Iosr Journal Of Economics And Finance (Iosr-Jef)
E-Issn: 2321-5933, P-Issn: 2321-5925.Volume 16, Issue 1 Ser. 6 (Jan. – Feb. 2025), Pp 30-38
www.Iosrjournals.Org

Analysis Of Technical Efficiency And Rice Output Of Small-Scale Rice Farmers In Kirinyaga County, Kenya.

Henly Murimi[1], Dr. Samuel Muthoga[2]
(Department Of Economic Theory, Kenyatta University, Kenya)
(Department Of Economic Theory, Kenyatta University, Kenya)

Abstract:
Background*: The demand for rice in Kenya is growing, with yearly consumption increasing at a rate of 12 per cent per year. Kenya has thus put into place measures to reduce demand-supply gap. An initiative such as National Rice Development Strategy (N.R.D.S.) Phase 2 (2019–2030) has been implemented to accelerate rice production and close this gap. Despite these polices, rice output has grown slowly, while rice consumption has increased significantly faster than rice production. 949,000 metric tonnes of rice are consumed nationally yearly, compared to 180,000 metric tonnes produced. This research aimed to determine the technical efficiency of small-scale rice farmers in Kenya's Kirinyaga County and the effect inputs have on rice output.*
Materials and Methods*: The study adopted a cross-sectional research design. This study targeted 6000 small-scale farmers engaged in small-scale rice growing in the Mwea Irrigation Scheme. To get 362 farmers, the sample size was calculated using Cochran's methodology. A layered, multi-phase random sampling approach was used to choose the respondents. A survey questionnaire was used to gather quantitative data for this investigation. The respondents were the small-scale rice farmers in Kirinyaga County's Mwea Irrigation Scheme. This research used primary data, which was collected for the agricultural season of 2023. The assumptions of regression analysis were examined before running the regression, including homoscedasticity, multicollinearity and normality.*
Results*: The mean of technical efficiency was found to be 87.8% and ranged between 39.9% and 98.3%. This implied that technical inefficiencies exist among the small scale rice farmers in Kirinyaga County. The study found that the coefficients for fertilizer, farm size, labour and capital were positive and statistically significant revealing that and increase in the amount of fertilizer used, land size, labour and capital in rice production would result in an increase in rice output.*
Conclusion: *The study concluded that the technical efficiencies of small scale rice farmers in Kirinyaga County differs among the farmers. Further, the study concluded that small scale rice farmers in Kirinyaga County do experience technical inefficiencies which account for loss in rice output. The study also concluded that fertilizer, farm size, labour and capital contributes to changes in rice output.*
Key Word: *Technical efficiency; small-scale rice growers; production variables; rice output.*

Date of Submission: 29-01-2025 Date of Acceptance: 09-02-2025

I. Introduction

More than a fifth of the calories consumed worldwide come from rice, making it a significant crop (Gadal et al., 2019). It has been positioned as among major cereal worldwide in effort to combat hunger (Borresen & Ryan, 2014). The National Food and Nutrition Security Policy (N.F.N.S.P.), the Agriculture Sector Development Strategy (A.S.D.S.), Vision 2030, and other current food security strategies have prioritized rice cultivation. According to the Republic of Kenya (2008), phase two of the National Rice Development Strategy (N.R.D.S.) aims to increase domestic milled rice output to 1,301,000 metric tons by 2030. Among many other goals, the policies have been implemented to improve agricultural productivity and production, effectively use water for irrigation, practice excellent farm management, deploy appropriate production methods, and end poverty and hunger. The Kenyan government expanded the area used for rice farming in Mwea from 24,000 acres to 48,000 acres (Republic of Kenya, 2008).

Kenya's population has increased by 6% annually for over the last one decade, driving up demand for rice. (Arouna, et.al, 2021). Kenya imports more than 80% of its rice to fulfill the domestic market, which is 949,000 tonnes per year on average compared to an output of 167,000 tonnes annually. Kenya has never been able to meet this need.

The effectiveness of the strategies used to encourage rice yield and boost agricultural productivity in Kenya has been doubted several times. The Mwea Irrigation Scheme's rice productivity has been steadily declining over time, which has led to worries about production efficiency. Therefore, increasing rice yield is

needed because Mwea is the primary rice production plan. This may be accomplished by improving the effectiveness of rice farming by adopting innovative fertilizer applications and mechanization technologies. The current study aims to build growing awareness of atherosclerosis specific care of diabetes patient by examining efficacy of two most commonly prescribed statins in India.

II. Material And Methods

Mwea irrigation scheme was examined. Over 80% of Kenya's rice demands are met by this irrigation project, which is the largest in Kenya. A sample of small-scale rice growers participating in the Mwea irrigation scheme will be selected. Data for the study came from small-scale rice farmers in Kirinyaga County's Mwea Irrigation Scheme

Study Design: The research design used for the study was cross-sectional.

Study Location: Mwea irrigation scheme.

Study Duration: 2024.

Sample size: 362 small scale rice farmers.

Sample size calculation: The ideal sample size was found using Cochran's calculations, taking into account the necessary accuracy and confidence levels, the estimated percentage of the characteristic in the population, and another pertinent variable. The target population from which the sample was considered was 6000. The study assumed a Z score of 1.96 and margin of error of 95%. The sample size obtained was 362

Subjects & selection method: Multistage cluster sampling was used in this research. All the five blocks in Mwea Irrigation scheme namely Mwea, Wamumu, Karaba, Thiba and Tebere were selected, out of which, farmers in each block were randomly selected.

Data Collection Procedure methodology

A well-structured survey questionnaire was used to collect primary data regarding rice farming in Kirinyaga county, Kenya. The questionnaire was divided into sections that provided necessary data for the analysis. The researcher administered the questionnaires to the respondents with the help of research assistants and the respondents were left with them and given enough time to fill in. After a period of two weeks, the researcher collected the filled in questionnaires.

Statistical analysis

Data was first put into excel, and analysis was performed on STATA according to the study objectives. Descriptive statistics were employed to assess the data for technical efficiency in the first objective, where frequency, mean, and standard deviation were calculated. Descriptive statistics is a method that helps discover associations between or among selected variables (Dulock, 1993). The SFA and production function were used to achieve the study objectives. Correlation and regression analysis were used to assess the effect of inputs on rice output.

III. Result

Response Rate

The response rate was determined by dividing the total number of questionnaires that were completed and returned by the total number that was distributed and the percentage calculated. The total number of questionnaires that were distributed were 362. Out of there, 254 were filled and returned. This resulted to a response rate of 70%. This was adequate as depicted by Fincham (2008) that a response rate of approximating 60% for most research should be the goal of researchers.

Demographic Information

The demographic characteristics of the study respondents was obtained including the gender, age and the level of education. This was helpful in determining the characteristics of rice farmers in Kirinyaga County.

The gender of the respondents was analyzed and the findings were as presented in Table 1.

Table1: Tabulation of Gender

Gender	Freq.	Percent	Cum.
Male	167	65.75	65.75

Female	87	34.25	100.00
Total	254	100.00	

The findings showed that the gender of the majority of the respondents was male representing 65.75% while female respondents accounted for 34.25%. This implied that there are more male rice farmers in Kirinyaga County than female rice farmers. This could be explained by the cultural factors where male are the family heads hence are considered the owners of the farms and hence provided the needed information. The high number of men doing rice farming means that they are able to access financial resources easier due to cultural barriers that make it difficult for women to get easy access to financial resources. As such, this could result to higher technical efficiency since the men farmers are able to use the finances to purchase materials and machinery.
The age of the study respondents was also assessed and the findings were as in Table 2.

Table 2: Age

Variable	Obs	Mean	Std. Dev.	Min	Max
Age (yrs)	254	46.043	9.705	22	64

The age of the respondents according to the findings ranged between 22 years and 64 years. On average, the age was 46 years. This implied that the average age of the rice farmers in Kirinyaga county is 46 years. This means that rice farmers in Kirinyaga County are middle aged. Age could be a determinant of technical efficiency since experience in farming increase with age. This means that older farmers have adequate experience that has allowed them to gain more knowledge on how to increase the technical efficiency in rice farming hence this could lead to higher technical efficiency of rice farmers in Kirinyaga County.

The data for the highest level of education attained by the respondents of the study was also analyzed. The findings were as presented in Table 3.

Table 3: Tabulation of Education Level

Education Level	Freq.	Percent	Cum.
Primary level	86	33.86	33.86
Secondary level	134	52.76	86.61
Tertiary level	34	13.39	100.00
Total	254	100.00	

According to the findings, slightly above half of the respondents have a secondary level of education representing 52.76%. Those with primary level of education represented 33.86% while only 13.39% have a tertiary education. This implied that most of the rice farmers in Kirinyaga County have acquired only the basic education. Education is a factor that contributes to knowledge and hence the level of education of rice farmers could explain the levels of technical efficiency. More educated farmers are able to have the knowledge of proper use of rice production inputs and machinery and also are able to practice the right management of rice farming. This may increase the technical efficiency in rice farming. The differences in the level of education among small scale rice farmers in Kirinyaga County could therefore explain the disparities in technical efficiency in rice farming in the county.

Descriptive Analysis

The descriptive statistics were used to summarize the data. The study reported the mean, standard deviation and the minimum and maximum values. Table 4 presents the results.

Table 4: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Acreage (Ha)	254	.687	.456	.304	2.428
Yield (Tonnes)	254	4.543	2.858	2.2	15
Yield (Tonnes per Ha)	254	6.827	.938	1.071	7.907
Fertilizer (Tonnes)	254	.878	.554	.4	3
Rotavationhrs	254	5.001	18.744	.583	175
Transplanting (Days)	254	8.725	11.459	1.875	83.333
Leveling (hrs)	254	5.739	12.885	1	128
Weeding (days)	254	2.199	3.641	.125	26.667
Watering (man days)	254	29.618	5.664	8	37
Birds scaring (man days)	254	32.669	2.471	28	40
Harvesting (hrs)	254	10.037	28.459	.5	192
Transporting (hrs)	254	1.632	.95	.5	6

It was revealed from the findings presented in Table 4 that the average size of rice farms for each farmers was 0.687 hectares with the least being 0.304 hectares and the largest 2.428 hectares. The disparities in the size of rice farms could help explain the differences in the levels of technical efficiency. Farmers with larger pieces of rice farms may be able to make higher profits which can be ploughed back to acquiring the right inputs for rice production hence increasing the technical efficiency. Hence, farmers with larger rice farmers may have the advantage over farmers with smaller pieces of rice farms hence the differences on technical efficiency among small scale rice farmers in Kirinyaga County.

The total yield for each farm averaged 4.543 tonnes and the yields ranged between 2.2 to 15 tonnes. The average yield per hectare was 6.827 tonnes and the minimum and maximum yield per hectare was 1.071 tonnes and 7.907 tonnes respectively. These differences could be explained in terms of technical efficiencies. Farmers who have higher levels of technical efficiency may be able to have higher yields than farmers who experience technical inefficiencies.

The amount of fertilizer used by each farmer measured in tonnes averaged at 0.878 tonnes and the least amount used was 0.4 tonnes and maximum was 3 tonnes. The difference in the amount of fertilizer used could be explained in terms of the size of farm and this could also affect the technical efficiencies. Farmers with smaller rice farms may not need very large quantities of fertilizers as is needed with large farms. Further, the amount of fertilizer applied per acre of rice farm may also help explain the different levels of technical efficiency.

Further, it was observed that the average number of hours utilized in rotavation was 5.001 hours and the hours ranged between 0.583 to 175 hours. The number of days used up in transplanting was between 1 and 83 with an average of 8 days. Furthermore, the number of hours used in leveling was between 1 and 128 with a mean of 5.739. Weeding was accomplished in between 0.127 and 26 days averaging 2days while watering took between 8 and 37 man days with a mean of 29 days. Bird scaring as measured by man days averaged 32 ranging between 28 and 40. Finally, harvesting took on average 10.037 hours and ranged between 0.5 and 192 hours while transporting took between 0.5 and 6 hours averaging at 1.632 hours. The variability in the number of hours and days used in rotavation, transplanting, weeding and harvesting may imply that the machinery used are different. Farmers who are able to acquire machinery to carry out these tasks are able to do so in lesser time than the farmers who use manual labour. This could lead to differences in the levels of technical efficiency in rice production in the county,

Diagnostic Tests Results

Prior to conducting inferential analysis, diagnostic tests were performed and included the test for normality multicollinearity test and test for heteroscedasticity.

Normality Test

Normality test utilized the Kolmogorov–Smirnov test where a P value less than 0.05 indicates not normally distributed and a P value greater than 0.05 shows the data is drawn form a normally distributed population.

Table 5: Skewness/Kurtosis tests for Normality

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	adj_chi2(2)	Prob>chi2
Output	254	0.6115	0.408	26.990	0.064
Fertilizer	254	0.5895	0.534	24.100	0.069
FarmSize	254	0.6925	0.671	27.120	0.073
Labour	254	0.3700	0.226	10.900	0.060
Capital	254	0.3302	0.300	19.310	0.052

The findings showed that the P values were greater than 0.05 hence the data was normally distributed. This means that the estimation of the standard error and the confidence interval is done perfectly hence the p values in significance testing can be more reliable and interpretable. This heled increase the predictions.

Multi-collinearity Test

To test for mulicollinearity, VIF was utilized. VIF values that are greater than 10 indicate presence of multicollinearity. Table 6 shows the results.

Table 6: VIF Test for Multicollinearity

	VIF	1/VIF
Fertilizer	5.023	.199
FarmSize	5.001	.2
Capital	2.342	.427
Labour	1.441	.694
Mean VIF	3.452	.

The VIF value for fertilizer was 5.023, the VIF value for farm size was 5.001 while capital and labour had VIF values of 2.342 and 1.441 and the mean VIF was 3.452. This means that there was no multicollinearity. Therefore, it was concluded that the independent variables were not correlated and hence were truly independent which helped increase the precision of the estimated coefficients in regression analysis.

Heteroscedasticity Test

The test for heteroscedasticity was achieved using the Breusch Pagan test. Table 7 presents the findings.

Table 7: Breusch Pagan Test for Heteroscedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of Output
chi2(1) = 3.35
Prob > chi2 = 0.0673

The findings showed that the P value was 0.0673 which was greater than 0.05 hence indicating no heteroscedastcity was observed in the data. This means that the variance of the model residuals was equal hence they did not vary with changes in predicted values. This led to unbiased, consistent and efficient estimates of the coefficients and standard errors.

Correlation Analysis

Correlation analysis was performed in order to determine the strength of the association between the study variables. Table 8 presents the findings.

Table 8: Matrix of Correlation

Variables	(1)	(2)	(3)	(4)	(5)
(1) Output	1.000				
(2) Fertilizer	0.954	1.000			
(3)FarmSize	0.879	0.881	1.000		
(4) Labour	0.571	0.549	0.512	1.000	
(5) Capital	0.738	0.725	0.741	0.390	1.000

The findings showed that the correlation coefficient for the association between fertilizer and output was 0.954 which means that fertilizer has a positive association with output. Therefore, if the amount of fertilizer used in the farm is increased, the rice output of the firm would also increase. Increasing the quantity of fertilizer used increases the technical efficiency through additional nutrients useful for rice thus making the production capacity of the rice farm to increase. Therefore, rice output increases with increased fertilizer. This agreed with Abu (2011) who observed that rice fields using fertilizer could increase production. This however contrasted with the findings by who showed that at 5 per cent probability level, fertilizer usage had negative correlation with rice yield.

The findings also showed that the correlation coefficient for the correlation between farm size and output was 0.879. Hence, it was revealed that farm size and output have a positive correlation. This implies that when the size of the farm is increased, the rice output would also increase. Increase in the size of the farm where rice if grown increases the technical efficiency of the rice farm through economies of scale which makes rice production efficient. These findings concur with the findings by Lema, Tessema, and Abebe (2017) who found that land was positively correlated with rice output.

It was further revealed that the correlation coefficient for labour and output was 0.571 which means that labour and output have a positive correlation. Therefore, if labour is increased, so does the rice output. This can be explained through changes in labour efficiency which leads to labour productivity hence increased rice output. These findings were in line with findings by Anthony, Alabi, Ebukiba, and Gamba (2021) who demonstrated that the quantity of rice output harvested was positively and significantly impacted by the labor input measured in person-days. The findings however disagreed with Ntiritu (2014) who discovered that rice productivity is reduced when the workforce is used more extensively.

Furthermore, the findings revealed a positive association between capital and output since the correlation coefficient was 0.738. This implied that with an increase in capital applied, rice output in the farm would increase. This aligns with the Classical Theory of Production by Cobb and Douglas (1928) that explains that maximum yield is produced when a certain combination of production units including capital are used.

Technical Efficiency Scores of Small-Scale Rice Farmers in Kirinyaga County

In order to determine the technical efficiency of small scale rice farmers in Kirinyaga County, the study applied the stochastic frontier analysis. The technical efficiency was calculated and the results were as in Table 9.

Table 9: Technical Efficiency

Variable	Obs	Mean	Std. Dev.	Min	Max
tef	254	.878	.082	.399	.983

From the results, the mean technical efficiency was 0.878 and the minimum technical efficiency was 0.399 and the maximum was 0.983. This implied that on average, small scale rice farmers lose about 12.2% of rice output due to technical inefficiencies. This was similar to the findings by Anang, Bäckman, and Sipiläinen (2016) who found that rice has an average technical efficiency of 63.8% meaning that farmers were not using technology to the fullest extent possible to produce rice. Similarly, Lema, Tessema, and Abebe (2017) established that the average technical efficiency score obtained by the projected Cobb-Douglas stochastic frontier production function was found to be 77.2 percent.

The findings were similar to the findings by Omondi and Shikuku (2013) who estimated technical efficiency of rice farmers in Ahero Irrigation Scheme, Kisumu County, Kenya and found the level of efficiency of rice farmers to be 0.82. The level of technical efficiency was also similar to the level of 83% obtained by Kitsao (2015) for system of rice intensification method of rice production in West Kano irrigation scheme in Kenya which as significantly higher than for the conventional method (75%). This hence helps explain the differences which can be related to the inputs used and in what quantity.

The technical efficiency was however higher than the calculated technical efficiency level of 72% by Ntiritu (2014) who estimated rice production efficiency in Mwea irrigation scheme. This was also higher than the average technical efficiency of 79.72% estimated by Agnaza and Agbodji (2022) in Togo. The difference was also observed in the level of 73% obtained by Ndayitwayeko and Korir (2012) in Burundi. The findings also contrasted greatly with the technical efficiency rate obtained for rice production in Benin by Miassi et al. (2023) which was 51%. These variations can be explained by the differences in the size of the farm, use of capital equipment, labour and the quantity of fertilizer applied. Other factors such as level of education, access to finances and other resources as well as the level of technology used in rice production.

Rice Output of Small-Scale Rice Farmers in Kirinyaga County

To determine the rice output of small scale rice farmers in terms of the amount of fertilizer use, farm size, labour and capital, the cobb Douglas production function was estimated. The results obtained were presented in Table 10.

Table10: Cobb Douglas Production Analysis Results

Output	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Fertilizer	.48	.087	5.49	0.000	.308	.651	***
Farm Size	.429	.096	4.48	0.000	.241	.616	***
Labour	.049	.023	2.14	.032	.004	.094	**
Capital	.066	.027	2.47	.013	.014	.119	**
Constant	1.724	.072	23.81	0.000	1.583	1.866	***
Insig2v	-5.018	.318	-15.79	0.000	-5.641	-4.395	***
Insig2u	-3.272	.23	-14.22	0.000	-3.723	-2.821	***

Mean dependent var	1.368	SD dependent var	0.504
Number of obs	254	Chi-square	3611.872
Prob > chi2	0.000	Akaike crit. (AIC)	-273.337

*** *p*<.01, ** *p*<.05, * *p*<.1

LR test of Sig:ma_u=0: Chibar2(01)=11.55 Prob>=Chibar2=0.000

The form of frontier production equation used in the study was;

Output = $\beta 0 + \beta 1 \ln Fert + \beta 2 \ln Farmsize\ \beta 3 \ln Lab + \beta 4 \ln Cap + + Vi - Ui$

Where:

Fer is the quantity of fertilizer used (measured in tons) to produce a ton of rice per hectare

Farm size is total area under rice cultivation, measured in hectares(ha) $\beta 0$ is a constant

Lab is the quantity of labor (man days) used to produce a large amount of rice.

Cap-Amount of machinery used to produce one ton of rice per hectare.

$\beta 1$ $\beta 2$, $\beta 3$ $\beta 4$ are coefficients that were estimated.

The results obtained revealed that the coefficient for fertilizer was positive (β=0.48) and statistically significant at 1% confidence level (P=0.000). This implied that the amount of fertilizer used contributed significantly to an increase in rice output. Further, according to these results, 1% increase in the amount of fertilizer used would result in 0.48% increase in rice output. This was consistent with Omondi and Shikuku (2013) who discovered that the fertilizer coefficient had a positive effect on paddy productivity. The findings however contrasted those of Fani, Innocent, and Celina (2016) whose study showed that fertilizer use had a negative connection with small-scale rice output.

According to the results, farm size also produced a positive coefficient (β=0.429) and was statistically significant at 1% level (p=0.000). This implied that the size of the farm where rice is cultivated is a factor that contributes significantly to an increase in rice output. If the size of the firm increases by 1%, rice output would increase by 0.429%. This was in line with Apiors, Kuwornu and Kwadzo (2016) whose findings revealed that land size cultivated, was a significant factor that positively influenced partial factor productivity.

Further, the coefficient for labour was also positive (β=0.049) which was statistically significant at 5% level (p=0.032). This implied that labour contributes significantly to an improvement in rice output. If the labour was increased by 1%, rice output would increase by 0.049%. This concurred with Anthony, Alabi, Ebukiba, and Gamba (2021) who revealed a significant and positive relationship between the quantity of rice production harvested and the labor input, measured in man-days. These findings however disagreed with those of Ntiritu (2014) who found that increasing the use of labour decreases rice output. The findings also disagreed with the findings by Kasmin and Kartomo (2020) whose results showed that the number of workers had no discernible effect on the productivity of rice farming.

Furthermore, the coefficient for capital was positive (β=0.066) and also statistically significant at 5% level (p=0.013). This implied that capital is a factor that contributes significantly to an improvement in rice production. If the amount of capital increases by 1%, rice output would increase by 0.066%. This concurred with Liu, Shi and Gao (2022) whose study results suggested that agricultural machinery services have a positive effect on cultivated land productivity.

The likelihood ratio test that there is no inefficiency was rejected at 5% level wince the P value was 0.000<0.000. This implied that technical inefficiencies exist among the small scale rice farmers in Kirinyaga County. Further, in stochastic frontier analysis, a negative value of lnsig2u and lnsig2v indicates decreasing technical efficiency over time and highlights inefficiencies.

IV. Discussion

The study undertook to investigate the technical efficiency and rice output of small-scale rice farmers in Kirinyaga County as the main objective. The specific objectives of the study were to estimate the technical efficiency scores of small-scale rice farmers in Kirinyaga County and to determine rice output of small-scale rice farmers in Kirinyaga County. The data for the study was obtained from small scale rice farmers in Kirinyaga County. In order to achieve the first objective, a stochastic frontier analysis was performed and the second objective was achieved by estimating the Cobb Douglas production function.

The mean of technical efficiency was found to be 87.8% and ranged between 39.9% and 98.3%. This implied that on average, small scale rice farmers lose about 12.2% of rice output due to technical inefficiencies. The likelihood ratio test that there is no inefficiency was rejected at 5% level wince the P value was 0.000<0.000. This implied that technical inefficiencies exist among the small scale rice farmers in Kirinyaga County.

The technical inefficiency in rice production could lead to deficiencies in supply of rice which has negative implications on food security. Therefore, factors that could increase the technical inefficiencies such as the increase in rice farm, use of adequate amount of fertilizer in rice production and adoption of technology could address this problem.

The study found that the coefficient for fertilizer was positive and statistically significant revealing that and increase in the amount of fertilizer used in rice production would result in an increase in rice output. The application of fertilizer in rice production provides additional nutrients such as nitrogen and phosphorus that rice need for production hence increasing the productivity of rice without having to increase other factors such as farm size. This could imply that small farms of rice can produce higher yields of rice if fertilizer is applied than large farms with no fertilizer use.

The study also established that the coefficient for firm size was positive and statistically significant. This implied that an increment in the size of farm where rice is cultivated would lead to an increment in rice output. Large farms use modern technology, reduce costs associated with rice production hence enhancing technical efficiency which in turn increases rice yields. This is made possible through economies of scale. Increased rice yields lead to enhanced food security.

Similarly, the coefficient for labour was found to be positive and significant which implied that an increase in labour would result in an increase in rice output. The ability to acquire enough labour as required in rice production increases labour productivity. More so, the more the labour the more the work done and the larger

the size of rice farm that is worked on which in turn increases the technical efficiency and consequently rice yields increase.

Finally, and in a similar manner, the study found that the coefficient for capital was positive and statistically significant which also indicated that an increase in capital would lead into an increase in rice output. The use of machinery in rice production enhances the technical efficiency in rice production which leads to higher rice output. This is because the use of machinery helps reduce labour and time required and costs associated with rice production. The use of technology also helps preserve land fertility hence increasing the yields.

V. Conclusion

The results obtained showed that the technical efficiency of rice farmers ranged from 39.9% to 98.3% and averaged at 87.8%. The study concluded that the technical efficiencies of small scale rice farmers in Kirinyaga County differs among the farmers. Further, the study concludes that small scale rice farmers in Kirinyaga County do experience technical inefficiencies which account for loss in rice output. The technical inefficiencies are associated with the amount of fertilizer applied in different rice farms, the amount of labour applied, the capital invested in terms of machinery and the size of the farm. The differences observed account for the technical inefficiency observed.

The study also showed that fertilizer, farm size, labour and capital have a positive effect on rice output. Therefore, the study concludes that fertilizer, farm size, labour and capital contributes to changes in rice output. With increased use of fertilizer in rice production, rice output is enhanced. Therefore, rice farmers are able to improve on rice output when they increase the amount of fertilizer they use in the production of rice. A unit increase in quantity of fertilizer applied will increase the technical efficiency of rice production resulting in increased rice output. Application of fertilizer enhances land nutrients level hence increasing rice yields.

Further, the study concludes that the larger the size of the farm, the higher the rice output. Farmers with larger pieces of farms on rice cultivation are able to produce larger amounts of rice. An increase in the size of the farm leads to an increase in technical efficiency of rice production. Large pieces of land under rice cultivation are able to use economies of scale hence reducing the amount of labour and other costs associated with rice production hence increasing technical efficiency and then the rice output. Furthermore, the study concludes that the more the labour the higher the rice output. Increasing the amount of labour in terms of man days increases the output of rice. An increase in the amount of work that can be done by one person in a rice farm means increased labour efficiency. The higher the labour efficiency the higher the returns in the farm. Labour increases the technical efficiency which eventually lead to higher rice output. Finally, the study concludes that an increment in capital in terms of machinery used leads to an increment in rice output. The use of machines in doing farm work results in time saving hence increasing the technical efficiency of the farmers which leads to increased rice production. The use of machinery reduces, labour, time and other costs of rice production and also hekp retain most of the lands fertility.

References

[1]. Abu, O. (2011). Fertilizer Usage And Technical Efficiency Of Rice Farms Under Tropical Conditions: A Data Envelopment Analysis (D.E.A.). Journal Of Agricultural Sciences, 2(2), 83–87.

[2]. Agnaza, M., & Agbodji, A. E. (2022). Technical Efficiency And Production Risk Of Rice Farmers In Togo. Review Of Agricultural And Applied Economics (RAAE), 25(2).

[3]. Anang, B. T., Bäckman, S., & Sipiläinen, T. (2016). Technical Efficiency And Its Determinants In Smallholder Rice Production In Northern Ghana. The Journal Of Developing Areas, 311-328.

[4]. Anthony, L., Alabi, O. O., Ebukiba, E. S., & Gamba, V. (2021). Factors Influencing Output Of Rice Produced And Choice Of Marketing Outlets Among Smallholder Farming Households, Abuja, Nigeria. Sarhad Journal Of Agriculture, 37(1).

[5]. Apiors, E. K., Kuwornu, J. K., & Kwadzo, G. T. (2016). Effect Of Mechanisation Use Intensity On The Productivity Of Rice Farms In Southern Ghana. Acta Agriculturae Slovenica, 107(2), 439-451.

[6]. Arouna, A., Fatognon, I. A., Saito, K., & Futakuchi, K. (2021). Moving Toward Rice Self-Sufficiency In Sub-Saharan Africa By 2030: Lessons Learned From 10 Years Of The Coalition For African Rice Development. World Development Perspectives, 21, 100291.

[7]. Borresen, E. C., & Ryan, E. P. (2014). Rice Bran: A Food Ingredient With Global Public Health Opportunities. In Wheat And Rice In Disease Prevention And Health (Pp. 301-310). Academic Press.

[8]. Cobb, C. W., & Douglas, P. H. (1928). A Theory Of Production. American Economic Review, Papers And Proceedings Of The Fortieth Annual Meeting Of The American Economic Association, 18(1, Supplement): 139–65.

[9]. Dulock, H. L. (1993). Research Design: Descriptive Research. Journal Of Pediatric Oncology Nursing, 10(4), 154-157.

[10]. Fani, D. C. R., Innocent, O. U., & Celina, B. (2016). Analysis Of Technical Efficiency Of Small Scale Rice Farmers In The West Region Of Cameroon: A Stochastic Frontier Approach. International Journal Of African And Asian Studies, 21, 17-22.

[11]. Fincham, J. E. (2008). Response Rates And Responsiveness For Surveys, Standards, And The Journal. American Journal Of Pharmaceutical Education, 72(2).

[12]. Gadal, N., Shrestha, J., Poudel, M. N., & Pokharel, B. (2019). A Review On Production Status And Growing Environments Of Rice In Nepal And In The World. Archives Of Agriculture And Environmental Science, 4(1), 83-87.

[13]. Kasmin, M. O., & Kartomo, K. (2020). Factors Affecting The Production Of Rice Farming In Polenga Village, Kecamatan Watubangga District Kolaka Regency. Agribusiness Journal, 3(2), 15-19.

[14]. Kitsao, G. K. (2015). Technical Efficiency Differentials Between Conventional And System-Of-Rice Intensification Methods Of Rice Production In West Kano Irrigation Scheme, Kenya (Doctoral Dissertation, University Of Eldoret).

[15]. Lema, T. Z., Tessema, S. A., & Abebe, F. A. (2017). Analysis Of The Technical Efficiency Of Rice Production In Fogera District Of Ethiopia: A Stochastic Frontier Approach. Ethiopian Journal Of Economics, 26(2), 88-108.
[16]. Miassi, Y. E., Akdemir, Ş., Dossa, K. F., & Omotayo, A. O. (2023). Technical Efficiency And Constraints Related To Rice Production In West Africa: The Case Of Benin Republic. Cogent Food & Agriculture, 9(1), 2191881.
[17]. Ndayitwayeko, W. M., & Korir, M. (2012). Determinants Of Technical Efficiency In Rice Production In Gihanga (Burundi) Irrigation Scheme: A Stochastic Production Frontier Approach.
[18]. Ntiritu, G. M. (2014). Estimating Rice Production Efficiency In Kenya: A Case Study Of Mwea Irrigation Scheme (Doctoral Dissertation, University Of Nairobi).
[19]. Omondi, S. O., & Shikuku, K. M. (2013). An Analysis Of Technical Efficiency Of Rice Farmers In Ahero Irrigation Scheme, Kenya. Journal Of Economics And Sustainable Development, 4(10), 9-16.
[20]. Republic Of Kenya, & Ministry Of Agriculture. (2008). National Rice Development Strategy (2008–2018).