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Full Length Research Paper

Determination of socio-economic factors influencing rural household's decision to raise goat in Sindhuli District, Nepal

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Goat (*Capra hircus*) is one of the important sources of rural economy in Nepal. As various programs are aiming to enhance livelihood of rural denizens through goat promotion, it is therefore crucial to understand socio-economic determinants on decision to raise goats by rural households. So, this study was carried out in two, out of seven, local administrative units (Wards) of Marin rural municipality, Sindhuli using three stage sampling technique. A household survey using pretested questionnaire was administered to a randomly selected sample of 100 respondents of which 59% were females and 41% were males. Multiple linear regression analysis using Stata was performed to ascertain socio-economic determinants (sex, education, income, household size, farming experience (years), membership of saving and credit institution, off-farm activities involvement and land size) of goat raising. Results showed that household size had a positively significant relation (p<0.05) whereas farming experience (years) and off-farm activities involvement had a negatively significant relation (p<0.05) on goat raising. Rest of the factors had either positive (education, income and membership of saving and credit institution) or negative (sex and land size) relations but were all statistically insignificant (p>0.05). The study suggests that the result should be considered by any authorities that aim for goat promotion among rural farmers.

Key words: Goat, multiple linear regression, rural household, socio-economic determinants.

INTRODUCTION

Nepal, predominantly remaining an agrarian economy, engages about 66% of its total population directly in agriculture sector (FAO, n. d.). This sector alone contributed 28.8% to its total Gross Domestic Product (GDP) in fiscal year (FY) 2016/17 and estimated to be contributing 27.6% in FY 2017/18 (MoF, 2018). Nepalese

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agriculture is mostly integrated with livestock (mainly cattle, buffalo, goat, sheep, poultry, pig, etc.) and this livestock contribute approximately 11% to the country's GDP (FAO, 2005; MoLD, 2017) and 25.68% to the agricultural GDP (MoAD, 2014). This shows significant role of livestock in the economy of Nepal.

Among the diverse livestock raised in Nepal, goat (*Capra hircus*) is one of the indispensable components as 49.82% of households (2.79 million of 5.6 million) rear goats with the average holdings of 3.3 per household (CBS, 2012). Additionally, goat alone constitutes 10 – 15% of total livestock population in the country over the last ten years (MoALD, 2020); contributes to national meat production by 20% and has about 12% share in total livestock GDP (HIN, 2012). In terms of size of goat herd (9.2 million) as of 2011, Nepal is ranked eighth in Asia and nineteenth worldwide (Dennis et al., 2014). About 83% of the total population of Nepal live in rural areas (CBS, 2011; MoLD, 2017) where goat is considered to be one of the major sources of livelihood. It provides tangible benefits like cash income, meat for consumption, manure, skins, and fiber (Semakula et al., 2010; Hassen and Tesfaye, 2014) and intangible benefits like savings, insurance and socio-cultural purposes (Dossa et al., 2007; Tadesse et al., 2014). These demonstrate the importance of goats for Nepal.

Past few years, many national (FORWARD, CEAPRED, RIMS Nepal, etc.) and international non-governmental organizations (Heifer International, Dan Church Aid, CARE Nepal, etc.) including government bodies have been promoting goat raising program across Nepal for poverty reduction, income generation, employment, livelihood enhancement, and food and nutrition security. Although goat raising programs prioritized offers a great scope to farmers and also the existence of goat market due to increasing meat demand as it is an income elastic commodity (CBS, 2011), the domestic production is still insufficient. To address this demand and supply gap, significant number of live goats is imported from India and Tibet every year (HIN, 2012). According to MoALD (2020), the number of imports of live goats was 316,049 with an import value of 2.652 billion Nepali rupees (approximately 26.52 million US$) in 2018/2019. Many underlying reasons could be prevailing behind this predicament. However, a comprehensive insight to uncover these reasons would be a prerequisite if its full potential is to attain and make Nepal self-sufficient on goat. For this, farmers' socio-economics have been identified as an instrumental (Aslan et al., 2007). Also, despite various researches have been conducted in many other aspects of goats so far, there still lacks sufficient empirical studies that provide better understanding of socio-economic determinants on decision to raise goats by rural household. Therefore, this study was conducted with an objective to ascertain the socio-economic determinants on decision to raise goats among rural farmers in Sindhuli. This information may provide a basis for the intervention programs of different organizations that aims to increase goat production, and consequently meet the demand from domestically produced goods.

MATERIALS AND METHODS

Description of the study area

The study was carried out in September, 2019 in Marin rural municipality of Sindhuli district, Nepal. This rural municipality is situated in west of district headquarter, Sindhulimadi. It was formed by merging former three village development committees viz; Mahadevsthan, Kapilakot and Kalpabrikshya and borders Kamalamai municipality in east, Hariharpurgadhi rural municipality in west, Ghyanglekh rural municipality and Kavrepalanchok district in north and Sarlahi district in south at present. The study area is also known as the bread basket of the Sindhuli district. For the study, only two (6 and 7) local administrative units (Ward) of Marin rural municipality were selected randomly out of seven (Figure 1).

Sampling procedure and data collection

The respondents were selected through three stage sampling technique. At stage one, Sindhuli District was purposively selected based on the logistic considerations and accessibility to the study areas. At stage two, a simple random technique was applied to select two administrative unit viz ward 6 and 7 where the number of households are 948 and 941 respectively (CBS, 2017). This list of households was used as a primary sampling frame. From that, list of total goats raising farmers was prepared in consultation with the local concerned authorities, which was approximately 50% of total households. This list was used as a sampling frame to select 100 households (50 from each administrative unit) randomly for data collection. Only the heads of household were interviewed. Both primary and secondary data were used. The primary data were collected by household survey using a paper based pretested survey questionnaire in local common language (Nepali). It included information on household demographic data, income level, land size ownership, membership to saving and credit institution, farming experience (years), off-farm involvement and number of goats raised. Similarly, secondary data were collected using related documents from government of Nepal, articles, journals, and online sources, etc. to obtain necessary data and information.

Data entry and analysis

The data recorded were coded in MS-Excel and analyzed using both MS-Excel and Stata (Version 11.1). MS-Excel was used for descriptive statistics to summarize the findings of the study. Likewise, Stata was used for regression analysis to understand the socio-economic determinants on decision to raise goat among rural farmers. Since the dependent variable for this study is not dichotomous, multiple linear regression analysis was performed which is shown by the following relationship.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots\ldots\ldots\ldots + \beta_8 X_8 + e$$

Y = dependent variable; decision to raise goat
β_0 = constant
$\beta_1, \beta_2, \beta_3, \ldots\ldots\ldots, \beta_8$ are coefficients of the independent variables e = error term
The description of the variable tested is summarized in Table 1.

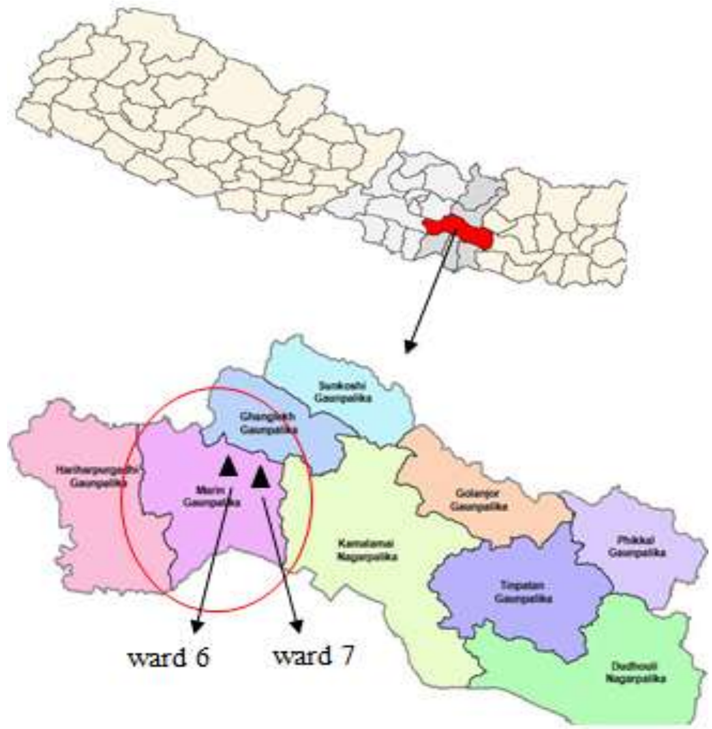

Figure 1. Study area.

Table 1. Description of variables with their codes.

Variable	Variable code	Description
X_1	*sex_c*	Sex of the respondent (male or female)
X_2	*edu_c*	Education level (formal education status of respondent)
X_3	*income_c*	Income level (per month income level of household)
X_4	*HH_size_c*	Household size (Number of persons living in the household)
X_5	*experience_c*	Farming experience (in years)
X_6	*membership_c*	Membership to saving and credit institution (yes or no)
X_7	*off_farm_a_c*	Off-farm involvement (yes or no)
X_8	*land_size_c*	Land size owned (Kattha*)

*One Kattha equals 338 square meters. It is a commonly used local measurement unit.

RESULTS AND DISCUSSION

Description of demographic and other characteristics of the respondents

Of the total household/respondents (n = 100) surveyed randomly, 59% were females while 41% were males, with an average age of 48 years. Most of the respondents had no education (57%) followed by primary (27%); secondary (12%) and university level (4%). Majority (64%) were Hindus with diverse ethnic background (Gurung/Magar – 42%, Newar – 19%, Chhetri – 17%, Brahmin – 16%, and Dalits – 6%) whose major source of income was agriculture (79%). Similarly, the majority respondents (50%) had household size of 5 – 7 members compared to household with 2 – 4 members (23%), 8 – 10 members (22%) and > 10 members (5%). Most of the households (71%) had earning < Rs. 10,000 per month followed by Rs. 10,000 – 20,000 (22%), Rs. 15,000 – 20,000 (5%), and > Rs. 20,000 (2%) to sustain livelihood. About 52% are found to be involved in other off-farm activities and 70% are members of saving and credit institution with 64% having farming experience for 5 – 10 years. On an average, each household had seven goats and majority (30%) had land holding 1 – 2 Kattha compared to > 4 (27%), 3 – 4 (16%), 2 – 3 (12%), < 1 (9%), and none (6%). The detail description on demographic and other characteristics of the respondents is presented in Table 2.

Table 2. Characteristics of the respondents.

Particulars	Number of respondents	Percentage
Average age of respondent (years)	48	-
Sex		
Female	59	59
Male	41	41
Education		
No education	57	57
Primary level	27	27
Secondary level	12	12
University level	4	4
Ethnicity		
Brahmin	16	16
Chhetri	17	17
Dalits	6	6
Gurung/Magar	42	42
Newar	19	19
Religion		
Buddhist	30	30
Christian	1	1
Hindu	64	64
Muslims	2	2
Secular	3	3
Major income source		
Agriculture	79	79
Business	6	6
Job/Service	7	7
Remittance	7	7
Other	1	1
Income in Rupees (month)		
< 10,000	71	71
10,000 - 15,000	22	22
15,000 - 20,000	5	5
>20,000	2	2
Household size		
2 to 4	23	23
5 to 7	50	50
8 to 10	22	22
> 10	5	5
Farming experience (years)		
< 5	6	6
5 to 10	64	64
11 to 15	16	16
> 15	14	14
Membership in saving and credit institution		
No	30	30
Yes	70	70

Table 2. Contd.

Off-farm involvement		
No	48	48
Yes	52	52
Land size (Kattha)		
None	6	6
< 1	9	9
1 to 2	30	30
2 to 3	12	12
3 to 4	16	16
> 4	27	27
Average goat holding per household	7	-

Source: Field Survey (2019).

Table 3. Multiple linear regression results of household decision to raise goat.

Source	SS	df	MS		
Model	36.6248476	8	4.57810595	Number of obs	100
Residual	199.165152	91	2.18862805	F(8, 91)	2.09
Total	235.79	99	2.38171717	Prob > F	0.0445
				R-squared	0.1553
				Adj R-squared	0.0811
				Root MSE	1.4794

goat_raising	Coef.	Std. Err.	t	P> l t l	[95% Coef.	Interval]
sex_c	-0.0159057	0.3126888	-0.05	0.96	-0.63702	0.605212
edu_c	0.0428266	0.1877356	0.23	0.82	-0.33009	0.41574
income_c	0.0786216	0.1802999	0.44	0.664	-0.27952	0.436765
HH_size_c	0.3763769	0.1871363	2.01	0.047	0.004654	0.7481
experience_c	-0.3798391	0.1730659	-2.19	0.031	-0.72361	-0.03607
membership_c	0.3927652	0.3409909	1.15	0.252	-0.28457	1.070102
off_farm_a_c	-0.7671639	0.3016069	-2.54	0.013	-1.36627	-0.16806
land_size_c	-0.0716709	0.0920322	-0.78	0.438	-0.25448	0.11114
_cons	7.67085	1.045445	7.34	0	5.594201	9.747498

Linear regression model estimates

Table 3 shows the multiple linear regression results of household decision to raise goats. It indicates that of the total eight variables (sex, education, income, household size, farming experience, membership of saving and credit institution, off-farm activity involvement, and land size) tested, only three variables were significant. Household size had a positively significant ($p<0.05$) relation on rural household decision to raise goat in study location, whereas off-farm activity involvement and farming experience (years) had a significant ($p<0.05$) but negative relation. Remaining variables had either positive (education, income, and membership of saving and credit institution) or negative relation (sex and land size) but were all statistically insignificant ($p>0.05$). The F-statistics was significant at 5% and R-squared was estimated to be 0.1553 implying that 15.53% of total variation in the output was accounted for by the independent variables.

The study found that the coefficient of sex *(variable code: sex_c)* is negative (-0.0159057) but was not statistically significant ($p>0.05$). However, similar researches conducted in southern Benin by Dossa et al. (2008) and Jaitner et al. (2001) in Gambia observed that females are more inclined towards goats than males while Jaza et al. (2018) observed the males are more likely to adopt goat raising activity than female. Similarly, the education *(variable code: edu_c)* level of the respondents was not statistically significant (p>0.05), but had a positive relation (0.0428266). Likewise, income level *(variable code: income_c)* of respondents was not statistically significant (p>0.05), but had a positive relation (0.0786216). With the household size *(variable code: HH_size_c),* it had a positive relation (0.3763769) on decision to raise goat and was statistically significant (p<0.05). This means with every one unit increase in household size, there will be an increase of 0.38. This is contrary to study conducted by Offor et al. (2018) where household size has negative and significant effect on small ruminants raising. Furthermore, farming experience *(variable code: experience_c)* had a negative relation (-0.3798391) on decision to raise goat and was statistically significant (p<0.05). This means that with every one unit increase in farming experience, goat raising decision will be reduced by 0.38. This is in line with the study conducted by Jaza et al. (2018) in Cameroon where they observed that respondents with more farming expereince are less likely to adopt goat raising activity. On the contrary, in a study conducted in Osun State of Nigeria by Fakoya and Oluruntoba (2009), they observed that farming experience had direct and positive impact on small ruminant production. Membership of respondents in saving and credit institution *(variable code: membership_c)* was also not statistically significant (p>0.05) but had a positive influence (0.3927652). In case of off-farm activities involvement *(variable code: off_farm_a_c)*of the respondents', it had a negative relation (-0.7671639) on decision to raise goat and statistically significant (p<0.05). This indicates that with every one unit increase in off-farm activities involvement, goat raising decision will be reduced by 0.77. This is in line with Dossa et al. (2008) where they observed that household member to own small ruminants decreased when they find off-farm employment. On the contrary, the study conducted by Offor et al. (2018) and Fakoya and Oloruntoba (2009) observed that farmers' income from other sources have positive effect on output of small ruminant animals. Land size *(variable code: land_size_c)* had a negative influence (-0.0716709) on goat raising decision but was statistically insignificant (p>0.05).

CONCLUSION AND IMPLICATIONS

The objective of this study is to understand the socio-economic determinants on decision to raise goat among rural households. This empirical evidence conducted at Marin rural municipality of Sindhuli district showed that household size (positive), farming experience (years) and off-farm activities involvement of farmers (negative) are the main three determinants out of eight among rural farmers. Although researches have proven that goat raising is one of the major sources of living and many concerned stakeholders (governmental, non-governmental, and others) thus are promoting goat program in rural areas as one important intervention to reduce poverty, they should now consider the findings of this study for their relevant future activities, that is, more goat raising program should be only geared towards household having larger members, if the production is to increase and contribute to making Nepal self-sufficient.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Analysis of the technical efficiency of maize producers in the Municipality of Bembèrèkè in the North of Benin

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In Benin, maize plays a key role, both in production systems and in commercial transactions and population feeding. Smallholders are facing a decline in productivity due, among other things, to difficulties in accessing agricultural inputs such as improved seeds and fertilizers (NPK and Urea). The project "Sustainable intensification of maize production among small producers in the departments of Alibori and Borgou in Benin" attempted to solve these problems in its intervention areas. The objective of this research is to analyze the technical efficiency of the maize producers of the Municipality of Bembèrèkè who benefited from the project's support. The sample of the study consists of the 95 farmers benefiting from the project interventions in the Municipality of Bembèrèkè. Data on quantities and prices of inputs used as well as quantities and labour costs were collected. We used the stochastic production frontier to calculate the beneficiaries' technical efficiency scores. The results of the analysis show that the average yield obtained on the experimental plot is 1422 kg/ha compared to 1005 kg/ha for the control plot. In addition, the average value of the technical efficiency scores of all the farms studied is 65.2%, varying from 8.8 to 100%. This means that the current production level can be further increased by an average of 34.8% using the same quantities of inputs. The technical efficiency obtained by producers on the experimental plots is higher than that obtained on the control plots. It is 68.5 and 62% respectively. The comparison test performed on the mean difference between the two groups shows that this difference is significant (probability = 0.004). This shows that the technological packages disseminated as part of the project activities have a clear impact on the technical efficiency of producers. The Government must then encourage farmers to make greater use of certified maize seed and specific fertilizers at subsidized prices.

Key words: Technical efficiency, stochastic production frontier, maize, project, Benin.

INTRODUCTION

In Benin, maize plays a key role, both in the production systems, in the local economy and in the diet of the population (Yo and Adanguidi, 2017). To date, it is the most widely consumed cereal, far ahead of rice and sorghum despite its low productivity (Houndétondji et al., 2014). It is the staple food of about 65% of the

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population, especially in the south of Benin. As a result, it is heavily involved in commercial transactions at the local, national and sub-regional levels. Maize production, which stood at 1,376,683 tonnes in 2016, 1,514,914 tonnes in 2017 and 1,543,973 tonnes in 2018, represented an increase of 1.92% between 2017 and 2018.

Given its importance, maize has been selected as one of the six key agricultural products in the Government's Action Programme for the period 2016-2021 (Government Action Programme, 2016). Maize is used in several forms (Toleba, 2017; Houssou et al., 2019): (a) in human food with consumption patterns varying from one region to another or from one social category to another (fresh or green product, dry shelled and cooked seeds, dry ground seeds in flour or semolina); (b) in animal feed; (c) It is also a raw material for the agro-industry (in the manufacture of beverages such as beer and improved infant and adult flours. Depending on the intensification gradient, four cropping systems can be distinguished (Yo and Adanguidi, 2017):

i) traditional maize cultivation led by smallholders without the use of exogenous inputs with a low productivity of around 0.8 ton per hectare;
ii) semi-intensive maize cultivation using mineral fertilizer and improved variety seeds for a yield of 1.5 ton per hectare to 3 tons per hectare;
iii) intensive maize cultivation, which involves large mechanized and fully fertilized farms with yields of up to 5 tons per hectare with hybrid varieties;
iv) and off-season crops grown mainly in the flood recession areas of the Ouémé Valley and on the banks of rivers and streams throughout the country.

The "traditional crop" system represents more than 60% of maize producers. And the low productivity of small farms is mainly due to: (i) the unavailability of specific inputs (improved seeds, NPK and Urea fertilizers), (ii) the low level of application of improved production techniques, (iii) the lack of adequate training and information, and (iv) the storage problems. In addition, the effects of climate change, which have become increasingly sensitive in recent years, through irregular rainfall and frequent droughts, are additional constraints to be taken into account.

In response to these difficulties, the Government of Benin, with the support of FAO, has developed the project "Sustainable intensification of maize production among small producers in the departments of Alibori and Borgou in Benin", implemented in three Municipalities, namely Bembèrèkè, Gogounou and Kandi.

To date, no real assessment has yet been made of the effects of this project on maize producers in the Municipality of Bembèrèkè. The objective of this research is to analyze the impact of the activities carried out under this project on the technical efficiency of the maize producers, and to determine whether these impacts are influenced by the gender, given the share of women participants in the project. To do this, after presenting the methodology of the study, we will compare maize yield levels and technical efficiency levels with or without the project support in relation to the gender of the farm managers. Some recommendations will be made at the end.

DATA AND METHODOLOGY

Study areas and data collection

This study was carried out in the Municipality of Bembèrèkè in the department of Borgou in northern Benin. In this Municipality, 95 households are supported by the project. We selected all of them for the field surveys. As part of the project activities, each beneficiary received 10 kg of certified maize seed, NPK fertilizer (100 kg) and Urea (50 kg). Their capacities have also been strengthened on the best maize production practices developed by the National Institute of Agricultural Research of Benin. Each beneficiary has an experimental plot of 0.5 ha on which the inputs made available by the project and the best practice are used, and a control plot of 0.5 ha on which the farmer also used his traditional practice (local seed, no chemical fertilizer). Data on the quantities and costs of inputs used, including maize seed, chemical fertilizers (NPK and Urea), organic fertilizer, herbicide and labour (for soil preparation, seeding, weeding, fertilizer and herbicide application and harvesting) were collected during the 2017 crop year. Some socio-demographic characteristics of the beneficiaries (age, sex, household size) were also collected.

Model specification

There are two families of methods used to estimate technical efficiency:

i) The parametric methods that have the advantage of taking into account hazards other than inefficiency (stochastic frontiers). The disadvantages of these methods include the obligation to represent the technology by a particular parametric form; moreover, it is not possible to separate the various components of inefficiency for multi-product technologies (Chaffai, 1997).
ii) The non-parametric methods that offer the possibility of decomposing the various types of inefficiency (technical, allocative and scale). The technology here is not represented by a functional relationship; the disadvantage here is that inefficiency measures can be affected by measurement errors and/or variable forgetting (Chaffai, 1997).

In this study, we used the stochastic production frontier (SFA) method developed simultaneously by Aigner et al. (1977), Battese and Corra (1977) and Meeusen and van den Broeck (1977) to calculate technical efficiencies.

The original specification involved a production function specified for cross-sectional data that had an error term that included two components, one to account for random effects and the other to account for the effect of technical inefficiency. This model can be expressed as follows (Coelli, 1996):

$$P_i = Y_i\beta + (W_i - Z_i) \quad \text{where} \quad i = 1, 2, \ldots, N \qquad (1)$$

where P_i is the production of the ith farm; Y_i is a k×1 vector of the inputs of the i^{th} farm; β is a vector of unknown parameters; W_i are random variables that are supposed to be iid. N (0, σ_W^2) and

Table 1. Variables used to estimate the production function and expected signs.

Variable	Meaning of variable	Expected signs (+/-)
Y_{eng}	Quantity of NPK and Urea fertilizer used (kg)	+
Y_{org}	Quantity of organic materials used (Bag of 50 kg)	+
Y_{her}	Quantity of herbicides used (L)	+
Y_{mo}	Quantity of labour used (Man-Day)	+
P_{rec}	Quantity of maize harvested during the season (kg)	+

independent of Z_i, which are non-negative random variables that are assumed to explain the technical inefficiency of production and are often assumed to be iid [N (0, σ_Z^2)].

The measurement of technical efficiency (TE) in relation to the production frontier (1) is defined as follows:

$$TE_i = E(P_i^*|Z_i, Y_i)/E(P_i^*|Z_i = 0, Y_i)$$

where P_i is the output of the i^{th} farm, which will be equal to Z_i when the dependent variable is in original units and will be equal to exp(Z_i) when the dependent variable is in logarithm.

In the case of a production frontier, TE_i will have a value between zero and one. The Cobb-Douglas production frontier is as follows:

$$Ln(Z_i) = \beta_0 + \sum_{i=1}^{k} \beta_i \ln(Y_i) + (W_i - Z_i) \qquad (2)$$

where Z_i, is the output of the producer i, β_0 the constant expressing the value of productivity which is not influenced by the production factors, β_i the elasticity of production with respect to each factor, W_i the purely random variable out of control, Z_i the technical inefficiency of the producer i. Y_i represents the factors of production. The expected signs of the different variables of the model are presented below (Table 1).

RESULTS AND DISCUSSION

Description of the model variables

Table 2 presents the descriptive statistics of the variables used in the analyses. The analysis of this table shows that men represent 63% of the project beneficiaries compared to 37% for women. The surveyed farms benefited from the experimental plot of NPK fertilizer and Urea. The quantity of chemical fertilizer offered under the project is lower than the doses recommended by the extension services, which is 200 kg/ha (150 kg of NPK and 50 kg of Urea) (Balogoun et al., 2013). This gap is justified by the logic of the project, which choses a limited chemical fertilizer application approach with quality seeds and the best practice and sustainable land management approach to better impact yields. The data in the table also show that chemical fertilizer is also used on control plots that are intended to replicate normal farming practice. This is proof that producers are aware of the level of soil degradation. It was also found that crop residues were used as fertilizer on the plots, but on a variable scale between control and experimental plots. In addition, herbicide is systematically used by producers to address the problem of agricultural labour shortages. The average yield of maize is 1213 kg/ha. However, the table also shows a minimum yield of 168 kg/ha (reflecting the extreme degradation of some crop plots in the study area and the minimum that has been achieved with the local seed without chemical fertilizer) and 2250 kg/ha (the maximum that has been achieved through the project activities). There was also a slight difference in performance between men and women.

Comparison of maize yield levels between the experimental and control plots

Table 3 shows the maize yield levels obtained on the experimental and control plots. The average yield obtained on the experimental plot is 1422 kg/ha compared to 1005 kg/ha for the control plot. However, the comparison test carried out on the difference in the mean between the two groups shows that this difference is significant (probability = 0.000). This is therefore proof that the use of certified seeds of maize, NPK fertilizer and urea, as well as the respect of the best practice, have a significant impact on the yields obtained on the experimental plots.

Estimation results of the production function model

As stated earlier in the methodology, we used the Stochastic Production Frontier (SPF) as a model instead of the Data Envelopment Analysis (DEA). The advantage of the SPF over the DEA is that it makes it possible to explain the deviations observed between the random production frontier and the production actually observed through the technical inefficiency of the farm and random factors (climatic factors, omission of certain explanatory variables, etc.).

Table 4 presents the results from the estimation of the Cobb-Douglas stochastic production frontier model. Analysis of these results shows that the model is globally

Table 2. Descriptive statistics of the variables used.

Beneficiaries	Variable	Obs	Average	Standard deviation	Minimum	Maximum
Male producers	Y_{eng}	120	128.875	34.855	50	150
	Y_{org}	120	2.398	5.019	0	20
	Y_{her}	120	2.642	1.208	1	6
	Y_{mo}	120	19.133	10.926	8	56
	P_{rec}	120	1229.083	356.707	168	2250
Women producers	Y_{eng}	70	127.429	36.700	50	150
	Y_{org}	70	2.364	4.856	0	20
	Y_{her}	70	2.686	1.246	1	6
	Y_{mo}	70	19.057	9.820	8	48
	P_{rec}	70	1186.971	370.160	250	2000
Male and women producers	Y_{eng}	190	128.342	35.456	50	150
	Y_{org}	190	2.386	4.947	0	20
	Y_{her}	190	2.659	1.219	1	6
	Y_{mo}	190	19.105	10.506	8	56
	P_{rec}	190	1213.568	361.319	168	2250

Table 3. Comparison of maize production levels with and without the project (in kg/ha).

Group	Obs	Mean	Standard Error	Standard deviation	[95% Conf. Interval]	
Control plot	95	1005.179	23.131	225.449	959.253	1051.105
Experimental plot	95	1421.958	36.112	351.978	1350.256	1493.659
Difference		-416.779	42.885		-501.376	-332.182
t-Test	t = -9.7186			Probability = 0.0000		

Table 4. Estimation of the producer stochastic production frontier parameters.

LnP_{rec}	Coefficient	Standard Error	z	P>|z|	[95% Conf. Interval]	
LnY_{eng}	0.464	3.20e-06	1.4e+05	0.000	0.464	0.464
LnY_{org}	0.022	4.55e-07	4.8e+04	0.000	0.022	0.022
LnY_{her}	0.158	5.87e-06	2.7e+04	0.000	0.158	0.158
LnY_{mo}	0.042	2.76e-06	1.5e+04	0.000	0.042	0.042
Constante	5.062	0.000	2.7e+05	0.000	5.062	5.062
$Ln\sigma_W^2$	-38.542	402.398	-0.100	0.924	-827.228	750.143
$Ln\sigma_Z^2$	-1.090	0.103	-10.63	0.000	-1.291	-0.889
σ_W	4.27e-09	8.60e-07			2.3e-180	7.8e+162
σ_Z	0.580	0.030			0.524	0.641
σ^2	0.336	0.034			0.268	0.404
λ	1.36e+08	0.030			1.36e+08	1.36e+08

Number of observations = 190; Log likelihood = -34.322; Wald Chi^2 (4) = 6.51e+10; Prob > Chi^2 = 0.000.

significant at 1% significance level (Probability = 0.000). The constant predicted by the model is also statistically significant at 1% significance level. The Cobb-Douglas stochastic production frontier model also reveals that all production factors have positive and significant effects at 1%.

Table 5. Comparison of technical efficiency levels with and without the project.

Group	Obs	Mean	Standard Error	Standard deviation	[95% Conf. Interval]	
Control plot	95	0.619	0.017	0.168	0.585	0.653
Experimental plot	95	0.685	0.018	0.172	0.650	0.720
Difference		0.066	0.025		-0.115	-0.017
t Test	t = - 2.6785			Probability = 0.004		

The results in the table also make it possible to analyze the sources of inefficiency, which are of two types: technical inefficiency related to random shocks and inefficiency from the producer.

The coefficient of the parameter is significantly different from zero at 1% significance level. This means that part of the producers' inefficiency is due to technical errors.

Since the coefficient of the parameter is not significant, this will mean that non-controllable random factors do not significantly influence the efficiency of producers.

The Lambda value (λ), measuring the relative variability of the two sources of inefficiencies (σ_z/σ_w), is equal to 1.36e+08; this means that the productive inefficiency explains essentially the differences at the border in the production systems.

Furthermore, the results of the test of the ratio of $\sigma_z = 0$, stipulating the non-inefficiency of productive origin, show the presence of inefficiency in the production systems (Probability = 0.0000).

Comparison of technical efficiency levels with or without the project

The average value of the technical efficiency scores of all the farms studied is 65.2%, varying from 8.8 to 100%. This means that the current production level can be further increased by an average of 34.8% using the same quantities of inputs.

The average technical efficiency score found in this study (65.2%) is almost similar to that found by Aminou (2018), which is in the order of 65.4%. It is smaller than what has been found by other authors who have worked on maize in Benin: Toleba et al. (2016) have obtained an average technical efficiency score of 80% and Amegnaglo (2018) has found 75%.

The low technical efficiency score obtained by the beneficiaries of this study is due to the fact that they applied the new measures recommended by the project on already poor soils.

The finding of this study is not, however, a peculiarity of Benin. Studies carried out elsewhere on the technical efficiency of maize producers using the stochastic production frontier have given a lower average efficiency score than the 65% found in Benin:

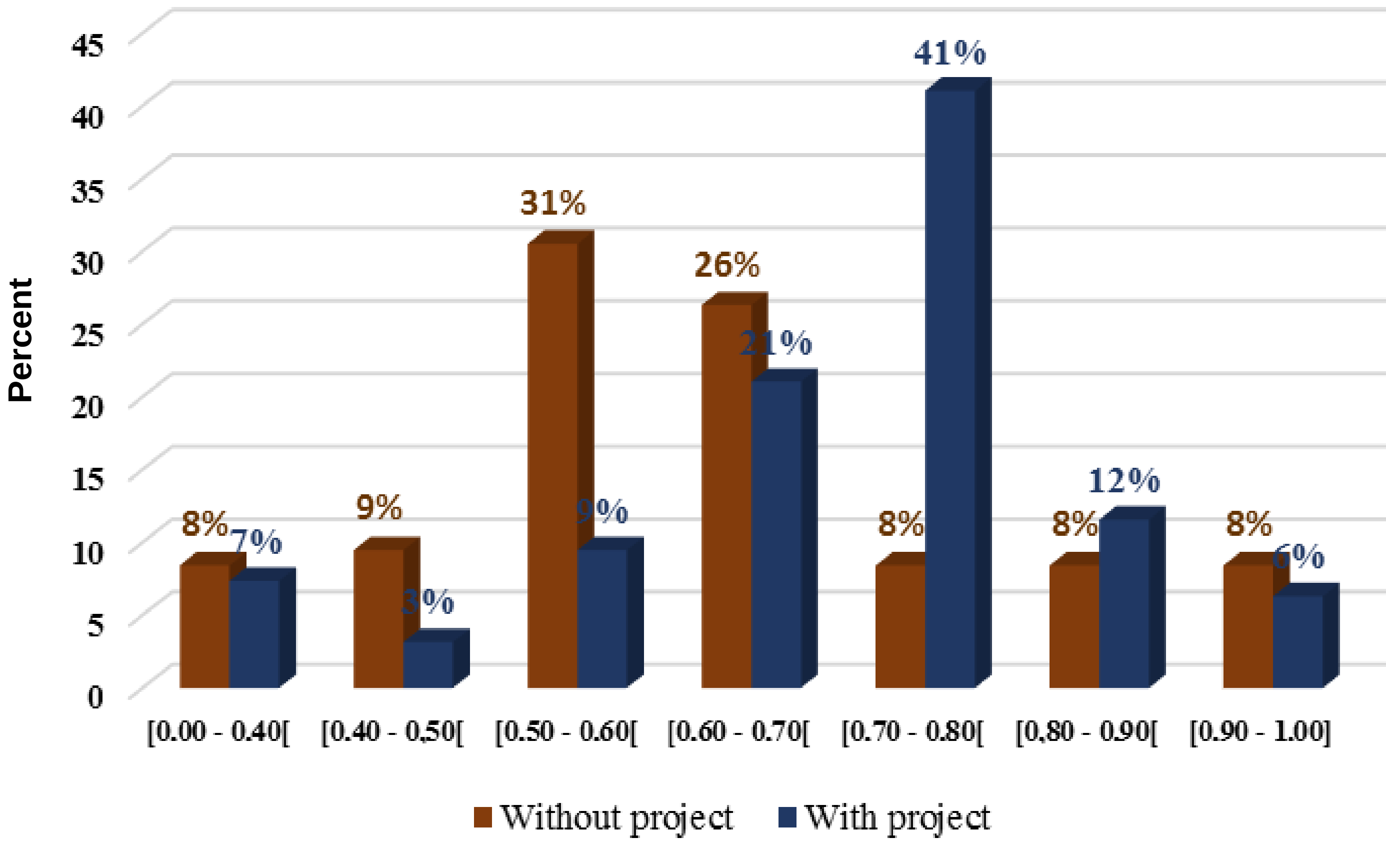
i) Olarinde (2011) studied 300 maize producers in Oyo and Kebbi States in Nigeria using the Translog production border. He found that producers are not technically efficient, with an average technical efficiency score of 55.88% (Oyo State) and 57.58% (Kebbi State).
ii) Chiona et al. (2014) in a study conducted in Central Zambia found an average technical efficiency score of 50% with a minimum of 2% and a maximum of 84%.
iii) Ng'ombe and Kalinda (2015) in another study also conducted in Zambia where farms adopted minimum tillage technology found average technical efficiency score of 60% (Half-normal distribution) and 71.7% (exponential model) respectively. The minimum score obtained is 9.3 and 8.5% respectively. The maximum score is 89.3% (Half-normal distribution) and 90.9% (exponential model).
iv) Bidzakin et al. (2014) in a study conducted in Ghana found an average technical efficiency score of 61% with a minimum of 11% and a maximum of 100%.
v) Kitila and Alemu (2014) in a study conducted in Ethiopia found an average efficacy score of 66% with a minimum of 6% and a maximum of 92%.

Comparison of results in Table 5 shows that the technical efficiency obtained by producers on the experimental plots is higher than that obtained on the control plots. It is 68.5 and 62% respectively. The comparison test performed on the mean difference between the two groups shows that this difference is significant (probability = 0.004). This shows that the best practice disseminated as part of the project activities have a clear impact on the technical efficiency score of the producers.

Graph 1 shows the distribution of efficiency with and without the project. The analysis shows that:

i) 48% of producers obtained a technical efficiency score of less than 60% on the control plots compared to 20% on the experimental plots.
ii) 59% of producers obtained a technical efficiency score varying between 70 and 100% on the experimental plots compared to 25% on the control plots.

This confirms once again the positive impact of the best practices teached by the project. This result confirms the observations made by Achigan-Dako et al. (2014) who already pointed out that the unavailability of quality seeds in Benin is one of the main constraints to the sustainable intensification of agricultural production. The same authors also stated that seeds are an important factor of production whose control determines the yield of the crop.



Graph 1. Distribution of efficiency scores with and without the project.

Table 6. Comparison of technical efficiency levels between men and women.

Group	Obs	Mean	Standard Error	Standard deviation	[95% conf. interval]	
Control plot	70	0.640	0.021	0.176	0.598	0.682
Experimental plot	120	0.659	0.016	0.171	0.628	0.690
Difference		-0.019	0.026		-0.070	0.032
t Test	t = - 0.732			Probability = 0.232		

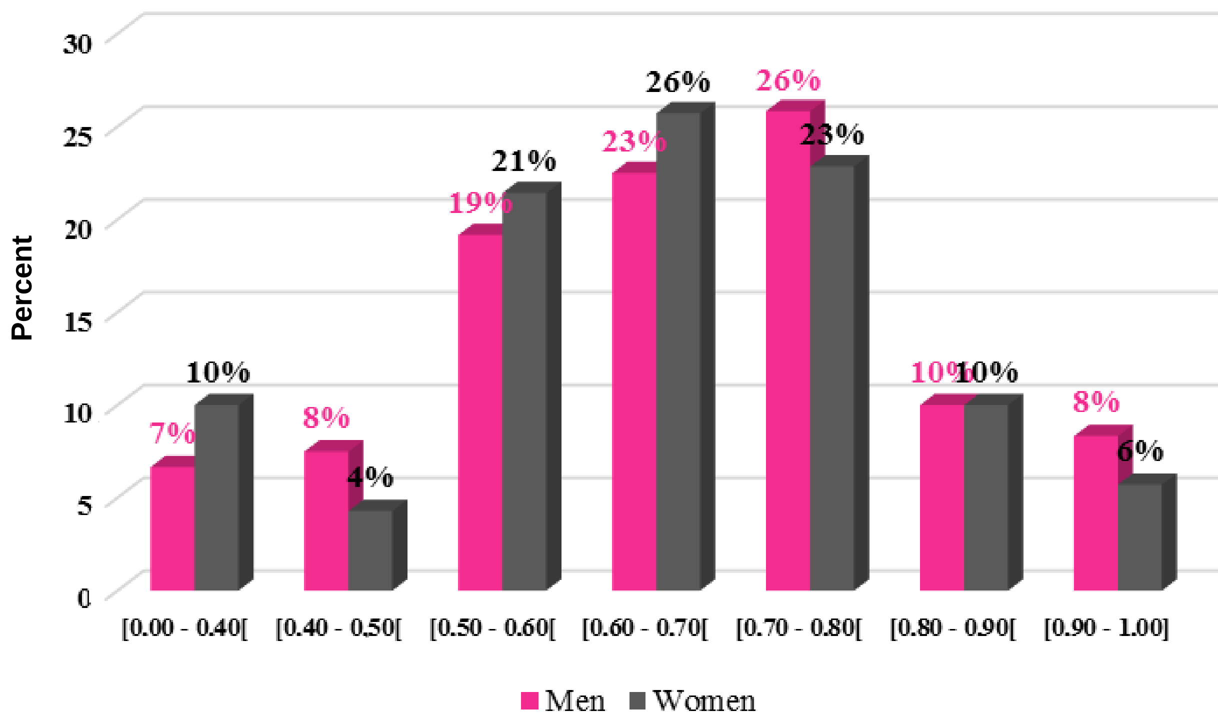
Comparison of technical efficiency levels between men and women producers

We have examined here whether the producer sex has some impact on his level of technical efficiency. The results in Table 6 show that the technical efficiency obtained by men producer is 66% for all plots combined compared to 64% for women producer. In addition, the comparison test carried out on the difference in the mean between men and women producer shows that this difference is not significant (probability = 0.2325).

This result has been confirmed in Graph 2, which shows the distribution of efficiency scores between men and women producers with and without the project. It is easy to see that:

i) 36% of women producers obtained a technical efficiency score of less than 60% compared to 33% of men.
ii) 44% of men producers obtained a technical efficiency score between 70 and 100% compared to 39% of women producers.

This means that the sex of the maize producer has no impact on the level of technical efficiency, unlike the results of the work of Toleba et al. (2016), Amegnaglo (2018) and Aminou (2018), who identified the producer's gender as a determinant of technical efficiency. This would certainly be due to the fact that all project beneficiaries (male and female) had access to the same technology package and inputs (certified maize seed,



Graph 2. Distribution of effectiveness scores among men and women.

NPK and urea fertilizer).

CONCLUSIONS AND RECOMMENDATIONS

The results of our research clearly show the predominant role of the quality of agricultural inputs in improving maize yield in Benin. Certified maize seeds used on the experimental plots combined with a limited supply of chemical fertilizers (NPK and urea) have boosted yields on relatively poor soils. The central government must then encourage the emergence of local private actors specialized in the supply of quality certified maize seeds throughout the national territory. The State must also continue to make specific fertilizers available for maize at subsidized prices in order to facilitate poor people's access to these inputs.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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Economic resources utilisation in maize production: Evidence from Central Region, Ghana

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This study was undertaken to improve the efficiency of maize farming in the Central Region of Ghana. A stochastic frontier cost function, applied to cross-sectional data, was used to analyse firm level cost efficiency of production and its determinants. Efficiency of resource utilization was analysed using marginal value product of inputs. Results from the Cobb-Douglas stochastic cost frontier model and a farm-specific efficiency model showed that the mean cost efficiency was 94.95%. Furthermore, all production inputs were inefficiently allocated. Access to extension services, experience and access to credit had positive relationships with cost efficiency. The study concludes that maize farmers are not fully efficient in resource combination and allocation. Improved technologies and innovations should be made accessible to farmers by public and private extension service providers to increase efficiency of their maize farms.

Key words: Cost efficiency, allocative efficiency, cost frontier, marginal value product, maximum likelihood estimates.

INTRODUCTION

The prospect of increasing agricultural productivity to cope with the problem of feeding the nine billion of the world's population by 2050 has been given impetus by scientific breakthroughs in crop and animal research. While this is good for global food security, the same argument cannot be made for the African continent (Godfray et al., 2010). Maize production in Ghana is predominantly done under rain-fed conditions by smallholder farmers who are often poorly resourced despite the crop accounting for 50% of the total cereal production in Ghana (Darfour and Rosentrater, 2016). This lack of resources makes increasing the efficiency of the farmers very difficult.

Schultz (1964) suggests that there are relatively few inefficiencies in the allocation of production inputs in traditional agriculture, and hypothesizes that when peasant farmers are given the right economic and environmental conditions, they can efficiently allocate factors of production. Hence, this study looks at efficiency as the best option in productivity improvement and puts to test Schultz's proposition with regard to economic conditions. Efficiency in production and allocation of resources is also crucial to ensure sustainability of small-scale maize production in Ghana.

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Conceptualisation of what constitute inputs with respect to the outputs they generate or are expected to generate and measurement of the levels of use of such inputs often poses serious challenges. Varian (1992) offers a valuable approach. He notes that a firm produces outputs from various combinations of inputs and in order to study firm choices we need a convenient way to summarize the production possibilities of the firm, i.e., which combinations of inputs and outputs are technologically feasible.

Farrel (1957) was the first to introduce the measure of productive resource use efficiency. He proposed that efficiency is measured in a relative performance rather than the absolute performance. A firm is said to be efficient if it is operating on the production frontier. This study was therefore undertaken to analyse the resource utilisation of maize farmers in the Central Region of Ghana to find out how efficient the farmers are in their allocation of resources.

METHODOLOGY

Study area and population

The Central Region of Ghana is the study area. The region covers a land area of 9830 km^2 with a coastline of 168 km bordering its southern part and a rural population constituting 62.5% of its total population of 2,563,228. Majority of the labour force in the region (55.4%) are into agriculture. Maize is the predominant staple crop in the Central Region of Ghana (Ghana Statistical Service, 2019).

Design

A cross-sectional survey research design with quantitative approach was adopted for the study. The design was employed because the study sought to bring to fore causal relationships between sets of variables.

Sampling and sampling technique

A multi-stage sampling procedure was adopted. A sample of 101 maize farmers were chosen from each of three participating districts to give a total sample size of 303 randomly selected maize farmers. This was based on Bartlett et al. (2001) sample size determination table for obtaining data meant for regression analysis. However, 302 respondents were valid for analysis, giving a response rate of 99.7%. The rejection of one of the case was due to the fact that most of the items were not fully completed by one of the enumerators. Fryrear (2015) recommends response rate of 80% and above for surveys of this kind. Since the response rate was way above the benchmark, the study proceeded with the analysis.

Instrumentation and data collection

A structured interview guide was used for the collection of data from participants. Levels of formal education among the farmers, and their ability to read and write, were uncertain, hence the use of this particular instrument to enable interviewers to aid respondents in the interpretation of questions. Data was collected on the following defined variables:

Output (Y): Quantity of maize grains harvested which is measured in kilograms/ha.
Land (Lan): Total area planted to maize in hectares. The variable was used to investigate the influence of farm (land) size on output.
Labour (Lab): Total number of family and hired labour employed in maize production, measured in person-days. Eight man-hours is equal to one person-day.
Equipments (Equ): Cost of items (cutlass, sprayer, hoe, tractor, sack, etc.) that are directly involved in the production process, measured in Ghana Cedis.
Fertilizer (Fer): Quantity of commercially formulated plant nutrient used per hectare of land, measured in kilogram.
Seed (See): Total quantity of maize seed sown, measured in kilograms. The quantity of seeds per hectare determines the plant population which has influence on yield. This variable was averaged over the cropped area.
Extension: Number of times a farmer had access to extension service during the production season.
Age: Age of the primary decision maker, measured in years.
Gender: Measured as a dummy variable and has the value of 1, if a farmer is a male and 0, if female.
Household size: Number of persons in the farmer's household.
Experience: Number of years engaged in maize farming.
Access to credit: Measured as a dummy variable; 1 represents a yes response and 0 for a no response.

Analytical framework

Descriptive statistics is used as the framework for describing the state of resource utilisation in maize production in the region. Statistical techniques such as means, percentages, frequencies and standard deviations (with the help of SPSS Statistics version 21 outputs) are used to describe the state of maize production by analysing:

1. The socio-economic characteristics of the farmers,
2. Techniques of production,
3. Levels of inputs and output,
4. Cost of inputs and output and
5. Market information

Further, the determination of efficiency is done for both the cost and allocative efficiencies of the maize farmer. The framework for the cost efficiency determination in this study is input-output analysis and also makes use of the Cobb-Douglas production function technique. In assessing the determinants of production efficiency, a causal relationship framework is adopted. This allows for the relation of the farmer's level of efficiency to the various factors that bring about this level of efficiency. A multiple linear regression is used to show how each of the determinants influence the dependent variable-cost efficiency. Marginal analysis is used to determine the allocative efficiencies of the farmers. The software used for this part of the analysis is frontier 4.1.

Analytical model of stochastic frontier cost function

This study adopts the stochastic production frontiers (SPF) analysis to estimate the allocative efficiency of maize farmers in the Central Region of Ghana. This is achieved by transforming the production frontier into cost frontier. According to Coelli (1996), the composite error term specification of the production frontier is simply converted from (V_i - U_i) to (V_i + U_i) in order to specify the cost frontier function. The cost frontier dual to the production frontier is thus specified as:

$$\ln(C_i)=\alpha_0+\Sigma_i\alpha_i\ln P_{ij}+\gamma\ln(Y^*_i) \quad (1)$$

where C_i is the minimum cost to produce output Y, P_{ij} is a vector of input prices, and α is a vector of parameters to be estimated. Y^*_i is the observed output adjusted for statistical noise and is specified as:

$$\ln(Y^*_i)=\beta_0+\Sigma\beta_i \ln X_{ij} - u_i = \ln(Y_i) - v_i \qquad (2)$$

According to Coelli (1996), the computer programme, Frontier 4.1, calculates predictions of individual firm technical efficiencies from estimated stochastic production frontiers, and predictions of individual firm cost efficiencies from estimated stochastic cost frontiers. The measures of technical efficiency relative to the production frontier $Y_i = x_i\beta + (V_i - U_i)$, and of cost efficiency relative to the cost frontier $Y_i = x_i\beta + (V_i + U_i)$, are both defined as:

$$EFF_i = E(Y_i^*|U_i, X_i)/ E(Y_i^*|U_i=0, X_i), \qquad (3)$$

where Y_i^* is the production (or cost) of the i^{th} firm, which will be equal to Y_i when the dependent variable is in original units and will be equal to $\exp(Y_i)$ when the dependent variable is in logs. In the case of a production frontier, EFF_i will take a value between zero and one, while it will take a value between one and infinity in the cost function case. In this cost function the U_i now defines how far the firm operates above the cost frontier. If allocative efficiency is assumed, the U_i is closely related to the cost of technical inefficiency. If this assumption is not made, the interpretation of the U_i in a cost function is less comprehensible, with both technical and allocative inefficiencies possibly involved.

The cost efficiency of individual farmers is now defined in terms of the ratio of the predicted minimum cost (C_i^*) to observe cost (C_i). That is:

$$CE_i = C_i^*/C_i = \exp(U_i) \qquad (4)$$

From Equation 4, cost efficiency is simply the reciprocal of the cost efficiency given by the production frontier model generated by the Frontier 4.1 computer program. Hence, cost efficiency varies between zero and one.

Empirical model for estimating cost efficiency of maize farmers

Cost efficiency has been investigated in a number of papers. In this study, the cost frontier dual to the production frontier function presented in Equation 1 is used for the estimation of cost efficiency. In this function, independent variables are the prices of inputs for production and the total output that is adjusted for any statistically noise calculated by function 2. The operational model in this study is

$$\ln C_i = \ln \beta_0 + \beta_1 \ln P_1 + \beta_2 \ln P_2 + \beta_3 \ln P_3 + \beta_4 \ln P_4 + \beta_5 \ln P_5 + \beta_6 \ln Y^* \qquad (5)$$

where C_i stands for cost of production per farm, measured in Ghana Cedis (GH¢); P_1 represents hired price per hectare of land, in GH¢; P_2 symbolizes hired price per person-day, in GH¢ /persons-day; P_3 signifies cost of equipment, in GH¢; P_4 stands for cost of fertilizer, in GH¢/kg; P_5 represents cost of seeds in GH¢/kg; Y^*represents the observed output (maize) adjusted for any statistical noise, contained in v_i; $\beta_0, \beta_1, ..., \beta_6$ are coefficients of unknown parameters to be estimated.

Factors affecting efficiency of farmers

The inefficiency model is implicitly defined for this study as:

$$\mu_i = \delta_0 + \sum_{m=1} \delta_m W_{mi} \qquad (6)$$

Explicit function is defined as:

$$\mu_i = \delta_0 + \sum^7_{m=1} \delta_m W_{mi} \qquad (7)$$

where W = farmer specific variables and δ = Coefficient of unknown parameters.

The operational Cobb-Douglas function for the inefficiency is specified as:

$$\mu = \delta_0 + \delta_1(Ext) + \delta_2(Age) + \delta_3(Gen) + \delta_4(HHs) + \delta_5(Exp) + \delta_6(Cre) \qquad (8)$$

Empirical model of cost inefficiency

The distribution of mean inefficiency (μ) is related to the farmer's demographic variables and allows heterogeneity in the mean inefficiency term to investigate sources of differences in technical efficiencies of the farmers. Cost inefficiency effects are a function of various observable factors, such as access to extension services, age, gender, household size experience and access to credit, experience, occupation, location of firm, and availability of buyers. Following Onumah et al. (2010), the model for various operational and firm-specific variables hypothesized to influence technical efficiency in traditional maize production is defined in Equation 9.

$$\mu_i = \delta_0 + \sum_{m=1}^{7} \delta_m z_{mi} \qquad (9)$$

where Z_s are exogenous variables, δ_0 and δ_m are coefficients of inefficiency, Z_1 is access to extension services, Z_2 age of farmer, Z_3 is gender of farmer, Z_4 is household size of farmer, Z_5 is experience of farmer, and Z_6 is access of credit by a farmer.

Operationally, Equation 9 can be expanded as follows:

$$\mu_i = \delta_0 + \delta_1(Ext) + \delta_2(Age_i) + \delta_3(Gender_i) + \delta_4(HHSize_i) + \delta_5(Experien._i) + \delta_6(Credit_i) \qquad (10)$$

Empirical analysis of efficiency of resource utilization

The study assumed that maize production is a function of land, labour, equipment, fertilizer and seed. Efficiency of input allocation was estimated following physical production relationships derived from the Cobb-Douglas production function.

The resource utilization efficiency index (r) was obtained by using MLE estimates of the Cobb-Douglas function. The marginal physical product of land was estimated based on its estimated regression coefficient. This was followed by estimating the marginal value product (MVP) of land. The MVP of land was then compared with its marginal factor cost (MFC). Thus, the efficiency of land allotment (r) was determined by the ratio of MVP to MFC.

The allocative efficiency index of capital employment was calculated from:

$$r = \frac{MVP}{MFC} \qquad (11)$$

The value of MVP was estimated from Equation 2. The same procedure was followed to estimate the allocative efficiency of labour, equipment, fertilizer and seed.

Table 1. Descriptive statistics of farmer and farm specific variables.

Variable	N	Min.	Max.	Mean	Std. dev
Age (years)	302	23	76	46.15	10.15
Household size (#)	302	1	20	5.40	3.40
Level of education (years)	302	0	15	5.04	4.55
Income per annum (GH¢)	302	50	8000	1479.97	1292.52
Level of experience (years)	302	2	55	19.84	10.19
Home-farm distance (km)	302	0	7	2.47	1.14
Extension visits (#)	302	0	31	2.47	2.50

RESULTS AND DISCUSSION

The state of resource utilisation in maize production in the Central Region of Ghana

This description of the state of resource utilisation in maize production covers farmer characteristics as well as access to and usage of resources and the outputs of maize churned out from the production process.

Mean age of maize farmer

The average age of farmers was 46 years with a range of 23 to 76 years (Table 1). The age distribution indicate that majority of the farmers are youth and are within the working age group.

Household size

Farmers have an average household size of 5 with a range of 1 to 20 (Table 1). This means that about four dependents of the farmer may contribute efforts towards the production of maize.

Level of formal education

The average number of years of schooling was estimated to be 5 years with a range of 0 to 15 years (Table 1). This shows that majority of farmers have not gone beyond primary education level which is an indication that they have low level of education.

Annual income of farmers

On the average, maize farmers earn GH¢1,480 with a range of GH¢50-GH¢8000 as income per annum (Table 1).

Experience in maize farming

The level of experience of farmers was estimated to be 20 years on the average with a range of 2 to 55 years (Table 1). This is an indication that the maize farmers in the study area are mostly experienced.

Access to extension services

Some farmers reported that they had no access to extension services during the production season. The mean extension visits in the study area is 2.5 visits per production season with minimum of zero and a maximum thirty one visits and a standard deviation of 2.50401 (Table 1). Although extension services accessed at no direct cost to the maize farmer, its usage is known to impact positively on the overall output of the farmer (Owens et al., 2001).

Summary statistics of input and output variables

Table 2 shows summary statistics of output and input variables as well as some inefficiency source variables. There were differences in the number of observation (n) due to the fact that some of the respondents could not provide responses of some of the variables of interest. Hence, the differences in the number of observation.

Cost of inputs

The mean cost values of the individual variables are displayed in Table 2. The average cost of land was GH¢170.10 with a standard deviation of 348.18. This variation in standard deviation is an indication that farmers operated at different land sizes. The average cost of labour was GH¢ 801.56 with a standard deviation of GH¢ 827.96. The variability and mean of average cost of labour incurred by the farmers is a reflection of the fact that most of the farm operations were done manually which are labour intensive and costly. Farmers spent GH¢ 32.02, GH¢ 44.20, GH¢26.38 and GH¢105.90 on equipment, fertilizer, pesticide and seed, respectively.

Cost analysis

The mean total cost of production is GH¢1173.59. The

Table 2. Descriptive statistics of input and output variables.

Variable	n*	Minimum	Maximum	Mean	Std. Dev.	% Input Costs
Land size	302	0.40	23.00	1.83	2.11	-
Cost of land	302	15.00	345.00	170.10	348.18	14.38
Persons-day	302	17.50	435.90	63.91	59.99	-
Labour cost	302	200.00	7200.00	801.56	827.96	68.19
Cost of equipment	302	0.00	621.50	32.02	74.49	2.62
Quantity of fertilizer	302	0.00	475.00	58.11	81.46	-
Cost of fertilizer	302	0.00	372.00	44.20	61.57	3.66
Quantity of pesticide	289	1.00	22.00	3.64	3.31	-
Cost of pesticide	289	7.50	165.00	26.38	10.12	2.14
Quantity of seed	302	1.00	100.00	21.10	12.13	-
Cost of seed	302	8.00	1750.00	105.90	186.37	9.01
Total cost	302	248.00	1725.00	1173.59	1131.34	100.00
Quantity of output	302	38.00	12000.00	1166.91	1117.15	-
Value of output	302	190.00	60000.00	2240.47	2144.92	-

n* is number of participants who responded to the items, those who did not respond to the items are excluded from the analysis.

cost analysis shows that cost of land accounts for 14.38% of total cost, cost of labour accounts for 68.19%, cost of equipment accounts for 2.62%, cost of fertilizer accounts for 3.66%, cost of pesticide accounts for 2.14% while cost of planting materials accounts for 9.01%.

Summary of input-output analysis

On the average, farmers spent GH¢1173.59 on inputs used to produce the maize, obtained a revenue of GH¢2240.48. Thus, making a gross profit of GH¢1066.89 per one maize production season. This profit is 90.91% of the total cost of production and 47.62% of the total revenue obtained.

Efficiency of maize production in the Central Region of Ghana

The cost efficiency of maize production as well as the allocative efficiencies of input utilisation for the various inputs is presented as the following.

Analysis of cost efficiencies of maize farming at firm level

The cost efficiency (CE) indices of the maize farmers in the Central Region ranged from 85 to 99%, with an average of 95.95%. This means that if the average farmer in the sample was to achieve the CE level of its most efficient counterpart, the farmer could realize a 4% cost saving (that is, 1–[95 /99]) which falls far below the 63%. Paudel and Matsuoka (2009) reported among maize producers in the Chitwan District of Nepal. Moreover, farmers who got the highest score of cost efficiency above 95% were 238 households which represented 88% of the total surveyed farmers.

Resource utilisation

Table 3 shows that the quantity of seed used in farming maize has the highest efficiency index of resource utilization (21.11), followed by land (2.63), fertilizer (2.54), labour (0.39), and equipment (0.14). Wongnaa et al. (2019) reported that maize production in Ghana is noted to be profitable but this profitability will be adversely affected if prices of relevant inputs, such as pesticides, fertiliser, herbicides, labour and seeds, are increased.

The allocative efficiency ratios (r) for land, fertilizer and seed are greater than 1 and are in agreement with Ogundari (2008) study of rain-fed rice farmers. These resources are, therefore, underutilized in maize farming. The farmers need to increase the quantity of these inputs to enable them maximize profit since marginal value product is greater than marginal factor cost or unit price of inputs.

The allocative efficiency ratios (r) for equipment and labour are below a score of 1. This means that these resources are over utilised in maize farming. It also means that the over utilised inputs are paid more than their marginal value products. By implication, the use of these resources should be reduced. The over utilization of equipment may be due to the fact that many equipment and tools are used at a time than as required, hence, unnecessarily increasing the cost of equipment. The result also shows that maize farming in the region involves the intensification of labour by the maize

Table 3. Marginal value analysis of input utilisation in the Central Region of Ghana.

Variable	Mean	Elasticity	MPP	MVP	MFC	r
Output	1166.91					
Land	1.83	0.20	127.53	244.86	92.95	2.63
Labour	63.90	0.14	2.56	4.91	12.54	0.39
Equipment	32.02	0.002	0.07	0.14	1.00	0.14
Fertilizer	58.11	0.05	1.00	1.92	0.76	2.54
Seed	21.10	0.99	54.75	105.12	4.98	21.11

Average price of output= GH¢1.92.

producing farm firms. A similar study by Kuwornu et al. (2013) on resource use efficiency of maize production in the Eastern Region of Ghana revealed that agro-chemicals and hired labor are under-utilized whereas seed, fertilizer and family labor are over-utilized by maize farmers in the region.

Bravo-Ureta and Pinheiro (1997) carried out study to estimate economic, technical and allocative efficiencies of peasant farming in the Dominican Republic. Results indicated that farmers were 0.44 efficient. These results were said to be in line with a 0.43 allocative efficiency for a sample of wheat and maize farmers in Pakistan, though peasant farms in Paraguay were said to be more efficient with 0.70 and 0.88 allocatively efficient compared with peasant farmers in the Dominican Republic.

Determinants of maize production efficiency in the Central Region of Ghana

The determinants of cost efficiency of maize production among the maize farmers of the Central Region of Ghana are shown in the stochastic cost frontier model below. Also shown are the effects of these determinants.

Maximum likelihood estimates of stochastic cost frontier function and inefficiency model

The stochastic frontier production function estimates of maize farming in the Central Region of Ghana are presented in Table 4. The table shows that the coefficients of all the parameters are positive and significant at 1% level. It is therefore concluded that maize yields are more responsive to the entire regressor variables included in the model.

Gamma (γ) has a value of 0.9999 and is significant at 1% level. This is an indication that almost all the variation observed from the frontier cost can be attributed to cost inefficiency among the maize farmers but not to random shocks such as statistical and data collection errors which are outside the control of the farmers. It implies that the one-sided cost inefficiency error component dominates the symmetric random error component in explaining the variation between frontier cost and actual cost of maize farmers. Again it also means that the model fits the data. The non-zero value of γ suggests that there are differences in cost efficiencies among maize farmers. It implies that inefficiency effect is present in the model and so the stochastic frontier model is adequate representation of the data but not the ordinary traditional average response function. The statistically significant value of 0.0201 in the stochastic cost frontier is significantly different from zero, indicating a good fit of the model and the correctness of the specified distributional assumptions.

Cost inefficiency source model

In the cost inefficiency model, results showed that the coefficients of all the exogenous variables included in the model are significant. Coefficients of extension, experience and credit had their expected negative signs. This implies that when the levels of these variables are increased, output and for that matter cost efficiency of farmers will increase accordingly. Coefficient of age also had its expected positive sign.

Coefficient of extension was expected to be negative. Accordingly, the coefficient of the variable is negative implying that the higher the number of times the farmers receive extension services, the less their level of inefficiency and hence the higher will be the level of efficiency (Kuznets, 1966).

Coefficient of age variable was expected to be positive. Findings from this research showed that the variable is positive and significant at 10% level. Younger farmers are likely to have some formal education, and therefore might be more successful in gathering information and understanding new practices, which in turn will improve their cost efficiency through higher levels of allocative efficiency.

Debebe et al. (2015) posited that the important factors that affected technical, allocative and economic efficiency of smallholder maize producers in Southwestern Ethiopia are family size, level of education, extension service, cooperative membership, farm size, livestock holding and use of mobile. It is established that for optimal use of

Table 4. Maximum likelihood estimates of stochastic frontier cost function for cost efficiency in the Central Region of Ghana.

Variable	Coefficient	std. error	t-ratio
Regressor			
Constant	-0.0073***	0.0017	-4.2049
Output	-0.0013**	0.0005	-2.4060
Land	0.0230***	0.0027	8.6632
Labour	0.0090***	0.0024	3.7988
Equipment	0.0035***	0.0007	4.9586
Fertilizer	0.9496***	0.0023	412.2862
Seed	0.0119***	0.0009	12.9851
Exogenous			
Constant	-0.3245***	0.0465	-6.9855
Extension	-0.0375***	0.0017	-22.0021
Age	0.0027**	0.0012	2.2239
Gender	0.0378*	0.0209	1.8117
HHSize	0.0171***	0.0054	3.1721
Experience	-0.0051**	0.0020	-2.5744
Credit	-0.7133***	0.0365	-11.9525
Variance parameter			
Sigma-squared	0.0201***	0.0012	17.2096
Gamma	0.9999***	0.0000	74083.9080

*, **, ***Statistically significant at levels of 10, 5 and 1% respectively.

resources in maize production in Ghana, quantities of fertilizer, herbicide, pesticide, seed, manure and land should be increased while the use of labour, farm tools and equipment should be reduced (Awunyo-Vitor et al., 2016).

Gender variable (being male) was positive. This means that male farmers are more inefficient compared to female farmers in maize farming in the study area. This finding is consistent with the results of Dolisca and Jolly (2008). These authors related their result to the fact that after land preparations women normally carry out the remaining activities involved in production process at the farm and this is more evident in Africa.

Coefficient of household size is significantly positive in the model. This means that maize farmers in the study area become more cost inefficient with increase family size, consistent with Abdulai and Eberlin (2001).

Experience, the number of years of maize cultivation achieved by household head, is used as a proxy for managerial input. Increased farming experience may lead to better assessment of importance and complexities of good farming decisions, including efficient use of input. The expected sign for experience variable is negative. In accordance with this expectation, the variable is negative in the cost inefficiency model. This implies that farmers who had more experience on cultivating maize had lower cost inefficiency, and this result agrees with Khai et al. (2008), Kareem et al. (2008) and Rahman (2003) findings that more experienced farmers are less cost inefficient in their allocation of resources for production than the new farmers who are progressive and willing to implement new production systems.

Access to credit is negative in the cost inefficiency model, meaning that this factor increases the cost efficiency of maize farmers. This is in conformity with the work of Abdulai and Huffman (1988). The estimated coefficient of credit availability in profit inefficiency model in their study on rice farmers in Ghana was negative which meant that their profit inefficiency decreased with increase in credit availability.

Paudel and Matsuoka (2009) analysed the cost efficiency of maize production in the Chitwan District, Nepal with a view to predict economic efficiencies using stochastic frontier cost function. Maximum-likelihood (ML) estimates of the parameters revealed that estimated coefficients of cost of tractor, animal power, labour, fertilizer, manure, seed and maize output gave positive coefficients and were significant at 5% levels. This study therefore agrees with most of the findings of Paudel and Matsuoka.

Conclusions

Based on the results of this study, the following conclusions were made about the state, efficiency and efficiency determinants of maize production in the Central Region of Ghana. Maize farming in the Central Region is predominantly the work of adult married males who have relatively low level of formal education and majority of whom do not have access to credit. Of the total cost of maize production in the region, land accounts for 14.38%, labour accounts for 68.19%, equipment accounts for 2.62%, fertilizer accounts for 3.66%, pesticide accounts for 2.14% while cost of planting materials accounts for 9.01%.

Maize farmers in the Central Region are not fully cost efficient and can increase yield with no additional resources. Resources employed in maize farming are not efficiently allocated, whiles equipment and labour are over utilised, land, fertilizer and seeds are underutilised. The effects of extension, experience and credit are negatively related to the level of cost inefficiency effects, whiles age, gender and household size are found to be positively related to cost inefficiency. The results indicate a significant random component in the cost inefficiency effects and that all the variables have significant influence on the magnitude of cost inefficiencies of farmers in the study area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Analyzing the determinants for the adoption of good practices as regards climate change adaptation in the Northern region of Burkina Faso

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Unfavorable agro-climatic and edaphic conditions have led to the development of many adaptation strategies to climate change in the northern region of Burkina Faso. This study analyzed the determinants of goods practices adoption as regards adaptation to climate change (GPACC). It used panel data (2016-2018) collected from a sample of 1,221 women and 335 men within the operational farmer's organizations in the provinces of Zondoma and Passoré. Results of the multinomial Logit model showed that adoption of GPACC is determined by the socio-economic characteristics of men and women including the institutional opportunities and farms characteristics. These factors included years of experience in farming, production costs, access to credit, the possession of ruminants, soils type and availability of inputs on time. However, the relevance of the variables and the meaning of their influence partially varied depending on GPACC and the smallholder' gender. Therefore, it is essential to build-up technical, socio-economic and institutional capacities to reach a massive adoption of GPACC. However, all these capacity-building actions should take into account the findings as regards the specificity of each producer category.

Key words: Determinants, adoption, goods practices, climate change, women, men, multinomial logit, Burkina Faso.

INTRODUCTION

Droughts of the 1970s and soils deterioration led the innovative farmers from the Northern region of Burkina Faso to develop water and soils conservation techniques (WSC) such as zaï, stone lines, mulching, half-moons, grassed strips, etc. (Belemviré et al., 2008; Sawadogo et al., 2008; Taonda et al., 2008). Since then, agricultural research has been improving such traditional techniques by putting in place other technologies such as improved seeds varieties and mineral and organic fertilization techniques likely to enhance their efficiency. Several studies showed that such techniques increased yields and agricultural incomes (Sawadogo, 2006; Belemviré et

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al., 2008). However, the combination of the integrated management of nutritive elements (combination fertilizers and organic manure) further amplified this yield (Zougmore et al., 2004, 2010).

Despite the multiple efforts achieved to disseminate these techniques, we qualify as good practices for adaptation to climate change (GPACC) (MAAH, 2018), food insecurity and poverty issue are still prevailing particularly in rural area. Indeed, the coverage rate of cereals need within the Northern region was 72% against 109% at the national level. This food insecurity derived either from the low adoption of GPACC or from the non-compliance with the technical form to implement these practices, resulting in low soil productivity. Unfortunately, the latest information on the current use of GPACC are missing as well as the favorable factors to their adoption. Several authors were dealing with the issue related to the adoption of the agricultural innovations in various African countries (Mounirou, 2015; Hassan and Nchemachena, 2008; Deressa et al., 2009; Ouédraogo et al., 2010; Folefack al., 2012; Salhi et al., 2012; Mabah-Tene et al., 2013; Mbétid-Bessane, 2014; Sale et al., 2014; Ouédraogo and Tiganadaba, 2015; Yabi et al., 2016; Rabé et al., 2017). The results of these studies showed that the social, economic, institutional and technical factors determined the adoption of strategies to adapt to climate change. However, the studies conducted in Burkina Faso were restricted to the either the strategies individually taken, or to the association of water and soil conservation (WSC) techniques, or their combinations with farmyard manure and/or with mineral fertilizers (Ouédraogo et al., 2010; Ouédraogo and Tiganadaba, 2015; Sigué et al., 2018). Unfortunately, these practices did not take into account the adoption of GPACC in terms of combining WSC techniques with organic matter and/or mineral fertilizers under cropping systems using seeds of improved varieties or even gender issue. Furthermore, most of these authors used annual data. Considering the previous works, this study aims to analyze the determinants of GPACC adoption by women and by men in the Northern region of Burkina Faso using panel data.

Based on the random utility theory, it assumes that the determinants of adoption of GPACC vary according to farmers' practices and gender issue. Gender analysis could provide useful information feeding decision-making tool for actors in the rural area. Practically speaking, women and men did not have the same socio-economic benefits (MPF, 2012). In Burkina Faso, unlike men, women had poor access to the production means, to financial and extension services (Ouoba et al., 2003; MPF, 2012). However, women represented more than 52% of the country's population (MPF, 2012). As a result, it will be difficult to reduce the rural communities' vulnerability without a strong involvement of women in the adaptation strategies. Finally, using the panel data improves the robustness of the results and therefore makes easier their dissemination or extrapolation.

MATERIALS AND METHODS

The study area

This research has been carried out in the provinces of Zondoma and Passoré located in the Northern of Burkina Faso. These provinces have unfavorable agro-climatic and edaphic conditions. They belong to the Sudano-Sahelian agro-climatic domain with an annual rainfall ranging between 500 and 864 mm (Ganou, 2005; Tiama et al., 2018). Soils are mostly poor in nutrients and formed of lateritic plateaus and ferruginous cuirasses. Women represent in average 53.8% of the population (INSD, 2008). These two provinces were chosen because they hosted the project "Financial Services and Deployment of Agricultural Innovations in Burkina Faso (SFDIAB)" during which data was collected in 187 villages of 9 municipalities.

The choice of sample

For this study, a purposive sampling was used. A list of farmers' organizations (FOs) has been drawn up in collaboration with technicians of the agricultural department. After that, FOs were selected based on their farming practices, including their dynamism and market orientation. Data were collected over three consecutive years. 1,556 farmers (1,221 women and 335 men) participated to the three annual surveys. All selected farmers freely agreed to participate to this survey. Data collected focused on the farmers' socio-economic and institutional characteristics, the environment of the farms and the adaptation practices to climate change.

The analysis approach

This research basically assumes that farmers' socio-economic and institutional characteristics, the production environment of farms are the determinant factors for adopting GPACC. It is based on random utility theory stating that adoption is a function of the random utility perceived by producers from innovation. We assumed that this utility depends on the observable variables and unobservable characteristics captured by the error term. In designating U_{ij} as the utility that the producer (j) gets out of an option choice (j), β_j a set of parameters associated with the explanatory variables X_i of option j, ε_{ij} the error term and $\beta_j X_{ij}$ the deterministic part, the random utility function can be written as follows:

$$U_{ij} = \beta_j X_{ij} + \varepsilon_{ij} \quad \text{(McFadden, 1974)} \qquad (1)$$

The choice of the multinomial logit model

Logit and Probit are the most used models in the literature to model adoption when the dependent variable is dichotomous (Ouédraogo et al., 2010; Folefack et al., 2012; Salhi et al., 2012; Sale et al., 2014; Yabi et al., 2016; Rabé et al., 2017). However, Logit or Multinomial Probit is the most appropriate when the dependent variable has more than two modalities. But, because of its simplicity, in terms of calculating the probabilities of choice, its easy estimation and the globally concave form of its probability function, the Logit multinomial model is mostly used in Africa (Deressa et al., 2009; Mounirou, 2015; Ouédraogo and Tiganadaba, 2015). Our modeling was focused on unordered choices. To achieve this, we used the independent multinomial Logit model. It is a model for which the utility function is a linear function whose parameters differ according to the modalities and for which the explanatory variables vary only according to individuals (Ouédraogo and Tiganadaba, 2015).

Model specification

Based on the utility theory, the option j is chosen by the farmer against option (l) if only the utility associated with option j is greater than that of l ($U_{ij}>U_{il}$). However, this utility cannot be actually observed. Only the adoption of practice j by farmer i, materialized by yij can be observed. This dependent variable takes 1 if the producer chooses practice j and 0 if he does not. The model is based on the independence hypothesis of irrelevant alternatives (Ouédraogo and Tiganadaba, 2015). Let P be the probability the farmer i chooses practice j on time t, P can be written as follows:

$$P\left(y_{ijt} = 1\right) = P\left(U_{ijt} \geq U_{ilt}\right) \text{ for all } l \neq j \quad (2)$$

The multinomial model on time t can be expressed as follows:

$$P(y_{it} = j) = \frac{exp\,(\beta_j X_{ijt})}{\left[\sum_{i=0}^{J} exp\,(\beta_j X_{ijt})\right]} = \frac{exp\,(\beta_j X_{ijt})}{\left[1+\sum_{i=1}^{J} exp\,(\beta_j X_{ijt})\right]} \quad (3)$$

The parameters associated with the explanatory variables are interpreted as deviations compared to the non-adoption. Under the normalization hypothesis $\beta_0=0$, the probability associated with the non-adoption of GPACC is:

$$P\left(y_{it} = 0\right) = \frac{1}{\left[\sum_{j=0}^{J} exp\,(\beta_j X_{ijt})\right]} = \frac{1}{\left[1+\sum_{j=1}^{J} exp\,(\beta_j X_{ijt})\right]} \quad (4)$$

Specification of the model's parameters

Five modalities are retained for the dependent variable Y (technology groups or possible choices), which is the adoption of GPACC:

(i) ***Group 0*** = male and female producers who do not adopt any GPACC;
(ii) ***Group 1*** = male and female producers adopting one GPACC or the water and soils conservation techniques (WSC), or organic manure (OM) , or chemical fertilizer or improved seeds varieties (IS);
(iii) ***Group 2*** = male and female adopters of two GPACCs (WSC + OM or WSC + chemical fertilizers or WSC + IS or OM + chemical fertilizer or OM + IS or chemical fertilizer + IS);
(iv) ***Group 3*** = male and female adopters of three GPACC (WSC + OM + chemical fertilizer or WSC + OM + IS or OM+ chemical fertilizer + IS);
(v) ***Group 4*** = male and female adopters of four GPACC (WSC + OM + chemical fertilizer + IS).
The ***WSC techniques*** refer to the technologies which stock or reduce runoff and make it available for agricultural production in order to mitigate the effects of season variations and improve agricultural production reliability (FAO, 2011).
Organic matter (OM) is incorporated to soil as farmyard manure or compost.
Seeds of improved varieties (IS) refer to those created or developed in agronomic research centers.

The choice of explanatory variables was guided by the literature on the determinants of adoption of agricultural innovations and by statistical tests of multicollinearity. By adding the "robust" option to the multinomial Logit control on panel data (femlogit) during the estimation to correct the possible presence of heteroscedasticity and obtain more robust results, some variables have been eliminated because 'of they had zero (or almost zero) within-group variance. Therefore, the relevant explanatory variables are recorded in the Table 1.

RESULTS

Descriptive statistics of explanatory variables

Table 2 presents the descriptive statistics of the model explanatory variables. The results show that the households average size of our sample is 13 persons including both men and women. Women have an average of 11 years of experience in agricultural production compared to 17 years for men. The average number of visits by the extension agent per year is 1.4 for women and 1.6 for men. The average extra-agricultural income is 5,400XOF for women against 19,325XOF for men. The saving amount is 7,118XOF for women and 38,780XOF for men. The total average production costs are 49,151XOF and 148,605F XOF respectively for women and men. About 44% of the soils used by women are gravels compared to 55% for men. An approximate average of 28% of women and 21% of men has access to credit. The rates of participation to a specialized training are respectively 12.6 and 17.3% for women and men. Female and male producers said they have good quality inputs. About 77% of women and 75% of men said inputs are provided on time in their area. Most of our sample individuals have at least one small ruminant. The proportion of women owning a ruminant is 45.18% against 61.14% for men.

Adoption rate of good practices regarding adaptation to climate change

Adoption rate of GPACC varies according to the farmer' age and gender (Table 3). However, the GPACC are mostly adopted by men compared to women. During the survey (three years), an average of 87% of women and 96% of men has adopted at least one GPACC. The association of two GPACC is the option mostly adopted by women (32.05%) while men mainly adopt three GPACC (39.60%). the adoption rates of the combination of four GPACCs (CES + FO + SA + Fertilizers) considered in the literature as the best option is low; 6 and 14.13% respectively for women and men.

Results of econometric analyzes (results of multinomial logit model)

Table 4 shows the results of the multinomial Logit model estimation. The model is said to be globally significant,

Table 1. Explanatory/independent variables of the multinomial model.

Variables	Types of variable	Description of explanatory variables	Expected signs
Size	Quantitative	The number of persons in the household	+
Exp	Quantitative	Number of years of experience in agricultural production	+
Exrev	Quantitative	Non-agricultural incomes in XOF	+
Savings	Quantitative	The amount saved by the producer in XOF	+
Credit	Qualitative	Access to credit. This reaches value 1 if the farmer has access to credit and 0 if he has not.	+
Visit	Quantitative	Number of visits conducted by the disseminating worker in the farmers' farms	+
Forma	Qualitative	Participation to a specialized training. This reaches the value 1 if that is the case and 0 if not.	+
CTP	Quantitative	Production total cost expressed in XOF	-
Quali_Input	Qualitative	Farmers' perception on the input's quality. The variable reaches the value 1 if the input is deemed as of good quality by the farmers and reaches 0 if not	+
Input_time	Qualitative	Availability of inputs on due time. The variable reaches the value 1 if the producer affirms that the inputs are available on due time in their area and 0 if this not the case	+
Soil	Qualitative	Type of soil used by the farmer. Soil=1 if of the farm soil is mostly made up of gravels or laterites and 0 if not.	+
Prum	Qualitative	This variable represents the ownership of small ruminants (sheep, goats, etc). This reaches the value 1 if the farmer owns at least one small ruminant and 0 if he does not.	+
Rum	Qualitative	This represents the ownership of ruminants (oxen or donkeys). The value of this variable reaches 1 of the farer owes one ruminant and 0 if he does not	+

The model was estimated separately for women and men using the likelihood maximum method (which follows a Chi-square law) with the software STATA version 15.

Table 2. Descriptive statistics of the explanatory variables introduced in the Multinomial Logit model among women and men.

Variable	Average	Standard deviation	Minimum	Maximum	Average	Standard deviation	Minimum	Maximum
	Women				Men			
	Quantitative variables							
Size	13	7,19	1	66	12.6	7	1	50
Exp	11.1	9.3	0	90	16.8	12.44	1	75
Exrev	5400.4	22372.03	0	1000000	19315	62961.97	0	750000
Savings	7118.0	28702.20	0	750000	38780	332462.40	0	10000000
CTP	49151	38997	525	285018	148605	118647	1300	905753

Qualitative variables				
	Women		Men	
	Frequency	Percentage	Frequency	Percentage
Credit	1024	27.96	208	20.7
Soil	1617	44.14	552	54.93
Input_time	2821	77.01	793	78.91
Quali_input	3426	93.53	931	92.64
Forma	462	12.61	174	17.31
Prum	2803	76.52	916	91.14
Rum	1655	45.18	613	61.14
N	3663		1005	
N	1221		335	

N= observation number over three years; n= sample size.
Source: Survey data 2016-2018.

Table 3. Adoption rates of GPACC based on gender.

Methods	Frequency	Percentage	Frequency	Percentage
	Women		Men	
No GPACC	471	12.86	38	3.78
One GPACC	835	22.80	135	13.43
Two GPACC	1174	32.05	292	29.05
Three GPACC	969	26.29	398	39.60
Four GPACC	220	6.01	142	14.13
N	3663	100	1005	100
n	1221		335	

N= number of observation over three years; n= sample size.
Source: Source: survey data of agricultural campaigns 2015-2016, 2016-2017, 2017-2018

when the likelihood value is greater than that of the Chi-square at the same degree of freedom at a given threshold (1, 5 or 10%). The likelihood ratio test indicates that the two models are globally significant at 0.01% threshold with coefficients of determination (R2 of Mac Fadden) equal to 0.3967 and 0.3117 respectively for women and men. Thus, the hypothesis of simultaneous nullity of all the coefficients is rejected, implying that the variables introduced into the models contribute together to explain the decisions regarding the adoption of GPACC by women and men.

The analysis of the results reported in Table 4 shows that the coefficients of the extra-agricultural incomes and savings variables are zero regardless of the GPACC modality.

For the adoption of a GPACC, the coefficients of the variables "number of years of experience" in agriculture (Exp), total cost of production (CTP) and type of soil (Soil) are all positive and significant at a threshold of 10% among women. For men, the coefficients of the variables significant at 10% are "agricultural experience", "total cost of production", "access to specialized training" and "type of soil". The coefficients of the variable's "experience" and "total cost of production" are positive while those of the variables "access to specialized training" and "type of soils" are negative. For the probability of adoption of two GPACC among women, the coefficients of the variables "agricultural experience", "total cost of production" and "ownership of ruminants (Rum)" are all positive and significant at 1% threshold. The coefficients of the variables "total cost of production", "access to specialized training" and "type of soil" are significant at a threshold below or equal to 5% for men. At this level, only the coefficient of the variable "total cost of production" is positive. For the probability of adoption of three GPACC, the coefficients of the variables "experience in agricultural production", "access to agricultural credit (Credit)", "total production cost", "type of soil, "availability of inputs on time" and ownership of ruminants are positive and significant at 10% threshold. Among men, the significant coefficients are those of the variables "agricultural experience", "total cost of production" and "access to specialized training". Except the coefficient of the variable "access to specialized training" which is negative, those of the other variables are positive.

Finally, for the probability of adoption of four GPACC, the coefficients of the variables "access to credit", "total cost of production" and "type of soil" are all significant at 5% threshold and are positive. For men, the coefficients of the variables "access to credit", "total cost of production", "access to specialized training" and "ownership of small ruminants" are significant at 10% threshold. Except the coefficient of the variable "access to specialized training" which is negative, those of the other variables are positive.

DISCUSSION

Interpretation only concerns significant coefficients. Descriptive statistics show that men adopt GPACC more than women. This situation can be explained by the low access of women to production factors compared to men (MPF, 2012). The econometric results show that the determinants for adopting GPACC depend on the farmer's practices and gender.

Probability for adopting one GPACC

Analyzing these results shows that the experience in the agricultural production has a positive influence on the probability to adopt one GPACC among men and women. The positive influence of this variable can be explained by the fact that women's experience in farming is essential to improve their capacity in appraising and mastering GPACC. It provides an understanding of the challenges for adopting agricultural innovations. This result is in line with that of Debalke (2014) and Mbétid-Bessane (2014) respectively in Ethiopia and the Central African Republic. Nkamleu and Coulibaly (2000) and Mbétid-Bessane (2014) believe that experienced farmers

Table 4. Results of the multinomial Logit model estimation .

BPACC	Coefficients	Std. Err.	z	P>z	Coefficients	Std. err.	z	P>z
	Women				Men			
One GPACC								
Size	0.0199	0.0204	0.98	0.329	-0.036	0.097	-0.37	0.711
Exp	0.0260*	0.0152	1.7	0.089	0.0423*	0.0256	1.65	0.098
Exrev	0	0	-0.3	0.762	0	0	-1.05	0.295
Credit	0.1137	0.2471	0.46	0.645	-0.7706	0.8732	-0.88	0.378
Savings	0	0	0.37	0.708	0	0	-0.14	0.892
Equi	0.7854	0.7369	1.07	0.287	-0.1026	1.1929	-0.09	0.931
CTP	0.0001***	0	8.35	0.000	0.0001***	0	2.76	0.006
Soil	0.4639**	0.2077	2.23	0.026	-0.9852*	0.5397	-1.83	0.068
Intput_time	-0.0597	0.2512	-0.24	0.812	-1.3301	0.829	-1.6	0.109
Quali_Intrant	0.1017	0.409	0.25	0.804	-1.1095	1.1438	-0.97	0.332
Forma	-0.1716	0.3689	-0.47	0.642	-2.8368**	1.1757	-2.41	0.016
Prum	0.071	0.293	0.24	0.809	0.0135	1.1661	0.01	0.991
Rum	0.2042	0.2216	0.92	0.357	0.1419	0.7225	0.2	0.844
Two GPACC								
Size	-0.0046	0.0248	-0.19	0.852	-0.0134	0.0939	-0.14	0.886
Exp	0.0447**	0.016	2.79	0.005	0.0426	0.0282	1.51	0.131
Exrev	0	0	-2.36	0.018	0	0	-0.8	0.424
Credit	0.1975	0.2601	0.76	0.448	-0.4411	0.8485	-0.52	0.603
Savings	0	0	0.74	0.46	0	0	-0.08	0.936
Equi	0.3192	0.7289	0.44	0.661	-0.3533	1.1477	-0.31	0.758
CTP	0.0001***	0	12.67	0.000	0.0001***	0	2.98	0.003
Soil	0.3492	0.2196	1.59	0.112	-1.1848**	0.5257	-2.25	0.024
Input_time	0.1877	0.2649	0.71	0.478	-1.3146	0.8605	-1.53	0.127
Quali_Input	0.3676	0.4235	0.87	0.385	-0.8622	1.0945	-0.79	0.431
Forma	0.0669	0.391	0.17	0.864	-3.2482***	1.2189	-2.66	0.008
Prum	0.1368	0.3253	0.42	0.674	1.5772	1.1683	1.35	0.177
Rum	0.6392***	0.2299	2.78	0.005	0.3777	0.7031	0.54	0.591
Three GPACC								
Size	-0.0346	0.027	-1.28	0.2	-0.0377	0.0969	-0.39	0.697
Exp	0.0368**	0.0178	2.07	0.039	0.0556*	0.0288	1.93	0.054
Exrev	0	0	-2.6	0.009	0	0	-0.77	0.441
Credit	0.5674*	0.2917	1.95	0.052	0.3936	0.8581	0.46	0.646
Savings	0	0	1.86	0.062	0	0	-0.18	0.854
Equi	0.1188	0.7903	0.15	0.88	-0.0087	1.2071	-0.01	0.994
CTP	0.0002****	0	15.17	0.000	0.0001***	0	3.41	0.001
Soil	0.5589**	0.2458	2.27	0.023	-0.7748	0.5599	-1.38	0.166
Input_time	0.5800*	0.3208	1.81	0.071	-1.0819	0.8673	-1.25	0.212
Quali_Input	0.5261	0.5461	0.96	0.335	-0.5579	1.05	-0.53	0.595
Forma	0.1562	0.4305	0.36	0.717	-3.5395***	1.1961	-2.96	0.003
Prum	-0.008	0.3905	-0.02	0.984	0.1653	1.2048	0.14	0.891
Rum	0.8077**	0.2639	3.06	0.002	1.0177	0.7241	1.41	0.16
Four GPACC								
Size	0.0103	0.0346	0.3	0.766	-0.0095	0.0997	-0.1	0.924
Exp	0.0226	0.0232	0.97	0.33	0.0387	0.0313	1.23	0.217
Exrev	0	0	-2.17	0.03	0	0	-1.12	0.265
Credit	1.0926***	0.3973	2.75	0.006	2.3895**	0.9622	2.48	0.013

Table 4. Contd.

Savings	0	0	1.74	0.082	0	0	-0.36	0.721
Equi	-0.4093	1.2173	-0.34	0.737	1.5674	1.3523	1.16	0.246
CTP	0.0002***	0	16.34	0.000	0.0001***	0	3.72	0
Soil	0.7257**	0.3611	2.01	0.044	-0.4465	0.6403	-0.7	0.486
Input_time	0.4322	0.4676	0.92	0.355	-0.9665	0.951	-1.02	0.309
Quali_Input	0.5624	0.8014	0.7	0.483	-1.3671	1.1923	-1.15	0.252
Forma	0.5653	0.5303	1.07	0.286	-4.5738***	1.2832	-3.56	0
Prum	0.2521	0.5196	0.49	0.628	-0.4495	1.3024	-0.35	0.73
Rum	-0.1197	0.365	-0.33	0.743	1.4226*	0.8134	1.75	0.08
Log Vraisemblance	-885.23702				259.7438			
Pseudo R2	0.3967***				0.3117***			
Wald Khi-2	474.01				133.05			
N	3246				879			
n	1221				335			

***: significative value to 1 %; ** significative value to 5 %; * significative value to 10%

had time to actually feel the positive effects of technologies on yields. The total production costs also influence the probability of women and men adopting a GPACC. The influence of this variable is positive indicating that the higher the cost, the higher the probability that women and men adopt a GPACC. This influence, contrary to the expected theoretical effect, could be linked not only to the personal adoption decision (one of the fundamental assumptions of the adoption model), but also to the technical and material assistance of farmers' organizations through sustainable rural development programs and mutual aid between farmers in the realization of the WSC (Ouédraogo, 2009). These assistances encourage adoption because these costs are partly borne by these programs. As for the soil type variable, the probability for adopting one GPACC increases more when the soil in the woman's field is of gravel type. These techniques are well suited to degraded and generally gravelly soils. However, among men, gravelly soils negatively influence the probability for adopting one GPACC among women. This apparent contradiction could be linked to the fact that men, being generally the household’s heads and having several types of soil, do not make a choice in practicing one GPACC; for these one, families ‘foods needs are covered by the adoption of one GPACC. Therefore, they perform their GPACC, regardless of the type of soil. Finally, the adoption of one GPACC also decreases when man has an access to a specialized training. A plausible explanation to this result would be that man having received such training prefer to invest more in other activities than in agricultural production.

Probability adopting two GPACC

In addition to experience in agricultural production and total cost of production, ownership of ruminants (donkey and / or oxen) improves the probability of women to adopt two GPACC. Ruminants are not only used in animal traction for plowing but also provide manure for soil amendment. Previous studies have shown that manure is used in crop fertilization in Burkina Faso (Belemviré et al., 2008; CRDI, 2014). The adoption of two GPACC among men is influenced by total production costs, soil type, and access to a specialized training. As with a GPACC, the gravel-type soil and access to a specialized training reduce the probability for adopting two GPACC. However, unlike adopting one GPACC, the total production costs are positively related to the adoption of two GPACC. The positive effect of the production costs for men and women’s adoption of two GPACC results from the technical and financial partners support and mutual aid among farmers of the study area.

Probability for adopting three GPACC

The probability for women to adopt three GPACC increases with experience, production cost, soil type, and ownership of ruminants. In addition to these already interpreted variables, the availability of inputs on time (Input-time) and access to credit improves the probability for women to adopt three GPACC. The relevance of the variable “availability of inputs on time” could be explained by the fact that, rural women have a lot of responsibility; in addition to their domestic work, they work in their husbands ‘farms. As a result, the more inputs are available in time, the better they can adjust the period of use. Furthermore, they have few financial capacity and limited areas (MPF, 2012) so that they would prefer not to waste their resources when respecting the cropping calendar becomes impossible due to the unavailability of inputs on time. The positive effect of “access to credit” is likely related to the fact that adopting three GPACC requires more investment than the others mentioned above. As a result, access to credit improves women's financial capacity and therefore their ability to adopt three GPACC. This result is in line with Ouédraogo et al. (2010), Mbétid-Bessane (2014), Rabé et al. (2017), Ouattara et al. (2018) and Traoré et al. (2019) in different African countries (Central African Republic, Burkina Faso and Niger). However, the insignificant effect of this variable among men suggests that they do not need any external financial support to adopt three GPACC.

Probability for adopting four GPACC

Variables “soil type”, “total production costs”, and “access to credit” positively influence the probability for women to adopt four GPACC. As in the case of three GPACC, access to credit improves women's cash flow and therefore their ability to adopt four GPACC. “Access to credit” also increases the probability for men to adopt four GPACC. Compared to the other modalities where this variable was not significant among men, this result seems to indicate that even if men have incorporated it extensively in their farming systems, adopting four GPACC implies to have strong cash. In other words, they need external financial support to adopt this GPACC method. In addition to credit, the total costs of production and ownership of ruminants positively influence the probability of adoption of four GPACC. The requirement of this modality in terms of economic need is confirmed by the variable “ruminant ownership” which is only significant for the adoption of four GPACC among men. Like the other GPACC modality, the “access to a specialized training” variable reduces probability for men to adopt four GPACC.

Conclusion

This study has showed that GPACC are adopted more by men than women. Determinants of adoption vary partially depending on the type of GPACC and farmer’s gender. Therefore, the adoption of a GPACC among women is determined by the number of years of experience of women in agricultural production, the total costs of production and the type of soil. These variables increase the probability for women to adopt GPACC. As for men, experience in production, total costs of production, soil type, and access to specialized training determine the adoption of a GPACC. While production costs improve the probability for adoption, soil type and specialized training decrease it.

Adoption of two GPACC among women is determined by years of experience, production costs and ruminant’s ownership. These variables favor the adoption of two GPACC. As for men, the adoption of this modality is determined by the total costs of production, the type of soil and access to specialized training.

As for the adoption of three GPACC among women, the following variables improve their adoption: the number of years of experience, production costs, ruminant ownership, access to credit, type of soil and availability of inputs on due time improve. As for men, the determinants factors for adopting this modality are “experience in production””, total production costs and access to specialized training. Production costs and experience favor adoption, while specialized training negatively affects it.

Adoption of four GPACC among women is determined by production costs, access to credit, and soil type. Determining variables for men to adopt four GPACC are: access to credit, production costs, access to specialized training, and ownership of ruminants. Except the access to training, all other variables increase the probability for adopting four GPACC. As an overall, the socio-economic variables of the producers, the institutional opportunities of the production environment and the farms characteristics determine the adoption of GPACC. However, the relevance of these variables varies according to GPACC and gender even if some appear to be common to all GPACC for a given category of farmers. Therefore, projects and programs aimed at promoting the large-scale adoption of GPACC must take into account these factors and the specificity of needs according to the producers’ categories to better achieve their objective.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Relative profit efficiency of Anchor Borrowers Programme (ABP) beneficiary and non-beneficiary rice farmers in Kebbi State, Nigeria

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Profit efficiency refers to the extent at which a firm makes not only profit but its ability to maximize profit. A comparative analysis was conducted to evaluate the profit efficiency of Anchor Borrowers Programme (ABP) beneficiary and non-beneficiary rice farmers in Kebbi State, Nigeria. Multistage sampling technique was used to select 499 ABP beneficiary and non-beneficiary rice farmers each giving a sample size of 998. A well-structured questionnaires were administered in order to collect data. Data collected were analyzed using Stochastic Frontier Profit Function Model. The results revealed that farm efficiency index varied from one farmer to another and ranged from 0.44 to 0.99, with a mean of 0.94 for the beneficiary farmers, while for non-beneficiary farmers, the maximum efficiency was 0.90 with 0.11 minimum efficiency and a mean of 0.74 The results revealed that the two categories of farmers were not efficient in maximizing profit, however, ABP beneficiary rice farmers were more profit efficient than the non-beneficiary rice farmers. This suggests that ABP has improved the profit efficiency of the beneficiary rice farmers. It is recommended that since ABP enhances the profit efficiency of the beneficiary rice farmers, policies should be tailored towards inclusion of other farmers to benefit from ABP intervention in Nigeria.

Key words: Profit efficiency, Anchor Borrowers Programme (ABP), beneficiary rice farmers.

INTRODUCTION

Rice is a staple food for about 2.6 billion people in the world. It is the most important staple food for a large number of the world human population. It is the second highest worldwide production after maize (FAOSTAT, 2017). Consequent upon maize crops been grown for the purposes other than human consumption; rice is said to be the most important grain with regard to human nutrition and calorie intake (Usman, 2011). Rice provides more than one fifth of the calorie consumed worldwide by human species, though relatively lower in protein compared to other cereals, it contains a better balance of amino acids (Oyewole and Ebukiba, 2010).

Nigeria is the leading consumer and largest producer of rice in Africa and simultaneously one of the largest rice

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importers in the world. Rice being an important food security crop, is an essential cash crop generating more income for Nigerian farmers than any other cash crop in the country. In 2008, Nigeria produced approximately 2 million metric tonnes of milled rice and imported roughly 3 million metric tonnes, including the estimated 800,000 metric tonnes that is suspected to enter the country illegally on an annual basis (NBS, 2007). According to Usman (2011), over the past several decades rice has established itself as a preferred staple food in Nigeria. For the purpose of ceremonial occasions, rice has grown in importance as a component of Nigerian diets. An average Nigerian consumes about 24.8 kg of rice per year, representing 9% of the total calories intake (FAO, 2001). The increased consumption of rice has led to its demand far exceeding supply except policy measures are put in place to improve production.

The program thrust of the ABP is provision of farm inputs in kind and cash (for farm labour) to small holder farmers (SHF) to boost production of these commodities, stabilize inputs supply to agro processors and address the country's negative balance of payments on food. At harvest, the SHF supplies his/her produce to the agro-processor (Anchor) who pays the cash equivalent to the farmer's account. The programme evolved from consultations with stakeholders comprising Federal Ministry of Agriculture and Rural Development, State Governors, millers of agricultural produce, and smallholder farmers to boost agricultural production and non-oil exports in the face of unpredictable crude oil prices and its resultant effect on the revenue profile of Nigeria (Central Bank of Nigeria (CBN), 2016). In order to boost agricultural output, provide food security and reduce importation of Agricultural commodities particularly those Nigeria has a comparative advantage to produce, the CBN established the ABP. The Programme which is intended to create a linkage between anchor companies involved in processing and the SHFs of the required major agricultural commodities.

For many years, Nigeria has been grappling with food insecurity and its attendant consequences leading to hunger, massive importation, and social disorders among others. In order to overcome the challenges posed by food insecurity so many agricultural programs were introduced with the sole aim of boosting food production, and stemming the tide of food insecurity and also leverage on Agricultural financing which is a key challenge in Agriculture, led to the setting up of ABP in order to boost the production of certain Agricultural commodities such as Rice, Maize, Sugarcane, Wheat among others.

Despite the prospects that greeted the launch of the ABP, with the hope that the program targets to alleviate poverty, increase income by enhancing the profit of the beneficiary farmers, an empirical study of the profit efficiency of the beneficiary farmers has not been documented in Kebbi State, Nigeria. This study hopes to provide information that would be useful to policy makers by serving as a guide on the success or otherwise of the ABP. It is against this backdrop that this study hopes to investigate the following questions.

Whether ABP beneficiary rice farmers maximize their profit?
What are the determinants of profit efficiency among ABP beneficiary rice farmers?

Conceptual framework

The conceptual framework for the study is based on the concept of technical efficiency of resource utilization and the concept of production by Coelli et al. (1998). Production is the transformation of a given set of inputs to produce output. In the light of rice production, farmers are required to combine certain measure of inputs such as rice, seed, land, labour, fertilizer agrochemicals and capital in order to produce paddy rice in which they sell so as to make profit. Given that for paddy rice to be produced that the farmers can be viewed have maximized profit, it requires that the resources be combined or appropriated in a definite proportion. Technical efficiency is the ability of the farmer to produce a given level of output using least amount of physical inputs. It signifiers a peak level of performance that uses the least amount of inputs to achieve higher amount of output, optimality is therefore required in deciding the level of inputs that are to be mixed.

Figure 1 depicts the concept of possible production set that is the set of all resources (inputs)-output combination that are feasible. If the obtained outlet lies along the frontier (the points from OF) the farm is technically efficient indicating the efficient subset of feasible production set. But if it lies below the frontier (point A), it means that it is technically inefficient because it could increase output towards the level associated with point B. without increasing input. Whereas points B and C represents efficient points.

The socioeconomic and institutional variables are expected to influence a farmer's profit efficiency. These factors includes marital status, age, educational level, household size, farming experience, cooperativeness seed variety, planting technology, income level among others.

Consequent upon the design of ABP targeted to provide incentives both in cash and in kind to the beneficiary rice farmers, the intervention from ABP was anticipated to influence the profitability and profit efficiency of the beneficiary rice farmers.

In the context of frontier literature, DD in Figure 2 represents profit frontier of farms in the industry (the best practice firm in the industry with the given technology. EE is the average response function (profit function) that does not take into account the farm specific inefficiencies. All farms that fall below DD are not attaining optimal profit given the prevailing input and output prices in the product

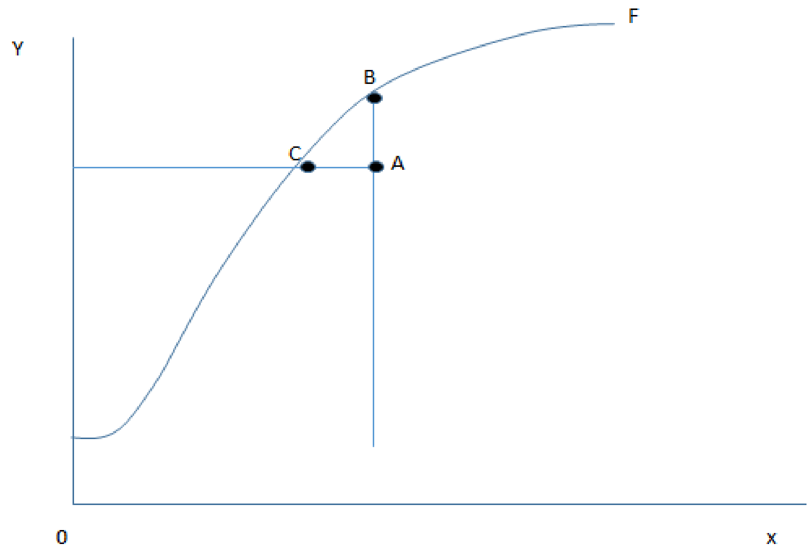

Figure 1. Production frontiers and technical efficiency.
Source: Coelli et al. (1998).

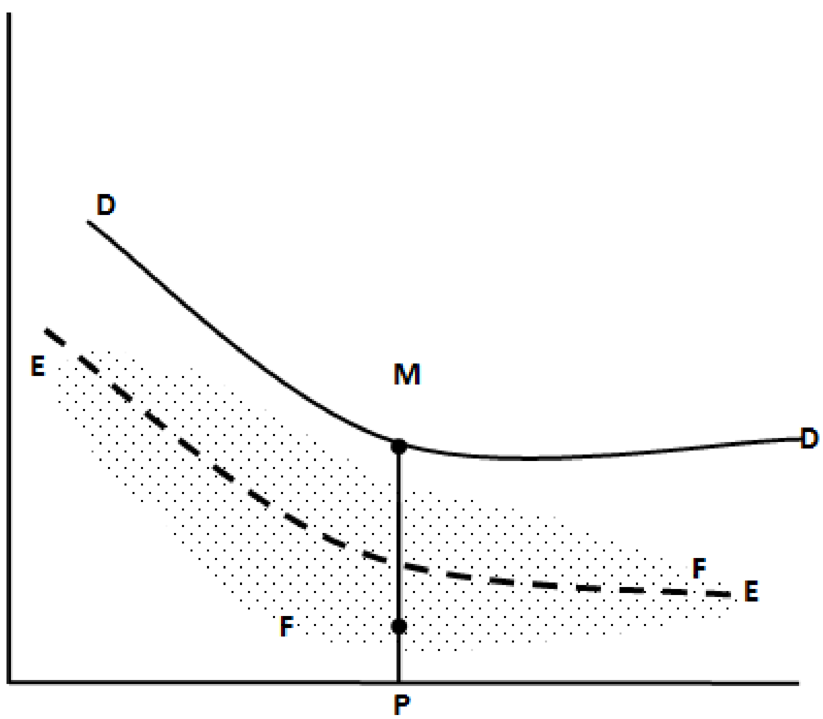

Figure 2. Frontier MLE Stochastic Profit Functions. Normalized input price given fixed price given fixed resources P_1/Zj.
Source: Ali and Flinn (1989).

and the input markets. They are producing at allocatively inefficient point F in relation to M in Figure 2. Profit inefficiency is defined as profit loss of not operating on the frontier. In Figure 1, a firm operating at F, is not efficient and its profit inefficiency is measured as FP/MP (Ali and Flinn, 1989; Sadoulet and De Janvry, 1995).

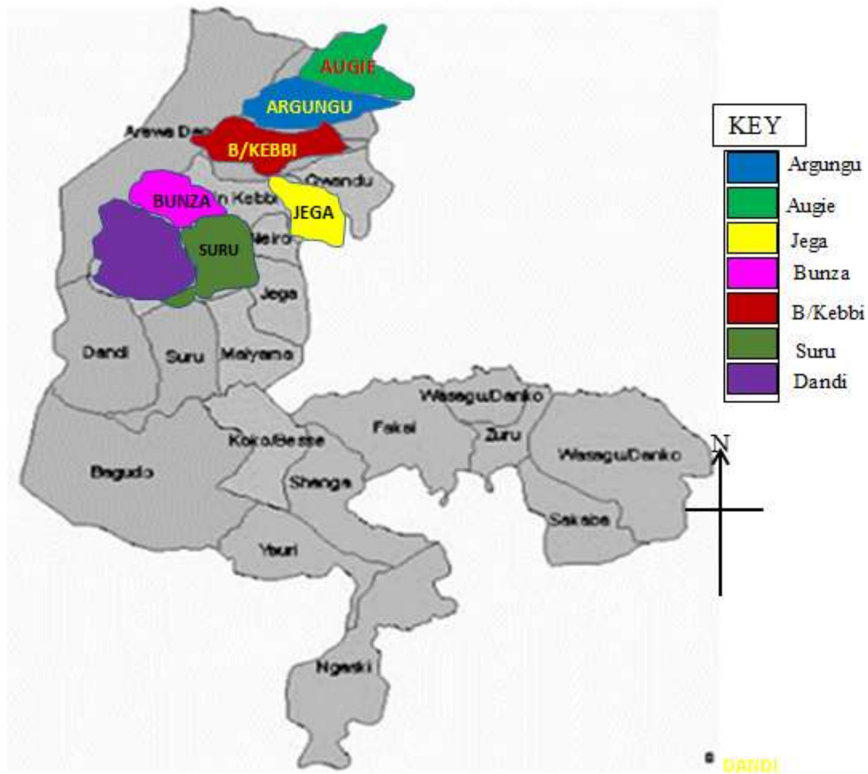

Figure 3. Map of Kebbi State showing the study area (Local Government Areas).

MATERIALS AND METHODS

Study area

The study was carried out in Kebbi State (Figure 3). The choice of Kebbi State was because that is where the ABP was first launched in Nigeria. The State is in north-western Nigeria, occupying a land area of about 36,229 km^2 Projecting the population of the State as at 2018 based on 2006 census at the growth rate of 2.38% reveals a total population of about 4.938,006 people. The state lies between latitudes 10° 05^1 and 13° 27^{1}N of the equator and between longitudes 3° 35^1 and 6° 03^{1}E of the Greenwich. This area is characteristic of Sudan savannah sub-ecological zone with distinct wet and dry seasons. Soils are ferruginous on sandy parent materials evolving from sedentary weathering of sandstones.

Over two-third of the population are engaged in agricultural production, mainly arable crop alongside cash crops with animal husbandry. The main crops cultivated include sorghum, millet, maize, cowpea, sweet potato, rice, vegetables and fruits. Cash crops grown here include soybeans, wheat, ginger, sugarcane, tobacco and gum-arabic.

Sampling procedure and sample size

To achieve the objective of the study, a multistage sampling method was adopted for the study. First, the purposive selection of 7 local government areas (LGA) with the highest concentration of Anchor Borrowers Programme beneficiary farmers in the state. The LGAs are Suru, Brinin-Kebbi, Bunza, Argungu, Augie, Dandi and Jega). Secondly, purposive selection of two villages/communities with the highest number of (ABP) beneficiary farmers from the 7 local government areas giving a total of 14 villages/communities. Thirdly, from each of the 14 villages/communities all together 499 beneficiary and non-beneficiary rice farmers each were proportionately selected randomly thus, giving a sample size of 998 rice farmers for the study (Table 1).

Data collection

Data on the socio-economic characteristics of both ABP beneficiary and non-beneficiary rice farmers, inputs and output such as farm inputs (fertilizer, seed, agrochemicals), labour, rice output and their various costs and the problems involved in accessing ABP intervention among beneficiary in the state were collected.

Stochastic frontier profit function and cost models

The Cobb-Douglas stochastic frontier profit function model was used to examine the profit efficiency and the determinants of profit efficiency for both ABP beneficiary and non-beneficiary rice farmers. The stochastic frontier profit function is the double log (Cobb-Douglass functional form) which is specified explicitly as follows:

$$\ln \pi = \beta_0 + \beta_1 \ln P_1 + \beta_2 \ln P_2 + \beta_3 \ln P_3 + \beta_4 \ln P_4 + \beta_5 \ln P_5 + \beta_6 \ln P_6 + \beta_7 \ln p_{7+} \beta_8 \ln \beta_8 + V_i + U_i \quad (1)$$

where π =normalized profit (₦) defined as gross revenue less variable cost, divided by price of output, P_1= normalized price of seed (₦) computed as total expenditure on seed divided by price of output, P_2= normalized wage of labour (₦) as total expenditure on

Table 1. Sampling frame and the sample size of ABP beneficiary farmers in the state.

Local government area	Sampling frame	Villages/Communities of the beneficiaries	Sample size
ARGUNGU	7,364	Argungu Gulma	74
AUGIE	5,421	Augie Bayawa	54
JEGA	3,020	Jega Basaura	30
BUNZA	8,446	Bunza Raha	84
BIRNIN KEBBI	10,909	Makera Zauro	109
SURU	11,549	Suru Dakin Gari	115
DANDI	3,347	Kamba Dole Kaina	33
Total	50,056		499

Source: Kebbi State Anchor Borrowers Office.

labour divided by price of output, P_3= normalized price of fertilizer (₦) as total expenditure on fertilizer divided by price of output, P_4= normalized price of Agrochemicals (₦) as total expenditure on Agrochemicals divided by price of output, P_5= Depreciation charges on Capital (farm implements) (₦), P_6= normalized price of land (₦) as total expenditure on land divided by price of output, P_7= normalized price of transportation (₦) as total expenditure on transportation divided by price of output, and P_8= normalized price of empty bags (₦) as total expenditure on empty bags divided by price of output

$V_i + U_{i\,=}$ Error term.

Inefficiency factors

Inefficiency in production and are often assumed to be independent of V_i such that U_i is the non-negative truncated (at zero).

U_i is defined as:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_{5+} \delta_6 Z_{6+} \delta_7 Z_7 + \delta_8 Z_{8+} \delta_9 Z_{9+} \delta_{10} Z_{10} + \delta_{11} Z_{11}$$

where U_i = Profit Inefficiency, Z_1 =Age (years), Z_2 = Gender (1 for male, 0 for otherwise), Z_3 = Marital status (1 for married, 0 for otherwise), Z_4= Educational level (years), Z_5 = Experience in rice farming (Years), Z_6 = House hold size (Number of members living in the family), Z_7= Membership of association (1 for yes, 0 for otherwise), Z_8= Amount of Credit accessed (Naira), $Z_{9=}$ Planting technology (1 for broadcasting, 0 for otherwise), $Z_{10=}$ Seed varieties (1 for improved, 0 for otherwise), $Z_{11=}$ Extension contact (1 for contact with extension, 0 for otherwise), and $\delta_0 - \delta_{11}$ = Parameters estimated.

RESULTS AND DISCUSSION

Summary statistics

Results in Table 2 revealed the mean value of total revenue for beneficiary rice farmers as ₦296, 020.00 and ₦200, 763, 30 for non-beneficiary rice farmers per hectare. Comparing this value with the total cost of production (₦ 145,192.38 and ₦138, 468.93 for ABP beneficiary and non-beneficiary rice farmers respectively, shows that production of rice among the two category of farmers was profitable. However, beneficiary farmers realized more profit than the non-beneficiaries as for every ₦1.00 invested ₦2,04 was realized as investment turn over for the beneficiary rice farmers while for every ₦1.00 invested ₦1.45 was realized as investment turn over. This implies that ABP improves the profitability of the beneficiary farmers.

Estimates of the stochastic frontier profit function

Results in Table 3 indicate the sigma squired value of 0.0327 and 0.1469 for ABP beneficiary and non-beneficiary rice farmers respectively, and the variance ratio of 97.9% and 89.9% for the two categories of farmers and are significant at 5% level, respectively. This parameter estimate ascertains the goodness – of - fit and

Table 2. Summary statistics for ABP beneficiary and non-beneficiary rice farmers.

Variable (₦)	Mean ABP beneficiary (₦)	Mean non-beneficiary (₦)
Total Revenue	296,020.00	200,763.30
Total Variable Cost	134,204.60	125, 049.49
Total Fixed Cost	10,987.78	13,419.44
Total Cost	145,192.38	138,468.93
Net Farm Income	150,827.62	62,294.37
Rate of return on investment	2.04	1.45

Table 3. Maximum likelihood estimates of the stochastic frontier profit function.

Variable	Beneficiary			Non-beneficiary		
	Coefficient	Standard error	t-ratio	Coefficient	Standard error	t-ratio
Constant (β_0)	12.08416***	0.0348	346.80	10.5374 ***	0.9988	10.55
Cost of Seed (X_1)	-.06129***	0.0037	-6.58	-0.2005	0.0200	-10.05
Cost of labour (X_2)	-.32549***	0.0071	-85.70	-0.8927***	0.1764	-5.06
Cost of fertilizer (X_3)	-.26833***	0.0077	-4.90	-0.0631***	0.0066	-9.60
Cost of agro chemicals (X_4)	-0.12715	0.0075	-7.06	-0.1437**	0.0568	-2.53
Cost of farm tools (X_5)	-.01720***	0.0038	-4.54	-0.0571***	0.0450	-7.27
Farm size(X_6)	-.09239***	0.0023	-7.06	-0.0486	0.0949	-0.51
Transportation cost(X_7)	-.08920***	0.0054	16.61	-0.0214	0.0021	-1.13
Cost of empty bag(X_8)	2.46796***	0.0086	288.35	1.9221***	1.7964	7.07
Diagnostic Statistics						
Sigma squared (σ^2)	0.0327***	0.0015	21.33	1.469	0.1614	9.1***
Gamma (γ)	0.9999***	0.0030	336.7	0.999	0.0027	372***
Log likelihood ratio test	845			133		

***Significant at 1%, **Significant at 5%.

the correctness of the specified distributional assumptions of the composite error term. The variance ratio/gamma(r = 0.979 and 0.899) for the two group of farmers signifies that the unexplained influences by the profit function are the major sources of the random errors indicating also that 97.9% and 89.9% of the variation in rice farming among the two categories of farmers is attributed to profit in inefficiency. This confirms the presence of the one sided error component in the model that makes the average function inadequate in representing the data.

For the ABP beneficiary farmers, the coefficient for seed cost, labour cost, fertilizer cost, Agrochemical cost, and cost of farm tools are negatively significant in determining profit efficiency at 1% level, respectively while transportation cost and cost of empty bags were positively significant at 1% level respectively. The implication of the negative coefficient is that increase in the price of these variables, would lead to a corresponding farmers' profit efficiency to decrease. This implied that increase in the cost of these variables with existing technology will reduce profit efficiency. For the non-beneficiary farmers, seed cost, labour cost, fertilizer cost, Agrochemicals cost and cost of farm tools were negatively significant in determining profit efficiency and cost of farm tools were positively significant at 1% level of probability. The significance of labour input could be due to the fact that it is an important factor of production. Farm production is subsistence and labour intensive. Merem et al. (2017) in their study among beneficiary and non-beneficiaries of developmental programme noted that labour is the second most import factor of production in rice production. The findings of this study are similar to that of Ogundari and Ojo (2005) who stated that labour and herbicides are the most important inputs contributing significantly to output.

Profit efficiency of rice farmers

The results in Table 4 reveal that profit efficiency ranged from 0.44 to 0.96, with a mean value of 0.94 for ABP beneficiary rice farmers while it ranged from 0.11 to 0.93 with a mean value of 0.86 for non-beneficiary rice farmers. Based on the mean efficiency estimate among beneficiary farmers, the average farmer requires 2.08%, that is, (1-(0.94/0.96) × 100) cost savings to attain the

Table 4. Frequency distribution of profit efficiency estimates.

Efficiency	Beneficiary	Non-Beneficiary
0.21-0.30	-	14
0.31-0.40	-	3
0.41-0.50	1	4
0.51-0.60	3	2
0.61-0.70	6	3
0.71-0.80	12	Nil
0.81-0.90	65	271
0.91-1.0	412	202
Total	499	499
Mean	0.94	0.86
Minimum	0.44	0.11
Maximum	0.96	0.93
t-value	10.14***	

Table 5. Determinants of profit efficiency among ABP beneficiary and non-beneficiary rice farmers.

Variable	ABP Beneficiary			Non-beneficiary		
	Coefficient	Standard Error	t-ratio	Coefficient	Standard Error	t-ratio
Constant	1.0604***	0.001368	-5.36	-0.7675***	0.000704	7.09
Gender	-0.0090***	0.000658	-3.68	-0.1393***	0.029388	-4.74
Marital status	0.0385***	0.00030	-7.82	-0.0588***	0.013674	4.30
Age	-0.0097***	0.00038	-6.24	-0.0091***	0.001449	-6.28
Educational level	-0.003***	0.00016	-7.82	0.0334***	0.007749	-4.31
Household size	-0.0049***	6.25005	7.42	-0.0060***	0.007749	-3.10
Farming experience	- 0.0085***	0.0000416	-2.42	-0.0042***	0.001935	-2.61
Cooperative	-0.0357***	0.000045	-8.88	0.0683***	0.001609	-3.27
Seed variety	-0.0091	0.13000	-3.07	-0.0165***	0.020887	-2.49
Planting technology	-0.0048***	0.00023	-2.74	-0.0415***	0.006627	-4.25
Income	-0.0028**	3.03E-05	-9.23	-0.0098***	0.003427	-2.86

***Significant at 1%, **Significant at 5%.

status of the most efficient beneficiary farmer and 7.5%, that is, (1-(0.86/0.99) × 100) to achieve the level of the most efficient non- beneficiary farmer. The least performing beneficiary farmer would need 54.2% cost savings and non-beneficiary farmer would need 88.2% to become the most efficient farmer

The difference in the profit efficiency of the two categories of farmers could be attributed to the ABP support granted to the beneficiaries in terms of seed, chemicals, cash, fertilizer, training etc. system of production, and difference in the quantity of input used by the two groups of farmers which offered them advantage over non-beneficiary rice farmers. Even though the fact that the profit efficiencies of all sampled farmers are less than 1 is an indication that no farmer reached the frontier of production. Thus, opportunity still exists for increasing farmers' productivity through increasing efficiency in the use of existing resources.

The estimated t-value of 10.14 was significant at 1% level indicating that there is significant difference in the profit efficiency of the two categories of farmers. Since the beneficiaries were expected to have more access to farm inputs, credit facilities, and extension advisory services from the ABP which could place them on production advantage over their colleagues who are not benefiting from the program. The result suggests that ABP beneficiaries are more prudent in maximizing profit compared with their counterparts.

Determinants of profit efficiency among ABP beneficiary and non-beneficiary rice farmers

The result in Table 5 for the beneficiary farmers indicates that the coefficients of gender, marital status, age, educational level, household size farming experience cooperativeness, seed variety planting technology and income are negative and statistically significant at 1% level of probability respectively. This tally with the apriori expectation. In a one- step stochastic frontier estimation, the parameter for a negative sign of a variable in the Z – vector implies that the corresponding variable would reduce profit inefficiency (or increase efficiency). In the case of non-beneficiary farmers the result is similar to that of the beneficiary farmers.

Conclusion

Results revealed that both ABP beneficiary and non-beneficiary rice farmers were not efficient in the use of existing resources, however, ABP beneficiary rice farmers are more profit efficient with a mean value of 0.94 compared with the non-beneficiary rice farmers having a mean profit efficiency estimate of 0.74. It is thus concluded that ABP enhances the profit efficiency of the beneficiary rice farmers. Result further revealed that ABP beneficiary rice farmers realized more profit than the non-beneficiary rice farmers suggesting that ABP is an intervention that should be advocated to reach all categories of farmers in Nigeria in order to boost profit and efficiency among farming households in Nigeria.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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