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Analysis of gender differentials in technical efficiency of smallholder rice farmers in Ashanti region of Ghana

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This study examined the differences in re source use and technical efficiency between male female rice farmers in the Ashanti Region of Ghana. The stochastic production frontier model was used to assess the technical efficiency of the rice farmers. Female rice farmers were found to be producing at high levels of inefficiency. The predicted efficiencies differed substantially from between 2 and 85 %, with mean efficiency of 24%. The low mean efficiency index is an indication of inefficiencies in resource use. Also, female headed farms recorded a mean technical efficiency of 16.5% with a range of between 2 and 66%. The male headed farms, on the other hand, showed a mean technical efficiency of 30.8 %, and a range between 2 and 85%. The results imply that on the average, female rice farmers are relatively technically inefficient than their male counterparts. The paper concludes that since women farmers contribute about 60% of domestic food supply in Ghana, it is important that efforts should be made to build the capacity of women farmers to produce efficiently.

Key words: Gender differentials, resource us e, rice farmers, smallholder, technical efficiency .

INTRODUCTION

Agriculture is the mainstay of Ghana's economy, contributing about 40% of GDP, about 35% of foreign exchange earnings, and 60% of employment (Republic of Ghana, 2008). Over 80% of the populace has their main livelihood activities centered on agriculture (GoG, 2006). However, the agriculture sector has been experiencing fluctuations in growth over the past ten years (MoFA, 2011). In 2011, the sector experienced a very low growth rate of 0. 8% as against 5.3% in 2010. Total food production in 2010 was higher than in 2011. Total food production was 28,756,000 metric tonnes in 2010 as against 28,008,000 in 2011. The decline in growth of food production was due to a decline in cereal production including rice. All cereal crops, including rice, experienced a decline of about 14.84%. Output decreased from 218,000 tonnes in 2010 to 186,000 tonnes in 2011 (MoFA, 2011). Statistics from the Regional Agricultural Development Unit (RADU) indicate that

the decrease in output has resulted in a deficit in rice production in Ghana. The national deficit in rice increas ed from 324,700 tonnes in 2010 to 367,400 tonnes in 2011 (NDPC, 2004). In terms of yield or output per hectare, all cereal crops including rice recorded a decrease. The decline ranged from 1. 24 tonnes per hectare in 2010 to 1.03 tonnes per hectare in 2011 for all cereal crops, representing 16.60% decrease in yield (MoFA, 2011).

Rice, which is an important cash crop, is also an important food staple consumed by majority of Ghanaians in both rural and urban communities across the country. Rice consumption per capita in Ghana has increased by more than 35% over the last ten years (MoFA, 2011). The consumption per head for rice has risen from 11 kg in 1992 to 21.6 kg in 2003 (B&FT, 2011). This was due to the liberalization of the domestic market in 1992 in the course of the adjustment programmes which started in 1983, and led to the invasion of the local rice mark et by foreign companies (FAO, 2007). The importation of rice is ousting the loc al rice off the domestic market and that is making many local rice farmers lose their jobs.

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Besides the huge importation of rice, local rice farmers are not technically efficient enough to meet the demand of the market. It is therefore, not surprising that the 800,000 Ghanaian rice farmers in the country could not satisfy the rice demand in 2011 (MoFA, 2011). Ghana needed to import a huge amount of rice to augment local production. The importation of rice of the year 2011/2012 was 330,000 tonnes (B&FT, 2011), up from 320,000 tonnes in 2010/2011. The increasing volume of imported rice implies increasing expenditure on the commodity. Ghana spends 300 million US dollars on rice importation (B&FT, 2011). Factors such as climate change and poorly organized markets for local rice have been implicated in the low output of rice which may account for the significantly higher imports experienced in recent years. However, it is doubtful that these factors alone would have been responsible for such increase in imports and consumption. The current widespread practice of traditional rice cultivation, which is dominated by women, is perceived to be the key reason for the deficit (Gladwin and McMillan, 1989; Ardayfio-Schandorf et al., 1996; Bortei -Doku, 1990).

Farming activities in tropical Africa has always been dominated by rural women who grow a substantial amount of the staple foods, yet, they still have much less access to knowledge, technology, credit and land than their male counterpart (Minia, 2004). African women on small scale rain-fed farms produce up to 70-80% of the domestic food supply in most sub-Saharan African societies (Gladwin and McMillan, 1989). On average, they also provide 46% of the agricultural labour. However, women's yields are too low by Green Revolution Standards (3 to 4 tonnes per hectare for food grains), and much lower than men's yields in societies where a comparison can be made (for example, where men grow the same crops on different fields or where yields of female headed households can be compared to those of male headed households) (Due et al., 1991).

Gender differences in productivity have been shown to be due to differences in the intensity of use of productive inputs (such as fertilizer, manure, land and labour, credit, extension training, and education) rather than in differences in the efficiency or management styles of men and women (Quisumbing, 1996). Because women farmers lack access to cash and/or credit to acquire modern yield-inc reasing inputs of production, they tend to produce less, and more of their crops are consumed within the family (Gladwin, 2002). In Ghana, the Structural Adjustment Programme (SAP) also tended to disproportionately burden women. The removal of subsidies, which have caused a rise in input prices, and liberalization measures, which have res ulted in a flood of cheap imports, have further harmed local food producers, especially women farmers (Kraus, 1991). Bortei -Doku (1990) observed that women are responsible for about 80% of the food produced in Ghana. In the rice sector, it is estimated that about 66% of rice producers in Ghana

recorded negative returns indicating loss in employment and source of livelihood, not only for farmers but also for other actors in the value chain during the period of 2002-2004 (a survey by GoG, 2006). Estimates by Udry (1996) show that if productive inputs like fertilizer, manure, and labour could only be reallocated within the African household from men to women's crops, in some societies the results could mean an increase in the value of household output in the range of 10-20%.

In response to the widespread gender disparity in terms of access to farm credit and technical logistics in rice production, the government of Ghana has introduced pro-gender special crop interventions like block farms, the Neric a Rice Dissemination Project, the Inland Valley Rice Development Project, the Sustainable Lowland Rain-fed Rice Production Project and the Rice Sector Support Project, with the expectation that the deficit in rice production will decline in the immediate future. This paper, thus, tries to examine the gender differentials in technical efficiency of smallholder rice farmers in the Ashanti region of Ghana. The paper employs the stochastic frontier production model in the analysis.

METHODOLOGY

Method of data collection

Data used for the study were obtained from cross - sectional survey of the rice producers in the Ashanti Region. The Region has three out of the four major rice ecologies in Ghana (rainfed lowland, rainfed upland and valley bottom). With the assistance of Crop Research Institute (Kumasi) and Ministry of Food and Agriculture, ten villages were purposively selected based on the concentration of smallholder rice producers. These villages are Aframso, Kobriti, Yabraso, Saboline, Ashakoko, Hiawoawu, Kyenkyenkura, Kwasiakan, Nokwareasa and Kasei. At least ten farmers were randomly selected from each of the rice producing villages. Respondents in the survey included farmers who grow rice as a sole crop or as an intercrop. Farmers were selected on the basis of rice production, and gender. A total of 100 farmers were interviewed. At least, 5 out of 10 respondents were women.

Stochastic frontier production model

The stochastic frontier production function model used by Parikh and Shah (1994), which was derived from the composed error model of Aigner et al. (1977), and Meeusen and van den Broeck (1977) was applied in the analysis of the data for the study. The stochastic frontier analysis concerns the estimation of frontiers, which envelop data, rather than with functions which intersect data (Kumbhakar and Lovell, 1980). The frontier production shows the maximum output obtainable from given quantities of inputs representing maximum

Table 1. Hypothesis tests.

Null Hypothesis	Likelihood	χ^2 statistic	$\chi^2_{0.95}$	Decision
1. H_0: $\gamma = 0$	-162.5	70.3	11.07	Reject the null; no technical inefficiency in the model
2. $H_0: \delta_1 + \ldots + \delta_6 = 0$	-365.13	113.4	13.4	Reject the null; variables included in the inefficiency effect model have no effect on the level of technical inefficiency

*The critical values for the test of null hypothesis were obtained from Table 1 of Kodde and Palm (1986).

efficiency. Technical inefficiency is measured from the frontier level. The stochastic frontier production function specification enables the separation of output shortfalls due to technical inefficiency from those caused by random disturbances.

The stochastic frontier production function model used by Parikh and Shah (1994) begins by considering a stochastic production function with a multiplicative disturbance term of the form:

$$y = f(x;\beta)e^\varepsilon \qquad (1)$$

Where:

y is the quantity of agricultural output; x is a vector of input quantities; β is a vector of parameters and e is a constant/exponent; ε is a stochastic disturbance term consisting of two independent elements u and v, with

$$\varepsilon = v - u \qquad (2)$$

Equation 1 can thus be re-written as:

$$y = f(x;\beta) \cdot exp\,(v - u) \qquad (3)$$

The measure of technical efficiency for each farm can be calculated using the formula:

$$TE = exp \cdot [E\{u/\varepsilon\}] \qquad (4)$$

And u in equation (4) is defined as:

$$u = f(Z_b;\delta) \qquad (5)$$

Where Z_h is a vector of farmer-specific factors, and δ is a vector of parameters.

The symmetric component, v, accounts for random variation in output due to factors outside the farmer's control, such as weather and diseases. It is assumed to be independently and identically distributed as $N \sim (0, \sigma_v^2)$. A one-sided component $u \geq 0$ reflects technical inefficiency relative to the stochastic frontier. The advantage of this model is that it allows for

simultaneous estimation of the production part of the frontier model and the individual technical efficiency/inefficiency component.

RESULTS

Test of hypothesis

The first null hypothesis in Table 1 specifies that there is no technical inefficiency effect in the production function. This null is rejected for rice producers in the study area. Thus, it can be concluded that the explanatory variables in the efficiency model do contribute significantly to the explanation of the technical efficiency effects for the rice producers. As pointed out by Coelli and Battese (1996), if a null hypothesis includes $\gamma = 0$, then the statistic has asymptotically a mixed Chi-squared distribution, since by its definition γ has to be non-negative.

The second null hypothesis states that the variables included in the inefficiency effects model have no effect on the level of technical inefficiency. This null hypothesis is also rejected for rice producers, showing that the joint effect of these variables on technical inefficiency is statistically significant. A standard t-test for independent samples was used to test for statistical significance of the difference in gross revenue of male rice farmers and their female counterparts in the Ashanti Region. The mean difference for the gross revenue of male rice farmers and their female counterparts is significantly different from zero. The null hypothesis of equality of means is rejected under variance assumption ($Pr(T < t) = 0.009$). The gender index is negatively associated with the level of technical inefficiency at the 1% level of significanc e. This implies that men are more productive than the women in the area so far as rice production is concerned.

Estimates of the stochastic production frontier model

The maximum likelihood estimates of the model parameters are computed using the frontier models routine of the Statistical package STATA with a Cobb-Douglas functional form. The test for the presence of inefficiency was carried out by estimating the stochastic frontier production function and conducting a likelihood-ratio test assuming the null hypothesis of no technical

Table 2. Maximum likelihood estimates of the stochastic production function.

Variable	Coefficient	Standard Error	T-statistic
Production part			
Constant	14.360*	7.66	0.061
Farm Size	0.667**	0.303	0.026
Labour	0.148**	0.069	0.012
Herbicides (cedis)	0.881	0.634	0.164
Fertilizer (cedis)	0.950**	0.473	0.037
Seed (cedis)	1.875***	0.536	0.008
Inefficiency effect (μ)			
Constant	-0.654	0.982	0.666
Gender of the farmer (male = 1, 0 otherwise)	-0.011***	0.003	3.667
Age (years)	0.413***	0.015	27.533
Education (years)	-0.517	1.223	0.131
Farming experience (years)	-0.114***	0.012	-9.500
Extension contacts	-0.948	0.612	-1.549
Credit (Access = 1, 0 otherwise)	-2.400***	0.166	-14.458
Variety of rice seed (improved = 1, 0 otherwise)	-1.056***	0.152	-6.947
Model diagnostics			
Likelihood ratio (1)	-162.50		
Sigma square	30.32		
Gamma	0.34		
Prob> Chi 2	0.008		
Wald Chi2 (6)	70		
Wald Chi2 (4)	113		
Likelihood ratio (2)	-365.5		

***, ** and * represent statistical significance at the 0.01, 0.05 and 0.1 levels, respectively. Source: Computed from survey data, 2012.

inefficiency. This test statistic is computed automatically when the frontier model is estimated using STATA. The parameters and related statistical test obtained from the stochastic frontier production function analysis are presented in Table 2. The estimated coefficient for farm size, labour, fertilizer and seeds are positive and statistically significant at least at the 5% level. A 1% increase in expenditure on fertilizer, and seed will lead to about 0.95 and 1.87% increase in gross revenue respectively (*ceteris paribus*).

The result is consistent with the work of Chinwuba and Odjuvwuederhie (2006) who found expenditure on labour, fertilizer and seed y ams, which constitute the material input variables, shown by the frontier production function, to positively affect farm revenue of smallholder farmers in Southeastern Nigeria. Fertilizer is a major land augmenting input that increases yield per hectare by improving fertility of the soil. The result is also consistent with the work of Weir (1999) who found fertilizer to have a positive and significant impact on output. Abdulai and Huffman (2000) found a negative relationship between the use of fertilizer and the level of profit inefficiency in the Northern region of Ghana. The estimated coefficient of herbicide though positive is not statistically significant even at the 10% level of significance. This implies that expenditure on herbicide will not lead to any significant increase in the gross revenue of rice producers in the area (Table 2).

Source s of efficiency

The sources of efficiency/inefficiency were examined using the estimated δ coefficients associated with the inefficiency effect. The inefficiency effects examined are those relating to age, gender, farming experience, education, access to credit, extension and seed variety. A negative sign on a parameter explaining inefficiencies means that the variable is improving technical efficiency, while for a positive sign, the reverse is true. As indicated in Table 2, the estimated coefficient on age is positive and statistically significant at the 1% level. This implies that older farmers are relatively less efficient in rice production. Since labour productivity decreases with age, younger farmers tend to be more productive than their

older compatriots. The estimated c oefficient on gender of the farmer (male = 1, female = 0) is negative and in consonance with *a priori* expectation. It is statistically significant at the 1% level. This implies that inefficiency is less on male plots than their female counterparts. The result is consistent with the findings of Due and Gladwin (1991). Also in relation to the findings of Akinwuni and Djato (1997), they emphasized that the relative inefficiency of women rice farmers is not just because they are female but rather due to constraints that disproportionately affect them.

The estimated coefficient on years of experience is negative, conforming to *a priori* expectation, and it is statistically significant at the 1% level. The implication is that farmers with more experience in rice production are more efficient than the inexperienced ones in the area. The result is consistent with the work of Bravo-Ureta (1994) who observed positive relationship between economic efficiency and experience in a study of dairy farms in New England. Rice farmers in the study area tend to us e the knowledge acquired through experience on soil, and crop management in their farm operations.

The seed variety dummy was found to be negative and statistically significant at the 1% level. This implies that those farmers who adopted new rice technology in the form of improved rice seed were more efficient than those who used the traditional rice technology, a result consistent with that of Seyoum et al. (1998) in Ethiopia. The estimated coefficient on education is not statistically significant but has the expected negative effect on inefficiency. The result, however, implies that the years of education tend to have no significant effect on the inefficiency levels of the rice farmers in the study area. The result is consistent with findings by Bravo-Ureta and Evenson (1994) on peas ant farmers in Paraguay. Seyoum et al. (1998) demonstrated that education does not significantly affect the efficiency of farmers using traditional methods. Weir (1999) also found a threshold effect that implies that at least four years of schooling are required to lead to significant effects on farm level technical efficiency, irrespective of gender.

The estimated coefficient on access to credit is negative, agreeing with *a priori* expectation, and statistically significant at the 1% level. This suggests that farmers who have access to credit tend to be more efficient in rice production. This finding is consistent with the work of Abdulai and Eberlin (2001), which shows a positive association between credit and input use and farm productivity in Nicaragua. The availability of credit helps to finance the procurement of material inputs which have a positive effect on rice production.

The estimated coefficient on number of contact with extension officers is negative according to *a priori* expectation but is not statistically significant even at the 10% level. The result implies that more contact with extension officers tend to have no significant effect on the inefficiency levels of farmers in the study area. The result

is not consistent with findings obtained by other researchers (Ali and Byerlee, 1991; Rahman, 2003; Owens et al., 2001) because it is expected that more contact with extension workers will increase the farmer's likelihood of adopting improved rice technologies which will eventually increase the efficiency level of the rice farmer. The result is not surprising because the rate of adoption of land augmenting technologies such as improved seed and fertilizer is very low in the Ashanti Region. About 70% of the respondents use the traditional technology (traditional rice seed). Thus, knowledge disseminated by extension officers to the rice farmers may not affect their output significantly, as the knowledge is on improved rice variety.

The inefficiency component of the disturbance term (µ) of the estimated frontier model is significantly different from zero ($p = 0.008$) indicating the presence of statistically significant inefficiency in the data. The likelihood ratio, sigma square and gamma parameters present results on the behavior of the error term outlined in the inefficiency model. The gamma measures the percentage variations in plot output due to technical inefficiency. If gamma is significantly different from zero, it implies that there is technical inefficiency in rice production. The percentage variation in plot output due to technical inefficiency (gamma) is 34%. The maximum likelihood estimates of the inputs parameters show the expected signs for all production inputs.

Efficiency indices among smallholder rice producers in the Ashanti Region

Table 3 indicates that female headed farms recorded a mean technical efficiency of 16.5% with a range between 2 and 66% and a standard deviation of 21.3%. The male headed farms, on the other hand, showed a mean technical efficiency of 30.8%, a range between 2 and 85% and a standard deviation of 26.5%. The results imply that on the average, male rice producers are relatively technically efficient than their female counterparts, a result that is statistically significant at the 1% level.

Given the specification of the Cobb -Douglas production function, the predicted efficiencies differ substantially among farmers, ranging between 2 and 85%, with mean efficiency of 24% and a standard deviation of 22.5%. This low mean technical efficiency is an indication of high inefficiency in resource use. The distribution of the technical efficiency level in Table 3 shows that rice production on most plots is technically inefficient. For instance, the modal efficiency score group is 11-20 accounting for 30% of the total sample of rice farms, followed by 0-10 accounting for 29%. Only 3% of rice farms have technical efficiency scores of more than 70%. The mean technical efficiency for the area is lower than that for most farmers in African countries whose mean technical efficiency range between 55 and 79%. This

Table 3. The distribution of efficiency indices among s mallholder rice producers.

Efficiency index	Male frequency	Percent	Female frequency	Percent	Total frequency	Percent
0- 10	6	12	23	46	29	29
11- 20	17	34	13	26	30	30
21- 30	12	24	9	18	21	21
31- 40	3	6	2	4	5	5
41- 50	1	2	1	2	2	2
51- 60	5	10	1	2	6	6
61- 70	3	6	1	2	4	4
> 70	3	6	0	0	3	3
N	50	100	50	100	100	100
Min	2		2		2	
Max	85		66		85	
Mean	30.8		16.5		24.5	
STD	26.5		21.7		23.3	

Figure3.1Frequency distribution of farm-specific efficiencies in the stochastic production frontier
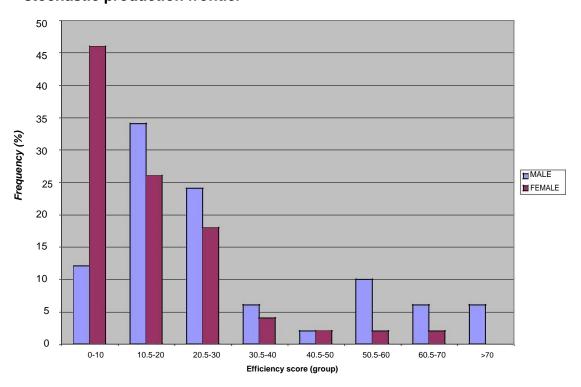

Figure 1. Frequency distribution of farm-specific efficiencies in the stochastic production frontier. Source: Smallholder rice farmer survey, 2011.

finding is similar to the studies of Heshmati et al. (1996) who obtained mean technical efficiency of 25% for the cereal farmers in rural Uganda and Weir et al. (2000) who recorded a mean technical efficiency of 35% for cereal crop farmers in rural Ethiopia. The mean technical efficiency observed in the study area is also close to that of Mochebelele and Winter-Nelson (2000) who obtained mean technical efficiency of 36% for rural households that send migrant workers from Lesotho to South African mines and 24% for households that do not send migrant labour.

Figure 1 shows that the modal efficiency class for the women rice producers is 1-10 and about 72% of the women's farms have technical efficiency levels below 21%. Their male counterparts on the other hand have their modal class as 11-20 and about 46% of the men's farms have technical efficiency levels below 21%. The result implies that technical efficiency is relatively higher

on the men's rice farms than on that of their female counterparts.

DISCUSSION

This study set out to evaluate gender differentials in technical efficiency of smallholder rice producers in the Ashanti Region of Ghana. Since rice is becoming a major food crop, especially in institutions such as schools and hospitals, its production is very crucial to the attainment of both food and income security of farmers. The efficient utilization of the scarce resources in the rice sector will improve the self-sufficiency ratio of the country and make the country a net exporter of rice. The maximum likelihood estimates of the parameters of the stochastic production function and inefficiency effects were found using the STATA software. This package estimates the two models simultaneously. To test for the functional form, the respective likelihood ratio tests were computed and their results compared with the critical values obtained from Kodde and Palm (1986). The results of the likelihood ratio tests showed that the factor input variables: labour, fertilizer and seed (valued in Cedis), and land had positive influence on the technical efficiency levels of the farmers in the area.

The analysis further showed that the sampled farmers are not technically efficient in rice production. They had different levels of technical efficiency ranging from 2 to 85%, and a mean technical efficiency of 24%. Also, female headed farms recorded a mean technical efficiency of 16. 5% with a range of between 2 and 66%. The male headed farms, on the other hand, showed a mean technical efficiency of 30.8%, and a range between 2 and 85%. The results imply that on the average, female rice producers are relatively and technically inefficient than their male counterparts. The statistical results show that women are less educated, have smaller plots, use less fertilizer and have relatively smaller yield and less gross revenue than their male counterparts; and these may be accountable for the observed inefficiencies on female rice farms.

In analyzing the sources of inefficiency of the rice farmers, six factors were identified. These were years of formal education, gender of farmers, access to credit, contact with extension officers, age of the farmer, the farmer's experience in rice production and the seed variety planted by the farmer. The gender index was found to be a significant factor in reducing inefficiency in the area. Men farmers, owing to their relatively higher level of education, and ability to access credit to finance the acquisition of farm inputs, were more technically efficient than their female counterparts. Having more contacts with extension officers was found to be influencing technical inefficiency negatively but it was not statistically significant in the area. Rice farmers with more experience in rice production were found to be more efficient. Also, older farmers were found to have higher

levels of technical inefficiency. Education (in years) had the appropriate sign but was not statistically significant. This result implies that less years of formal education is not significantly associated with the level of inefficiency in the study area.

The seed variety index was found to be negative and statistically significant. This implies that those farmers who adopted new rice technology were more efficient than those who used the traditional rice technology. The four hypotheses tested show that first, all farmers are not operating at technically efficient level; secondly, expenditure on material inputs such as fertilizer and rice seed positively affect gross revenue; thirdly, the variables included in the inefficiency model explain the observed variations; fourthly, there is relatively less observed inefficiency on the farms of male rice farmers as compared to their female counterparts.

Conclusions

The objective of this study is to examine the gender differentials in technical efficiency of smallholder rice farmers in the Ashanti region of Ghana. This study assessed the specific factors that determine farm-specific technical efficiency and explained the factors affecting the efficiency levels observed. Finally, this study examined the variability in the technical efficiency levels among male and female rice farmers. The results of this study showed that majority of rice farmers were not technically efficient, given the technology they use and that there was a potential to increase their efficiency levels by improving the observed factors that determine their efficiency. The study further showed that the major variables affecting technical efficiency were expenditure on labour, fertilizer and rice seed used for rice production. This implies that any policy made to improve access to fertilizer and improved seed will go a long way to improve the technical efficiency levels of farmers in the area. There is therefore the need for extension officers to strengthen educational activities so that the farmers will adopt existing improved varieties since about 70% of the sampled farmers still use local varieties with little yield.

The variables, access to credit, farmer's years of experience in rice production and the seed variety planted by the farmer, were found to be significant in reducing the inefficiency levels of rice farmers in the area. The farmer-specific variables such as farming experience, education, extension visits and access to credit, might be influencing the farmer's ability to use available technology; a situation that might be contributing to the observed variations of technical efficiency amongst them. The survey results revealed that women and men farmers were found to be different in certain characteristics such as size of land under cultivation, input use levels (including fertilizer), level of education, and access to credit. Women showed a lower resource endowment and lower level of education.

Gender-sensitive safety net programs that recognize women as rice producers will be worth an effort to reduce the inefficiency levels of rice producers in the Ashanti Region of Ghana. Rice farmers, especially the women, need to be better supported, if Ghana is to ever experience an increase in local rice production.

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