Profit Efficiency among Smallholder Rice Farmers in Central Liberia

Saysay[1*] J. L. Gabagambi[2], D.M. Mlay[2], G.I
1. Department of Planning and Development, Ministry of Agriculture, P. O. Box 10-9010, Monrovia, Liberia
2.School of Agricultural Economics and Business Studies, Sokoine University of Agriculture, P. O. Box 3007, Chuo Kikuu, Morogoro, Tanzania

Abstract
Rice is staple food in Liberia and therefore self-sufficiency in rice production remains a major concern. However, Liberia is experiencing insufficiency in rice production due to high production cost and low national average output of 1.2 t/ha, which is significantly low as compared to other West African Countries. This has resulted in the increased importation of rice in the country consequently taking significant portion of the nation's foreign exchange. The best and most effective way to improve productivity and profitability is through more efficient utilization of scare resources. This study was conducted to analyze profit efficiency among smallholder rice farmers in Nimba and Bong Counties, Central Liberia. The results indicated that smallholder rice farmers were not operating at full profit efficiency level. Profit efficiency level varies among the farmers ranging from 13% to 93%, with mean efficiency level of 67%. To operate on the full profit efficiency levels, on average, the sample rice farmers would need to reduce their costs by approximately 28%. Inefficiency in rice production was significantly influenced by farming experience, household size, access to credit and extension services, membership to farmers' group and market information access ($P<0.05$). It is recommended that in order to improve profit efficiency among smallholder rice farmers, there should be programs which focus on increasing access to credit and extension services and farmers should be encouraged to join or form association which may bring benefits to them.
Keywords: Profit efficiency, smallholder rice farmers, Liberia

1.0 Background

Rice is staple food in Liberia and therefore self-sufficiency in rice production remains a major concern. The significance of rice in the Liberian diet can be elucidated by its demand and consumption pattern over the years. Average annual production from 2009-2012 was about 290,600 metric tons whereas the total average annual consumption was over 400,000 metric tons (NRDS, 2012; FAO, 2013). However, insufficiency in rice production is related to high production cost and low output. This has resulted in the increased importation of rice in the country consequently taking significant portion of the nation's foreign exchange.

Liberia has huge potential in rice production. It has very good annual rainfall of approximately 2000mm; cultivation without irrigation becomes increasingly possible and favorable climatic conditions that can facilitate year round production of rice. It is endowed with about 600,000 ha of irrigable land in which less than 10% has been used (Lançon and Erenstein, 2002; NRDS, 2012), and is one of the African countries with the highest amount of renewable water resources per inhabitant: more than 71 000 m^3/year (FAO, 2005).Liberia has alluvial soils that contain largest amount of plant nutrients for annual crop production.

Despite the high production potential, yield in Liberia is just about 1.2 t/ha (NRDS, 2012; FAO, 2013; USAID-BEST, 2014). This is low when compared to other West African States with 2.7 t/ha in Ghana, 3.0 t/ha in Côte d'Ivoire, 3.4 t/ha in Mali, 4 t/ha in Benin and 7.0 t/ha in Senegal (WARDA and NISER, 2001; Donkoh and Awuni, 2011; Oladele *et al*., 2011; Donkor and Uwusu, 2014). The yield gap is approximately triple when compared to the national rice development strategy potential yield target of 4 t/ha (NRDS, 2012). The above figures depict a big potential for increased output. It has also been noted by USAID-BEST 2014 that due to the predominance of traditional farming practices, the absence of mechanization, and low levels of public sector support, Liberia has the lowest rice yields in West Africa. Growth rates for yield increases have also been slower than other countries in the region. For example, from 2001 to 2013, the annual productivity growth in yield was only 1.6% as compared to 2.1% in Ghana, 5.4% in Mali, 5.8% in Senegal, 6.3% in Cote d'Ivoire and 6.8% in Sierra Leone (USAID-BEST, 2014). This combination of low productivity and low growth rates results in limited marketable surpluses of local rice and lagging farm income. Furthermore, rice production cost in Liberia is high. For instance, the cost of producing a ton of paddy in Liberia is USD 320 while production of a ton of paddy rice costs USD 220 in Ghana and Nigeria, USD 210 in Senegal, USD 180 in Mali, and USD 140 in Benin (CILSS *et al., 2011).*

For the past ten years, there have been many interventions in the agriculture sector by the government and its partners to enhance the productive capacity of farmers to boost rice production in Liberia through research and development. The Liberia National Rice Development Strategy envisions self-sufficiency with focus on increasing the coverage of lowland rice hectares, adoption and diffusion of appropriate agricultural production technologies such as using high yielding rice varieties, fertilizer, field protection chemicals, labour saving machines and building an export capacity for rice production with the goal of doubling current production by 2018 (NRDS, 2012). This implies that Liberian farmers not only need to be more efficient in their production activities, but should also be responsive to market indicators, so that scarce resources are utilized efficiently to increase productivity as well as profitability, and ensure supply to the urban market. Also, the relationships between efficiency, market indicators and household characteristics have not been well studied in Liberia. Given this backdrop, the present study sets out to analyze profit efficiency of smallholder rice farmers and to identify farm-specific characteristics that explain variation in efficiency of individual farmers. An understanding of production efficiency, market indicators and farm - specific characteristics could provide policy makers with useful information to design programs that can contribute to measures needed to expand the food production potential for the nation.

2.0 RESEARCH METHOD

2.1 Research Area and Data

Liberia is divided into fifteen (15) counties and further sub divided into districts. This study covered the central region which comprises four counties (Margibi, Grand Bassa, Bong and Nimba) with predominant rice cultivators (55%) and is generally suitable for rice production; hence it was appropriate for this study. Specifically, the study focused on two representative counties namely: Nimba and Bong which ranked the highest in the 2011 rice production with about 61,600 (21.2 %) and 60,900 (21.0 %) metric tons respectively. The combined estimates of these two counties accounted for 42.2 percent of the total production and 41.2 percent of area of rice harvested in Liberia (NRDS, 2012).

Nimba County has a total geographic area (of land and water) of Nimba is 2,300 km^2 and a population of about 462,000 persons (LISGIS, 2008). Subsistence farming is currently the main source of income of the people of Nimba. The typical farming pattern is slash-and-burn and annual bush fallowing. The main food products are rice, cassava, plantain, banana, yam, and sweet potatoes. Some 75% of farm produce is used for family consumption. Cash crop production of rubber trees, cocoa, sugar cane and coffee is the other main source of income in the County.

Bong County is situated roughly at the geographic center of Liberia. It has a population of about 333,500 persons (LISGIS, 2008). Bong County is situated in the Mountain and Plateau zones of the agro-ecosystem of Liberia, where citizens traditionally grow rice, cassava, maize, oil palm, cocoa, coffee, rubber and sugar cane.

Multistage stratified random sampling was adopted. One district from each County was selected. At the first stage, villages from each district were stratified into two, viz. upland and lowland rain-fed villages and they were selected on the basis of their rice production potential. In the second stage, farmers were selected by simple random sampling method and they were selected from village list of rice producers on probability proportional to size basis. Thus, in all 400 cultivators (200 from Nimba and 200 from Bong) were selected from the villages. Data were collected with the use of a structured questionnaire to collect input-output data of the farmers. In addition, information on average input prices were also collected from the respondents.

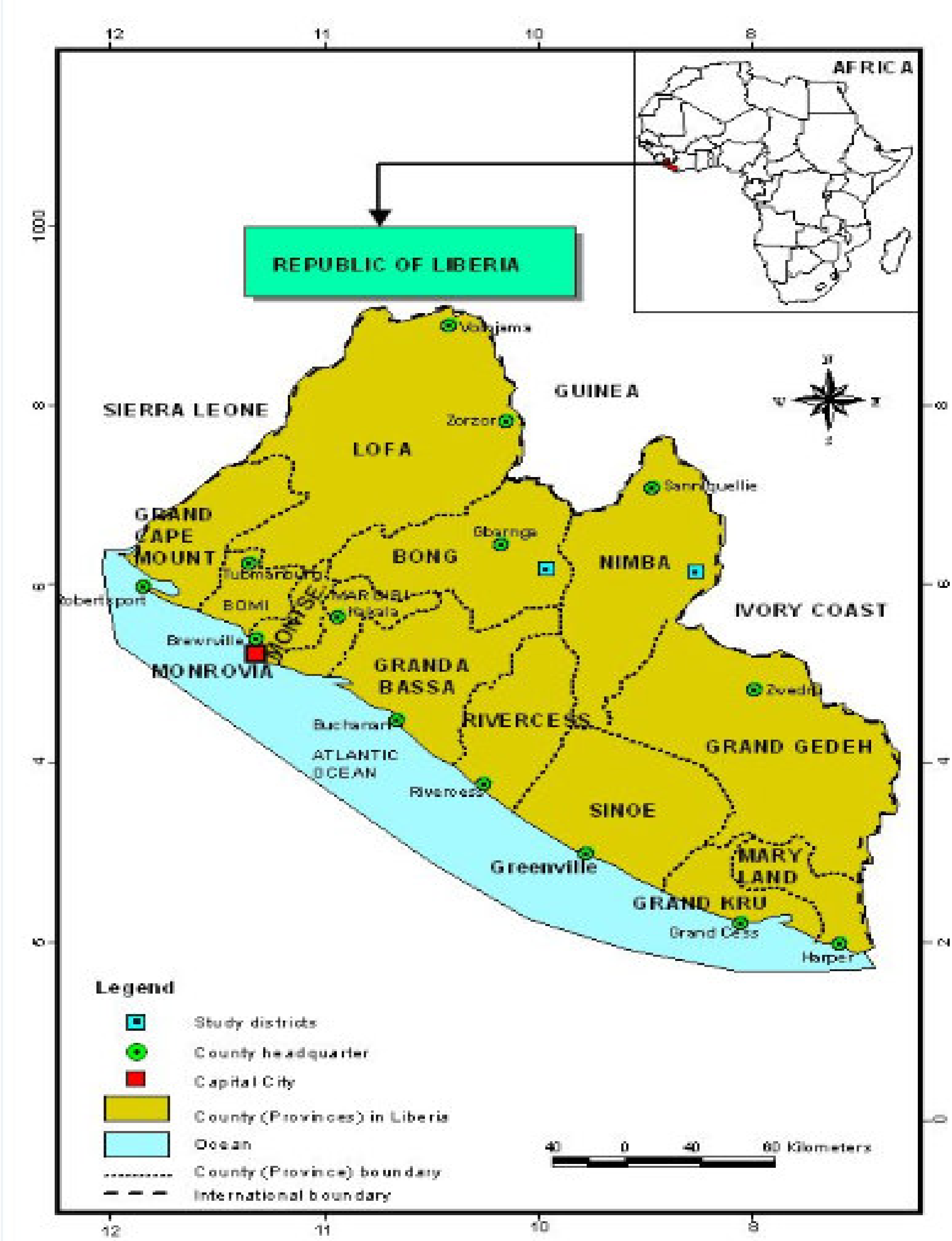

Figure 1: Map of the study area

2.2 Empirical Approach

2.2.1 Measuring efficiency using stochastic frontier profit function

Farrell (1957), defined efficiency in his pioneering study as the ability to produce a given level of output at lowest cost. He distinguished three types of efficiency: (1) technical efficiency, (2) price or allocative efficiency and (3) economic efficiency which are the combination of the first two. Technical efficiency is an engineering concept referring to the input-output relationship. A firm is said to be efficient if it is operating on the production frontier (Ali and Byerlee, 1991). On the other hand, a firm is said to be technically inefficient when it fails to achieve the maximum output from the given inputs, or fails to operate on the production frontier. Technical efficiency represents a farm's ability to produce a maximum level of output from a given level of inputs. Allocative efficiency is the ability of a farm to use inputs in optimal proportions, given their respective prices and available technology (Rahman, 2003). The combination of technical and allocative efficiency provides the level of economic efficiency. That is to say, if the farm uses resources allocatively and technically efficient it is said to have achieved total economic or profit efficiency.

Profit efficiency is defined as the capability of a farm to achieve the highest possible profit, given the prices and levels of fixed factors of that farm (Ali and Flinn, 1989). Ali et al. (1994) stated that profit function approach combines the concepts of technical and allocative efficiency in the profit relationship and any error in the production decision is assumed to be translated into lower profits or revenue for the producer. Profit inefficiency in this context is defined as the profit-loss from not operating on the profit frontier, recognizing farm specific prices and resource base. Rahman (2003) explained that production inefficiency is usually analyzed by its three components-technical, allocative, and scale inefficiency. In an agricultural perspective, a profit-maximizing farm can be inefficient due to these three components (Kumbhakar, 1987).

Stochastic frontier production function is the most popular approach to measure efficiency (Rahman, 2003; Coelli *et al*, 2005). Yotopoulos *et al* in Ali and Flinn (1989) argued that a frontier production function approach may not be appropriate when estimating efficiency when in reality farmers face different prices and have different factor endowments. As a result, they have different best-practice production functions and, thus, different optimal operating points (Rahman, 2003). This led to the application of stochastic profit function models to estimate farm-specific efficiency directly and simultaneously (Kumbhakar, 2001; Kumbhakar *et al*., 1989; Rahman, 2003; Ali and Flinn, 1989; Dwi *et al*, 2014). The highest or maximum profit function that can be obtained is called the profit frontier. Therefore, in order to identify the factors affecting rice yield and analyze the profit efficiency among rice farmers in Central Liberia, stochastic profit frontier function model is applied consistent with the concept of Battese and Coelli (1995).The stochastic profit function is defined as

$$\pi_i = f(P_{ij}, Z_{kj})Exp.\varepsilon_i \dots \dots (1)$$

The error term $\boldsymbol{\varepsilon}_i$ is assumed to behave in a manner consistent with the frontier concept (Tsue*et al.,* 2012) that is, the error term is composed of two random parts.

$$\varepsilon_i = V_i - U_i \dots \dots (2)$$

V_t is the symmetric error term and it is assumed that it is an independently and identically distributed (iid) two-sided error term $V_i \sim iid(0, \sigma_v^2)$ representing the random effects and factors outside the farmer control such as measurement errors, omitted explanatory variables and statistical noise, U_i is a non-negative variable with one-sided distribution that is truncated, half normal or exponential representing the profit inefficiency of the farmer. In other words, the error term measures the profit shortfall (π_i) from its maximum possible value (π_i^*)given by the stochastic frontier (Ali and Flinn, 1989).

In the inefficiency profit frontier model, the inefficiency effects U_i in equation (2) is expressed as

$$U_i = \partial_0 + \sum \partial_i Z_{di} \dots \dots (3)$$

Where: Z_i = (I x m) vector of farm specific variables, which varies across respondent and not over time. ∂= (m x I) vector of unknown coefficients of the farm specific inefficiency variables. The U_i is a non-negative one-sided error term representing the inefficiency of the farm. Thus, it represents the profit shortfall from its maximum possible value that will be given by the stochastic frontier.

The model can be estimated by Maximum Likelihood using a single step or two step procedures. A single step is conducted by estimating both the efficiency and inefficiency variables in a single equation. The two step procedure requires estimating the profit efficiency model and ignoring the inefficiency variables in the first stage and predicts the inefficiency effects then regress against the set of exogenous variables suspected as sources of inefficiency in the second stage. The two step procedure is biased due to misspecification of the model estimated in the first stage hence the single step provides efficient estimates (Battese and Coelli, 1995).

2.2 Empirical Model

The rice production translog profit function model specification was derived as follows:

$$ln\pi' = \alpha_0 + \sum_{i=1}^{4}\alpha_1 lnP_i + \frac{1}{2}\sum_{i=1}^{4}\sum_{k=1}^{4}\tau_{ik}lnP_i\, lnp_k + \sum_{i=1}^{4}\sum_{l=1}^{1}\emptyset_{il}lnP_i\, lnZ_l + \sum_{l=1}^{1}\beta_l lnZ_l + \frac{1}{2}\sum_{l=1}^{1}\sum_{q=1}^{1}\varphi_{lq}lnZ_l\, lnZ_q + v - u \quad (4)$$

And

$$u = \delta_0 + \sum_{d=1}^{11}\delta_d W_d + \omega \quad (5)$$

Where,

π' = Restricted profit (total revenue less total cost of variable inputs) normalized by price of output (Py)

P_i =Price of the i[th] input (Pi) normalized by the output price (Py), where (i = 1, 2, 3, and 4)

So that

P_1 = Seed cost normalized by output price of rice (Py)

P_2 = Fertilizer cost normalized by output price of rice (Py)

P_3 = Herbicide cost normalized by output price of rice (Py)

P_4 = Labour cost normalized by output price of rice (Py)

Z_l = The quantity of fixed input (1 =1)

Z_1 = Area planted with rice (hectare under rice)

v =Two sided random error

u =One sided half-normal error

ln =Natural logarithm

W_d = Variables explaining inefficiency effects

d_1 = Education

d_2 = Farming experience

d_3 = Off-farm income

d_4 = Household size

d_5 = Occupation

d_6 = Lack of credit

d_7 = Lack of extension services

d_8 = Group membership

d_9 = Market information access

d_{10} = Variety

d_{11} = Agroecology

The above model was estimated by single step procedure using FRONTIER version 4.1. In order to select the functional form, test the distributional assumption of the error term and the existence of inefficiency, the generalized likelihood ratio (LR) test can be used. These tests employ the following calculation (Greene, 2012).

$$LR(\lambda) = -2\left\{ln\frac{L(H_0)}{L(H_1)}\right\}$$

$$== -2\{ln[L(H_0)] - ln[L(H_1)]\} \quad (6)$$

$L(H_0)$and $L(H_1)$ denote the values of the likelihood function under the null hypothesis(H_0) and alternative(H_1) hypothesis involve, respectively.If the given null hypothesis is true, λ has approximately chi-square distribution or chi-square distribution when the null hypothesis involves $\lambda = 0$ (Coelli, 1995; Khan et al., 2010).

3.0 Results and discussion

3.1 Test Statistic

For the selection of the functional form, the Cobb-Douglas and the translog profit functions were tested. The null hypothesis was the Cobb-Douglas log likelihood values in the sense that it is the restricted form of the translog function. Based on the results in Table 1, the null hypothesis was rejected and thus, considering the translog functional form preferable to best represent the data. Hyuha (2006), while estimating profit efficiency among rice farmers in Uganda also did reject a Cobb-Douglas profit function, while Nganga *et al*. (2010), did reject a translog profit function while studying profit efficiency among Kenya smallholder milk producer. Hence, selection of the functional form depends on test statistic.

The selection of the appropriate distributional assumption of the error term was the second test statistic. Cognizant of the fact that translog stochastic frontier profit function was suitable for the data, hypothesis as to whether the profit efficiency level is appropriately estimated using a half-normal $(\mu = 0)$or a truncated–normal distributional assumption of $U_i(\mu > 0)$. The null hypothesis was the half normal distribution and the alternative was the general truncated normal distribution. The null hypothesis was rejected implying that the truncated-normal distributional assumption is more appropriate for the rice farmers in Bong and Nimba counties.

The evaluation of the presence of inefficiency was the third hypothesis. This can be done by considering farm specific factors and their effects on the overall profit efficiency of farmers. The null hypothesis was the functional form that had no inefficiency factors and the alternative had the inefficiency factors (equation 5). The hypothesis was tested by using the generalized likelihood ratio test based on the values of log likelihood function under Ordinary Least Square (OLS) and maximum likelihood estimation (MLE). The null hypothesis was rejected. This result is also supported by the estimated r value of 0.963 and strongly statistically significant at 1% level (Table 2), indicating that a high level of inefficiency exist among rice farmers in the study area.

Table 1: Log likelihood tests for underlying hypotheses

Null hypothesis	λ	Critical values	Decision
$H_0: \beta_{ij} = 0$	29.8	24.4[b]	Rejected
$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \delta_{10} = \delta_{11}$	219.3	3.8[a]	Rejected
$H_0: \gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \delta_{10} = \delta_{11}$	77.7	21.7[b]	Rejected

[a]Critical value for the hypothesis of the one sided error is obtained from chi square table
[b]Critical value obtained from table 1ofKodde and Palm (1986)

3.2 Maximum likelihood estimates of the profit efficiency model

The translog profit efficiency frontier function was estimated through single step procedure. The maximum likelihood estimates of the parameters of the stochastic profit frontier model are presented in Table 2. The results show that the parameter estimated coefficient sigma squared (σ^2) and gamma (γ) are statistically significant at 1% level. The parameter gamma (γ) is 0.963, which is interpreted that about 96% profit variation is caused by efficiency difference and the rest 4% is caused by external factors which are not included in the model, which is due to random shocks outside the farmer's control. The gamma value is significant and close to one, indicating that the factor affecting inefficiency is essential. The estimation results in Table 1 indicate that the coefficients for seed cost and fertilizer cost were negative, indicating that these variables are cardinal parameters influencing rice farmers profit. Cost of seed was statistically significant. Holding all factors constant (ceteris paribus), if farmers' seed and fertilizer costs increase (decrease), profit will decrease (increase). Hence, programs or policy that can enhance the reduction in the costs of seed and fertilizer will effectively increase rice farmers' profit.

The coefficient for area cultivated with rice is positive and not significant. The positive coefficient implies that an increase in the area cultivated with rice, increases farmers' profit. Hyuha (2006) and Jude (2012) found that an expansion of the land area cultivated under rice can achieve higher output (yield) and increase profit. In addition, it is interesting to note that the coefficients of herbicide and labour costs were positive but, only labour cost was statistically significant at 1%. It means that an increase in the costs of labour and herbicide will increase farmers' profit. The indication is that labour and herbicide costs are important variables in rice production; reinforcing the evidence that rice farming in the study area is labour intensive. As more labour is applied in smallholder rice production, output will increase ceteris paribus, will increase profit. This result is similar to that of Dwi et al. (2014) on vegetable farming in West Java, Indonesia.

Table 2: Maximum likelihood estimates for parameters of the stochastic Profit frontier model

Variable	Coefficient	Standard Error	T-ratio
Constant	-18.538	0.103	-18.015***
Ln Area planted	1.299	1.165	1.115
Ln Seed cost	-1.399	0.930	-1.503*
Ln Fertilizer cost	-0.768	0.887	-0.866
Ln Herbicide cost	0.614	0.928	0.662
Ln Labour cost	9.897	0.561	17.638***
(Ln Area planted)^2	0.055	0.073	0.743
(Ln Seed cost)^2	0.016	0.102	0.157
(Ln Fertilizer cost)^2	-0.052	0.078	-0.666
(Ln Herbicide cost)^2	-0.029	0.048	-0.605
(Ln Labour cost)^2	-0.950	0.091	-10.442***
Ln Area planted*Ln Seed cost	-0.315	0.144	-2.180**
Ln Area planted*Ln Fertilizer cost	-0.004	0.111	-0.034
Ln Area planted*Ln Herbicide cost	0.069	0.129	0.537
Ln Area planted*Ln Labour cost	-0.093	0.209	-0.443
Ln Seed cost*Ln Fertilizer cost	-0.086	0.093	-0.930
Ln Seed cost*Ln Herbicide cost	-0.102	0.101	-1.011
Ln Seed cost*Ln Labour cost	0.232	0.186	1.249
Ln Fertilizer cost*Ln Herbicide cost	0.101	0.101	0.994
Ln Fertilizer cost*Ln Labour cost	0.234	0.166	1.409*
Ln Herbicide cost*Ln Labour cost	-0.079	0.167	-0.476
Sigma-squared (σ^2)	3.381	0.643	5.257***
Gamma (γ)	0.963	0.009	106.508***
Number of observations = 400; Log likelihood function = -329.49; LR test = 219.28			

***Significant at 1%; **Significant at 5%; *Significant at 10%

3.3 Profit efficiency distribution

The frequency of farm specific efficiency scores for the rice farmers in the study area is presented in Table 3. Rice farmers in Nimba and Bong Counties exhibit a wide range of profit efficiency ranging from 13% to 93%. It is essential to note that this wide variation is not only unique to Liberia, as similar results have been reported by other scholars and researchers in other places. Sadiq and Singh (2015) obtained a minimum of 12% and a maximum of 95% for maize farmers in Niger State, Nigeria. Galawat and Yabe (2012) reported a minimum of 45.2% and a maximum of 99.2% for rice farmers in Brunei Darussalam. Also, Dwi *et al.* (2014) obtained a minimum of 0% and a maximum of 89% for vegetable farmers in West Java, Indonesia. Furthermore, Wang *et al.* (1996) reported efficiency levels ranging from 6% with mean of 62% for rural farm households in China. The results show that rice farmers achieved on average 67% level of efficiency in the study area. This implies that the average rice farmer in Central Liberia could increase profit by 33% to attain frontier by improving their technical and allocative efficiency. This result conformed to the findings of Rahman (2003), Maganga *et al.* (2012), Galawat and Yabe (2012) and Sadiq and Singh (2015) who reported mean profit efficiency levels of 0.77 for Bangladeshi rice farmers, 0.74 for Malawi sweet potato farmers, 0.81 for Brunei Darussalam rice farmers and 0.71 for Nigerian maize farmers, respectively.

According to the results (Table 3), there is a wide gap between the profit efficiency level of best and worst farmers. To bridge the gap, the average farmers needs a cost saving of 28% i.e. $[1-(0.67/0.93)*100]$ to attain the frontier, while the least profit efficient farmer requires a cost saving of about 86% i.e. $[1-(0.13/0.93)*100]$ to become the best efficient farmer in the sample. With the fact that none of the rice farmers in the study area on the frontier (i.e. efficiency ratio is less than one), it depict that more than the profit maximizing level of the input vector was employed. The results are consistent with the finding of Maganga *et al.* (2012).

Table 3: Deciles Frequency Distribution of Profit Efficiencies of rice Farmers.

Efficiency range	Frequency	Relative efficiency (%)
0.10 - 0.20	9	2.3
0.21 – 0.30	14	3.5
0.31 – 0.40	28	7.0
0.41 – 0.50	28	7.0
0.51 – 0.60	38	9.5
0.61 – 0.70	62	15.5
0.71 – 0.80	107	26.8
0.81 – 0.90	110	27.5
0.91 – 0.99	4	1.0
Total	**400**	**100**
Minimum	**0.13**	
Maximum	**0.93**	
Mean	**0.67**	
Standard deviation	**0.187**	

3.4 Source of inefficiency in rice production

It is very expedient to identify the sources of inefficiencies for policy purposes which can be done by investigating the relationship between farm/farmer characteristics and the computed profit inefficiency. The results of the inefficiency model are presented in Table 4. The variables of the inefficiency were expected to explain the determinants of profit efficiency in rice production among farmers. The sign of the variables in the inefficiency model is very important in explaining the observed level of profit efficiency of the farmers. A negative sign on the coefficient implies that the variable had an effect in reducing profit inefficiency, while a positive coefficient signifies the effect of increasing inefficiency (Galawat and Yabe, 2012).

The estimated coefficient associated with farming experience, carries the expected negative sign and is statistically significant at 1% level. The result implies that those with experience are better performers than those without. In other words, rice farmers with more years of experience tend to operate at significantly higher level of profit efficiency. The results are consistent with Sadiq and Singh (2015). The estimated coefficient of household size is negative and statistically significant at 1% level. Since rice production is labour intensive, the result implies that farmers with increased household size have available labour for rice farming which could increase the quantity of rice produce. Hence, an increase in household size, deceases farmer's profit inefficiency (increases profit efficiency). The results collaborate with Kowale (2006).

The results show a negative relationship and statistically strong significant effect between inefficiencies and membership in farmer's organization/cooperative. Membership in farmer`s organizations/cooperatives allows the farmers to have the opportunity of sharing information with other farmers and input prices on rice production practices by interacting with other farmers. Therefore, inefficiencies among farmers can be reduced if farmers join or form an organization. The dummy coefficient of variety variable showed negative correlation and is not statistically significant. Rice variety cultivated are an important input factor and determine productivity and farming production. Farmers who adopted improved (high yield) variety compared to local variety tend to have more profit efficiency and incur less profit-loss. These results suggest that adopting improved variety in farming will improve profit efficiency.

Access to market information (input and output markets) tends to help farmers purchase input at the right quantity, time, and price. The result shows a negative coefficient and strongly statistically significant effect of access to market information. Hence, access to market information can affect farming profit efficiency. The results are consistent with Wadud and Rashid (2011) and Dwi *et al.* (2014). On the other hand, lack of credit and extension and agroecology had positive coefficients and strongly statically significant at 1% level. Lack of credit increases profit inefficiency in rice farming. Credit constraint may increase inefficiency of farmers by limiting the adoption of technologies and the acquisition of important information for increasing productivity. Furthermore, credit is a catalyst to the use of improved technology such as fertilizer, high yielding seeds, etc., which in turn lead to a reduction in profit inefficiency. Credit is an important determinant that can increase profit efficiency (Hyuha *et al*., 2007; Dwi *et al*. 2014). Like credit, lack of extension services increases profit inefficiency and decreases profit efficiency. The positive coefficient of lack of extension services reveals that farmers who have no access to extension services perform poorly operating at higher level of inefficiency than farmers who have access to extension services. Therefore, extension services serve in reducing profit inefficiency in rice production.

The dummy coefficient of agroecology variable showed positive correlation and is strongly statistically significant at 1% level. Farmers in the lowland ecology perform better significantly better in operating at higher level of profit efficiency than farmers in the upland ecology. Farm location is important in enhancing efficiency since farms may operate under different altitude or climatic conditions and different soil quality and availability of water.

Table 4: Maximum likelihood Estimates for parameters of the profit inefficiency model

Inefficiency Variable	Parameter	Coefficient	Standard Error	t-ratio
Constant	δ_0	1.441	0.967	1.490*
Education	δ_1	0.067	0.127	0.528
Farming experience	δ_2	-1.591	0.342	-4.648***
Off-farm income	δ_3	0.364	0.621	0.586
Household size	δ_4	-2.930	0.772	-3.796***
Occupation	δ_5	0.955	0.928	1.029
Lack of credit	δ_6	2.908	0.828	3.511***
Lack of extension services	δ_7	3.237	1.114	2.906***
Group membership	δ_8	-3.324	1.051	-3.163***
Market information access	δ_9	-5.078	1.280	-3.965***
Variety	δ_{10}	-0.434	0.596	-0.729
Agroecology	δ_{11}	5.849	1.677	3.486***

***Significant at 1%; **Significant at 5%; *Significant at 10%

4.0 Conclusion and recommendation

This paper used stochastic translog profit frontier model to examine profit efficiency among rice farmers in the Central Region of Liberia using farm level data obtained from 400 rice producers. The study showed that smallholder rice farmers are not operating at full profit efficiency level. The profit efficiency level of smallholder rice farmers in the study area range from 13% to 93%, with mean profit efficiency level of 67%; indicating that there are clear opportunities that exist for increasing farmers' efficiency by an average of 33% through their technical, allocative and scale efficiencies. To operate on the full profit efficiency levels, on average, the sample rice farmers would need to reduce their costs by approximately 28%. Among those factors that have significant influence on profit efficiency are experience in rice farming, household size, access to credit and extension services, membership to farmer group/association and access to market information. Lowland rice farmers are more efficient and incur less profit loss than upland rice farmers. Hence, it is recommended that in order to improve profit efficiency among smallholder rice farmers, there should be programs with focus on increase access to credit and extension services and farmers should be encouraged to join or form association which may bring benefits to them. In order to reduce costs of rice production, there is need to focus on bringing micro-finance institutions closer and accessible to smallholder farmers to enhance their ability in purchasing the much needed inputs. Alternatively, inputs credit guarantee scheme can help farmers to timely acquire inputs which will increase productivity and hence reduce inefficiency. Lastly, development and rehabilitation of more lowland with improved irrigation facilities.

Acknowledgement

Many thanks and appreciations to WAAPP and Liberia Ministry of Agriculture for funding this research and sponsoring my PhD studies at Sokoine University of Agriculture.

References

Ali, F., Parikh, A. & Shah, M.K. (1994). Measurement of Profit Efficiency Using Behavioural and Stochastic Frontier Approaches. *Applied Economics*, 26,181 – 188.

Ali, M. & Byerlee, D. (1991). Economic efficiency of small farmers in a changing world: A survey of recent evidence. *Journal of International Development,* l3 (1):1-27.

Ali, M., & Flinn, J.C. (1989). Profit Efficiency among Basmati Rice Producers in Pakistan Punjab. *American Journal of Agricultural Economics*, 71, 303 – 310.

Battese, G. & Coelli, T. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics* 20: 325 – 332.

CILSS, FAO, FEWS NET, WFP (2011). The 2008 rice crisis: Shock and new challenges. West Africa Challenges. [http://www.oecd.org/dataoecd/44/53/4 8356981.pdf] Accessed on 3/29/2014.

Coelli, T. J. (1995). Recent developments in frontier modelling and efficiency measurement*. Australian Journal of Agricultural Economics* 39(3): 219 – 245.

Donkor, E. &Uwusu, V. (2014). Effects of land tenure systems on resource-use productivity and efficiency in Ghana's rice industry. *African Journal of Agricultural and Resource Economics* 9 (4): 286-299.

Donkoh, S.A. &Awuni, J.A. (2011). Adoption of farm management practices in lowland rice production in Northern Ghana. *Journal of Agricultural and Biological Science* 2(4): 84–93.

Dwi, R., Arief, D., Mangara, T. &Dedi, B. D. (2014). Impact of Infrastructure on Profit Efficiency of Vegetable

Farming in West Java, Indonesia: Stochastic Frontier Approach. *J. ISSAAS,* 20(1):77-92

FAO (2005). *Land and Water Development Division.* Water Report No. 29.Food and Agricultural Organization, Rome, Italy. 89pp.

FAO (2013). National workshop on rice and aquaculture for productivity increase and market development in West Africa.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society* 120: 253 – 281.

Galawat, F. & Yabe, M. (2012). Profit Efficiency in Rice Production in Brunei Darussalam: A Stochastic Frontier Approach. *J. ISSAAS,* 18 (1):100-112

Greene, W.H (2012). *Econometrics Analysis.* (Seventh Edition). Pearson Education, Inc., Publishing Prentice Hall, Upper Saddle River, New Jersey. 1188pp.

Hyuha, T., (2006). Profit efficiency among rice farmers in Uganda. Unpublished Ph.D thesis, Makerere University, Uganda. 146pp.

Hyuha, T.S., Bashaasha, B., Nkonya, E., &Kraybill, D. (2007).Analysis of profit inefficiency in rice production in Eastern and Northern Uganda. *African Crop ScienceJournal,* 15(4): 243-253.

Jude, A.K. (2012). Technical Efficiency 0f Upland Rice Producers in South Western Uganda. Msc. Thesis, Makerere University, Uganda. 84pp.

Khan, A., Huda, A. and Alam, A. (2010). Farm household technical efficiency: A study on rice producers in selected areas of Jamalpur District in Bangladesh. *European Journal of Social Sciences,* 14(2): 262-271.

Kodde, D.A. and Palm, F.C. (1986). Wald criteria for jointly testing equality and inequality restrictions. *Econometrica,* 54(5): 243-1248.

Kolawole, O. (2006). Determinants of Profit Efficiency among Small-Scale Rice Farms in Nigeria, Paper presented in Agricultural Economists Conference, Gold Coast, Australia.

Kumbhakar, S.C. 1987. The Specification of Technical and Allocative Ineffciency in Stochastic Production and Profit Frontiers. Journal of Econometrics 34: 335-348.

Kumbhakar, S.C. 2001. Estimation of Profit Function When Profit Is Not Maximum. American Journal of Agricultural Economics 83:1-19.

Kumbhakar, S.C., B. Biswas & D.V. Bailey. 1989. A study of Economic Efficiency of Utah Dairy Farmers; A Systems Approach. Review of Economics and Statistics 71:595 – 604.

Lançon, F &Erenstein, O (2002). Potential and prospects for Rice production in West Africa.*Sub-Regional Workshop on Harmonization of Policies and Co-ordination of Programmes on Rice in the ECOWAS Sub-Region Accra, Ghana,* 25-28 February 2002.

Liberia National Rice Development Strategy (2012). *Ministry of Agriculture.* Republic of Liberia. 42pp.

LISGIS (Liberia Institute of Statistics and Geo- Information Services) (2008). National Population and Housing Census. Monrovia, Liberia.

Maganga, M.A., Edriss, A.K. &Matchaya, G.C. (2012). Unexploited Profit among Smallholder Farmers in Central Malawi: What are the Sources? International Journal of Applied Economics, 9(2): 83-95

Nganga, S.K., Kungu, J., de Ridder, N. & M. Herrero, M. (2010). Profit efficiency among Kenyan smallholders milk producers: A case study of Meru-South district, Kenya. *African Journal of Agricultural Research,* 5(4): 332-337

Oladele, O.I., Kolawole, A. &Wakatsuki, T. (2011). Land tenure, investment and adoption of Sawah rice production technology in Nigeria and Ghana: A qualitative approach. *African Journal of Agricultural Research*, 6(6): 1519–24.

Rahman. S. 2003. Profit efficiency among Bangladeshi rice farmers. *Food Policy* 28: 483-503.

Sadiq, M.S. and Singh, I.P (2015). Application of stochastic frontier function in measuring profit efficiency of small-scale maize farmers in Niger State, Nigeria. Journal of Agricultural Economics, Extension and Rural Development: 3(1): 229-239

Tsue, P. T., Lawal,W. L. &Ayuba,V. O. (2012). Profit Efficiency among Catfish Farmers in Benue State, Nigeria. *African Journal of Food, Agricultural, Nutrition and Development* 12 (6): 1684 – 5374.

USAID-BEST (2014). Liberia: the role of markets in food security, pre Ebola crisis. *USAID Office of Food for Peace-FINTRAC INC, Washington D.C.* 54pp.

Wadud, I.K.M.M & Rashid, H.A. (2011). Profit Efficiency and Farm Characteristics: Evidence from the Rice Farmers in Bangladesh. *Paper presented at the Barcelona European Academic Conference, Barcelona, Spain.*1053-1062.

Wang, J., Wailes, E.J. & Cramer, G.L. (1996). A Shadow-Price Frontier Measurement of Profit Efficiency in Chinese Agriculture. *American Journal of Agricultural Economics* 78(1): 146-156.

West Africa Rice Development Association and Nigerian Institute of Social and Economic Research (2001). *Report of the Stakeholders Workshop. Ibadan, Nigeria*, 8–9 November 2001. pp. 1 – 18.