IMPROVING THE EFFICIENCY OF INLAND VALLEY RICE PRODUCTION IN NORTHERN GHANA

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ABSTRACT
In northern Ghana rice cultivation is believed to have a great potential in reducing poverty levels. Despite this, present yields are generally low due to lack of water control systems, high level of risks caused by uneven rainfall distribution, and inefficient farming practices. Against this background three interventions have been introduced in the Tamale area of the Northern Region of Ghana, namely: the Agence Francaise de Development /Ministry of Food and Agriculture Lowland Rice Development Project (AFD/MOFA-LRDP); the Transfer of Effective Irrigation and Water Resources Management Project (TEIWRMT); and the Gollinga Irrigation Scheme of the Ghana Irrigation Development Authority (GIDA). The objective of this paper is to identify the socio-economic factors that influence the inefficiency of farmers under the three rice cultivation schemes. The method of analysis involves a one-step estimation of a stochastic frontier model. Though the average efficiency is low, it is relatively high for intensive rice cultivation with improved water harvesting schemes such as bunds and water regulating structures. Other factors that reduce farmers' inefficiency are: education; extension visits; farmers' experience and group membership. However, general inaccessibility increases farmers' inefficiency. To help bring the much needed development in northern Ghana it is important that rice cultivation be supported with more of the following: water harvesting and regulating structures; improvement in the road net-work; as well as education and extension services, among others.

INTRODUCTION
The vision for Ghana's agricultural sector is "a modernized agriculture culminating in a structurally transformed economy and evident in food security, employment opportunities and reduced poverty" (MOFA, 2008). In the Ghana Poverty Reduction Strategy (2003-2005) (GPRS 1) agriculture was to be made modern to bring about rural development; and in the Growth and Poverty Reduction Strategy (2006-2009) (GPRS 11), the sector was to be the panacea for economic growth and development. Rice is vital to the Ghanaian economy; it is a source of employment and cash for numerous Ghanaian farmers. Rice is grown both as a food and a cash crop by 10% of the farmers mainly located in the northern savannah, but also in the forest zone of the Brong Ahafo, Ashanti and Western regions (MOFA, 2000). The Northern Region possesses a great potential for rice culti-

vation, and lowlands represent the largest area but are mostly unused. Official sources put the area of lowlands liable to flooding in the region at 400,000 hectares. Inland valley production systems (lowlands and midlands) account for 75% of domestic rice production. They have the highest potential for rice production due to their hydrological characteristics such as high water retention capacity. Despite this high potential, present yields are generally low due to the lack of water control systems, the high level of risks caused by uneven rainfall distribution, and the low level of input use (LRDP Mission 1 M&E Report, 2001).

Against this background three interventions have been introduced in the Tamale area of the Northern Region of Ghana, namely: the Agence Francaise de Developpment /Ministry of Food and Agriculture Lowland Rice Development Project (AFD/MOFA-LRDP); the Transfer of Effective Irrigation and Water Resources Management Project (TEIWRMT); and the Gollinga Irrigation Scheme of the Ghana Irrigation Development Authority (GIDA). The AFD/MOFA-LRDP Project was implemented by a twinning of French and Ghanaian Consulting Firms, SOFRECO and PAB Development Consultants of France and Ghana respectively; the latter being under the overall oversight of the Ministry of Food and Agriculture (MOFA). TEIWRMT on the other hand is an IWMI/ Japan Cooperative Program while the Gollinga Irrigation Scheme is one of the irrigation schemes operated by the Ghana Irrigation Development Authority (GIDA).

The AFD/MOFA-LRDP Project is an intensive rain-fed rice cultivation scheme with improved water harvesting schemes such as bunds and water regulating structures. Farmers in the TEIWRMT project area are engaged in rain-fed rice cultivation but with limited or no water harvesting schemes. On the other hand, farmers under the Gollinga Irrigation Scheme do not only practise intensive cultivation, they have the opportunity to cultivate two rice crops in a year, one in the rainy season with supplementary irrigation if necessary and the other in the dry season purely on irrigation. These projects cut across four local authority areas of the region namely; the Tamale Metropolitan area, the Savelugu/Nanton, Tolon/Kumbumgu and Central Gonja districts.

The Lowland Rice Development Project (LRDP) was designed to focus simultaneously on improving production, processing and marketing of the rice produced by small scales farmers. The Project aimed at developing a profitable and sustainable intensive rice production system in the Northern Region, with the hope of adapting the process to other regions in the North Savannah zone. The research on transfer of effective irrigation and water-resource management techniques is a three year (Jan.2007- Dec. 2009) Program with the main objectives as follows: to evaluate and select inland valley wetland sites in northern Ghana that are best suited for Paddy rice cultivation; and determine the most suitable sites to the least suitable sites based on biophysical, technical socio-economic, and ecological/ environmental variables. The Gollinga Irrigation Scheme is located in the Tolon/Kumbungu district of the Northern Region. Constructed in 1974, The Gollinga Irrigation Scheme is a gravity irrigation system with a potential irrigable area of 100 hectares out of which 40ha (40%) have been developed and put under cultivation. 156 farmers (132 males and 24 females) from 5 adjoining communities are involved in rice cultivation under the scheme. Vegetables such as pepper and okra are also cultivated in a relatively small scale. The objective of this paper is to identify the socio economic factors that influence the efficiency of farmers under the three irrigation schemes. This forms part of the overall objectives of determining and quantifying socio-economic, agronomic, water management, market access, and settlement parameters as well as environmental factors that are required for assessing the suitability of inland valleys for rice cultivation.

METHOD OF ANALYSIS

Efficiency studies have been well expounded in the literature (Farrell, 1957; Aigner *et al.,* 1977;

Jondrow *et al.,* 1982; Battese and Coelli, 1993; 1995). Farrell (1957) proposed that efficiency of a firm consists of two components: technical and allocative. Technical efficiency reflects the ability of a firm to obtain maximal output from a given set of inputs, and allocative efficiency reflects the ability of a firm to use the inputs to optimal proportions, given their respective prices and the production technology. These two measures are then combined to produce a measure of total economic efficiency. In illustrating this, Farrell assumed firms using two inputs (x_1 and x_2) to produce a single output (y), and operating under constant returns to scale. It is also assumed we have knowledge of the unit isoquant of fully efficient firms. This is represented by the curve *IS – IS'* in Figure 1 below which is reproduced from Battese (1992).

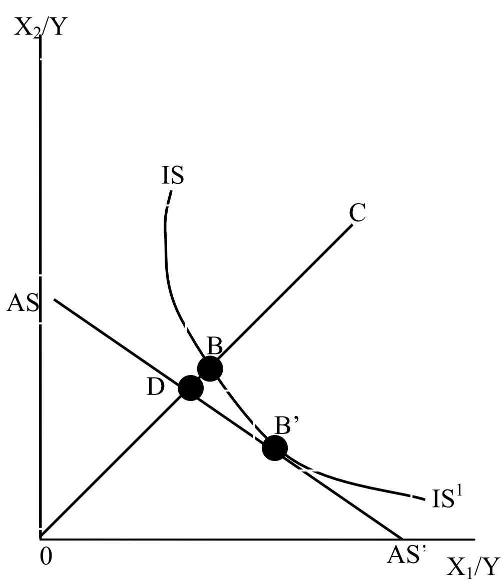

Fig. 1: Technical, Allocative and Economic Efficiency

From Figure 1 above, a firm operating at B is technically efficient because it is operating on the isoquant *IS – IS'*. However if a firm is operating at C it is not efficient because it is far away from B and indeed the origin 0. In this case the technical inefficiency of the latter may be measured by the distance BC, which is the amount by which the firm's inputs can be proportionally reduced without reducing output. Thus, in a ratio form the technical efficiency (TE) of this firm is measured by $TE_i=OB/OC$ which is equal to 1-*BC/OC*. This implies that technical efficiency lies between zero and one. Thus technical efficiency of one implies the firm is fully efficient (while zero efficiency implies the firm has no technical efficiency). From the diagram the input price ratio may be represented by the slope of the straight line *AS-AS'*. With this, the allocative efficiency *(AE)* of the firm can also be calculated. At point C the allocative efficiency, AE is defined as the ratio of *OD/OB* (i.e. $AE_i=0D/OB)$ since the distance DB represents the reduction in (production) costs if production were to occur at the allocatively (and technically) efficient point *B'* instead of the technically efficient, but allocatively inefficient point B. The product of technical efficiency *TE* and allocative efficiency *(AE)* is economic efficiency *(EE)* given as:

$$EE = TE_i \times AE_i = (0B/0C) \times (0D/0B = (0D/0C) \quad (1.1)$$

Like technical efficiency, allocative and economic efficiency are bounded by zero and one.

In terms of stochastic frontier estimation, Battese and Coelli's (1993; 1995) formulations are most appropriate because they make one-step estimation possible to correct for any inconsistencies. Using a Cobb Douglas production function, Battese and Coelli's (1995) stochastic frontier model may be specified as;

$$y_i = f(x,\beta) - u_i + v_i \quad (1.2)$$

Where y is output, x_i is a vector of inputs, β is a set of parameters to be estimated, u_i is a one-sided error, which says that each observation should lie on or below the frontier. This residual represent technical inefficiency; v_i is the usual two-sided error that represents random shifts in the frontier. That is, while u_i measures the factors responsible for that firm's inefficiency such as mismanagement, v_i measures the random variation in output (y_i) due to factors such as luck, climate and natural disasters.

Note that whereas the factors measuring a firm's inefficiency are within its control, factors that measure the random variation in output are outside the firm's control. V_i is assumed to be identically and independently distributed as $N(0, \sigma^2_v)$ random variables, independent of u_i which is distributed as a truncated normal (at zero) of the $N(\mu,\sigma^2)$ distributions. u_i is independently, but not identically distributed; Note that $\varepsilon_i = v_i - u_i$ is the composed error term.

There are two objectives in stochastic frontier analysis: The first is the estimation of an efficiency level of each producer and the second is the incorporation of exogenous variables into the frontier to find the extent to which such variables influence technical efficiency. In this case the exogenous variables are believed to affect output through producer performance. As implied from Figure 1, the technical efficiency (*TE)* of a given firm (at a given time period) is defined as the ratio of its mean production (conditional on its level of factor inputs and farm effects) to the corresponding mean production if the firm utilizes its levels of inputs most efficiently. Thus,

$$TE_i = \frac{E\left(Y_i^* \mid U_i, X_i\right)}{E\left(Y_i^* \mid U_i = 0, X_i\right)} = \exp\left(-U_i\right) \qquad (1.3)$$

where the numerator is the output of the i^{th} firm and the denominator is the potential output or the average output of all the efficient firms in the same industry as the i^{th} firm.

$$Y_i^* = \exp\left(Y_i\right) \qquad (1.4)$$

And TE_i will take a value between zero and one. Thus Equation 1.2 takes the form

$$\left.\begin{aligned} \ln(y_i) &= f(x_i;\beta) + v_i - u_i \qquad (1.5a) \\ u_i &= w_i'\delta + e_i \qquad (1.5b) \end{aligned}\right\}$$

Where;

w_i is a vector of independent socio economic variables

δ is a vector of parameters to be estimated and e_i is a two sided error term with $N(0,\sigma^2)$. The other variables are as defined above.

Following from equations 1.5a and 1.5b the empirical model that specifies the technical efficiency of rice farmers is given as:

$$\begin{aligned} \ln(y_i) &= \beta_0 + \beta_1 \ln(land) + \beta_2 \ln(mandays) \\ &+ \beta_3 (labourcost) + \beta_4 \ln(rentcapital) \\ &+ \beta_5 (crop\exp) + v_i - u_i \end{aligned} \qquad (1.6a)$$

$$\begin{aligned} \mu_i &= \delta_0 + \delta_2 (Age) + \delta_3 (Educ) + \delta_4 (HHsize) \\ &+ \delta_5 (Group) + \delta_6 (Experience) + \delta_7 (Extension) \\ &+ \delta_8 (Training) + \delta_9 (Dfarm) \\ &+ \delta_{10} (Dtown) + \delta_{11} (Accessibility) \end{aligned} \qquad (1.6b)$$

In this study we limit ourselves to the estimation of technical efficiency because we do not have adequate data on input and output prices which are necessary for the estimation of allocative efficiency. Besides, the study is cross sectional and it is anticipated that prices do not vary significantly among the households who are all within the same region. Equations 1.6a and 1.6b are estimated by maximum likelihood, using the computer program, FRONTIER version 4.1 (Coelli, 1996). Battese and Coelli's (1993; 1995) one-step/simultaneous estimation procedure is used. The maximum likelihood estimation yields consistent estimators for β, δ, γ, and σ^2_e

where $\gamma = \sigma^2 / \sigma_s^2$ and $\sigma_s^2 = \sigma_v^2 + \sigma^2$

The following hypotheses are to be tested:

$$Ho: \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 = 1 \qquad (1.7a)$$

$$Ho: \gamma = \delta_0 .... = \delta_{11} = 0 \qquad (1.7b)$$

$$Ho: \delta_1 = ... = \delta_{11} = 0 \qquad (1.7c)$$

The parameters are as defined earlier.

Equation 1.7a is the null hypothesis that returns to scale is constant. Equation 1.7b tests the hypothesis that the technical inefficiency effects u_i are not present. The technical inefficiency effect model can only be estimated if the inefficiency effects are present. If the one-sided error term in the production function is not present then the model is an ordinary production function which can be estimated by OLS (i.e. the model is equivalent to the traditional average response model). However if u_i is present it means that we were right in using the stochastic frontier approach. Note that the inefficiency term u_i could be present but may not be influenced by the independent variables in the inefficiency model (1.6b), hence the last hypothesis (1.7c) to find out whether the independent variables do determine technical inefficiency.

The generalised likelihood ratio test statistic is used to test the above hypotheses as

$$\begin{aligned}\lambda &= -2\{\ln[L(H_O)/L(H_1)]\} \\ &= -2\{\ln[L(H_0)] - \ln[L(H_1)]\}\end{aligned} \tag{1.8}$$

where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the null and alternative hypothesis H_0 and H_i respectively: If the given null hypothesis is true then λ has approximately a chi-square (χ^2) (or a mixed chi-square distribution). On the other hand, if the null hypothesis involves $\gamma = 0$, then the asymptotic distribution involves a mixed Chi-square distribution (Coelli, 1995).

Data

As indicated earlier, the sampling frame of the study is the communities covered by the three project areas (AFD/MOFA-LRDP, TEIWRMT and Gollinga Irrigation Scheme). The communities are in four districts, namely; the Tamale Metropolitan area, the Savelugu/Nanton, Tolon/Kumbumgu and Central Gonja districts; all in the Northern Region of Ghana. Stratified and random sampling techniques were used to select the households for the study. That is 100 households were selected at random from communities in each of the three projects totalling 300. However, the total number of households for whom we had adequate data for all the variables was 201 which still cuts across all the three projects and four districts. The farms were however, rain-fed and exclude dry season farming.

Definition of variables

In this study land is the total size in acres of plot that the household cultivated during the 2007/2008 farming season. This may be owned by the household or rented. Labour is in the form of family labour, exchange labour or hired labour. It involves all the human efforts that went into the farming operation, namely: land preparation (including bund making and maintenance); seed planting; weed and pest control (including bird scaring); soil fertility management; and harvesting, collection, transporting and threshing. In this study labour has been categorized under two, namely, man days and cost of hired labour. Capital is made up of the hiring of tractor (for ploughing and harrowing) and knapsack sprayers for spraying of herbicides and insecticides, among others. Input expenditure includes costs of herbicides such as roundup and inorganic fertilizers such as urea, ammonia, NPK15-15-15 as well as NPK20-20-20. The rest of the variables are defined in Table 1 below.

RESULTS AND DISCUSSION

As mentioned earlier, the objective of this study is to estimate and find out the determinants of the efficiency level of the farming households in our sample. Tables 2 and 3 contain the results of the maximum likelihood estimation of the stochastic frontier model (Equations 1.6a and 1.6b). The results in Table 3 are first discussed.

The first test of hypothesis is constant returns to scale. That is, the sum of the coefficients of "land", "man-days", "hired labour cost", "rental capital" and "crop expenditure" (β_1, β_2, β_3, β_4 and β_5) is equal to one (see Table 3). The second is that there are no inefficiency effects in our model. That is to say that the inefficiency term u_i is absent and that the model is an ordinary average response model with v_i as the only error term. The last test says that the variables in the inefficiency effects model (socio-economic indicators) do not explain the inefficiency term u_i. All the three null hypotheses are rejected (see Table 3), implying (1) non-constant returns to scale, (2) the presence of the inefficiency term u_i and (3) the explanatory variables determine u_i respectively.

It is observed in Table 3 that the sum of β_1, β_2, β_3, β_4 and β_5 is equal to 1.4. The rejection of the first null hypothesis confirms that this value is significantly greater than one, which further means that returns to scale are increasing.

The second null hypothesis says that there are no technical inefficiency effects in our model. The rejection of the hypothesis means that there are technical inefficiency effects in inland valley rice production in the study area. What this further means is that the average response model is not an adequate representation of the analysis and that we were right in estimating a stochastic frontier model. In table 2 the coefficient and the standard error of γ is 0.99 and 0, respectively. This confirms the fact that the true γ-value is greater than zero (as indicated in the test). However, since the coefficient is almost equal to one it means that v_i component of ($\varepsilon_i = v_i - u_i$) is almost zero implying that there are no random errors such as weather failure or other natural disasters. As Coelli *et al.* (1998) argue, this is surprising considering the fact that agricultural production is characterised by a lot of uncertainties. However, in our study area it could be argued that the intervention of the projects has gone a long way to cushion farmers against some of these risks. In general the smallness of v_i implies that the stochastic frontier that we estimated is not different from a deterministic frontier model in which there are no random errors (v_i).

The inefficiency term u_i could be present but may not be influenced by the socio-economic variables. The rejection of the third null hypothesis that the socio-economic variables do not explain u_i underscores the advantage of the stochastic frontier analysis; in that we are able to explain the variation of the inefficiency term u_i among the farming households.

Table 1: Summary Definition of Variables

Variable	Description
Total output	Total Value in GH ¢ of household produce
Land	Natural logarithm of farm size/land area
Man days	Natural logarithm of household labour days
Labour cost	Natural logarithm of cost of hired labour in GH ¢
Rent capital	Natural logarithm of cost of capital rental in GH ¢
Crop exp.	Natural logarithm of other crop expenditure in GH ¢
Bunds	Dummy;1 if household has bunds on their farms;0 if otherwise
Age of household head	No of years
Education of household head	Number of years of schooling
Household size	No of members in the household
Group membership	Dummy;1 if household belongs to a farming group, 0 if otherwise
Experience	For how long household had been in rice cultivation
Extension visits	No. of times household had contact with extension personnel (either individually or in group) during 2007/2008 farming season
Training	Dummy; 1 if household got training in rice cultivation in the year 2007/2008; 0 otherwise
Distance to farm	Distance in miles from house to farm
Distance to town	Distance in miles from house to town
Accessibility	Dummy; 1 if house/settlement is accessible by vehicle; 0 otherwise. Note that some of the farmers had their farms at their settlements.

Table 2: Maximum Likelihood Estimates for Parameters of the Stochastic Frontier and Inefficiency Model

Variable	Parameter	Coefficient	Standard error	T-Ratio
Stochastic frontier				
Constant	β_0	5.48	0.40	13.86
Land	β_1	0.97	0.12	8.14***
Man days	β_2	0.22	0.09	0.26
Labour cost	β_3	0.08	0.04	2.00**
Rent capital	β_4	0.04	0.05	0.87
Other crop exp.	β_5	0.09	0.04	2.22**
Inefficiency model				
Constant	γ_0	-33.62	6.99	-4.8
Bunds	γ_1	-6.19	1.05	-5.90***
Age of HH head	γ_2	0.24	0.04	6.19***
Educ. of HHhead	γ_3	-1.11	0.27	-4.09***
Household size	γ_4	0.40	0.12	3.40**
Group membership	γ_5	-6.88	1.60	-4.29***
Experience	γ_6	-0.13	0.06	-2.07**
Extension visit	γ_7	-2.88	0.18	-15.75***
Training	γ_8	2.99	1.32	2.27**
Distance to farm	γ_9	0.22	0.13	1.68*
Distance to town	γ_{10}	1.37	0.34	4.07***
Accessibility	γ_{11}	3.76	1.12	-3.16**
Sigma squared		46.60	8.91	5.23***
gamma	γ	0.99	0.00	1105.40***
Log-likelihood function	-	-351.70	-	-
Mean efficiency	-	0.42	-	-

****, significant at 1% ** significant at 5% * significant at 10%*
Dependent variables of the stochastic frontier model and the inefficiency model are log of total value of crop output and efficiency levels respectively.

Table 3: Tests of Hypothesis for Returns to Scale and Coefficients of the Explanatory Variables for the Inefficiency Models

Null Hypothesis	Log-likelihood function (H_0)	Test statistic λ	Critical value	Decision
Test1 *HO*: $\beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 = 1$	-397.59	91.78	12.48 (4)	Reject H_0
Test 2 H_0: $\gamma=\delta_0 = ... = \delta_{11} = 0$	-446.97	190.54	24.05(11)	Reject H_0
Test 3 H_0: $\gamma=\delta_0 = ... = \delta_{11} = 0$	-362.35	21.30	19.05(11)	Reject H_0

Critical values are obtained from Table 1 of Kodde and Palm (1986, p.1246).
Figures in brackets are the number of restrictions. Hypotheses 1 & 2 are tested at 1% while hypothesis 3 is tested at 5%.

Average Efficiency and the Determinants of Output

From Table 2 the mean efficiency is 0.42. Earlier, we indicated that our model is a technical efficiency model because it does not include input and output prices. However, according to Battese and Coelli (1996) if the dependent variable of the model is "value of total output" rather than the physical quantities of output, the efficiency levels obtained are economic and not technical efficiencies and the u_is are "inefficiency effects" rather than "technical efficiency effects" (Battese and Coelli, 1996). The mean efficiency for this study is low though comparable to some other studies in developing countries (Donkoh, 2006; Bravo *et al.,* 1993). From the Appendix, we notice that the scores range from 0 to 90, most of them having less than 50% mark. In Seidu's (2008) study the technical efficiency for irrigators and non-irrigators were 0.51 and 0.53 respectively. However, Ogunyinka and Ajibefun (2004) found the average efficiency level to be 0.61

The first part of the stochastic frontier model shows the extent to which the conventional inputs (land, man-days, hired labour cost, rented capital and crop expenditure) directly shift or contrast the frontier, while the second part measures the inefficiency effects. It is observed that whereas land, hired labour and crop expenditure are significant and positive, (implying they shift the frontier) labour in man-days and rented capital are positive but not significant. The sum of the coefficients of all the variables (land, man-days, hired labour, rented capital and crop expenditures) is 1.40 confirming the earlier rejection of the null hypothesis that there are constant returns to scale. Since the figure is significantly greater than 1 we can say that returns to scale are increasing. Also, since the values of the inputs are in logs, the coefficients are elasticities:

The Determinants of efficiency

It must be mentioned that in the inefficiency model, we are concerned about the effects of the variables in reducing inefficiency; therefore, the signs are interpreted in the opposite way (compared to how the conventional inputs determine output in the first part of the model). Thus, if the coefficient of a variable has a negative effect on inefficiency it implies that that variable has a positive effect on efficiency. All the inefficiency effects variables are significant, most of them maintaining their expected sign. The effect on output of bund construction and maintenance is one of the important findings of this study. The study area being characterized by torrential rainfall, and with limited use of fertilizers, bund construction is very important in checking erosion and thus conserving the limited nutrients and moisture on the farms. More households in AFD/LRDP and GOIRRSCM areas had bunds than households in TEIWRMT area. The negative sign of the coefficient implies that the construction of bunds reduces inefficiency (or increases efficiency). Other variables that reduce households' inefficiency are: educational level of the household head; group membership; experience; extension visits; and accessibility to the farms. These findings are plausible considering the fact that an educated household head would be better informed about the need for the adoption of improved varieties and practices than the illiterate counterpart. Duncan (1997) asserts that education is essential for the progressive development of agriculture since access to relevant sources of information can increase one's chances of obtaining credit and adopting modern technology leading to increased output. Seidu (2008) also found farmers' education to be positively related to efficiency and stresses that education enables the farmer to understand the social and economic conditions governing his/her farming activities and thereby act appropriately to raise output. And in Bhasin's (2002) study education positively influenced the efficiency of tomato farmers but not onions and pepper farmers in Upper East region.

Group membership is another important factor that increases the efficiency of farmers, in the sense that it is a viable source of labour. This is against the backdrop of high cost of labour. In some communities 'nnoboa' has been formed whereby a group of farmers can help themselves on their farms on a reciprocal basis. One other importance of group membership is the fact that farmers are able to access credit facilities or other forms of assistance, which they would otherwise not be able to. There is a saying that “Practice makes a man perfect”. With several years of farming, the household is able to gather experience to guard against the present and the future. This translates into relative increase in yields or post-harvest handling. The negative sign of the coefficient of number of years of farming therefore does not come as a surprise. Furthermore, the greater the number of extension visits to the farmer, the greater the efficiency, other things being equal. This is because contact with extension staff exposes the household to modern agricultural inputs and practices. Also, frequent visits or interaction with the extension agents mean that there is more supervision and sharing of knowledge that goes a long way to keep the farmer on track. Our finding is consistent with that of Seidu (2008) and Bhasin (2002). Lastly, the more accessible the household is the greater the opportunity to be visited by help-agents such as extension staff and market women who would buy the household’s produce from the house without the household having to transport it to the market.

Quite surprisingly, from the results, the number of training increases inefficiency (or reduce efficiency). In some places the reason could be that the training is not beneficial but rather a waste of time to the farmer. Other variables that increase inefficiency are age of the household head, household size and distance from the house to the farm as well as to town. The positive sign of age implies that households headed by the relatively young are more efficient. Again, this is tenable because in a situation where the household head is very old and now a dependant, he may not exert much influence or inspire the other members of the household to work hard on the farms. Earlier, we noted that experience leads to efficiency. There appears to be a contradiction here but it is not, because old age does not necessarily mean long years of experience. We could have aged people who may have retired from formal employments and taken to farming. Such farmers may not be as efficient as younger ones who have been in farming for a long time. Young, energetic and hard-working heads are not only inspiring but a good example to emulate. In Donkoh (2006) household size was a significant negative determinant of inefficiency (implying it has positive effect on efficiency). Also, Seidu (2008) found that larger family size enhances technical efficiency on non-irrigated lands. He argues that larger family size allows for greater division of labour and specialization which leads to increased output. The variable however, was not significant in determining the efficiency of irrigating farmers. The positive sign in this study means that it impacts negatively on efficiency. The positive sign of the coefficients of the distance variables confirm the *a priori* expectation that when household members have to walk several kilometres to the farm they get tired even before they start work, hence reducing their efficiency. Similarly, a long distance from the house to town would mean that the cost in terms of walking or transportation would be high. This further means that the household may not be able to patronise the market with their produce in a manner that would bring efficiency.

Efficiency Scores across Rice Schemes Demographic Groups

Figures 2 to 10 further explain the estimation results in Table 2. In Figure 2 we notice that households with the Gollinga Irrigation Scheme (GOIRRSCM) register the highest average efficiency score (0.53)[1] followed by those with the Agence Francaise de Development /Ministry of Food and Agriculture Lowland Rice Development Project (AFD/LRDP) (0.46) and then the

[1]*It must be mentioned that in preparing the data for estimation all households with zero output were excluded. Most of these are with Gollinga Irrigation Scheme who indicated that the rains failed them in 2007/2008. Hence they relied on dry season farming. This is analysed in a different paper.*

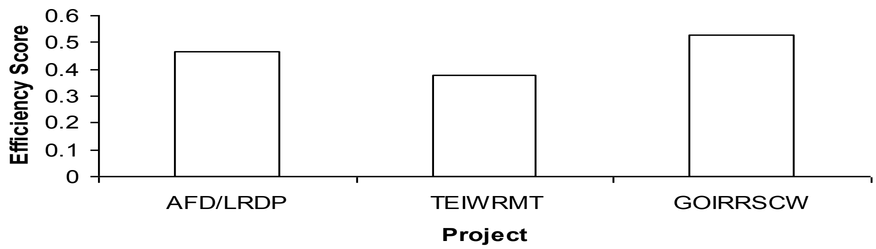

Fig. 2: Mean Distribution of efficiency scores by Project

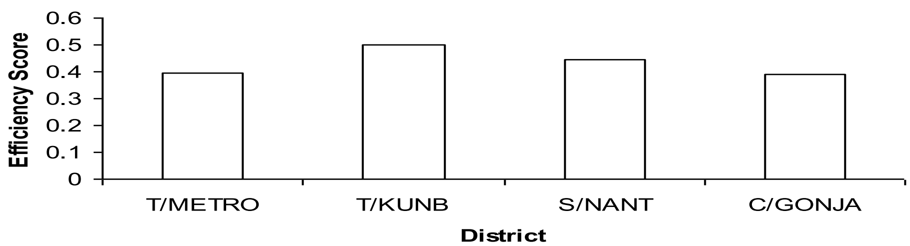

Fig. 3: Mean Distribution of efficiency scores by District

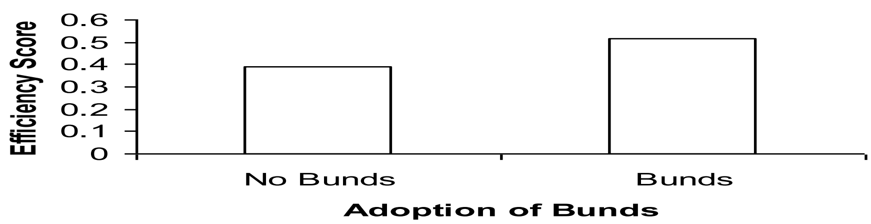

Fig. 4: Mean Distribution of efficiency scores by Adoption of bunds

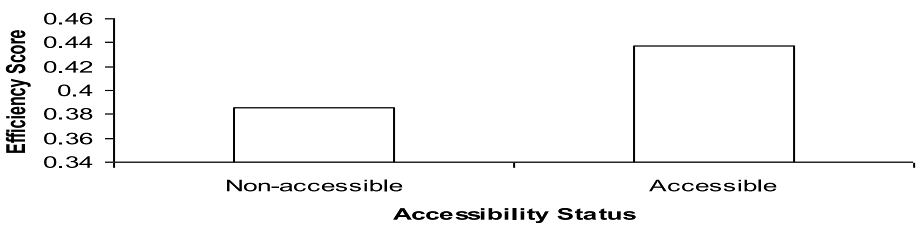

Fig. 5: Mean Distribution of efficiency scores by Accessibility Status

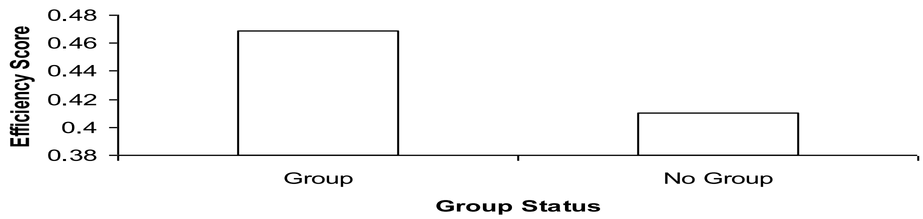

Fig. 6: Mean Distribution of efficiency scores by Group status

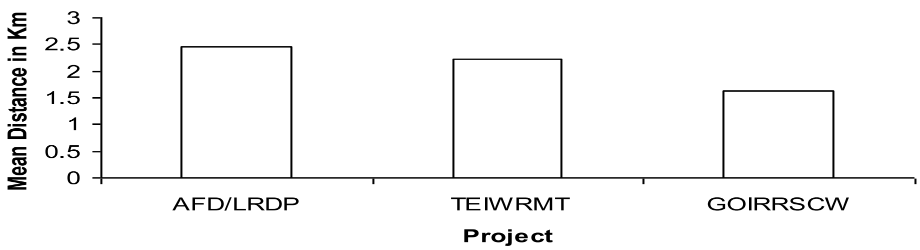

Fig. 7: Mean Distance to farm by Project

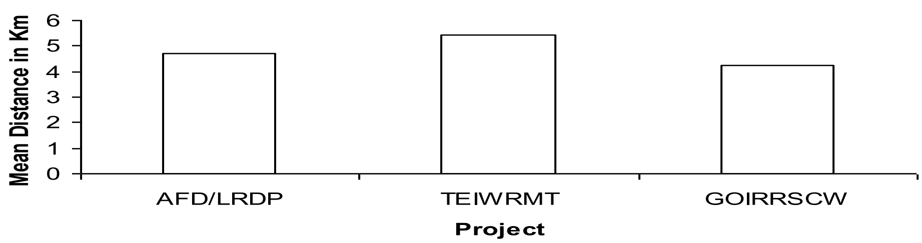

Fig. 8: Mean Distance to town by Project

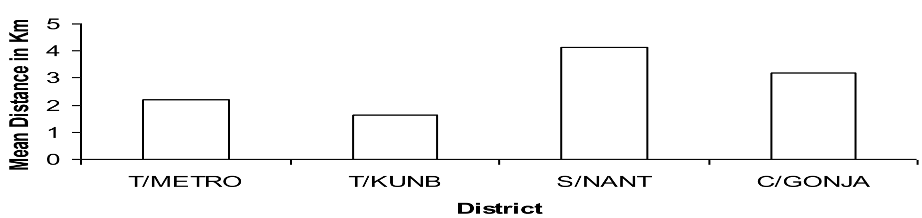

Fig. 9: Mean Distance to farm by District

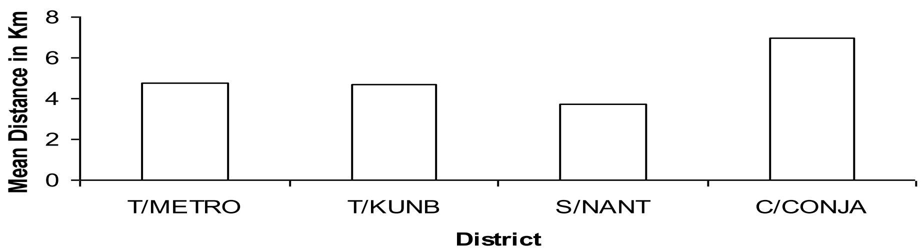

Fig. 10: Mean Distance to town by District

Transfer of Effective Irrigation and Water Resources Management Project (TEIWRMT) (0.38) in that order. It must be recalled that households in AFD/LRDP and GOIRRSCM areas do intensive rice cultivation with improved water harvesting schemes such as bunds and water regulating structures. It is not surprising therefore that they have higher efficiency than the households in the TEIWRMT area. The advantage that households with GOIRRSCM have over those with AFD/LRDP is that the former have the opportunity to irrigate their farms in the event of early stoppage of the rains, and even if they do not irrigate (as it happened in the 2007/2008), the farms stand to benefit from the capillarity of the water body upstream (i.e. being close to the stream, water may seep into these farms nearby to add to the moisture contents of the soils). This could explain its relative high average efficiency score. One other interesting finding in this study is the effect of openness of a community on household's efficiency. Recall that in the estimation results accessibility to community increases efficiency. This is depicted in Figure 5. Note also that in Figure 8 GOIRRSCM has the shortest mean distance in miles (4.25) from the community to town followed by AFD/LRDP (4.75) and TEIWRMT (5.4) in that order. It appears that as far as the projects are concerned, the closer a household is to a nearby town the greater the efficiency. Openness of a community means that farmers' can easily dispose of their produce.

Across Districts the Tolon/Kumbungu (T/KUMBU) tops (0.50) followed by Savalugu/Nanton (S/NANT) (0.44) and the Tamale Metropolitan (T/METRO) (0.40). Central Gonja (C/GONJ) records the lowest efficiency score (0.39). From Figure 10 however, we cannot establish a consistent negative relationship between efficiency and distance to town, though T/KUMBU records the shortest distance and the highest efficiency score. The positive and significant effects of bunds and group formation are confirmed by Figures 4 and 6 respectively: While households with bunds on their farms record average efficiency score of 0.51, households without bunds record 0.36. Similarly, the efficiency scores for households that are into groups and those that are not are 0.47 and 0.41 respectively. In terms of distance to the farm, households with GOIRRSCM have the shortest mean distance (1.63) followed by those with TEIWRMT (2.23) and AFD-LRDP (2.45). Across districts the order is T/KUMBU (1.64), T/METRO (2.23), C/GONJ (3.18) and S/NANT (4.15).

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be made from the findings**:**

1. The average efficiency of rice farmers in the four districts in the Tamale area is low (0.42) but comparable to other studies.
2. Efficiency is high for intensive rice cultivation with improved water harvesting schemes such as bunds and water regulating structures as opposed to those without.
3. Efficiency is also higher for households who are accessible by vehicles.

4. Other factors that increase farmers' efficiency are: education; extension visits; farmers' experience and group membership.

It is in the light of these that the following recommendations are made:

1. If rice cultivation in the north is to develop to reduce poverty, it would still need support in terms of water harvesting and regulating structures. It will also be helpful that projects come with the improvement of the road net-work.
2. The education sector must be given all the necessary attention to develop the human resource of the nation.
3. It is also important that the amount and quality of extension services are improved to ensure the adoption of improved technologies and farming practices. More extension staff need to be trained and motivated. One of such technologies is the construction and maintenance of bunds. Households whose farms require these should be given the necessary education and assistance. Also training programmes should be well organized to have its positive impact.
4. Considering the relatively high efficiency of households headed by younger adults, the Youth in Agriculture Programme (YAP) should be revived and carried to the letter.

REFERENCES

AFD/MOFA-LRDP (2001) Monitoring and Evaluation Report (Mission 1)

Aigner, D.J., Lovell, C.A.K. and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics* 6: 21-37.

Battese, G.E. (1992). Frontier production functions and technical efficiency: A survey of empirical applications in agricultural economics. *Agricultural Economics*, 7: 185-208.

Battese, G.E. and Coelli, T.J. (1993). A stochastic frontier production function incorporating a model of technical inefficiency effects. *Working Papers in Econometrics and Applied Statistics,* 69, Department of Econometrics, University of New England, Armidale.

Battese, G.E and Coelli, T.J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics* 20: 325-32.

Battese, G.E., Malik, S.J. and. Gill, M.A *(*1996). An investigation of technical inefficiencies of production of wheat farmers in four districts of Pakistan. *Journal of Agricultural Economics,* 47: 137-49.

Bhasin, V.K (2002). Agricultural productivity, efficiency and soil fertility management practices of vegetable growers in the Upper East Region of Ghana. Report submitted to SADAOC Foundation.

Bravo-Ureta B.E. and Pinheiro, A.E. (1993). Technical, economic and allocative efficiency in peasant farming: evidence from The Dominican Republic. *The Development Economies*, 35(1): 48-67.

Coelli, T.J. (1995). Estimators and hypothesis tests for a stochastic frontier functions: A monte carlo analysis. *Journal of Productivity Analysis*, 6: 247-268.

Coelli,T.J. (1996). A guide to Frontier Version 4.1: A computer program for frontier production function estimation. [online] Available from: http://www.une.edu.au/econometrics/cepa.htm

[Accessed 11 December 2004]

Coelli, T.J., Prasada Rao, D S. and Battese, G.E (1998). *An Introduction to Efficiency and Productivity Analysis.* London: Kluver Academic Publishers.

Coelli, T. J. and Battese, G. (1996). Identification of factors which influence the technical inefficiency of Indian farmers. *Australian Journal of Agricultural Economics,* 40(2): 103-128.

Donkoh, S.A (2006). Technology adoption and Efficiency in Ghanaian Agriculture. Ph.D Thesis submitted to the of University of Reading, U.K (Unpublished)

Duncan, B.A (1997). *Women in Agriculture in Ghana.* Accra, Ghana: Friedrich Ebert Foundation

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of Royal Statistical Society*, A, 120(3): 253-81.

ISSER (2007). The State of the Ghanaian Economy. Accra-Ghana:

Jondrow, J., Lovell, C.A.K., Materov, I.S and Schimdt P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics*, 19(2/3): 233-238.

Kodde, D., and Palm, F. (1986). Wald criteria for jointly testing equality and inequality restrictions. *Econometrica*, 54(5): 1243-1248.

Kumbhakar, S.C. and Lovell, C.A K. (2000). *Stochastic Frontier Analysis.* Cambridge: Cambridge University Press.

MOFA (2000). Food and Agriculture Sector Development Policy (FASDEP) Accra: Ghana.

MOFA (2008) Agricultural sector plan (zero Draft)Accra: Ghana

NDPC (2005). Ghana Poverty Reduction Strategy (2003-2005) (GPRS 1) &Growth and Poverty Reduction Strategy (2006-2009) (GPRS 11)

Ogunyinka, E.O. and Ajibefun, I. (2004). Determinants of technical inefficiency on farm production: tobit analysis approach to the Nde farmers in Ondo State, Nigeria. *International Journal of Agriculture and Biology*, 355-358.

Seidu A. (2008). Technical efficiency of rice farmers in Northern Ghana. AREC

Appendix-Efficiency scores

Household	Efficiency	Household	Efficiency	Household	Efficiency	Household	Efficiency
1	0.54	51	0.55	101	0.42	151	0.00
2	0.82	52	0.29	102	0.52	152	0.23
3	0.26	53	0.35	103	0.00	153	0.00
4	0.62	54	0.67	104	0.53	154	0.33
5	0.54	55	0.19	105	0.00	155	0.00
6	0.54	56	0.69	106	0.59	156	0.26
7	0.86	57	0.00	107	0.28	157	0.00
8	0.61	58	0.73	108	0.53	158	0.24
9	0.70	59	0.00	109	0.61	159	0.75
10	0.61	60	0.34	110	0.00	160	0.00
11	0.37	61	0.05	111	0.29	161	0.73
12	0.24	62	0.61	112	0.14	162	0.50
13	0.41	63	0.60	113	0.33	163	0.61
14	0.69	64	0.80	114	0.41	164	0.56
15	0.59	65	0.60	115	0.47	165	0.25
16	0.18	66	0.84	116	0.51	166	0.45
17	0.31	67	0.81	117	0.21	167	0.82
18	0.59	68	0.00	118	0.68	168	0.00
19	0.71	69	0.77	119	0.74	169	0.56
20	0.58	70	0.56	120	0.16	170	0.56
21	0.61	71	0.42	121	0.00	171	0.56
22	0.13	72	0.62	122	0.75	172	0.60
23	0.48	73	0.17	123	0.00	173	0.00
24	0.68	74	0.55	124	0.49	174	0.71
25	0.32	75	0.20	125	0.62	175	0.00
26	0.78	76	0.60	126	0.64	176	0.00
27	0.33	77	0.00	127	0.53	177	0.38
28	0.32	78	0.66	128	0.68	178	0.18
29	0.63	79	0.00	129	0.90	179	0.55
30	0.49	80	0.51	130	0.73	180	0.00
31	0.56	81	0.00	131	0.90	181	0.52
32	0.32	82	0.53	132	0.00	182	0.49
33	0.47	83	0.65	133	0.62	183	0.65
34	0.23	84	0.63	134	0.12	184	0.35
35	0.00	85	0.58	135	0.00	185	0.65
36	0.63	86	0.63	136	0.60	186	0.36
37	0.72	87	0.31	137	0.34	187	0.00
38	0.43	88	0.78	138	0.00	188	0.61
39	0.65	89	0.72	139	0.64	189	0.39
40	0.03	90	0.49	140	0.67	190	0.35
41	0.54	91	0.60	141	0.00	191	0.57
42	0.46	92	0.00	142	0.29	192	0.57
43	0.22	93	0.73	143	0.71	193	0.78
44	0.00	94	0.71	144	0.23	194	0.22
45	0.39	95	0.48	145	0.02	195	0.28
46	0.28	96	0.54	146	0.30	196	0.53
47	0.36	97	0.54	147	0.71	197	0.61
48	0.41	98	0.66	148	0.00	198	0.70
49	0.00	99	0.53	149	0.00	199	0.50
50	0.39	100	0.43	150	0.12	200	0.43
						201	0.48