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Production Efficiency of Smallholder Rice Farms Under Contract Farming Scheme In Ghana

ABSTRACT

Aims: The study investigates the production efficiency of smallholder rice farms under contract farming and irrigation production in Ghana.

Methodology: Data was collected from 350 rice farmers selected through a multi-stage sampling technique using structured questionnaires. Descriptive and inferential statistics including stochastic frontier analyses were used to analyse the data with the help of STATA 14 and NLOGIT 5 statistical software.

Results: The results show that contract farms have higher efficiencies than their non-contract farm counterparts. There are clear differences in the distribution among contract and non-contract farms. The efficiencies of contract farms are significantly higher than the efficiencies of non-contract farms under irrigation production and they also have different efficiency distributions. Under the rain fed production frontier, efficiencies of contract farms are significantly higher than the efficiencies of non-contract farms and their distributions are also different. Contract farms under irrigation production have higher efficiencies than contract farms under rain fed production. The efficiencies of irrigation contract farms are significantly higher than the efficiencies of rain fed contract farms, however their distributions are similar across rain fed and irrigation production ecologies. Government should put in policies that will stimulate interest of farmers to get involved in contract farming. We also recommend investment to expand irrigable land area to increase access, as it is one of the reasons why farmers are not practicing irrigation production. Rice production through irrigation is currently very low.

Conclusion: Current increases in production volumes are associated more with expansion in area of production with very limited contribution from yield gain. With the current efficiency levels considerable increase in yield can be achieved through increase efficiency by getting more farmers involved in CF and also continues capacity building in good rice production practices. Aside this, CF also has more farmers attaining higher efficiency scores than their NCF counterparts.

Key words: Production efficiency, smallholder rice farms, stochastic frontier, contract farming, irrigation ecology

1. INTRODUCTION

There are a number of constraints that limit farm productivity and farm income in sub-Sahara Africa [1]. Cereal crop yields are estimated <1.5 ton/ha while the actual potential is more than 5 tons/ha. The low yields are largely attributable to low use of organic and mineral nutrient resources, which has also resulted in negative nutrient balances [2] [3]. The reasons for these poor yields also include; lack of sufficient information about production methods and practices and market opportunities. Poor access of credit and inputs are also important limiting factors. Smallholder farmers operating near subsistence are understandably more risk averse than larger farmers. They often prefer to produce enough food for the home before venturing in to the production of cash crops for an uncertain market [1].

Large-scale farming provides solution to some of these problems enumerated in that large scale farmers have better access to credit, better information about production and marketing opportunities, and greater tolerance of

47 risk. However, these advantages are offset by the higher costs and lower motivation of hired labourers
48 compared to family labour. As a result, large-scale agriculture is competitive in many African countries for only
49 a few cash crops, such as sugarcane, banana, plantain, pineapple, rubber tree plantations, cocoa plantations etc.
50 Studies suggest that large scale agriculture has become prominent in Kenya, Zimbabwe, and South Africa
51 largely because of favourable policies for large scale farmers [4].

52 Contract farming is therefore seen as a way to combine the advantages of large-scale production (improved
53 access to credit, better production methods, high technology adoption and high risk tolerance) with the strengths
54 of small-scale production (lower implicit labour costs, land accessibility and improved incentive of the farmer)
55 [1].

56 Besides the positive effects of contract farming (CF), several authors have, however, drawn the attention on
57 certain negative aspects of this instrument (biased relationships between contractors and farmers, negative
58 conditions for small-scale farmers, etc.) [5] [6]. Other critics also see contract farming as a way for large firms
59 to take advantage of the land and poverty of smallholder farmers, effectively paying them less than the
60 commercial agriculture. Hence CF is perceived to have a negative impact, leading to higher risk, indebtedness,
61 and income inequality [7] [8].

62 Contract farming has attracted the interest of agricultural projects, researchers, development organizations and
63 policymakers because of its perceived potential to provide solution/remedies to several of these agricultural
64 constraints simultaneously. Although reliable estimates are not readily available, international trends in
65 agriculture suggest that the prevalence of contract farming may well be increasing in developing countries. The
66 growth of high-value agriculture crops, the expansion of agricultural processing in developing countries, the
67 consolidation in the retail food sector, and the increased demand for quality and food safety are all driving the
68 need for contract farming in agricultural supply chains such as the local rice value chain [9].

69 Studies have shown that technical efficiency measures for Ghana's agriculture are Low. [10] found that average
70 profit efficiency for rice farmers in Northern Ghana to be 63%, with profit efficiency ranging between 16% and
71 96%. [11] provided evidence to show that smallholder rice farmers in the Upper East region of Ghana produce,
72 on average, 34% below maximum output. The estimated technical efficiency for smallholder irrigators and non-
73 irrigators was 53% and 51%, respectively using a simple t test to compare the significance of their means. [12]
74 in their study of rice farmers under irrigation in Tono also concluded that mean technical efficiency estimate for
75 irrigation rice farmers was 0.81 which is an improvement of earlier studies.

76 This study will enhance or improve on this knowledge by assessing economic, allocative and technical
77 efficiencies of farmers under contract farming and also assess the effect of production ecology (irrigation and
78 rainfed) on production efficiency using stochastic frontier analyses (SFA) approach to allow for in-depth
79 analyses of rice production efficiencies. Previous studies have duelled more on single components of rice
80 production efficiency and did not also disaggregate the production ecologies. The ultimate goal of any rice
81 producer is to attain economic efficiency which is a function of technical and allocative efficiencies. The present
82 study will go beyond the previous studies as indicated to compare efficiencies for irrigated and non-irrigated
83 ecologies and also between contract and non-contract producers to establish the effect of contract farming and
84 irrigation system on production efficiency.

85 Efficiency measurement is very important because it has a direct effect on productivity and economic growth.
86 Efficiency studies help firms to determine the extent to which they can raise productivity and incomes by
87 improving their efficiencies, with the existing resource base and the available technology. Such studies could
88 also support decisions on whether to improve efficiency first or to develop a new technology in the short run.
89 More importantly, enhanced efficiency will not only enable farmers to increase their yield and income but will
90 also give direction for the adjustments required in the long run to achieve food sustainability.

91 There are two main ways to increase rice production; through increase in farm size and through increase
92 productivity. However, land is a major constraint now and hence we need to concentrate on increasing efficiency
93 to increase productivity. The study will conduct a comparative analysis of farm level technical efficiency of
94 households with access to irrigation technology and those without access to irrigation technology. The main
95 objective of the study is to assess the impact of contract farming and irrigation ecology on farm household
96 technical, allocative and economic efficiencies in Ghana.

There exists a considerable body of literature that analyses the impact of contract farming on the performance of smallholder farms, however very little has been done on efficiency as a performance indicator [13] [14]. Out of thirty-three studies reviewed across Asia and Africa only one used efficiency as a performance indicator [15].

2. MATERIALS AND METHODS

2.1 The Study Area

This study covered northern, upper east and Volta regions of Ghana basically because of their rice production potential in the country which is mainly savannah. About 80% of total rice production in Ghana comes from these three regions.

2.2 Data Collection

Multi-stage sampling was used to sample the representative small-holder rice farmers in Northern, Upper East and Volta regions. At the first stage three regions were purposively selected based on the level of rice production. The three regions selected, produced about 80% of total rice produced in Ghana. At the second stage of the sampling, each selected region two production systems (irrigation and rain fed systems) was selected. At the third stage, of the sampling two management systems (Contract production and non-contract production systems) was selected from each of the production system.

At the fourth and the final stage of the sampling, a total sample of 350 smallholder rice farmers were randomly sampled and interviewed.

2.3 Data Analysis

The study employed both descriptive and inferential statistical analysis. Descriptive statistics (e.g., mean, minimum, maximums, standard errors of the mean, standard deviation) were used to summarize and describe 350 rice farmers. The stochastic frontier analyses were used to estimate the production efficiencies (technical, allocative and economic). Analyses were carried out using STATA 14 and NLOGIT 5.

The parametric stochastic frontier approach is applied to calculate the efficiencies of rice farms under the following frontiers of the observed data. The efficiency analysis is carried out based on four frontiers:

- Pooled data frontier, which analyzed all sample data together (n=350) and represent the general performance of all rice farmers under the two ecologies.
- Irrigation production frontier, which analyzed all irrigated farms data (n=133) and represents the irrigated rice farms performances with respect to CF.
- Rain-fed production frontier, which analyzed rain-fed farms data (n=217) and represents the rain-fed rice farm performances with respect to CF.
- Contract farming frontier, which analyzed CF farms data (n=140) and represents CF performance under different production ecologies.

The results of each frontier efficiency analysis are presented as the mean efficiency levels and the difference in means of contract and non-contract farmers' efficiency under different production ecologies. These results can be used as a benchmark to improve the efficiency of rice production in Ghana.

3.0 THEORETICAL AND ANALYTICAL FRAMEWORK

3.1 Measurement of production efficiency

The efficiency measure proposed by Farrell assume a known production function for the fully efficient decision-making unit (DMU). The production function of a DMU is generally unknown in practice, and relative efficiencies must be measured from the sample data available. Two approaches are used to estimate relative efficiency indices: the parametric or stochastic frontier production approach (SFA) and the nonparametric or data envelopment analyses (DEA) approach [16]. The SFA assumes a functional relationship between outputs and inputs and uses statistical techniques to estimate parameters of the function. It incorporates an error term made up of additive components: a symmetric component that accounts for statistical noise associated with data

measurement error² and a nonnegative component that measures inefficiency in production [16]. The stochastic frontier analyses (SFA) also allows for hypothesis testing. The disadvantage of SFA is that it imposes specific assumptions on both the functional form of the frontier and the distribution of the error term. In contrast, DEA uses linear programming methods to construct a piecewise frontier of the data. Because it is nonparametric, DEA does not require any assumptions to be made about functional form or distribution type. It is thus less sensitive to misspecification relative to SFA. However, the deterministic nature of DEA means all deviations from the frontier are attributed to inefficiency. It is therefore subject to statistical noises resulting from data measurement errors [16].

The choice of which method to use is uncl² [17]. A small number of studies make side-by-side comparisons of the two methods [18] [19] [20] [21] [22], but none of these studies drawn any conclusions about which method is superior. These studies typically find quantitative differences in efficiency scores between the two methods, but the ordinal efficiency rankings among DMUs tend to be very similar for both methods. Therefore, the choice of which method to use appears to be arbitrary, as it is pointed out by [23]. We use SFA approach for this study.

3.2 Stochastic production frontier analysis¹

Stochastic production frontiers were first developed by [24] and¹ [25] and are now widely used and reported in literature to measure farm performance [26] [27] [28]. The specification allows for a non-negative random variable, v_i , associated with the technical inefficiency (TE) of the i^{th} farm, to be generated, as well the normal error term, v_i , to capture random variation in output due to factors beyond the control of farmers, such as variation in weather patterns, measurement error or any unspecified input variable. The random error term can be positive or negative, and thus the frontiers vary about the deterministic part of the model, $\exp(x_i\beta)$.

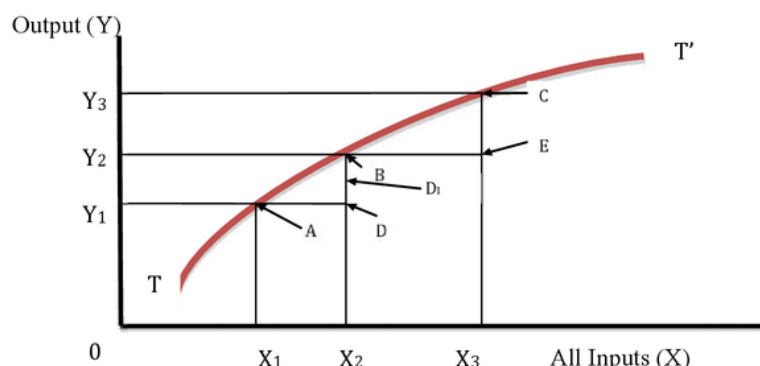


Figure 1: A Production frontier

¹ In Figure 1 above, Farm D uses X_2 inputs to produce Y_1 output. If there are no inefficiency effects, the frontier output could be D_1 . This is below the deterministic part of the frontier (point B), therefore the noise and inefficiency effects are negative. The distance between point D and point D_1 represents inefficiency, while the distance between D_1 and point B represents variation due to random events. Details on the estimation of the stochastic frontier together with the inefficiency equation, using maximum likelihood techniques, as well as the measurement of individual efficiency scores can be found in [26]. Applications of this technique to areas of economics include [29] [30] and [31].

3.3 Model specifications of SFA for technical, economic, and allocative efficiency

3.3.1 The production frontier function

$$Y_i = f(X_i, \beta) e^{v_i - u_i} \dots\dots\dots 5$$

where Y denotes output, X the factor inputs, the subscript i identifies the rice farm, β represents the parameters to be estimated and e the error term representing both inefficiency, u_i and noise factors, v_i . The production frontier shows the relationship between inputs (for example, labour, fertiliser, seed) and outputs (rice yield and cost of production), and the value of β indicates the relative importance (propensity) of each input to the production process [28]. A parametric production frontier needs to assume a functional form and two forms that are relatively easy to derive and commonly used in efficiency analysis are the Cobb-Douglas and the translog production functions.

A Cobb-Douglas stochastic frontier, using the terminology of [32] is defined by:

$$\ln(y_i) = X_i\beta + v_i - u_i \quad i=1, 2, \dots, N \quad \dots \dots \dots 6$$

Where:

$\ln(y_i)$ is the logarithm of the output of the i -th sample farm ($i = 1, 2, \dots, n$)

x_i are the logarithms of the input quantities used by the i -th farm

β is a column vector of unknown parameters to be estimated

u_i is the technical inefficiency (TE) of the i -th farm and in this study is assumed to be an independent and identically distributed (i.i.d.) half normal random variable, and

v_i is the random error term, assumed to be an i.i.d. normal random variable with zero mean and constant variance, σv^2 , independent of the u_i .

The technical efficiency of the i^{th} rice farm, in time period t , is given by the ratio of observed output to the maximum potential output, as defined by the frontier.

$$TE = \frac{y_i}{y_i^*} = \exp(-U_i) \dots \dots \dots 7$$

Where y_i = the total production frontier, y_i^* = the stochastic production frontier

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3.3.2 The cost frontier function

$$C_i = f(X_i, P_i, \beta) e^{v_i - u_i} \dots \dots \dots 8$$

where C denotes the total production cost observed, X_i is the output quantity for household i (rice produced), P_i is the input price vector used, β is the parameters to be estimated and e_i is the composite error term representing both inefficiency, u_i and noise factors, v_i .

$$AE = \frac{C_i}{C_i^*} = \exp(-U_i) \dots \dots \dots 9$$

Where C_i = the total production cost frontier, C_i^* = the stochastic cost frontier

$$EE = TE \times AE$$

EE = economic efficiency

The maximum likelihood estimation technique and linear programming will be used to analyse for the inefficiencies and the determinants of inefficiencies. In addition to estimating the levels of technical efficiency among farmers, the factors influencing efficiency can also be examined. The literature contains studies using a two stage model where the predicted inefficiency effects are regressed upon a vector of farm specific factors, such as age or experience of the farmer [31]. However, this method means that the farm specific factors in the second stage regression are not identically distributed as the model assumes. Hence, [26] recommend that the production frontier and the determinants of inefficiency be estimated in a single step model involving a stochastic production frontier as given above, as well as an equation that explains the technical inefficiency effects expressed as:

$$\mu_i = \delta_0 + z_i\delta_i \dots \dots \dots 10$$

Where z_i refers to farm specific variables and farmer attributes which are associated with technical inefficiency, and δ represents parameters to be estimated.

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4.0 RESULTS AND DISCUSSION

4.1 Effect of contract farming on the factors of production of farm households

According to table 1 below, the mean age difference between contract farmers and non-contract farmers is about 3.19 and is significant at 1% significance level. This implies farmer's age has a positive correlation with contract participation. However there is no significant difference between the contract farmers farming experienced and that of non-contract farmers experience in rice production. Contract farmers are richer than non-contract farmers and this is significant at 1%. There is no difference in the household size and also the available arable lands of the two groups.

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Table 1: Management System Effect on Means of farm households Characteristics

Farm household Characteristics	CF (n=140)	NCF (n=210)	Mean Difference	Z-statistic
	Mean	Mean		
Age of HHH (years)	46.41	43.22	3.19 ***	2.701642
Farmer experience (years)	22.94	24.20	(1.25)	-1.145
Wealth of farm HH GHS	8,256.64	3,214.71	5,041.93 ***	4.643198
Household Size Number	7	7	0.35	1.1456
Total household arable land (acres)	5.07	5.65	(0.58)	-1.52

*** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

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According to table 2 below the mean difference of rice farm size of contract farmers and non-contract farmers is about 0.35 hectares and significant at 1% significance level. The mean difference fertilizer use, seed use, labour used are 122kg, 28kg and 5 persons respectively, which are all significant at 1% level of significance. There is no difference in the prices of fertilizer and labour used. Seed price was significant at 1% level of significance with mean difference of -0.12 GHS, which implies non-contract farmers bought their fertilizers at relatively cheaper price than contract farmers. Yield is an important variable in assessing farm level performance and it is evidently clear that contract farmers have higher yields than their non-contract farmer colleagues with mean difference of 1,090kg per acre. Total output of contract farmers was far more than the output of non-contract farmers with a mean of about 3,360kg of paddy rice. Output price was also significant indicating contract farmers earn 0.15 GHS/kg more than their non-contract farmer counterparts. This implies their farm revenues will also be higher with a significant mean difference of 1,792 GHS. Cost of production of contract farmers is far more than that of non-contract producers with mean difference of 170 GHS. Gross margins mean difference is 1,622.00 GHS indicating contract farmers earn more profit than their counterparts.

Table 2: Production Status of Contract and Non-contract Farms

Variables	CF (n=140)	NCF (n=210)	Mean Difference	Z-statistic
	Mean	Mean		
Rice farm size in acres	3.28	2.4	0.88***	4.5
Fertilizer used in kg	314.43	192.20	122.23***	5.33
Seed used in kg	90.03	61.61	28.41***	2.82
Labour used	13	8	5.0***	4.9
Fertilizer price in GHS	1.11	1.81	-0.70	-1.57

Seed price in GHS	0.57	0.70	-0.12***	-2.84
Labour price in GHS	36.28	43.07	-6.79	-1.41
Yield per acres	1,743.08	652.99	1090.09***	10.56
Total output kg	4,880.41	1,520.11	3360.30***	10.75
Output price per kg in GHS	1.46	1.31	0.15***	5.1
Total Revenue GHS	2,642.00	850.08	1791.91***	10.17
Total cost of production GHS	584.98	414.91	170.07***	4.7
Gross margins GHS	2,057.01	435.17	1621.84***	10.32

*** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

4.2 Effect of agro-ecology on some factors of production of farm households

According to table 3 below, mean age difference between irrigation farmer and rain fed farmers is about 0.34 and is not significant. There is also no significant difference between the irrigation farmers farming experienced and that of rain fed farmers experience in rice production. Irrigation farmers are richer than rain fed farmers and this is significant at 1%. There is no difference in the household size and also the available arable lands of the two groups.

Table 3: Farm household's characteristics

Variables	Irrigation (n=133)	Rain fed (n=217)	Mean Difference	Z-statistic
	Mean	Mean		
Age of HHH	44.71	44.36	0.34	0.28
Farmer experience in years	22.50	24.42	-1.92	-1.73
Wealth of farm HH	8385.63	3298.29	5087.34***	4.5
Household Size	7	7	-0.24	-0.7
Total household arable land	5.43	5.41	0.02	0.0447

*** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

According to table 4 below the mean difference of rice farm size of irrigation farmers and rain fed farmers is about 0.34 acres and it is not significant. The mean difference of fertilizer use, seed use, labour used are 68.47kg, 23.13kg and 3 persons respectively which are all significant. There is no difference in the prices of fertilizer, seed and labour used. Yield is an important variable in assessing farm level performance and it is evidently clear that irrigation farmers have higher yields than their rain fed farmer colleagues with mean difference of 681.26kg per acre. Total output of irrigation farmers was far more than the output of rain fed farmers with a mean of about 1823.29kg of paddy rice. Output price is not significant indicating irrigation farmers and their rain fed counterpart receive the same price for their paddy rice. This implies their farm revenues will also be higher with a significant mean difference of 1,101.34GHS. Cost of production of irrigation farmers is far more than that of the rain fed producers with mean difference of 144.34 GHS. Gross margins mean difference is 957.00 GHS indicating irrigation farmers earn more profit than their rain fed counterparts.

Table 4: Production status of rain fed and irrigation farms

Variables	Irrigation (n=133)	Rain fed (n=217)	Mean Difference	Z-statistic
	Mean	Mean		
Rice farm size in acres	2.89	2.66	0.23	0.91
Fertilizer used in kg	283.54	215.08	68.47***	2.63
Seed used in kg	87.32	64.19	23.13**	2.13

Labour used	12	9	3**	2.29
Fertilizer price in GHS	1.73	1.40	0.32	0.48
Seed price in GHS	0.62	0.66	-0.04	-0.92
Labour price in GHS	38.96	41.21	-2.25	-0.47
Yield per acres	1511.41	830.15	681.26***	5.7
Total output kg	3994.67	2171.38	1823.29***	5.06
Output price per kg in GHS	1.40	1.36	0.04	1.47
Total Revenue GHS	2249.68	1148.34	1101.34***	5.52
Total cost of production GHS	572.43	428.09	144.34***	3.95
Gross margins GHS	1677.25	720.25	957.00***	5.4

*** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

13 Meta frontier analyses of contract and non-contract farms efficiency

The mean technical efficiency for contract farms and non-contract farms are 0.84 and 0.77 respectively. These imply contract farms can achieve their current outputs with about 16% reduction in inputs used and also reduced cost of production by 23%. The mean allocative efficiencies for contract and non-contract farms are 0.83 and 0.53 respectively. However, the mean economic efficiencies of the farms are 0.72 and 0.43 for contract and non-contract farms respectively. Farmers under contract farming are more efficient in their optimal allocation of resources while minimizing waste and inefficiency in their rice production. This implies contract farms and non-contract farms can achieve their current production levels with about 28% and 57% reduction in cost of production. Details are shown in table 5-9 below.

Table 5: Summary statistics of efficiency measures of contract and non-contract farms

Meta Frontier	CF (n=140)					NCF (n=210)				
	Mean	Min	Max	STD	SEM	Mean	Min	Max	STD	SEM
TE	0.84	0.40	1.00	0.17	0.01	0.77	0.34	1.00	0.18	0.01
AE	0.83	0.16	1.09	0.22	0.02	0.53	0.09	1.00	0.27	0.02
EE	0.72	0.10	1.00	0.28	0.02	0.43	0.07	1.00	0.30	0.02

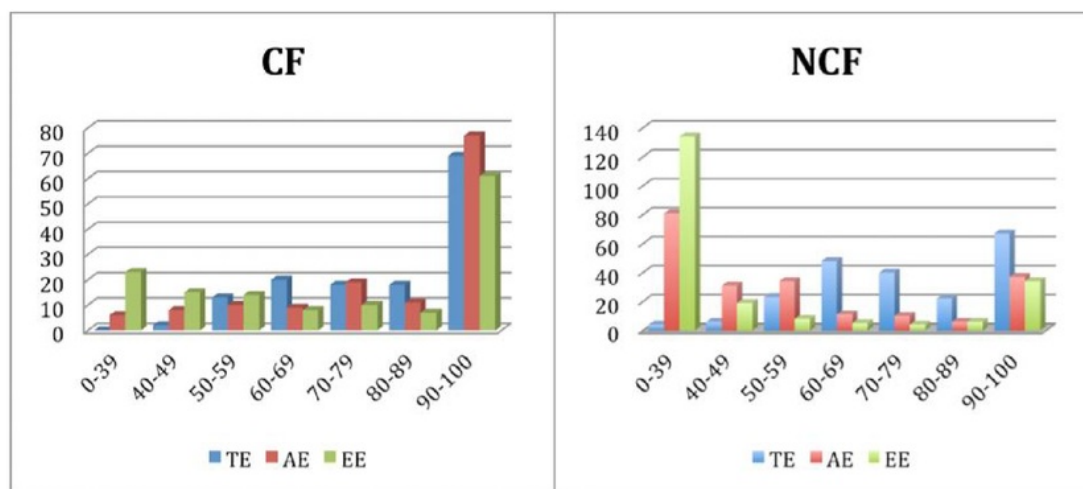
There is significant difference in the technical, allocative and economic efficiency means of contract and non-contract farms. This shows that the contract farms have higher efficiencies than their non-contract farm counterparts hence the null hypothesis is rejected. The efficiencies of contract farms are significantly higher than the efficiencies of non-contract farms.

Table 6: Mean differences of contract and non-contract farms

Meta Frontier	CF (n=140)	NCF (n=210)	Mean Difference	Z-statistic
	Mean	Mean		
TE	0.84	0.77	0.07***	3.5
AE	0.83	0.53	0.30***	11.38
EE	0.72	0.43	0.29***	9.23

*** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

Non-contract farmer's efficiency distribution shows that just about 4 farms are within technical efficiency score of 0-39% and 67 farms are within 90-100% efficiency score followed by 48 of them within 60-69% efficiency score as shown in figure below.



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310 Figure 2: Efficiency distribution of contract and non-contract farmer's farms

311 Contract farmer's efficiency distribution shows that there are no farms within technical efficiency score of 0-39%. Majority of contract farms (69) fall within efficiency score of (90-100%) followed by 20 of them within (60-69%) efficiency score. About 77 and 61 farms fall within allocative and economic efficiency scores of 90-100% respectively. There is clear difference in the distribution among contract farms and non-contract farms as shown in figure above.

316 6.4 Irrigation frontier efficiency of Contract and Non-contract farms

317 There is significant difference in the technical, allocative and economic efficiency means of contract and non-contract farms under irrigation production. This shows that the contract farms have higher efficiencies than their non-contract farm counterparts hence the null hypothesis is rejected. The efficiencies of contract farms are significantly higher than the efficiencies of non-contract farms under irrigation rice production.

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322 Table7: Mean differences of contract and non-contract farms under irrigation

Irrigation frontier	CF	NCF	Mean Difference	Z-statistic
	Mean	Mean		
TE	0.867	0.769	0.098	3.44***
AE	0.875	0.542	0.334	8.28***
EE	0.780	0.433	0.347	7.33***

323 *** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10%
324 significance level

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The distribution of the efficiencies across CF and NCF is presented in figure below. Majority of farms under contract farming are within 90-100% efficiency. However, majority of farms under NCF are within efficiency score of 0-39%. It is clear that the distributions are different and more farmers under CF recorded higher efficiencies compared to farmers who did not participate in CF.

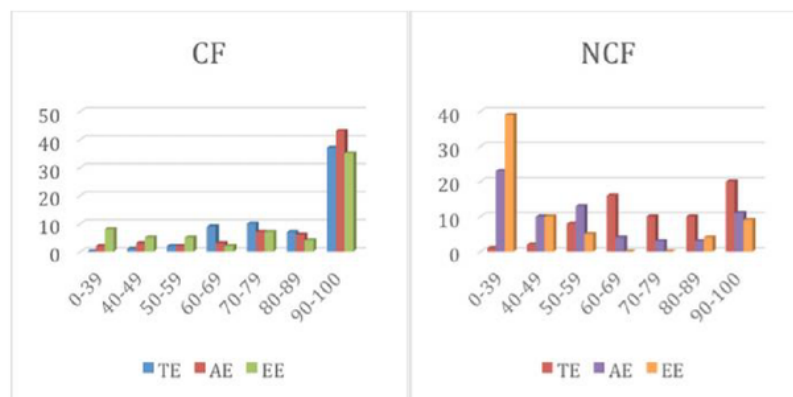


Figure 3: Efficiency distribution of CF and NCF under irrigation

6.5 Rain fed frontier efficiency of Contract and Non-contract farms

There is significant difference in the technical, allocative and economic efficiency means of contract farms and non-contract farms under rain fed production. This shows that the contract farms have higher efficiencies than their non-contract farm counterparts under rain fed production hence the null hypothesis is rejected. The efficiencies of contract farms are significantly higher than the efficiencies of non-contract farms under rain fed rice production.

Table 8: Mean differences of contract and non-contract farms under rain fed production

Rain fed efficiency	CF	NCF	Mean Difference	Z-statistic
	Mean	Mean		
TE	0.816	0.775	0.041	1.62**
AE	0.788	0.523	0.265	1.6***
EE	0.669	0.430	0.239	1.6***

*** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

The distribution of the efficiencies across CF and NCF under rain fed production is presented in figure below. Majority of farms under contract farming are within 90-100% efficiency. However, majority of farms under NCF are within efficiency score of 0-39%. It is clear that the distributions are different and more farmers under CF recorded higher efficiencies compared to farmers who did not participate in CF.

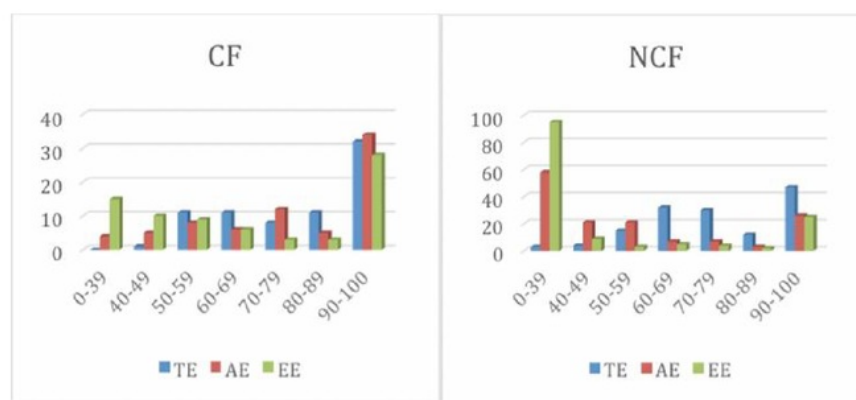


Figure 4: Efficiency distribution of CF and NCF under rain fed

6 CF frontier efficiency of irrigation and rain fed farms

There is significant difference in the technical, allocative and economic efficiency means of contract farms under irrigation and rain fed production. This shows that contract farms under irrigation production have higher efficiencies than their rain fed counterparts hence the null hypothesis is rejected. The efficiencies of irrigation contract farms are significantly higher than the efficiencies of rain fed contract farms. Hence CF works better under irrigation than under rain fed production.

Table 9: Mean differences of irrigation and rain fed contract farms

CF frontier	IRR-CF	RAIN-CF	Mean Difference	Z-statistic
	Mean	Mean		
TE	0.867	0.819	0.048	1.7**
AE	0.875	0.789	0.087	2.3***
EE	0.780	0.672	0.108	2.3***

*** Significant at 1% level of significance; ** significant at 5% significance level; *significant at 10% significance level

The distribution of the efficiencies of irrigation CF and rain fed CF is presented in figure below. Majority of farms under irrigation and rain fed ecologies were within 90-100% efficiency score. It is clear that the distributions are similar across rain fed and irrigation production ecologies.

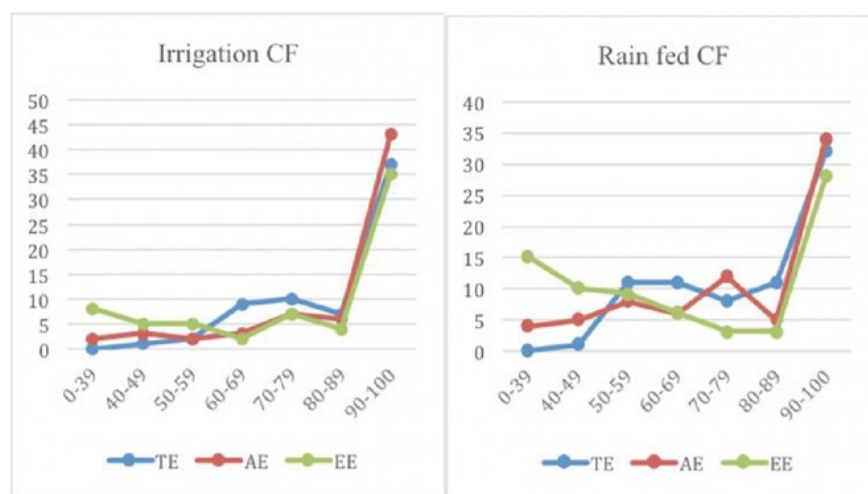


Figure 5: Efficiency distribution of irrigation and rain fed contract farms

5.0 CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion

The results show that there is significant difference in the technical, allocative and economic efficiency means of contract farms and non-contract farms. This shows that the contract farms have higher efficiencies than their non-contract farm counterparts hence the null hypothesis is rejected. There is clear similarity in the distribution among contract and non-contract farms.

Contract farms have higher efficiencies than their non-contract farm counterparts under irrigation production frontier hence the null hypothesis is rejected. The efficiencies of contract farms are significantly higher than the efficiencies of non-contract farms under irrigation rice production and they also have different efficiency distributions. Under the rain fed production frontier, efficiencies of contract farms are significantly higher than the efficiencies of non-contract farms and their distributions are also different. Contract farms under irrigation production have higher efficiencies than contract farms under rain fed production hence the null hypothesis is rejected. The efficiencies of irrigation contract farms are significantly higher than the efficiencies of rain fed contract farms, however their distributions are similar across rain fed and irrigation production ecologies.

The study has clearly established that CF has positive effect on technical, allocative and economic efficiency of rice farms in Ghana. It has also established that there are more farmers with high efficiency scores among CF than NCF. CF is more effective in irrigation ecologies than in rain fed ecologies. The efficiencies of contract farms are higher than the efficiencies of non-contract farms hence we recommend that government and her development partners should continue and intensify the introduction of CF as a management strategy to boost rice production and hence improve livelihood of farmers. Government should put in policies that will stimulate interest of farmers to get involved in contract farming. We also recommend investment to expand irrigable land area to increase accessibility as it is one of the reasons why farmers are not practicing irrigation production. rice production through irrigation is currently very low (20% of national production).

Current increases in production volumes is associated more with expansion in area of production with very limited contribution from yield gain. With the current efficiency levels considerable increase in yield can be achieved through increase efficiency by getting more farmers involved in CF and also continues capacity building in good rice production practices. Aside this, CF also have more farmers attaining higher efficiency scores than their NCF counterparts.

5.2 Recommendations

In order to sustain and improve efficiency of rice production systems in Ghana, we recommend that farmers should be encouraged to participate more in irrigation rice production than the rain fed productions since they are more efficient in their resource allocation. The efficiencies of contract farms are higher than the efficiencies of non-contract farms hence we recommend that farmers should be encouraged to get more involved in contract production.

It is clear from the results that contract farming has positive influence on technical, allocative and economic efficiencies of rice producers. Farmers will be more efficient when they produce rice under contract farming. Policy directives to promote contract farming will be in the right direction as it will help farmers maximize their rice production business.

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