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Research Article

Productivity and Technical Efficiency of Rice Production in Selected Areas in Kambia District, Northern Region

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Abstract: This study assessed technical efficiency of rice farmers in Kambia district, northern region of Sierra Leone. Multistage sampling technique was used to model 130 rice farmers in Kambia district. A stochastic frontier production function was used to estimate technical efficiency. The study further assessed the factors that affect technical efficiency of the rice farmers. All the coefficients were found to have positively influenced on rice productivity in the district. The level of efficiency of rice farmers was found to be 0.63. The study further found that gender and household size were significant determinants of technical efficiency. The finding of the study reveals that the majority of the sample households of male is 56.9% compared to 43.1 who were female, the average productivity of rice was 2.8 tons per hectare. The labor cost was the main cost item in rice production which took about 54.6% of the total variable cost which is Le 1,170,000, and followed by costs of seed and fertilizer. The enterprise budget analysis result indicates that experimented farmers obtained a profit ratio of 23.9% per hectare with benefit cost ratio of 1.98 with a breakeven price and yield of 42.58 per kg of 54 kg per hectare. Moreover, gross margin of rice production is more sensitive for grain price and yield fluctuations than input costs. The study therefore recommended policies that will ensure that costs of productive inputs are affordable to farmers and improving households' income through better prices for their output. Provision of labor saving equipment is also important in reducing inefficiencies in rice production through reduction in labor cost. Therefore, rice production is a profitable enterprise and the study recommend that research institution should focus on developing and promoting productivity and labor saving skills.
It is also recommended that land expansion in the short term should be promoted while improving rice farmers' productivity in the short, medium to long term to boost production levels. Also, for accelerated rice production, government policy should be geared towards encouraging large scale farmers to enter the rice sub-sector while government continues to improve the productivity of the smallholder rice farmers. Government should improve infrastructure especially roads to open up rice farming communities to market centres and reduce transactions costs and reduce the oligopolistic system operated by market women.
Keywords: Technical Efficiency, Stochastic Frontier Production Function, Productivity and cost, return.

1.0 Introduction

Rice is the single most important crop in terms of production, consumption and imports in Sierra Leone. Availability of rice is crucial to the well-being of Sierra Leoneans as the majority of its citizens are involved in its production. Low national production of this all-important staple would have negative effect on the economy of the country, as scarce foreign exchange would have to be expended to procure the commodity to meet the shortfall in demand. Poverty reduction and increased prosperity in Sierra Leone cannot therefore be addressed without sufficient attention being paid to improving rice productivity and production to achieve the national goal of self-sufficiency and food security.

Rice is produced in Sierra Leone in the upland and lowland. The lowland consists of inland valley swamps (IVS), mangrove, boliland and riverain grassland. The uplands account for approximately two-thirds of the acreage under rice, followed by the IVS. Grain yield in the upland is however generally lower than in the lowlands. While more land could be brought under cultivation in all the major ecologies, increasing the average yield in the upland and IVS through improved technology would significantly increase the availability of the grain and help meet the national goal of rice self–sufficiency and food security with less negative environmental consequences.

Rice is conspicuously in the livelihood systems of Sierra Leone, it serves both as a principal staple crop and as a central commodity for income generation by our smallholder farmer in the rural communities. Sierra Leone is one of the more important rice-producing and consuming countries in West Africa. Sierra Leone was an exporter of rice in the early 1950's. Since 1955 the agricultural sector has not been able to meet domestic needs; Imports from 1960 to 1970 averaged $2.7 million annually (USDA 1968, p. 18).

Self-sufficiency in rice production has become the central focus of the national agricultural policy as established by the Government of Sierra Leone. Rice is cultivating in all regions of Sierra Leone, of all rice producing regions Kambia took the maximum share of rice production about 80% of the national rice production.

Technical efficiency is the ability to achieve a higher level of physical output given a small level of production input. Hence the technical efficiency of rice farmers in the study area was needed to be measured to enable us knows how efficient rice production is in the region, so that policies and recommendations can be made to improve the production of the crop.

Rice is enlightening in all regions of Sierra Leone. Of all rice producing regions Kambia took the maximum share of rice production about 86% of the national rice production of which 91 % of the region rice production was came from Kambia (FAOSTAT, 2015, CSA, 2015).

Technical efficiency looks at the ability of farmers to maximize output while profit efficiency combines both technical and allocative efficiency but does not show specific factors responsible for the observed technical or allocative efficiency. It instead combines the two into profit efficiency. However, in light of the need to promote smallholder commercialization, there is an increasing use of purchased inputs (Sheahan and Barrett, 2017). This brings into perspective the other dimensions of efficiency—economic efficiency—which is the ability of farmers to use the least possible cost in production. This study focused on the allocative efficiency which looks at the ability of farmers to produce the maximum possible output (technical efficiency) at the least possible cost (economic efficiency) (Farell, 1957).

The objectives of the study include

1) To assess the socio-economic characteristics of rice farmers in the research area.
2) To analyze the structure of rice productions costs and determine profitability of rice production in the study area.

Literature Review

Rice is a major staple food crop that is consumed across all parts of Sierra Leone. The demand for rice in the country had been soaring and the rising demand was partly as a result of increased income levels, rapid urbanization, and the associated change in occupational structure (Akande, 2002). Moses and Adebayo (2007) asserted that per capita annual rice consumption level in the country increased by about 7.3% over the years. Due to the ever-increasing demand for the commodity across the country, rice has now transformed into a cash crop, especially in areas where the crop is produced. The activities involved in rice production contribute immensely to creating employment opportunities in the communities concerned (Daranola, 2005). As of 2012, the country imported about 2.8 million tonnes, which is a geometric increase from the 2007 total imports, which was about 1.7 million metric tonnes (FAO, 2013).

Sierra Leone has great potential to produce rice in both the dry and rainy seasons. It is estimated that the country has a cultivable land size of about 72 million hectares, with about 4.6 million hectares being utilized for rice cultivation. Similarly, only 50,000 hectares were being for irrigation out of the 3.14 million hectares of irrigable land suitable for rice irrigation (Kura, 2009). Rice production in Sierra Leone is dominated by smallholder farmers who cultivate small hectares of land using the traditional method of farming; yields are low and hence the wide gap of demand and supply (Ibrahim, 2014).

Dia *et al.,* (2009) emphasized that the pace of agricultural development in the country is closely related to the factors which affect the productivity of women labour. Efficient utilization of resources by farmers is central to increasing production which can contribute to economic growth. Resource use efficiency could be technical, economic, or allocative (Farell, 1957; Farell, 1957). Technical efficiency depends on the relationship between input and output, while technical efficiency considers the maximum potentials (Fan, 1999).

The stochastic frontier production function is commonly used to assess resource use efficiency using maximum likelihood procedures (Ogundari and Ojo, 2006). The method is asymptotically better than other estimators (Coelli, 1995; Yao and Liu, 1998). In assessing efficiency, efficiency entails the ability of the farmer's actual production point to lie on the frontier, while being below the frontier suggests technical inefficiency (Okoruwa and Ogundele, 2008). Similarly, economic efficiency depends on both technical and allocative efficiencies (Ogundari and Ojo, 2006; Kalirajan and Shand, 1999).

2.0 Materials and Method

Kambia District is a district in Northern Province of Sierra Leone with a geographical area of 3108 sq. km (1200 sq. miles). Its capital and largest city is the town of Kambia. The district boarders the republic of Guinea to the north, Port-Loko district to the south and Bombali district to the east. The district provides an important trade route to or from the Sierra Leonean capital Freetown to the Guinean capital Conakry.

Kambia district is divided into seven Chiefdoms namely; Gbinle Dixing, Briama, Magbema, Mambolo, Samu, Masungbala and Tonko Limba. As of the 2015 census the district population is ethnically diverse; the largest and most prominent ethnic groups are Temne, Susu, Limba, Fula, and Mandingo. The average household size is 7 people per family, Kambia district had a population of 341,690.

The district provides a vital trade route between Sierra Leone and the neighboring Republic of Guinea. The district is considered as the main rice bawl of Sierra Leone. It has a largest agricultural zone with extensive swamp areas found in every chiefdom, but more in the south-west, dominated by mangroves and grassland or savannah to the northeast.

Majority of the population are farmers and the major food crops grown by the people are; rice (the staple food), sweet potatoes, cassava and sorghum, while groundnuts and maize constitute the major cash crops.

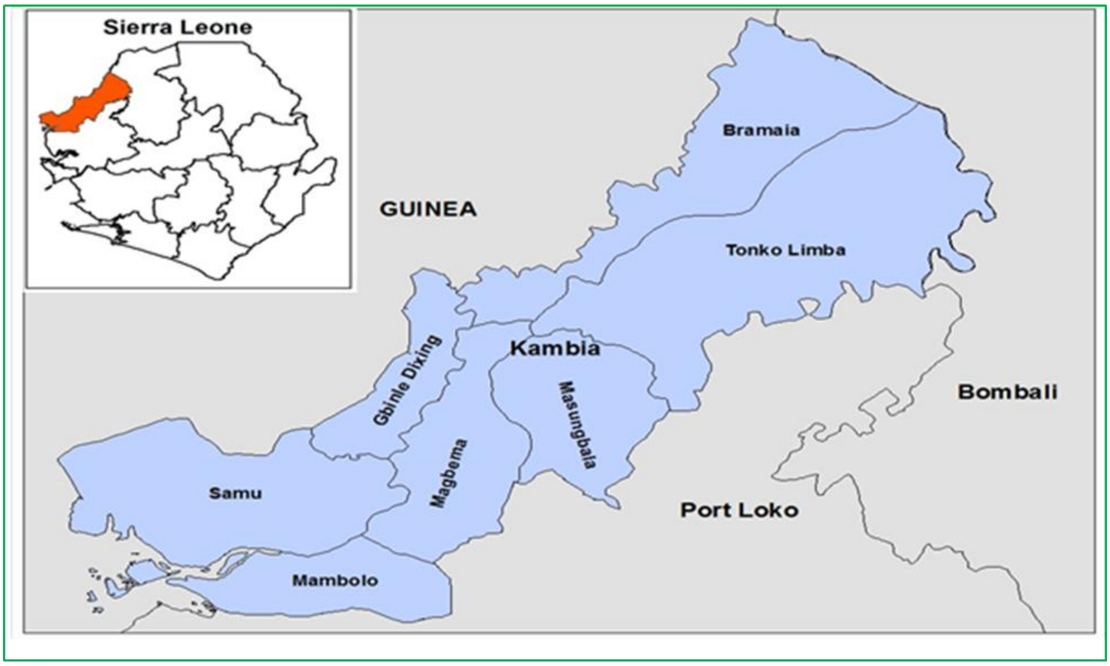

Figure 1. Map showing the various districts where the baseline survey was conducted

2.1 Data collection and analysis using analytical method

The study used both primary and secondary sources of data. Primary data were sourced through interviews with the rice producers using a structured questionnaire. The questionnaires captured data on farmer's rice production levels, costs incurred in rice production and production related socio economic factors. The household interviews captured data on rice yields, availability of labour, amount of inputs and type of inputs used in rice production, extension contacts, production costs and access to loans. Furthermore, information on age, sex, marital status, and education level of household head was also captured. Secondary data was sourced from publications from various stakeholders like Ministry of Agriculture, policy documents and past research findings on technical, allocative and economic efficiencies of agricultural products.

The study employed the stochastic frontier parametric approach specified by Battese and Coelli (1995) to evaluate TE, AE and EE of rice production. One-stage stochastic production frontiers approach was used to estimate the determinants and distribution of farmer efficiency in this analysis. This involves regressing output on the input variables, as well as the socioeconomic variables that determine inefficiency in rice production (Battese and Coelli, 1995). In order to correct for possible heteroscedasticity robust standard errors (presented in parenthesis) were estimated in both the stochastic production frontier and the stochastic cost frontier. The maximum-likelihood estimates (MLE) of the parameters of both functions were obtained using the program STATA. Furthermore, the elasticities of mean output were estimated at the means of the input variables.

Technical efficiencies could be estimated using Stochastic Frontier Approach (SFA) which is a non-parametric approach. The current study therefore employed the Stochastic Production Frontier Approach because most farmers operate under uncertain conditions (Abedullah and Ahmed, 2006). Review of literature showed that Cobb Douglas and Translog production Functions are the widely used forms in agriculture. However, Translog production Function specification suffers from multicollinearity problem as a result of the square and interaction terms of the inputs used (Hussain *et al.*, 2012). The current study therefore estimated a Cobb Douglas production function, specified as:

$$Yi = f(Xi; \beta) + Vi - Ui \qquad \text{equ 1}$$

Where Yi is output or production (or logarithm of production) of the i-th farm, Xi is the vector of input quantities used by the ith farm, β is a vector of unknown parameters to be estimated, f () represents an appropriate function (e.g Cobb-Douglas, Translog, etc). The term V_i is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer; examples are weather, disease outbreaks and measurement errors. The term Ui is a non-negative random variable representing inefficiency in production relative to the stochastic frontier.

The random error Vi is assumed to be independently, and identically distributed as N(o, $ó_v^2$) random variables independent of the Ui's which are assumed to be non-negative truncation of the N(o, $ó_u^2$) distribution (i.e half-normal distribution) or half-exponential distribution.

Technical Efficiency (T.E) model is thus:
T.E = Yi / Yi* = f (Xi; β) exp (Vi-Ui)/f (Xi; β) exp (Vi) = exp (-Ui)______________________equ 2

This production function is used in the measurement of efficiency in production. The advantages of using this production function are: (1) it introduces a disturbance term representing statistical noise, measurement error and exogenous shocks beyond the control of production units which would otherwise be attributed to technical efficiency. (2) it provides the basis for production structure and the degree of inefficiency.

Technical efficiency (TE) is defined in terms of the observed output relative to production frontier, given the available technology, such that $0 \leq TE \leq 1$. The production function can be log linearized to be:

$\text{In } Yi = \beta_0 + \sum_{k=1}^{4} \beta k\ InXki + Vi - Ui$____equ 3

The production technology of rice farmers in Kambia district is assumed to be specified by the Translog Frontier Production Function specified as follows:

Y =f (Xi; β) + (Vi-Ui), i = 1, 2, ------ n____equ 4

$\text{In } Y = b_o + b_1 InX_1 + b_2 InX_2 + b_3 InX_3 + b_3 InX_3 + b_4 InX_4 + b_5 InX_5 + b_6 InX_6 + 1/2b_7 (InX_1)^2 + 1/2b_8 (InX_2)^2 + 1/2b_9 (InX_3)^2 + 1/2b_{10} (InX_4)^2 + 1/2b_{11} (InX_5)^2 + 1/2b_{12} (InX_6)^2 + b_{13} InX_1\ InX_2 + b_{14} InX_1\ InX_3 + b_{15} InX_1\ InX_4 + b_{16} InX_1\ InX_5 + b_{17} InX_1\ InX_6 + b_{18} InX_2\ InX_3 + b_{19} InX_2\ InX_4 + b_{20} InX_2\ InX_5 + b_{21} InX_2\ InX_6 + b_{22} InX_3\ InX_4 + b_{23}\ InX_3\ InX_5 + b_{24} InX_3\ InX_6 + b_{25} InX_4\ InX_5 + b_{26} InX_4\ InX_6 + b_{27} InX_5\ InX_6 + V_i - U_i$_____________________________________equ 5

Where: Y = Rice Output (Kg),
X_1 = farm size (hectare)
X_2 = seed input cost (Le)
X3 = family labor cost (Le)
X_4= hired labor cost (Le)
X5 = Fertilizer application cost (Le)
X6= Herbicide application cost (Le) b_0, b_1, b_2 ….. , b_{27} are regression parameters to be estimated while

Vi = symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer, examples are weather, disease outbreaks and measurement errors. Ui = a non-negative random variable representing the inefficiency in production relative to stochastic frontier.

In addition, Ui is assumed in this study to follow a half normal distribution as is done in most frontier production literature.

In order to determine factors contributing to the observed technical efficiency in rice production, the following model was formulated and estimated jointly with the stochastic frontier model in a single stage maximum likelihood estimation procedure using the computer software Frontier version 4.1 (Coelli, 1996).

$TEi = a_0 + a_1Z_1 + a_2Z_2 + a_3Z_3 + a_4Z_4 + a_5Z_5 + a_6Z_6 + a_7Z_7 + a_8Z_8 + a_9Z_9$ ………………equ. 6 Where TEi is the technical efficiency of the i^{th} farmer,

Z_1 is farmers' age (years),
Z_2 is sex of farmers (Dummy variable: 1 = male, 0 = female),
Z_3 is marital status, (Dummy variable: single = 1, married = 2, divorced = 3, separated = 4, widowed = 5),
Z_4 is household size (Number of persons),
Z_5 is educational level, (years),
Z_6 is farm size (Ha).

While a_0, a_1, a_2 …….. a_6 are regression parameters to be estimated.

Stochastic Frontier Production functional form is used in this study because the coefficients estimated directly represent elasticity of production (Abedullah and Ahmad, 2006). Stochastic Production function is adequate in the representation of the production process since we are only interested in the efficiency measurement, and not production structure (Taylor and Shonkwiler, 1986). Furthermore, Stochastic Frontier Production function has been widely applied in estimating farm efficiencies (Kalirajan and Shand, 1986; Onyenweaku and Ohajianya, 2005; Hussain *et al.*, 2012, Samuel and Kelvin, 2013).

There is evidence that socio economic variables influence producer's efficiency, which will be included in the inefficiency model (Seyoum *et al.*, 1998; and Oladeebo and Fajuyigbe, 2007).

The inefficiency effects model is specified as: $\mu_= \gamma_0 + \gamma_k \sum_{k=1}^{9} Zki$________________________equ. 7

3.0 Results and Discussion

3.1 Socio-Demographic Characteristics of Respondents

Table 1. Socio-Demographic Characteristics of Respondents

Variable	Frequency	Percent
Sex		
Male	74	56.9
Female	56	43.1
Total	**130**	**100.0**
Education		
Illiterate	48	36.9
Read and write/ Religious school	32	24.6
Primary and junior secondary (1-8)	35	26.9
Secondary school (9-12)	15	11.5
Total	**130**	**100.0**
Source: Field Survey Data, (2021).		

From table 1, the majority of the sample households of male is 56.9% compared to 43.1 who were female. Regarding the education status of the household head, 36.9% of the sample households were illiterate, and 24.6% and 26.9% were capable of reading and writing and had attended at most primary school and above, respectively.

Table 2. Socio-Demographic Characteristics of Respondents

Variable	Mean	Standard Deviation	Min	Max
Age	50	15.75	20	80
Household Size	5.73	3.02	3	10
Cultivated land size	2.85	2.52	0.75	2.5
Rice cultivated land	1.62	1.34	0.75	1.88
Livestock Ownership (TLU)	6.55	3.78	1.76	14.52
Source: Field Survey Data, (2021).				

The mean age of household heads from table 2 is 50 years and household size of the sample family circle were 5.73, on average the sample households own 2.85 hectare of cultivated land of which on average 1.62 hectare were allocated for rice production. The sample family circle also owned 6.55 livestock.

Table 3. Land under rice production and attained yield by sample household

Category	Frequency	Percent
Small (<1 ha)	59	45.4
Medium (1-10 ha)	43	33.1
Large (> 10 ha)	28	21.5
Total	130	100.0
Source: Field Survey Data, (2021).		

Table 3 above shows the basis of land allocated to rice production, the sample households were categorized in to three groups, viz small (<1 ha), medium (1-10 ha) and large above 1 ha. Out of the total sample of households , 45.4% majority were allocated small land size for rice production followed by medium land size and few of them were allocated land more than 10 ha hectare of land for rice production. Regarding the productivity all categories of land size that was produced more than 3 tons per hectare which was more than the national average of 2.8 tons per hectare.

Table 4. Maximum Probability Estimates Determinants of Technical Efficiency

Variable	Parameter	Estimate	t-ratio
Intercept	∂_0	16.0943	8.1805**
Age (Z_1)	∂_1	-1.0528	-3.3907**
Sex (Z_2)	∂_2	0.1647	1.3511
Marital Status (Z_3)	∂_3	0.1906	3.1093**
Household size (Z_4)	∂_4	-0.1544	-3.4388**
Educational Level (Z_5)	∂_5	0.3752	3.6569**
Farm size (Z_6)	∂_6	1.0893	4.1688**
** Significant at 1% level; Source: Field Survey Data, (2021).			

The estimated determinants of technical efficiency among rice farmers in Kambia, Northern Region of Sierra Leone are presented in Table 8, the coefficients of marital status (Z_3), education (Z_5), and farm size (Z_6) were positive and significant at 1% level of probability, indicating a direct relationship with technical efficiency, while the coefficients of age (Z_1) and household size (Z_4) were negative and significant at 1% level of probability, indicating an inverse relationship with technical efficiency. These results imply that these variables are determinants of technical efficiency of rice farmers in Kambia, Northern Region of Sierra Leone. The coefficient of age (Z_1) was negative and significant, implying that the older the farmer becomes the less his/her technical efficiency in rice production. The coefficient of marital status (Z_3) was positive and significant, implying that married farmers have higher technical efficiency than their unmarried counterparts. The coefficient of household size (Z_4) was negative and significant, indicating that increase in household size leads to reduction in technical efficiency of rice farmers. The coefficient of education level (Z_5) was positive and significant, implying that higher education leads to improvements in technical efficiency of rice farmers. The coefficient of farm size (Z_6) was positive and significant, indicating that rice farmers that cultivate larger hectares have higher technical efficiency.

Table 5. Cost-benefit analysis on rice farmers for one hectare of farm land

	Component	**Operations**		**Av. Total cost**	
	Income Yield(kg)/loss/(Le)	53 bushels			
1	Sales price/Le	50,000.00		Le 50,000.00	
	Gross farm income			Le 2,650,000.00	
2	Production cost	Av. Unit price/Le/Ha	Av. Qty/Ha	Total Cost (Le)	%
	Variable Expenses				
3	Seeds (kg)/ha	108,000.00	1 bushel	Le 108,000.00	5.1
4	Fertilizer (Kg)	500,000.00	50kg	Le 500,000.00	13.4
	Labour (man. day)/ha	15,000.00	78	Le1,170,000.00	54.7
	Total Variable Cost			Le 1,564,666	73.2
	Fixed Expenses				
	Land/Ha	40000.00	1ha	40,000.00	1.9
5	Hoe/ha	26,541.00	8	209,750.00	9.8
6	Cutlass/ha	22,125.00	6	144,041.67	6.7
7	Shovel/ha	35,000.00	4	140,000.00	6.5
	Axe	40,000.00	1	40,000.00	1.9
8	Total Fixed Cost			Le 573,750	26.8
	Total cost (TVC+TFC)			Le2,138,416.00	
	Net farm income (TR-TC)			Le 511,584.00	
	Profit Ratio				23.9%
Source: Field Survey Data, (2021).					

The average gross returns per hectare for rice farmers in the study area is **Le 2,650,000.00**. The average total variable cost (TVC) for the rice farmers is **Le 1,564,666** with labour cost, constituting the highest variable cost, which stood at an average of **Le 1,170,000** per hectare season the average total fixed cost for the rice farmers is **Le 573,750** also, the average total cost for the investment **Le 2,138,416 respectively.** The average net farm income for the rice farmers was **Le 511,584.000** implying that rice production in the study areas was profitable.

3.2 Breakeven point

The table below shows that when the sales price is fixed at Le 50,000/ bushel/ton, at least to 42.8 yield in ton/bushel/ha of rice must be produce to make a profit, otherwise only a loss will be incurred as inferred from the table below, inversely when 50 ton/bushel/ha is produced the price must be over Le 2,138,416.00 to make a profit.

Breakeven point = Total fixed cost/Rise in sales price = 2,138,416/50,000 = 42.8

Table 6. Estimated breakeven points in the yield and the prices

Sales Price (Le/bushel)	**Breakeven point in the yield (ton/Ha)**	**Yield (ton/ha)**	**Breakeven point in the sales price (Le/ton)**
Le 50,000	42.8	53 bushels	Le 2,138,416.00
Source: Field Survey Data, (2021).			

Table 7. Statistics of output and input of rice production in the study area

Variable	Mean
Rice (Kg/ha)	3723.25
Land size (Hectare)	2.32
Seed input (Kg/ha)	63.45
Family labor (man days/ha)	109.32
Hired labor (man days/ha)	45.52
Fertilizer application (Kg/ha)	48.68
Herbicide application (Kg/ha)	2.42
Source: Field Survey Data, (2021).	

Table 7 showed the mean values of output and inputs used in rice production in Kambia district. Rice farmers in Kambia district, Northern Sierra Leone harvested 3723.25Kg/hectare of rice in 2021 harvesting season. Farmers on the average applied 63.45Kg of seed input on one hectares of land. The average family and hired labor inputs used were 109.32 and 45.52 man days per hectare respectively with 48.68Kg/hec of fertilizer and 2.42Kg per hectare of herbicides whose costs were Le 5,841.60/hec and Le 605.00/hec respectively. The total cost of labor was Le 1, 170,000.00 per hectare.

Table 8. Maximum probability estimates of the stochastic production function for Rice production in Kambia Northern Sierra Leone.

Variable	Parameter	Estimate	t ratio
Intercept	b_o	13.9006	7.1307**
Land	b_1	0.3142	3.8647**
Seed Input	b_2	0.5833	4.6851**
Family labor input	b_3	0.2942	2.8481**
Hired labor input	b_4	0.3155	2.7082**
Fertilizer application	b_5	0.4716	3.8094**
Herbicide application	b_6	0.2038	3.8311**
Log likelihood function=		-106.3045	
Sigma (δ^2)		7.5102	3.8889**
Lamda (λ)		6.1047	3.1299**
Gamma (γ)		0.7884	3.0914**
**Significant at 1% level; Source: Field Survey Data, (2021).			

The Maximum Probability estimates of the stochastic frontier production parameters for rice farmers were presented in table three. The coefficients of land (X_1), seed (X_2), family labor (X_3), hired labor (X_4), fertilizer application (X_5), and herbicide application (X_6) have the desired positive signs and are statistically significant at 1% level showing direct relationship with rice output. This is contrast to the findings of Samuel *et al.*, (2013), who found out that only fertilizer application and labor coefficients were positive and significant while chemical cost coefficient is negative and significant in Technical Efficiency of Rice farmers in Irrigation.

The estimated variance ($Ó^2$) is statistically significant at 1% indicating goodness of fit and correctness of the specified distribution assumptions of the composite error term. Besides, the variance of the non-negative farm effects is a small proportion of the total variance of rice output. Gamma (γ), derived as ($\lambda^2/1 + \lambda^2$) is estimated at 0.7884 and it is statistically significant at 1% level indicating that only 79% of the total variation in rice output is due to technical inefficiency.

In contrast to this Samuel *et al.*, (2013) found the gamma estimate of the Ahero Irrigation scheme; Kenya to be 0.999 meaning that 99.9% of the variations in productivities among rice farmers is due to farmers specific inefficiencies. They concluded that because the physical conditions such as weather and soil characteristics were similar.

The variance ratio parameter, Lamda (λ) = (λ^2u/λ^2v) is estimated at 6.1047 and it is statistically significant at 1% level, implying that variation in actual rice output from maximum rice output between rice farms mainly arose from differences in farmer practices rather than random variability.

Table 9. Elasticity of Production and Return to Scale rice production

Variable	**Elasticities**
Land	0.3142
Seed Input	0.5833
Family labor (man days)	0.2942
Hired labor (man days)	0.3155
Fertilizer Application	0.4716
Herbicide Application	0.2038
Total	2.1826
Source: Field Survey Data, (2021).	

The estimated coefficients of a Cobb Douglas production function can be directly interpreted as elasticities of production. Table four showed an increase return to scale because the total elasticities was 2.1826, meaning that the values of inputs used in the production of rice should be reduced.

Seed input had the highest elasticity of production of 0.5833 and herbicide application had the lowest (0.2088). This implied that a ten percent increase in seed input and fertilizer application will lead to 5.8% and 4.7% increase in rice production respectively.

Table 10. Distribution of farmers according to level of efficiency

Efficiency Range	**Frequency**	**Percentage (%)**
≤ 0.50	30	10.00
0.51–0.60	90	30.00
0.61–0.70	115	38.40
0.71–0.80	22	7.30
0.81–0.90	34	11.30
0.91–1.00	09	3.00
Total	**300**	**100**
Mean technical efficiency: 0.626; Minimum Technical Efficiency: 0.384; Maximum Technical Efficiency: 0.941; **Source:** Field Survey Data, (2021).		

Technical efficiency of individual rice farmers was presented in Table 7. The content of Table 7 showed that the individual technical efficiency indices ranged between 0.384 and 0.941 with a mean of 0.626. The results showed that 90.0% of the rice farmers had technical efficiency index above 0.50. Thus, this result on technical efficiency of rice farmers implies that the rice farmers are technically inefficient in resource utilization since the overall technical efficiency index was less than 1.00 or 100%.

Therefore, the hypothesis which states that rice farmers in Kambia, Northern Sierra Leone are technical inefficient in resource use is hereby accepted. The mean technical efficiency of 0.626 obtained in this study implied moderate level of technical efficiency in resource use and is consistent with the low variance of the farm effects in the study area.

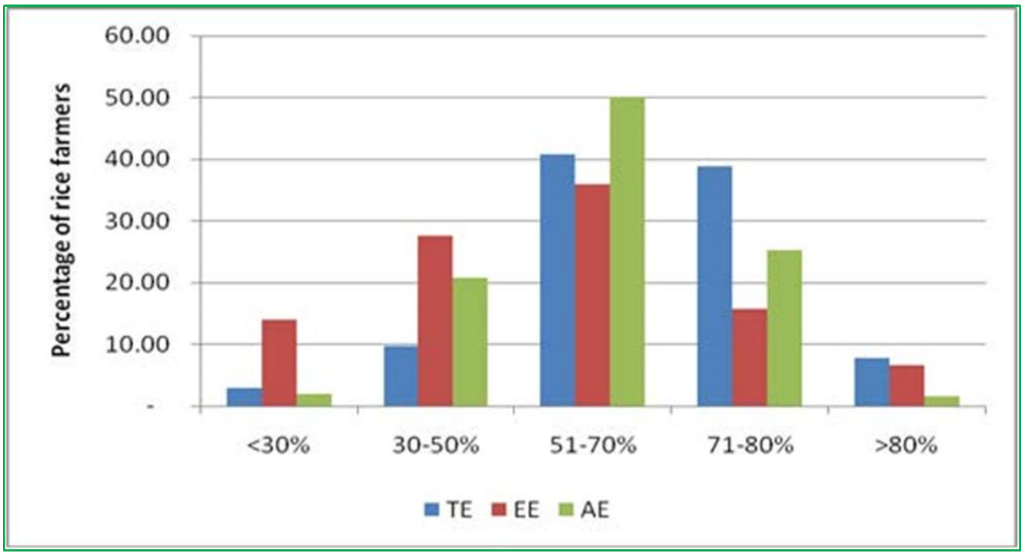

Figure 2. Proportion Efficiency in Rice Production in Kambia

Figure 2 shows the distribution of efficiency estimates and is apparent that the scope of efficiency gains is fairly large. Economic efficiency in smallholder rice farming system could be increased by up to 50 percent using the current production technology. This therefore implies that smallholder productivity could double if key factors that are currently constraining overall efficiency are addressed adequately.

4.0 Conclusion

The study showed that rice farmers in Kambia district Northern Region of Sierra Leone are technically inefficient in using the productive resources when the production frontier and derived technical, allocative and economic efficiencies is used. The result of Cobb Douglas production function showed that increase in all the resources will lead to an increase in rice output. Policies should therefore aim at reducing the cost of productive inputs such as fertilizer, herbicides and seed. Also, government should make available direct to rice farmers, appropriate labor-saving technologies such as mechanization and bird scarring mechanism at subsidized rate to reduce labor cost. Marital status, educational level and farm size were found to be important determinants of technical efficiency. Policies should therefore target improving the educational status of rice farmers and increasing the farm size of rice farmers. Improving farmers' efficiency in rice production therefore has a potential of increasing rice production in the region and in the country as a whole. This in turn will have direct effects of increased local rice output, hence food security, increased income among rice farmers and reduction of supply and demand gap that will reduce rice import bill which is on the high side in the country. Beside the profitability, rice production by smallholder farmers was sensitive for both fluctuations in price and yield variability.

5. Recommendations

1) In order to improve smallholder rice farming there is critical need of improving the way farmers are organized so that they can have access to credit, input and output markets as well as technological advice. All this in turn requires better infrastructure and the development of efficient input and output markets. Improvement of smallholder efficiency hence relies on the improvement of smallholder policy and institutional environments.
2) Policies and plans that promote rural education, credit access, better soil fertility management and better infrastructure and markets will greatly assist smallholder rice farmers realize the unexploited production gains from rice and accompanying profitability. It is thus recommended that these farmers be mobilized in groups so as to benefit from institution innovations. These include; the commodity warranty schemes, contract farming from which they can learn and share farming experiences, new farming technologies, can access inputs and acquire extension support all in one package.

3) Decreasing mechanism should be in place related to labor intensive procedures so as to minimize the costs of production of rice in the district.

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