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An Evaluation of Economic and Scale Efficiencies of Rice Production under the Anchor Borrowers Programme in Kogi State, Nigeria: A DEA Approach

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Abstract

The persistent deficit in local rice supply in Nigeria had among other factors been attributed to the technical, allocative and scale inefficiencies of rice farmers producing independently. Research in this area of rice production continues as the deficit in rice supply remains unresolved. This study evaluated the economic efficiencies of irrigated and rain-fed rice production under the Anchor Borrowers Programme in Kogi State, Nigeria. Multi-stage sampling procedure was used to select a sample of 361 respondents from a population of 7,015-member Rice Farmers Association of Nigeria (RIFAN) in Kogi State for the study. Data were obtained from primary sources with the aid of a well-structured questionnaire and analyzed using inferential tools. Data Envelopment Analysis was carried out to estimate the technical, allocative, economic and scale efficiencies of rice farmers under the Programme. Results of the DEA analysis showed a mean economic efficiency of 0.44 for irrigated rice farmers and 0.34 for rain-fed rice farmers with scale efficiency of 0.93 and 0.89 respectively. These indicate that farmers supported by the Anchor Borrowers Programme were both economically and scale inefficient. The study recommends amongst other points that the Programme should engage Extension Agents to train farmers on effective use of inputs and climate-smart technologies to address the problem.

Key Words: Economic, Efficiency, Rice, Production, Programme

Introduction

The Federal Government of Nigeria launched the Anchor Borrowers Programme (ABP) on 17th November, 2015. Like similar previous programmes involving the rice sub-sector, the broad objective of the programme is to increase agricultural output, particularly rice and significantly improve the capacity utilization of processors by creating effective linkage between small scale farmers and large-scale processors (CBN, 2016). Related to this, are specific objectives to grow farmers from subsistence to commercial production levels and reduce agricultural commodity importation to conserve foreign exchange.

However, after years of implementation, the Anchor Borrowers Programme's effect is yet to make the expected improvement in rice output. Nevertheless, rice (*Oryzae spp*) continues to rank as one of major staple food consumed across all geo-political and socio-economic classes across Nigeria (Oyedepo and Adekambi, 2017; Kamai *et al.*, 2020), owing to its high consumption by households and used for celebration of religious and cultural festivals (Amaechina and Eboh, 2017; Bitrus *et al.,* 2021).

Because of the high acceptability of rice, it is regarded as an essential food and cash crop that generates more income for Nigerian farmers than any other cash crop in the country, hence, demand for it continues to rise (Gona *et al*., 2020). The per capita consumption of rice in Nigeria is 32kg with consumption increasing by 4.7% annually in the last decade, reaching annual consumption of 6.4 million tons in 2017 and accounting for 20% of Africa's cumulative consumption (Thrive Agric, 2020). Increase in demand for rice is attributed to population growth and shift in diet towards rice at the expense of other coarse grains with population growth accounting for 3% of the increase while shift in diet and other related reasons (increased income levels and urbanization) accounting for 97% (Nwaru and Iheke, 2010).

Notwithstanding, as of 2019, statistics by Thrive Agric (2019) indicate that Nigeria was the largest producer of rice (paddy) in Africa with an average production volume of 8 million metric tons (55% of Africa's Production Volume of 14.6 million tons ahead of Egypt's 30%) and ranked as the 14th largest producer of rice in the world. Of this quantity, output from rainfed lowland accounted for half of total rice production in the country (Ayedun and Adeniyi, 2019).

Meanwhile, data on productivity per hectare from empirical studies also showed consistent increase. Ayedun and Adeniyi (2019) reported an average national yield of 1.8 tons per hectare for production in 2012 compared with expected yield of 3.0 tons per hectare for upland and 5.0 tons per hectare for lowland production systems. This increased to an average of 2.0 tons per hectare which is about half of Asia's yield. However, Kamai *et al*. (2020) showed that average rice yield per unit area are low and range between 2.0 and 3.0 tons per hectare compared to yields of 6-8 tons per hectare recorded on experimental plots.

Low yield per hectare coupled with inadequate cropped area render Nigerian rice output low and unable to cope with the current level of high demands. The short fall in production was complemented by massive importation of about 3 million tons of rice valued at $480 million annually (Kamai *et al.* (2020), exerting more pressure on scarce foreign exchange. To reduce Nigeria's dependency on rice importation by closing the gap in the shortfall of rice production, continued increase in local rice production had been pursued. To achieve this, successive Nigerian governments came up with various initiatives to increase local rice production. These, according to Gona *et al.* (2020), include the Anchor Borrowers Programme (2015 to date).

Though rice production had been on the increase (Sani *et al*., 2010; Gona *et al*., 2020; Amaechina and Eboh, 2017), the average yield across Africa remain very low due to poor technical efficiency of rice farmers (Abiola *et al*., 2021: Ike *et al*., 2022). Thus, the rice demand-supply gap remains unbridged and Nigeria continues to be a net importer of rice. Ayedun and Adeniyi (2019) also attributes the difficulties in improving the rice yield to inefficient farm management despite intensive use of inputs. Thus, determining the economic efficiency of rice production in Nigeria is very crucial to improvement of its yield as rice is a major source of daily food intake in the country (Abiola *et al.*, 2021) and its measures are useful for performance evaluation and policy purposes of which the concept of efficiency provides a theoretical basis. In addition, Amaechina and Eboh (2017) reported that 2 key socioeconomic factors in assessing crop performance apart from biophysical and institutional factors are the technical and resource use efficiencies on the farm. Nwaru and Nweke (2010) believe that the productivity of the farmers in general and rice farmers in particular can be enhanced through enhancing their technical and allocative efficiencies in response to better information and education. Furthermore, they assert that efficiency improvement has become a very important factor in increasing productivity in developing countries due to resource poverty while Malan *et al*, (2022) affirm that efficiency score is an important indicator in the measurement of sustainable rice development (Malan *et al*., 2022).

Several other authors had carried out separate studies on technical as well as resource use efficiency in rice production in different locations and under different programmes of government but no studies have been carried out to compare the economic efficiencies of irrigated and rain-fed rice production under the Anchor Borrowers Programme in Kogi State. This study aims to fill this gap.

The main objective of this study is therefore, to determine the economic efficiencies of irrigated and rainfed rice production under the scheme and specifically, the study is to;

i. estimate the technical, allocative, scale and economic efficiencies of rice farmers under the programme;
ii. compare the technical, allocative, scale and economic efficiencies of rice farmers under the programme;
iii. estimate returns to scale by farmers under the programme;
iv. analyze input use by farmers under the programme; and
v. make appropriate recommendations as basis for implementation reviews while the programme continues.

Methodology

Study Area and Population

The study was carried out in Kogi State, Nigeria and is located in the middle belt agro-ecological zone between Latitude 7°.45’.00N of the Equator and Longitude 6°45’.00 E of the Greenwich Meridian. It is popularly called the Confluence State because the confluence of River Niger and River Benue is at its capital, Lokoja. The river assets are huge and formed the basis for calling the State the confluence of opportunities for agricultural development.

The population of the study comprised 7,015 small holder Anchor Borrower Programme (ABP) beneficiary rice farmers in Kogi State. Of this number, 5,563 beneficiary farmers were engaged in rain-fed rice production while 1,452 beneficiaries were engaged in irrigated rice production (Kogi State RIFAN, 2021).

Sampling and Data Collection

Multi-stage sampling procedure was used to select 361 respondents from the population of 7,015 ABP beneficiary rice farmers. In the first stage, purposive sampling technique was used to select 6 LGAs with substantial rice production volumes from the 21 LGAs of Kogi State. Those selected were Lokoja, Ibaji, Kogi, Idah, Bassa and Ajaokuta. In the second stage, the total population of RIFAN members (5,698) in the six LGAs was subjected to the formula by Kreijcie and Morgan (1970) to determine the representative sample from the population. The sample size was determined to be 361. Structured questionnaire were used to collect primary data from the respondents by well-trained enumerators.

Data Analysis

Data Envelopment Analytical (DEA) tool was used to estimate the technical, allocative, scale and economic efficiencies of respondent rice farmers participating in the Programme. This tool was considered appropriate because it is a non-parametric, deterministic procedure for evaluating the frontier and employs the best-practice frontier (Bates *et al.*, 1996). Unlike the Stochastic Frontier Analysis, DEA does not impose any *a priori* parametric restriction on the underlying technology (Fletschner and Zepeda, 2002 and Wu and Prato, 2006). Therefore, the DEA approach is less sensitive to misspecification relative to SFA (Watkins *et al.,* 2014). Thus, DEA does not account for noise in the data. All deviations from the frontier was thus accounted for as inefficiencies.

In addition, there are multiple outputs and multiple inputs from the rice production systems and there is not an objective way to determine the efficiency of a farmer based upon one efficiency index formula. That is, more than one farmer may be technically efficient while producing different quantity of outputs and using different input levels. Thus, using DEA, the efficiency of a farmer is the 'ratio of its total weighted output to its total weighted inputs' (Gillespie *et al.* (1997)

Technical Efficiency:

Relying on Watkins *et al.* (2014), technical efficiency for the production systems were obtained using DEA model by solving the linear programming problem specified below;

$$TE_n = \min \theta_n \quad (1)$$

Subject to:

$$\sum_{i=1}^{1} \lambda_i x_{ij} - \theta_n x_{nj} \leq 0 \quad (2)$$
$$\sum_{i=1}^{1} \lambda_i y_{ik} - y_{nk} \geq 0 \quad (3)$$
$$\sum_{i}^{1} \lambda_i = 1 \quad (4)$$
$$\lambda_i \geq 0 \quad (5)$$

Where:

i = one to I farmer; j = one to J inputs; k = one to K outputs; x_{ij} = the amount of input j used by farmer i; ; x_{nj}= amount of input j used by farmer n; y_{ik} = amount of output k produced by farmer i ; y_{nk} = amount of output k produced by farmer n ; λ_i = non-negative weights for I firms; θ_n= a scalar ≤ 1 that defines the TE of farmer n. If θ_n= 1, it means the farmer is technically efficient and if the value is less than one, it means a technically inefficient firm with the level of technical inefficiency equal to 1 - TE_n.

Economic Efficiency:

The economic efficiency (EE) score for each farmer n was obtained by solving the following input-oriented DEA model to obtain the minimum cost:

$$MC_n = min\lambda_i x^*_{nj} \sum_{j=1}^{J} p_{nj}\, x^*_{nj} \quad (6)$$

Subject to:

$$\sum_{i=1}^{j} \lambda_i\, x_{ij} - x^*_{nj} \leq 0 \quad (7)$$
$$\sum_{i=1}^{I} \lambda_i\, y_{ik} - y_{nk} \geq 0 \quad (8)$$
$$\sum_{i=1}^{I} \lambda_i = 1 \quad (9)$$
$$\lambda_i \geq 0 \quad (10)$$

Where:

MC_n= the minimum total cost for farmer n; p_{nj} = the price for input j for farmer n ; x^*_{nj}= the cost minimizing level of input j for farmer n given its input price and output levels; all other variables are as previously defined. The economic efficiency for each farmer n can then be estimated using Eq. (11)

$$EE_n = \frac{\sum_{j=1}^{J} P_{nj} x^*_{nj}}{\sum_{j=1}^{J} P_{nj} x_{nj}} \quad (11)$$

Where:

The numerator is the minimum total cost obtained for farmer n based on eqs. (6) to (10) and the denominator is the actual total cost observed for farmer n. When EE_n =1, the firm is economically efficient and EE_n < 1 means the firm is economically inefficient.

EE for each firm can also be estimated as a product of technical efficiency and allocative efficiency, expressed as:

$$EE_n = TE_n \text{ X } AE_n \quad (12)$$

Allocative Efficiency:

The allocative efficiency (AE) score for each farmer n was estimated given both TE and EE for the farmer as follows:

$$AE_n = \frac{EE_n}{TE_n} \tag{13}$$

Where:
EE_n = economic efficiency calculated for farmer n using Eq. (11) and TE_n = technical efficiency calculated for farmer n using Eqs. (1) to (5). When the value of AE_n = 1, the farmer is allocatively efficient and an AE_n < 1 means it is allocatively inefficient.
The scale efficiency (SE_n) for a farmer n is estimated as follows:

$$SE_n = \frac{TE_{CRS_n}}{TE_{VRS_n}} \tag{14}$$

Where:
TE_{CRS_n} = technical efficiency of a farmer n under constant returns to scale and TE_{VRS_n}= technical efficiency under variable returns to scale. When SE_n = 1, it means the firm is operating at an optimal scale and when SE_n < 1, the firm is scale inefficient. Scale inefficiency arises as a result of the presence of increasing returns to scale (IRS) or decreasing returns to scale (DRS). The computer program DEAP version 2.1 developed by Coelli (1996) was used to estimate the technical, allocative, cost and scale efficiency of the rice farmers.

Results and Discussion

Technical, Allocative and Economic and Scale Efficiencies of Rice Farmers under the Programme

The technical efficiencies of the irrigated and rainfed farmers are presented both under the Constant Return to Scale (CRS) and Variable Return to Scale (VRS) as shown on table 1. The mean technical efficiency of irrigated rice farmers under the CRS was 0.76 while that of rainfed rice farmers was 0.62. The minimum efficiency score for the irrigated and rainfed farmers under this measure were 0.43 and 0.35 respectively while the maximum was 1.0. For the Variable Return to Scale (VRS), the mean technical efficiency score for the irrigated and rainfed rice farmers were respectively 0.82 and 0.70. The minimum efficiency score for the irrigated rice farmers was 0.53 while that of rainfed rice farmers was 0.46. The maximum score is 1.0. The scores from the VRS were higher than that of CRS because it does not take cognizance of standard error in the measurement. A total of 8 irrigated rice farmers (8.69%) and 7 rain-fed rice farmers (2.63%) attained full technical efficiency when assessed by CRS. Also, 17 irrigated rice farmers (18.47%) and 18 rainfed rice farmers (6.76%) attained full technical efficiency by the VRS. These group of farmers were likely to reduce their cost of production and improve their profits.

This implies that considering the CRS, 91.31% of irrigated rice farmers and 97.37% of rainfed rice farmers operated at various levels of technical inefficiencies in the production of rice under the programme. Specifically, 82 irrigated rice farmers and 212 rainfed rice farmers operated in the technical inefficiency range of 0.4 to 0.5 while 2 irrigated rice farmers and 47 rainfed rice farmers operated at 0.6 inefficiency level. However, on the average, the technically inefficient irrigated and rainfed rice farmers can increase their efficiencies by 0.24 (24 %) and 0.38 (38 %) respectively to attain full technical efficiency.

Comparatively, the technical efficiency scores obtained from this study are lower than that obtained by Gona *et al.* (2020) who obtained a minimum of 0.77 from his study on the effect of ABP on the technical efficiency of beneficiary farmers in Kebbi State, Nigeria. This could be due to years of commercialization of rice farming in Kebbi State. Notwithstanding, the result is lower than the mean technical efficiency scores of 0.81 obtained from study on the assessment of technical efficiency of rice production in north central Nigeria by Abiola *et al.* (2021); mean score of 0.80 obtained by Umanath and Rajasekar (2013) from their estimation of technical efficiency of paddy farms in India; and mean score of 0.80 by Watkins et al. (2014) from their measurement of technical efficiency in rice production in Arkansas, USA. Efforts must be made to improve the efficiency scores of 2.17 % of irrigated rice farmers and 17.66 % of rainfed rice farmers who operated lower than 0.50 efficiency score to economically allowable efficiency range of 0.50 to 0.99.

Furthermore, the table 1 shows that the mean allocative efficiency of the irrigated rice farmers was 0.57 while that of the rainfed rice farmers was 0.56. The minimum allocative efficiency score was respectively 0.27 and 0.29 while the maximum was 1.0. Only one farmer each from the irrigated and rainfed rice production systems attained full allocative efficiency. This implies that the rice farmers were not using inputs in a cost-minimizing level given the prices of inputs they used and that cost may on the average be reduced by 43% and 44% respectively to attain the level of the best allocative efficient farmer. This result is contrary to those obtained by Sani *et al* (2010), which showed that land, labour and fertilizer were under-utilized and needed to be increased to attain optimum allocative efficiency levels; Subedi *et al.* (2020) which reported that farmers in Jhapa district of Nepal did not attain allocative efficiency as there was either under-utilization or over-utilization of farm inputs; and Maamun (1979) that farm resources in Sulawesi were under-utilized and needed to be increased to attain allocative efficiency level.

Meanwhile, table 1 also showed that the mean economic efficiency of the irrigated rice farmers was 0.44 while that of rainfed rice farmers was 0.34. The minimum economic efficiency attained by the irrigated rice farmers was 0.21 while that of rainfed rice farmers was 0.16. The maximum attainable by both is 1.0. Only one farmer each from the two production systems attained full economic efficiency in rice production under the programme. This implies that most of the farmers were economically inefficient and could reduce the cost of rice production by 66% and 76% respectively and still achieve the same level of output.

In addition, the results indicate that the mean scale efficiency attained by the irrigated rice farmers was 0.93 while that attained by the rainfed rice farmers was 0.89. The minimum attained in either case was respectively 0.71 and 0.65 with 1.0 as the maximum attainable. A total of 9 farmers each (1.08% of irrigated rice farmers and 3.38% of rainfed rice farmers) attained full scale efficiency. The scale inefficient farmers in either case can increase their scale of production by 7% and 11% respectively to attain full scale efficiency.

Table 1: Technical, Allocative, Economic and Scale Efficiency Indexes of Respondents

Class	**TECRS**		**TEVRS**		**Allo. Efficiency**		**Eco. Efficiency**		**Scale Efficiency**	
	Irrig.	**Rainfed**	**Irrig.**	**Rainfed**	**Irrig.**	**Rainfed**	**Irrig.**	**Rainfed**	**Irrig.**	**Rainfed**
1	8	7	17	18	1	1	1	1	9	9
0.9 -- 0.999	6	11	13	5	0	0	0	0	56	127
0.8 -- 0.899	15	9	16	31	3	14	0	3	19	82
0.7 -- 0.799	33	39	28	68	10	27	2	0	8	38
0.6 -- 0.699	23	67	17	94	23	54	7	4	0	10
0.5 -- 0.599	5	86	1	46	24	67	15	16	0	0
0.4 -- 0.499	2	46	0	4	24	69	28	39	0	0
0.3 -- 0.399	0	1	0	0	6	33	29	90	0	0
0.2 -- 0.299	0	0	0	0	1	1	10	106	0	0
0.1 -- 0.199	0	0	0	0	0	0	0	7	0	0
Total	92	266	92	266	92	266	92	266	92	266
Mean	0.76	0.62	0.82	0.7	0.57	0.56	0.44	0.34	0.93	0.89
Min	0.43	0.35	0.53	0.46	0.27	0.29	0.21	0.16	0.71	0.65
Max	1	1	1	1	1	1	1	1	1	1

*Irrig. (Irrigated); Allo. (Allocative); Econ (Economic)
Source: Authors' Computation (2023)

Returns to Scale of Rice Farmers under the Programme

Table 2 show the summary of returns to scale of the respondents in the study. It showed that 85.75% of all the respondents made of 73.91% of irrigated rice farmers and 90.60% of rainfed rice farmers were producing at increasing returns to scale (sub-optimal scale). This implies that the cropped area by most of the farmers were too small and they could do better with an increase in scale. Also, 9.50% of the respondents made of 16.30% of irrigated rice farmers and 6.02% of rainfed rice farmers were operating at decreasing returns to scale (above optimal size) while only 4.75% of the respondents made of 9.78% of irrigated rice farmers and 3.38% of rainfed rice farmers were operating at constant return to scale (optimal size).

Table 2: Returns to Scale of Respondents

	Irrigated		**Rainfed**		**Pooled**	
Scale Efficiency*	**Freq.**	**Perc.**	**Freq.**	**Perc.**	**Freq.**	**Perc.**
IRS	68	73.91	241	90.60	307	85.75
CRS	9	9.78	9	3.38	17	4.75
DRS	15	16.30	16	6.02	34	9.50
Total	92	100.00	266	100.00	358	100.00

*IRS (Increasing Returns to Scale); CRS (Constant Returns to Scale); DRS (Decreasing Returns to Scale)

Source: Authors' Computation (2023)

Table 3 shows the test of difference in the means of technical, allocative and economic efficiencies of respondents in the study. The Z-Cal shows that there is significant difference in technical efficiencies between irrigated and rainfed rice farmers under the programme at 99% confidence level. Similarly, the Z Cal shows significant difference in economic efficiency between the irrigated and rainfed rice farmers at 99% confidence level. The difference in allocative efficiency between the respondents of the two production systems is however, not significant. This means that we reject the null hypothesis (H_o) that there is no significant difference in technical and economic efficiencies between the irrigated and rainfed rice farmers and accept the alternate hypothesis (H_a) that there is significant difference in technical and economic efficiencies of rice farmers under the Programme. We, however, accept the null hypothesis that there is no significant difference in allocative efficiencies between the irrigated and rainfed rice farmers under the programme.

Meanwhile, the null hypothesis that rice farmers under the irrigated and rainfed production systems of the programme were not technically, allocatively and economically efficient is rejected since 8 irrigated rice farmers (8.69%) and 7 rainfed rice farmers (2.63%) attained full technical efficiency; 1 irrigated and 1 rainfed farmers attained full allocative efficiency; and 1 irrigated and 1 rainfed farmers also attained full economic efficiency among the respondents.

Table 3: Test of Differences in Means of TE, AE and EE of Respondents

Efficiency/Group	Tech. Efficiency	Alloc. Efficiency	Eco. Efficiency
Irrigated	0.76	0.57	0.44
Rainfed	0.62	0.56	0.34
Z-Cal.	8.18***	0.58	6.26***
Z-tab (0.05)	1.96	1.96	1.06
Remarks	Significant	Not Significant	Significant

***p < 0.001
Source: Authors' Computation (2023)

Table 4 shows the summary of the input slacks for achieving optimum rice output. The distribution of the slack presented on the table follows the Variable Returns to Scale (VRS) assumption and indicates the excess of input used (Haruna *et al*. (2020). According to Sivasankari *et al*. (2017), expenditures can be reduced by decreasing the inputs by the amount of the slack, without reducing the output. Table 4 showed that all the farm inputs were used in excess but seed, fertilizer, and labour were the most excessively used. For rainfed rice producers, farm labour recorded the highest mean input slack of 40.22. This means that 23.14% of man-day were used in excess. This was followed by seed with mean input slack of 23.43 indicating that 19.38% of seeds were used in excess. The excessive use of labour could be attributed to the availability and use of family labour for farm operations but for which immediate cash payments were not made but charged as opportunity cost. Also, the excessive use of seeds could be attributed to the habit of rice seed broadcasting by the majority of farmers interviewed. Though, fertilizer was used in excess, only 4.58% from a mean slack of 13.18 was recorded.

For the irrigated rice producers, all the inputs were also used in excess but land, seed and labour were the most excessively used. Consequently, if the mean input used and mean input slack are compared, Land, seed and labour were over used by 9.92%, 8.82% and 7.45% respectively. These also occurred as a result of use of family labour and rice seed broadcasting respectively. Farmers in this category were likely to have unnecessarily increased their cost of production and consequently reduce their potential profits.

Table 4: Summary of Input Slacks for Achieving Optimum (Technically Efficient) Rice Output

	Rainfed				Irrigated			
Input	**Mean Input Used**	**Mean Input Slack**	**Input Slack over mean Input used (%)**	**No of Farmers**	**Mean Input Used**	**Mean Input Slack**	**Input Slack over mean Input used (%)**	**No of Farmers**
Land	1.69	0.33	19.41	204	1.82	0.18	9.92	52
Seed	120.87	23.43	19.38	190	130.83	11.54	8.82	56
Fertilizer	287.77	13.18	4.58	82	274.19	5.33	1.94	10
Herbicide	4.01	0.01	0.25	6	3.90	0.02	0.38	3
Labour	173.82	40.22	23.14	191	160.88	11.98	7.45	33

Source: Authors' Computation (2023)

Table 5 presents output and input targets for achieving optimum rice production. For the rainfed rice farmers, output target was 1,618 kg per ha but 1,567.63 was achieved. This left a short fall of 50.37kg (3.11%) of targeted output per ha. Conversely, all the inputs used for production over shot the targets for optimum output. Thus, 0.82 ha of land, 58.38 kg of rice seeds, 185.09 kg of fertilizer, 2.76 litres of herbicides and 81.13 man-days of labour were required for 1,618 kg of paddy but was exceeded by 0.87 ha, 62.49 kg, 102.68kg, 1.25 litres and 92.69 man-days respectively. Similarly, the output target for optimum production by irrigated rice farmers was 1,857.88kg per ha but only 1,805.05 kg per ha was achieved leaving a short fall of 52.82 kg (2.84%) of targeted output per ha. However, the mean targeted inputs were all exceeded. Hence, 1.28 ha of land, 93.16 kg of rice seed, 217.42 kg of fertilizers, 3.15 litres of herbicides and 116.73 man-days of labour targeted were exceeded by 0.54ha, 37.67 kg of rice seed, 56.77 kg of fertilizers, 0.75 litres of herbicides and 44.15 man-days of labour respectively. These excessive use of inputs and shortfall in projected output are evidences of technical inefficiency of the farmers.

Table 5: Output and Input Targets for Achieving Optimum (Technically Efficient) Rice Production

	Rainfed				Irrigated			
Output and Input	Mean Output Achieved/ Input Used	Mean Target	Excess/ Shortfall	Excess/ Shortfall (%)	Mean Output Achieved/ Input Used	Mean Target	Excess/ Shortfall	Excess/ Shortfall (%)
Output	1567.63	1618.00	-50.37	-3.11	1805.05	1857.88	-52.82	-2.84
Land	1.69	0.82	0.87	106.10	1.82	1.28	0.54	41.80
Seed	120.87	58.38	62.49	107.04	130.83	93.16	37.67	40.43
Fertilizer	287.77	185.09	102.68	55.48	274.19	217.42	56.77	26.11
Herbicide	4.01	2.76	1.25	45.29	3.90	3.15	0.75	23.81
Labour	173.82	81.13	92.69	114.25	160.88	116.73	44.15	37.82

Source: Authors' Computation (2023)

Table 6 relates the excess inputs used to the optimum input combination that minimizes input costs of rice production. For the rainfed rice producers, the mean input used for all categories of inputs exceeded the mean cost minimizing input levels targeted, except for herbicides that was lower. The mean cost minimizing input levels targeted for 0.55 ha were 41.51 kg of seed per ha, 163.86 kg of fertilizer per ha, 5.46 litres of herbicides per ha, 38.24man-days of labour per ha but 120.87kg of seed, 287.77 kg of fertilizer, 4.0l litres of herbicides and 173.82 man-days of labour were used for 1.69 ha of land, respectively. These resulted to an excessive use of 1.14ha of land (67.69%), 79.36kg of seeds (65.66%), 123.91kg of fertilizers (43.06%), 135.59 man-days of labour (78%) and shortfall of 1.45 litres of herbicides (36.21%) respectively.

Similarly, for irrigated rice production system, the mean cost minimizing input levels targeted for 0.86 ha were 65.33 kg of seed per ha, 85.95 kg of fertilizer per ha, 3.44 litres of herbicides per ha, 63.61man-days of labour per ha but 130.83kg of seed, 274.19 kg of fertilizer, 3.90 litres of herbicides and 160.88 man-days of labour were used for 1.82 ha of land, respectively. These resulted to an excessive use of 0.96ha of land (52.67%), 65.50kg of seeds (50.07%), 188.23kg of fertilizers (68.65%), 97.27 man-days of labour (60.46%) and 0.46 litres of herbicides (11.85%) respectively.

In summary, all the inputs were used above their cost minimizing quantities by both the irrigated and rainfed producers. However, labour (78%) was the most excessively used by rainfed farmers followed by fertilizer by the irrigated rice farmers. The excessive use of inputs by an average of 48.77% above their cost minimizing quantities by irrigated rice farmers and 43.64% by rainfed farmers were evidence that the farmers studied did not take input prices into serious consideration to attain allocative and economic efficiency.

Table 6: Analysis of Input used for Achieving minimum (Economically Efficient) Costs of Rice Production

	Rainfed				Irrigated			
Input	**Mean Cost Minimizing Input Used**	**Mean Input Used**	**Excess Input Used**	**Excess Input used over Mean input used (%)**	**Mean Cost Minimizing Input Used**	**Mean Input Used**	**Excess Input Used**	**Excess Input used over Mean input used (%)**
Land	0.55	1.69	1.14	67.69	0.86	1.82	0.96	52.67
Seed	41.51	120.87	79.36	65.66	65.33	130.83	65.50	50.07
Fertilizer	163.86	287.77	123.91	43.06	85.95	274.19	188.23	68.65
Herbicide	5.46	4.01	-1.45	-36.21	3.44	3.90	0.46	11.85
Labour	38.24	173.82	135.59	78.00	63.61	160.88	97.27	60.46

Source: Authors' Computation (2023)

Conclusions and Recommendations

The study finds that majority of the farmers from both production systems were not economically and scale efficient. The results of Data Envelopment Analysis showed that the mean technical, allocative, economic and scale inefficiency for the irrigated rice farmers were 0.76, 0.57, 0.44 and 0.93 respectively while those of the rainfed rice farmers were 0.62, 0.56, 0.34 and 0.89 respectively. This indicate that the irrigated rice farmers were generally more efficient. There was significant difference in technical and economic efficiencies between the irrigated and rain-fed farmers under the programme. However, the difference in allocative efficiencies between the irrigated and rain-fed rice farmers is not significant. Over use of input was obviously observed among majority of the respondents and responsible for the economic and allocative inefficiencies of the farmers.

The study recommend that effective extension service delivery system should be included in the programme package, where Extension Agents are posted to farm clusters to train farmers on effective use of inputs and climate smart technologies to improve yield. Also, input support packages of the programme such as fertilizer, herbicides, pesticides and improved seeds should be made available to the farmers before the commencement of the planting season to reduce the incidence of farmers selling off their redeemed inputs. These will go a long way to boosting the technical knowledge of the farmers; build their resilience against climate induced failures; and guarantee timely access to farm inputs so as to address the problems of inefficiencies.

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