.
Key words: Farm size, effect, rice production, Office of Niger, Mali

RESUME : Cette étude porte sur l'effet de la superficie sur la production du riz à partir des données collectées 105 riziculteurs dans la zone Office du Niger. La fonction de production de Cobb Douglass augmentée a été utilisée pour estimer les effets de la taille de l'exploitation rizicole et des caractéristiques socio-économiques des agriculteurs sur la production de l'exploitation rizicole. Les résultats montrent qu'il existe une forte corrélation entre la superficie et la production. Le coefficient de détermination (R2) qui est 82,21 % montrent que la superficie seule explique jusqu'à 82,21% de la production dans la zone. Le test de la significativité du modèle utilisé indique que ce modèle explique à 64,03% le résultat attendu avec une probabilité de 1%.
La somme des coefficients des facteurs de production est de 0,89 < 1. Cela montre un rendement d'échelle décroissant. Ce qui signifie que lorsque les facteurs de production (la superficie exploitée et la main d'œuvre totale employée) augmentent de 1 % la production totale augmente de 0,89 %.
Mots-clés: Effet, taille de l'exploitation ; production du riz ;Office of Niger ; Mali

I. INTRODUCTION

Mali has significant rice potential with areas considered suitable for irrigation is estimated at nearly 2,200,000 ha. However, this potential is only valued at 36% according to (1) and it is closely linked to the evolution of production systems.

This great potential could enable it to quickly achieve food security. Indeed, the interior delta of the Niger River is of inestimable wealth for the country and constitutes a major asset for the development of agriculture in Mali, a country where about 75% of the population lives off agriculture. The latter contributes 40% of the Gross Domestic Product (GDP) and provides nearly 30% of export earnings. As for rice, it represents about 30% of national cereal production and covers 80% of national needs. (2) .

The figures below show the evolution of production in area from 2000 to 2019

Figure 1: Production variation at the national level

Source: Data from (3) CPS/SDR/ON, 2019

At the national, between the 2000/2001 and 2018/2019 seasons, the cultivated areas in rice and total production in paddy increased respectively from 352 739 ha in 2001 to 790 642 ha in 2018, i.e., an increase of 124.1%. As for productions, they increased from 214 548 tons to 3 002 526 tons, i.e., an increase of 1 299.5%.

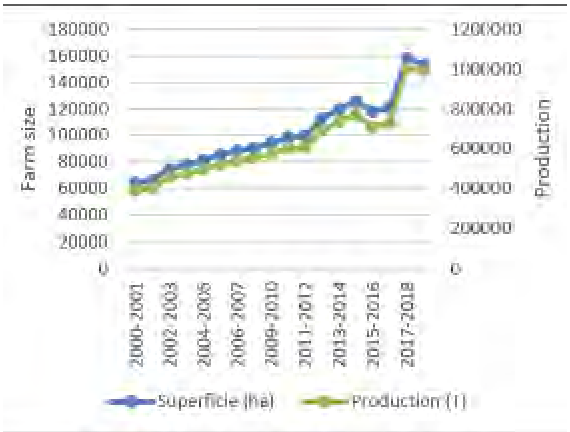

Figure 2 : Production variation in ON area
Source: (3) Data from ***CPS/SDR/ON, 2019***

As for the ON zone, the cultivated areas in rice during the same period increased respectively from 64 038 ha in 2001 to 153 452 ha in 2018, i.e., an increase of 139.6%. Regarding production, they increased from 390 630 tons to 993 879 tons, i.e., an increase of 154.4%. we noticed that production in the ON zone represents only 33.1% of national production.

It should also be remembered that the population in the ON zone was 236 116 persons in 2000 (4). It reached 600 913 persons in (5). As for the number of farms, it increased from 19 470 farmers in 2000 to 78 816 farmers in 2019, an increase of 304.8%. According to (6), the irrigated area per family has fallen dramatically since the end of the 1970s, to the point that access to irrigated land has become “the main issue for the future of family farming in this area.

For better understanding of production variation at the national level and in the ON area, the equation for the regression line has been computed. The figures below show the result of the regression as well as the equation line.

- *On a national level:*

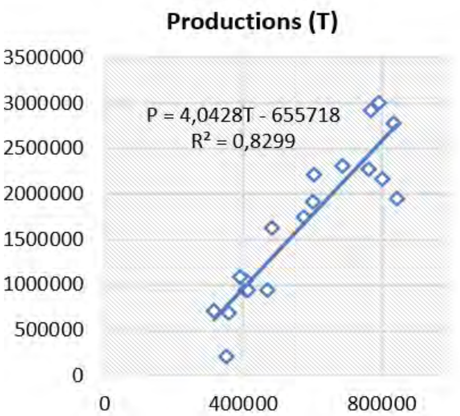

Figure 3: National Level
Source: (3) Data from CPS/SDR/ON, 2019

The equation for the regression line for national rice production is P = 4.0428T- 655 718. This explains if we increase the farm size by one-hectare, national production increases by 4.048 tons, all other variables being constant.

Tableau1: Dispersion and linear regression line of rice production as a function of rice farm size at national.

National level			
R	**R-squared**	**Adjusted R- squared**	**estimated std. Error**
0.910	0.8299	0.819	351 149
P = 4.0428T - 655718			

R: The correlation coefficient, the relation between the domestic rice production and the rice farm size is about 91% it shows a very high correlation.

R2: the coefficient of determination which is 82%. The adjustment is strong, the rice farm size alone explains up to 82% of national production.

- ***In the ON zone***

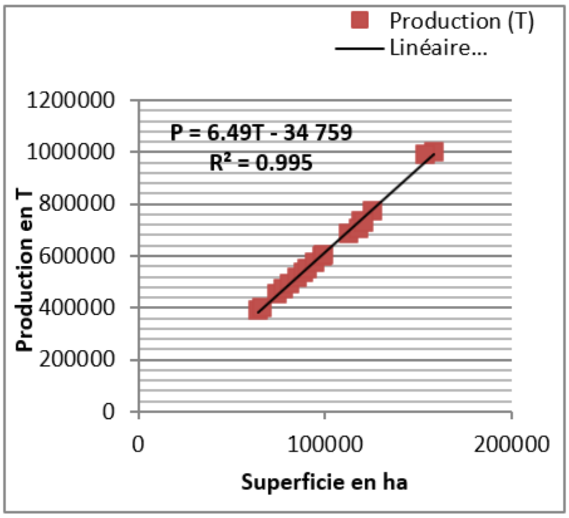

Figure 4: Regression line of production at the national Level

Source: (3) Data from CPS/SDR/ON, 2019

The equation of the regression line for rice production in the ON zone is P = 6.49T – 34 759 explaining that if we increase the farm size by one hectare, production in the zone increases by 6.49 tons, ceterus paribus.

Tableau2: Dispersion and linear regression line of rice production as a function of rice farm size at ON level

Office of Niger area			
R	**R-squared**	**Adjusted R-squared**	**estimated std. Error**
0.997	0.995	0.994	12 561.39

R: The correlation coefficient, the relation between rice production and rice farm size is 99.7%, this indicates almost a perfect correlation.

R2: the coefficient of determination is 99.5%. The adjustment is strong, the rice farm size alone explains up to 99.5% of the production in the ON zone.

Rice is the second component of Malian agriculture after millet and the country's main staple product (7). Despite this importance, its productivity still remains low, where yields are significantly lower than the potential yield estimated at 5 or 6 tons per hectare at the national level (8). This confirms the result of the regression which is 4.0428 tons.

II. MATERIAL AND METHODS

The data collection in the field was carried out over seven months (from June to December 2017). The investigations took place in all seven zones of the ON. However, in order to update certain information as part of this study, the investigations continued until February 2020. The survey was carried out among one hundred and five (105) rice farmers, twenty-one (21) focus groups and technical agents from different areas.

ANALYSIS METHOD AND TOOLS

This study is based on the augmented Cobb-Douglas function (9) which includes age, sex, educational level, matrimonial status household size to explain production level.
According to (10), the output produced Y is expressed in term of the use of a set of input variables X but the assumption is that, the use of these inputs is under effective control of the decision maker.
Y=f(X)
Where Y is the Output (or production of rice farm) produced and X is the input vector (x1,…,xn)
According to (11), the outcome of production can be explained not only by the factors that directly affect production but also the factors involved in the use of these factors which directly impact production. Thus, Y can be expressed as…
Y=F(K,Lab,seed,land,Exogenous variables)
In agricultural production, the output is expressed in term of capital, labour, land, seed, as direct input variables. Some other exogenous variables such as socio-economic characteristic can also affect the output produced. in such case we talk about the augmented Cobb Douglas production function that can be expressed as:
Y=F(k,lab,land,seed,age,sex,edu,hhs,μ_i) (1)

Where,

Y: is the production of rice farm. It is measured as total output produced.

K: capital used to produce; it is expressed in term of income of household producing rice;

Lab: labour force used by in rice farm in term of man per day
Seed: quantity of seed (whether improved or conventional)
Sex: the essence of that is to see if the sex of rice farmer is affecting rice production in the study area and to measure the average productivity between male and female
Age: Age of rice farmer. The objective of the use of age is to determine if the age is affecting rice production.
Education (EDU): It is used as multinomial variable none (0), alphabetise (1), koranic (2), Primary school (3), Secondary school (4) and Senior high school (5), university (6)
Household size (HHS): It is defined as a group of persons sharing the same living accommodation and pool some, or all, of their income and wealth. Certain types of goods and services, mainly housing and food are consumed collectively (12).
μi: unobserved variables that skip our attention in the regression
Agricultural productivity is defined as output per unit of input" or "output per unit of land area" by a number of scholars

$$E = \frac{Y}{X_i} \quad (2)$$

Where E represents the productivity level, Y is the output and Xi is the specific input.

The optimal output depends on the optimal combination of available set of inputs variables which are used as a production factor.
Optimal combination of inputs yields high productivity of the farm. So many factors can influence this optimal combination production, we have not only production factors (input variables) but also socio-economic variables which play an important role in the efficient use of the factors of production.
The logarithm transformation of augmented Cobb Douglas production function made the model linear in parameters. Thus, the parameters of inputs are interpreted as partial mean elasticity of production with respect to input variables.

2.1. Objective: rice farm size effects on production

Following (9), augmented Cobb Douglass production function was used to estimate effects of the rice farm size and socio-economic characteristics of farmers on the rice farm production.

$$Y_i = f(\beta_i, X_i, \delta_i, Z_i, \mu_i) \quad (3)$$

Linear functional form of Cobb Douglass production function

$$Y_i = \beta_0 + \sum \beta_i \ln X_i + \sum \delta_i Z_i + \mu_i \quad (4)$$

where Yi is the outputs of rice, Xi's are the explanatories variables β0 is the intercept or total

factor productivity, βi and δi are the parameters of the function to be estimated, Zi's are socio-economic characteristic or exogenous variables of the model and µi is the error term depicting unobserved variables.
Expanding the model
n of inputs variables. Among factors influencing rice.

$$Y = \beta_0 + \beta_1 land + \beta_2 \ln FertM + \beta_3 \ln FertO + \beta_4 \ln Lab + \beta_5 \ln Seed + \beta_6 PPC$$
$$+ \delta_1 Age + \delta_2 Sex + \delta_3 Edu + \delta_4 SM + \delta_5 HHS + \mu_i$$

(5

2.2. Hypothesis

H0: Farm size has no effect on the rice farm production
Ha: Farm size has a positive effect on rice the farm production
Validation of Hypothesis:
T-test was used to validate the null hypothesis (H0)

$$T\_cal = \frac{\beta_i - a}{SE(\beta_i)} \quad (6)$$

T-cal = calculated value, βi = estimated parameter for the ith explanatory variable and a is the restricted value,
SE (βi) = standard error of the ith parameter
If T-cal ≥ T-crit, reject Ho in favour of Ha

III. RESULTATS & DISCUSSION

3.1. RESULTATS

3.1.1. Description des variables quantitatives

The average production is 20.3 tons with a minimum of 1.27 tons, a maximum of 103.5 tons and a standard deviation of 18.5 tons. The average farm size is 4.9 hectares with a minimum of 0.75, a maximum of 20 hectares and a standard deviation of 4.10 hectares. The size of their household is 16 people on average with a minimum of 02 people and a maximum of 85. As for the number of active people, it is on average 6.3 with a minimum of 0 and a maximum of 40. The Average age of the head of household is 47 years with a minimum of 22 years, a maximum of 78 years and a standard deviation of 9.65 years.

Tableau 3: Descriptive analysis

Variable	Mean	Std. Dev.	Min	Max
Production (kg)	20323.66	18529.21	1275	103500
Farm size (m²)	49796.19	41058.37	7500	200000
Seed (kg)	348.5733	287.4086	52.5	1400
Fert M (kg)	1492.762	1232.937	150	6000
Fert O(kg)	2489.810	2052.918	375	10000
PPC (l)	8.857143	7.142005	1	35
Water-Fees (Fcfa)	333634.5	275091.1	50250	1340000
Lab_(heure)j	2151.886	2939.332	120	19200
Age	47.41905	9.653398	22	78
HHS	16.93333	16.56413	2	85
nb_Male	9.847619	11.45793	1	80
nb_female	8.447619	10.26662	0	64
nb_actif	6.361905	5.528117	0	40

3.1.2. Correlation analysis

This analysis measures the degree of correlation between quantitative variables such as total production (kg), farm size (m²), quantity of seed used (kg), organic and mineral fertilizers (kg), phytosanitary products (in liters), the water charge (F cfa) and the total labor force employed (in hours per day

Tableau 4: Correlation analysis

	V1	V2	V3	V4	V5	V6	V7	V8
Production (kg): V1	1.00							
Farm size (m²): V2	0.85	1.00						
Seed (kg) V3	0.85	1.00	1.00					
Fert M (kg): V4	0.85	1.00	1.00	1.00				
Fert O (kg): V5	0.85	1.00	1.00	1.00	1.00			
PPC (l): V6	0.85	0.99	0.99	0.99	0.99	1.00		
Water-fees (F): V1	0.85	1.00	1.00	1.00	1.00	0.99	1.00	
Lab_(heure)j : V1	0.59	0.58	0.58	0.58	0.58	0.58	0.58	1.00

The analysis of this table indicates a level of perfect correlation between the farm size and the quantity of seed used, organic and mineral manures, chemicals products, water fees. There is also a level of perfect correlation between the quantity of seed used and organic and mineral manure, chemicals products, water fees. We also observe a level of perfect correlation between the quantity of organic and mineral fertilizers used and chemicals products, the water fees.

Thus, these perfect correlations can be explained by the monitoring and supervision in the area by the technical agents. Almost all producers know that fertilizer requirements are estimated as follows DAP (100 kg / ha); NPK (200 kg / ha; Urea (200 kg / ha); and industrial organic fertilizers (1 ton / ha). Industrial Organic manure is used at a rate of 1ton/ha. Farmers, in the ON zone, use two varieties of seed (Kogoni 91-1 and ADNY-11) which are very popular with consumers. The cultivation of BG 90-2 is declining to the detriment of Kogoni 91-1 because of its greater vulnerability to viral infection (13).

Because of these perfect correlations, all of these input variables could not be used in our Cobb Douglas production function, hence the need to choose among these variables according to our objective. Thus, the farm size variable was favored in order to explain its importance amongst the different farms on production in the study area.

Tableau 5: Description of qualitative variables

Number of obs	=	105
F(7, 97)	=	64.03
Prob > F	=	0.0000
R-squared	=	0.8221
Adj R-squared	=	0.8092
Root MSE	=	.42116

lnproduction	Coef.	t	P>t
lnland	0.8809	7.53	0.000
lnlab	0.0125	1.01	0.315
sex_of_head	0.6418	2.00	0.048
sta_matri_chef	0.0446	0.56	0.58
Age_of_head	0.0014	0.32	0.751
Education	- 0.0067	- 0.27	0.789
Household size	- 0.0025	- 0.75	0.453
_cons	- 0.8904	- 0.91	0.366
RET	1.57		
RE sup-mot	0.89		

The test of the significance of the used model indicates that this model explains to 64.03% the expected result at 1% significant level.

R^2 is 82.21 shows us that the chosen independent variables explain 82.21% the dependent variable (production).

The sum of the coefficients of the production factors is 0.89 <1. This shows a decreasing return to scale. It means that, increasing production factors t (rice farm size and the total labor force employed) by 1%, will increase the total production by 0.89%.

This table is the result of the log linear regression of total production as a function of production factors such as farm size (the harvested area) and labor (total labor force employed) and socio-economic characteristics (sex, age, education level, household size and marital status).

The result indicates that the variable farm size has a positive significant effect on rice production at 1 % significant level with a coefficient 0.89 meaning that if the farm size is increased by 1% the quantity produced will increase by 0.88% all things being equal. The variable labour has positive effect on production but not significant. Among socio-economics characteristics, only sex has a positive significant effect on rice production at 5% significant level.

3.2. DISCUSSION:

Analysis of this result shows that only area and sex have a significant effect on rice production in the ON zone with a coefficient of 0.88 and 0.64 significant at 1% and 5% respectively. This result is supported by that of (14), who found that gender, size of cultivated area and wage significantly influence the technical efficiency of agricultural production.

It was also proved by(15) that the farm size factor has a significant effect on production, an increase of 1% of the production area leads to an increase in rice production of 0.51%.

In short, we found that the rice farm size variable has a higher contribution to the increase in production with a coefficient of 0.88.

Indeed, farmers with the largest cultivated areas are more technically efficient than those with small areas. On the other hand, he asserts that women farmers are technically more efficient than men in their operations. However, this result contradicts ours which proves men are technically more efficient than women in ON rice production.

Our result was also confirmed by (16), farm size is the dominant factor in improving rice production as well as technical efficiency of smallholder farmers in Sindh, Pakistan. Our result is in line to the conclusions of (17) and (18) who found a positive and significant link between area and production. So, this means that when rice farmers have enough land, their rice production considerably improves.

Regarding labor, it has a positive relationship with production but not significant, this may be due to a very high level of use of herbicides and tillers in the area. According to (19), 16% of farms would have expenses to remunerate external labor in the ON zone.

As for the level of education, it has a negative relationship with the production but not significant. The level of education of the producers has little or no effect on the productivity in the irrigated perimeter. on the other hand, according to the (7)DIAMOUTENE study in 2018, the level of education has a positive sign in agricultural production.

IV. CONCLUSION

With the secondary data that are available at the national level and in the ON zone showing if the area is increased by one hectare, the national production increases by 4.048 tons, all other variables being constant. And the rice farm size alone explains about 82% of national rice production. While in the ON zone, if the rice farm size increases by one hectare, rice production in the ON area will increase by 6.4899 tons. And the farm size alone is explaining up to 99.5% of the variation in rice production with a correlation coefficient R= 0.997. This shows an almost perfect correlation between the cultivated area and the rice production in the area.

The results of our surveys further confirmed that farm size has high effects on rice production in the study area. The coefficient of determination (R^2) is 82.21, this shows that the chosen explanatory variables explain 82.21% of the variation of explained variable (production).

Only area and sex are found to have a significant effect on rice production in the ON zone with a coefficient of 0.88 and 0.64 significant at 1% and 5% significant level respectively.

There is an important disparity between smallholder farmers' hold farm (min of 0.75 ha) and large holdings (max of 20 ha) who produce large quantities. However, there is a reduction in irrigated areas available per farmhouse due to the population explosion in the area. Over the years, the farm populations have grown (16 people on average). During the past 20 years, farm populations have increased from 19,470 persons in 2000 to 78,816 persons in 2019, i.e., an increase of 304.81%, which is more than the double of the increase the cultivated area 124.14%. The area ratio per holding fell from 3.29 ha/farmhouse in 2001 to 1.95 ha/farmhouse in 2019, i.e., a decrease of 40.73% of the average holding farm size per farmhouse.

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