

How Zakat Affects the Technical Efficiency of Irrigated Rice Farmers Adopting Higher-Yielding Varieties (HYV) in Kano State, Nigeria

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ABSTRACT

Rice farming in Kano State is yielding low turnover despite the fact that larger hectares of land are devoted to it than in other producing States. This study empirically analysed the technical efficiency of irrigated rice farming that uses Higher Yielding Varieties in Kano State. The study was designed to be cross-sectional and used a structured questionnaire to collect data from 590 irrigated rice farmers in Kano State. The study applied the Stochastic Frontier Model for data analysis. The outcome revealed that higher-yielding variety irrigated rice farmers have a weak efficiency index with a significant coefficient of Lambda, signifying the presence of technical inefficiency contributed by the year of farming experience, educational levels, and frequency of extension contacts. Also, the study indicates that higher-yielding varieties irrigated rice farmers have an average efficiency score of 0.128 (12.8% efficiency index) with a 77.2% efficiency gap to the optimum efficiency level. The minimum and maximum efficiency scores were 0.079 and 0.228 (7.9% & 22.8%), indicating that 66% of cost habit is required by the minimum-efficiency irrigated rice farmers to boost to a higher efficiency level. The study concludes that Higher Yielding Varieties irrigated rice farmers' technical inefficiency was attributed to the Zakah, year of farming experience, educational level, and frequency of extension contact, and Higher Yielding Varieties irrigated rice farmers enjoy a weak efficiency score. Lastly, the study recommends improving Higher Yielding Varieties utilization among irrigated rice farmers through effective and timely extension visitations.

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Introduction

One of the most urgent needs in the world today is the reduction of the pervasive problems of hunger and poverty in developing countries. Despite many efforts by governments, donors, and non-governmental organizations with some level of success, millions of people remain ill-fed, poorly housed, under-employed, and afflicted by a variety of illnesses; as a result, these people regularly suffer the pain of watching loved ones die prematurely, often from preventable causes (Norton, Alwang and Masters, 2010). Food security, poverty reduction and youth employment generation are the major issues that attract attention towards agriculture, which bring about a number of policies, programmes and resolutions directly or indirectly related to addressing such issues.

Food consumption globally, like its production counterpart, has grown by about 2.2 percent per annum since 1970, but in developing countries, consumption has grown faster by 3.7 percent, higher than 3.5 percent in production (Garba, 2019). Therefore, cereal imports globally have shown significant growth, reaching 455 million tons in 2024, with developing countries being major contributors. Nigeria, for instance, is projected to become the second-largest importer of rice, increasing imports by 2.4 million tonnes to 4 million tonnes by 2032. Also, Africa's cereal imports are expected to rise from about 18 million tonnes to about 29 million tonnes by 2032 (Obianefo et al., 2020)

Rice is one of the most important cereal crops grown globally and has been growing in importance due to its pervasive use and utility. Rice has been a staple human food source in many parts of the world whose consumption crosses cultures, religions, ethnic groups, and geographical boundaries; Nigeria remains the leading producer in the West African sub-region over the years (Garba, 2019). In fact, rice has been grown in virtually all the agro-ecological zones of the country, with the highest production from the North-western agro-ecological zone (Growth and Employment in States Number 4 [GEMS4], 2019). However, due to the rapidly increasing population growth and the shift in consumers' preferences in favour of rice, production of rice fails to meet its rising domestic demand (Egbodion and Ahmadu, 2015).

Persistent rise in the demand for rice and continuous decrease in the farm labour supply are the major factors that made farm modernization imperative globally. Insufficient rice production, shift in consumers' preferences towards rice consumption and the rapidly increasing population amounted to the hot rice demand in the world on one hand and the growing urban sector as well as the rural non-farm economy are the driving forces for the continuous decrease in the farm labour supply on the other hand.

Rijk (1989) reported that solving the problems of drudgery, high cost of production, low quality output, low cropping intensity as well as labour scarcity; technology options particularly the mechanization is required in rice cultivation. In line to this, Tilakaratna and Tilakaratna (2000) reported that through the history of farm technology various and appropriate options had been used, changing from time to time and today the major concern is that of lowering the cost of production, increasing productivity and solving the problem of labour scarcity. This study investigates the technical efficiency of irrigated rice farmers adopting Higher Yielding Varieties (HYVs) in Kano State. The study was organized in five sections. Besides this section, section two is the literature review; section three is the methodology; section four presents the results and discussion. Finally, section five covers conclusions and recommendations.

Literature Review

Empirically, Obianefo et al. (2020) investigated the technical efficiency of rice farmers in Anambra State value chain development programme, using primary data collected via a well structured questionnaire administered among 372 respondents. The study employed Cobb Douglas Stochastic Frontier Model, using sex and farming experience as the determinants of technical efficiency. The study found out that about 3.15% variation in the farmers' technical efficiency is explained by inefficiency factors. Also, the mean technical efficiency as predicted in the study was 84.76% which implies 15.24% operation below optimum production capacity. Also, Zoogah and Nakuja (2020) investigated modernizing extension services to improve rice productivity: Lessons from Ghana's planting for food and jobs program, to specifically analyze the productivity difference between beneficiaries and non-beneficiaries of the modernized extension service among rice farmers in the Talensi District of Ghana. Primary data is utilized based on a multi-stage sampling technique during the 2019 production season. The study applied an independent-samples t-test to analyse the data and found out that benefited farmers from the program were more productive than non-benefited ones, with an average yield 140kg/acre higher than their non-benefitted counterparts.

Ifeanyichukwu et al. (2016) analyzed the technical inefficiency in rice production among farmers in Ezza South LGA of Ebonyi State of Nigeria. The study used primary data collected using a structured and pre-tested questionnaire as well as oral interviews administered among the 120 selected rice farmers using a multistage sampling technique. The study adopted the Stochastic Frontier Production Function for data analysis and found that the level of technical inefficiency ranges from 0.24 to 0.98, with a mean technical inefficiency of 0.56. The major determinants of technical inefficiency in rice production in the study area include high cost of improved inputs, poor access to information, poor access to credit, and problems of diseases and pests. Another Study by Challa (2016) explored the prospects and challenges of agricultural mechanization in Oromia Regional State, Ethiopia. The study used a checklist and both structured and Unstructured Questionnaires to collect data and employed a multi-stage sampling technique to administer the questionnaires. Descriptive and Logistic regression were used to analyze the data. The study found that the technology utilization status was very low; socio-economic characteristics of respondents were the main contributors to the low utilization, and poor government attention was the most crucial factor for the malfunction of different stakeholders in the study area.

Furthermore, Yukio and Kimura (2016) carried out a study on modeling farm management modernization: Case study of Japanese rice farming corporation, using primary data collected using a questionnaire administered among 2,260 agricultural corporations across Japan in 2014 and 2016. The study utilized a Structural Equation Model and found that the sampled corporations did demonstrate moderate degrees of modernization; they have not yet completely changed from the conventional style to the modern one. Also, it found that farm modernization is significantly affected by both production and business management systems. Farm modernization has revolutionized agriculture and continues to do so today. Some of the most significant increases ever observed in Total Factor Productivity (TFP) in agriculture have been achieved as a result of the introduction of agricultural modernization. Agricultural modernization is a central, indispensable pillar for making farm operations efficient and productive insofar as it determines much of the efficiency and productivity of all the other inputs used in crop

production such as seeds, fertilizer, water, labour, and time. In short, modern agriculture would be impossible without advanced machinery solutions and the use of Higher Yielding Varieties (CEMA, 2014).

CEMA further reported that the use of modernization in farming still differs hugely across the globe. The United Nations Industrial Development Office (UNIDO) as cited in CEMA (2014) has defined 12 different levels of Agricultural modernization: the highest levels of modernization (levels 9–12) are typically found in the USA and Western European countries; average modernization levels range from level five in Morocco, level four in Botswana, to merely level one in Cameroon. By contrast, exceptionally low levels of modernization persist in many developing countries, particularly in Africa, which remains the most challenging region for modernization. Here, in Sub-Saharan Africa (SSA), land productivity is among the lowest in the world, and agricultural modernization has either stagnated or retrogressed in recent years (CEMA, 2014).

In this study, the Cobb-Douglas Production Function Theory developed by Paul H. Douglas and C. W. Cobb, which connects factor inputs and outputs, will be adopted as the theoretical anchor to hinge the entire study. Therefore, given the level of technology, the set of raw materials, labour, and capital to be used in paddy rice farming during the period of study is the set of input factors to be used in the model, and the paddy rice produced (turnout) at the end of the production period is the output. In this study, the said level of technology refers to the land-saving technology.

Therefore, the theoretical model based on the actual Cobb-Douglas is specified thus:

$$Q = AL^{\alpha}K^{\beta} \dots \dots \dots (i)$$

Where Q is output, L and K are inputs of labour and capital respectively while A , which is the residual often called technical change. A , α and β are positive parameters where $\alpha > 0, \beta > 0$.

Method

According to the University of Southern California Library [USCL] (2016), a research design is a systematic plan to study a scientific problem(s). It defines the study type and sub-types (if any), research question, hypotheses, data collection methods, and statistical analysis plan. The research approach in this study is cross-sectional and causal-effect. Causal effect, i.e., a nomothetic perspective, occurs when variation in one phenomenon, an independent variable, leads to, on average, variation in another phenomenon, the dependent variable. The selection of this type of design is informed by the fact that the study intends to carry out a survey among heterogeneous paddy rice irrigation farmers across the areas of the study in relation to their experience in utilizing HYVs in rice production. The design of this nature has greater confidence as it has internal validity due to the systematic subject selection and equity of groups being compared (USCL, 2016).

Population is the total number of units from which data can be collected, such as individuals, artifacts, events or organizations. In the words of Burns and Grove (2003), population has been described as all the elements that meet the criteria of being included in the study. This study will cover all paddy rice irrigation farmers in Kura Town, Kano State. Hence, the population of the study comprises all paddy rice farmers by irrigation across the area of the study, especially those who are officially registered in farming within the period of the study. Considering the above, the study will cover a total of 143,768 paddy rice irrigation farmers.

The sample size in this study follows the formula developed by Yamane (1967). Thus;

$$n = \frac{N}{1 + N(e)^2}$$

Hence at 5% (0.05), $n = \frac{143,768}{1 + 143,768 (0.05)^2} = 399$

Effort to address the issue of non-response bias led to the use of a higher sample of 590 based on the formula developed by Fox, Hunn and Mathers (2007). The sample frame of each rice production cluster follows the Proportional Factor as adopted in the work of Abdullahi and Tijani (2012). Proportional Factor was used to determine the sample size in the clusters purposively. With respect to the sampling technique, multi-stage cluster sampling will be adopted to select the paddy irrigation rice farmers. North West comprises those states that dominantly fall in irrigated land ecology in Nigeria with an average yield of 3.5 tonnes per hectare, which has been proven to be the most efficient compared to other farming ecologies in the country (Tope et al., 2012; Akintayo et al., 2010; Saka & Lawal, 2009).

Technique of Data Analysis

According to Tun & Kang (2015), Stochastic Frontier Model is a linear regression model with a non-normal, asymmetric disturbance terms which is used to model efficiency in agricultural economics literature in such a way that output is a function of a set of inputs, inefficiency and the random error. The Model was firstly introduced independently by Aigner, Lovell and Schmidt (1977) and Meeusen and Van Den Broeck (1977). The first application of the model was done by Battese and Corra (1977), while its first specification in Cobb-Douglas form using cross-sectional data was done by Kalirajan (1981). Elsewhere in Africa, Soyoun et al. (1998) used it to measure the technical efficiency of maize producers in eastern Ethiopia; Audu and Huffman (2000) used it to analyze the economic efficiency of rice farmers in northern Ghana; Mochebelele and Winter-Nelson (2002) used it to study smallholders' efficiency in Lesotho; Gautum and Jeffrey (2003) used it to measure efficiency among smallholder tobacco cultivators in Malawi.

In Nigeria, the model was used by Ajibefun and Daramola (1999) and Ajibefun, Battese and Daramola (2002) to investigate the sources of technical efficiency in poultry egg production in Ondo State and to determine the technical efficiency in smallholder food crop farming, respectively; Garba (2019) applied the same model to estimate the technical efficiency of irrigated rice farmers in Kano State. Also, Ogundele and Okoruwa (2006) used this model to analyze the technical efficiency differentials of two rice production technologies. According to Baten, Kamil and Hague (2009), the Stochastic Frontier Approach is preferred for assessing efficiency in agriculture because of the inherent stochasticity involved. Baten et al. (2009) further reported that several extensions of the Stochastic Frontier Model had been applied in empirical studies like Forsund et al. (1980), Schmidt (1986), Bauer (1990) and Battese (1992). Stochastic Frontier Model has been used in this study to achieve objective two.

Model Specification

Following Hidayah et al. (2013) the study proposes a multiplicative stochastic production function of the form:

$$Y_{it} = X_{it}\beta + \epsilon_{it} \dots \dots \dots (i)$$

Where:

Y_{it} = The rice output of the i th irrigation farmer.

X_{it} = A vector of K inputs used by the i th paddy rice irrigation farmer.

β = A vector of parameter to be estimated and

ϵ_{it} = The farm specific composite residual term comprising a random error i.e. V_i and an inefficiency component i.e. U_i , thus:

$$\epsilon_{it} = (V_{it} - U_{it}) \dots \dots \dots (ii)$$

$$(i = 1, 2, 3, \dots \dots N) \text{ and } (t = 1, 2, 3, \dots \dots T)$$

The two components of V_{it} and U_{it} are assumed to be independent of each other, where V_i is the two-sided normally distributed error term i.e. $V_{it} \approx N(0, \sigma_v^2)$ that captures the random effects outside the control of the farmer, like fire, incidence of pests, e.t.c. and U_{it} is a one-sided half-normal distributed efficiency component i.e. $U_{it} \sim |N(0, \sigma_u^2)|$ due the farmer's level of education, farming experience, e.t.c. Donkoh et al. (2015).

Transformation of the above equations to natural logarithms yields the Cobb-Douglas specification with Maximum Likelihood Estimators in Battese and Corra (1977) parameterization. Thus;

$$\ln Y_{it} = \beta_0 + \beta_1 \ln X_{it} + \epsilon_{it} \dots \dots \dots (iii)$$

The importance of Maximum Likelihood Estimation is not only for the estimation of parameters β_0 , β_1 and ϵ but also for the two variances of σ_v^2 and σ_u^2 . which is used to measure the value of γ which is the contribution of technical efficiency of the total residual effect. Therefore, the value of γ lies between zero and one ($0 \leq \gamma \leq 1$).

Empirically, the model proposes to follow the Cobb-Douglas Stochastic model specification as adopted from Ogundele and Okoruwa (2006). In the view of Baten et al. (2009), the Cobb-Douglas functional form is preferred to other functional forms if there are three or more independent variables in the model for simplicity in interpretation. Hence, the Cobb-Douglas stochastic frontier production function with 11 independent variables will be applied in this study. The selection of the variables follows the preceding studies adopted with little modifications from Bamiro and Aloro (2013); Girei, Dire, Iliya and Salihu (2013); Saka and Lawal (2009); Ogundele and Okoruwa (2006); Forsund, Lovell and Schmidt (1980).

According to Girei et al. (2013) technical efficiency effects are assumed to be independently distributed and U_i arises by truncation (at zero) of the normal distribution with a mean μ_i and variance σ^2 where μ_i is defined thus:

$$\mu_{ij} = \delta_0 + \delta_1 Z1_{ij} + \delta_2 Z2_{ij} + \delta_3 Z3_{ij} + \delta_4 Z4_{ij} + \delta_5 Z5_{ij} + \delta_6 Z6_{ij} \dots \dots \dots (iv)$$

Where

μ_{ij} = Technical efficiency of i th irrigated rice farmers;

$Z1$ = Nisab of Zakah;

$Z2$ = Year of farming experience;

$Z3$ = Level of farmer's education;

$Z4$ = Frequency of Extension Contacts;

$Z5$ = Household Size;

$Z6$ = Age of irrigated rice farmer;

$\delta_0, \delta_1, \delta_2, \delta_3, \delta_4, \delta_5$, and δ_6 are $0 < \delta \leq 1$

Thus, the empirical technical efficiency model is specified as:

$$TE_{ij} = \delta_0 + \delta_1 NZakah_{ij} + \delta_2 YearFarmExp_{ij} + \delta_3 EduLevel_{ij} + \delta_4 FreqExtCont_{ij} \\ + \delta_5 HhSz_{ij} + \delta_6 AgeIrrFarmr_{ij} \dots \dots \dots (v)$$

Results

Kano State, one of the 36 States of Nigeria, was created in 1967, and now it has 44 Local Government areas with a population of ... (). The State is characterized by a tropical wet and dry climate with a daily mean maximum temperature of 30^o C to 35^o C between March and May, with a mean temperature of 10^o C between the months of October and February. The wet season is from May to September, while the dry season lasts from October to April (KNARDA, 2008). Kano State is situated in the Sudan Savannah agro-ecological zone of Nigeria, which is located between the latitude 9^o30" and 10^o33" to 12^o37" North and longitude 7^o34 to 9^o25" East. The state has 22 dams occupying a total land area of about 18,684 Km square kilometers, equivalent to 22,000 hectares (2004).

Agriculture is among the predominant economic activities during the rainy and dry seasons. In the dry season, farming is carried out on an irrigation basis due to inadequate rainfall, except for some vegetables, gardening, and maize farming (Wali, 2012). Among the active irrigation resources is Challawa, Bagauda/Tiga, Kusalla, Tomas, Kafin Chiri, Jakara, Ruwan Kanya, Tudun Wada, Guzu-Guzu, Watari, Magaga, Pada, Gari, Karaye and Marsha (Abdullahi, 2015). The most important irrigation infrastructure in the State is the Kano River Phase I, which covers 15, 000 hectare (Hadeja Jama'are River Basin Development Authority [HJRBD A], 2004). Additionally, the available rice-producing sub-clusters include Larabar Gadon Sarki, Kura, Karfi, Dorawar Sallau, Garin Ali, Garun Babba, Kadawa, Ciromawa, Doka-Sati, Nata'ala, Zangon Buhari, Butulawa, Tagwaye, Dabai, Yarkawu and Lautaye (GEMS4, 2017).

Table 1. Socio-economic characteristics of Respondents

S/N	Item	Frequency	Percentage (%)
1	Gender		
	Male	530	92.98
	Female	040	07.02
	Total	570	100.00
2	Age		
	<25 Years	030	05.26
	25-50 Years	470	82.46
	>50 Years	070	12.28
	Total	570	100.00
3	Marital Status		
	Married	500	87.72
	Single	070	12.28
	Total	570	100.00
4	Household Size		
	1-5	270	48.77
	6-10	140	24.56
	>10	152	26.67
	Total	570	100.00
5	Level of Education		
	O level	368	64.56
	Diploma/NCE	040	07.02
	Degree/HND	010	01.75

	Postgraduate	010	01.75
	Islamic	142	24.91
	Total	570	100.00
6	Farm Size		
	< 1 Hectare	288	50.53
	1-2 Hectare	252	44.21
	>2 Hectare	030	05.26
	Total	570	100.00
7	Year of Farming Experience		
	< 5 Years	200	35.09
	5-10 Years	270	47.37
	>10 Years	100	17.54
	Total	570	100.00
8	Co-operative Membership		
	Farmers with Membership	238	41.75
	Farmers without Membership	332	58.25
	Total	570	100.00
9	Frequency of Extension Contact		
	No Contact	344	60.35
	One contact	053	09.30
	Twice	051	08.95
	Many Contact	122	21.40
	Total	570	100.00

Source: Researchers' Estimation, 2025.

Based on the outcome of Table 1, the majority of higher-yielding varieties irrigated rice farmers in Kano State were found to be predominantly male by gender (92.98%), with a very small number of females, only 7.2 per cent. Higher-yielding varieties irrigated rice farmers are mostly active and productive between the ages of 25-50 years (82.46%), married, with at least minimum of 1-5 household size (48.77%). Also, the majority of respondents were found to possess a minimum of O Level education, growing a farm size below two hectares (94.74%), with 5-10 years of HYVs irrigated rice farming experience (47.37%). The study further revealed that most of the Higher Yielding Varieties irrigated rice farmers do not have co-operative membership and enjoy little number of extension days.

Efficiency of Irrigated Rice Farmers

Table 2. Inefficiency Effect Score

Variables	Parameters	Coefficients	Standard Error	P-Value
NZakah	Z_1	-3.214	2.121	0.000
YrFarmExp	Z_2	-1.198	1.504	0.426
EduLevel	Z_3	-7.493	3.496	0.032
FreqExtC	Z_4	-0.750	0.632	0.236
HshlSz	Z_5	0.002	1.485	0.999
AgeIrrFarm	Z_6	1.408	1.363	0.302
Lambda		0.369	0.004	0.000

Source: Researchers' Estimation, 2025.

Table 2 show the value of Lambda is greater than zero i.e 0.369, signifying the presence of an inefficiency effect on the technical efficiencies of the irrigated rice farmers in the model. Also, it indicates the systematic inefficiencies that are unexplained by production and the dominant sources of random errors. Therefore, the significance of Lambda indicates that inefficiency variables made a significant contribution toward technical inefficiency of the irrigated rice farmers despite the fact that some variables i.e household size and age of irrigated rice farmers, indicated positive coefficients, and the majority of inefficiency variables with the exception of nisab of Zakah (0.000) are not statistically significant even at 10% level of significance.

Technical Efficiency of Respondents

Table 3. Specific Indices of Respondents' Technical Efficiency

Class Interval of Efficiency Scores	Frequency	Percentage (%)
0.0785-0.1084	133	23
0.1085-0.1384	200	35
0.1385-0.1684	148	26
0.1685-0.1984	15	03
0.1985-1.0000	74	13
Total	570	100

Mean Efficiency=0.128; Minimum Efficiency=0.079; Maximum Efficiency=0.228.

Source: Researchers' Estimation, 2025.

From the efficiency scores in Table 3, it can be observed that irrigated rice farmers were found to be 12.8 percent technically efficient. The highest or maximum efficiency irrigated rice farmers operate at a 22.8 per cent efficiency index. At the same time, the least or minimum efficiency irrigated rice farmers were operating at a 7.9 per cent efficiency index or level. Therefore, the average (mean) or most frequently occurring efficiency score among the irrigated rice farmers in Kano State is 12.8 per cent. By implication, the results obtained indicate that irrigated rice farmers should strive to boost their utilization of HYVs due to the existence of about a 77.2% efficiency gap to the optimum efficiency level. Therefore, average HYVs irrigated rice farmers in Kano State require 44%, i.e $1 - \frac{0.128}{0.228} * 100$ cost-saving habits to obtain the privilege of maximum efficiency. Additionally, the least or minimum performing irrigated rice farmers require 66%, i.e., $1 - \frac{0.079}{0.228} * 100$ cost-saving habits to upgrade to the highest or maximum efficiency in the use of HYVs.

Discussion

This result indicates that the residual variation in the model is not solely attributable to random shocks or factors beyond farmers' control, but also contains a systematic inefficiency component that affects farmers' ability to transform available inputs into output efficiently. Therefore, the central challenge facing HYV farmers is not merely the availability of production inputs, but also the effectiveness with which those inputs are managed and combined throughout the production process. This finding is particularly important because the adoption of high-yielding varieties does not automatically translate into high technical efficiency. The biological and technological advantages of HYVs can only be fully realized when farmers possess adequate managerial capabilities, technical knowledge,

access to relevant information, and appropriate cultivation practices. In this context, the statistically significant Lambda coefficient reinforces the argument that increasing rice productivity through HYV adoption should not be limited to expanding access to improved varieties, but should also focus on enhancing the quality of technology utilization, particularly farmers' capacity to apply the technology appropriately and efficiently. This interpretation is consistent with the broader agricultural productivity literature, which emphasizes that agricultural modernization can improve productivity but requires corresponding improvements in farmers' human and managerial capabilities. It is also broadly consistent with Ifeanyichukwu et al. (2016), who found that technical inefficiency in rice production was associated with constraints related to improved inputs, information, credit access, diseases, and pests.

The most substantive finding concerns the mean technical efficiency score of only 0.128, or 12.8%, with a minimum score of 0.079 and a maximum score of 0.228. These figures indicate that the sampled farmers operate considerably below the estimated production frontier and therefore have substantial room to improve output through more efficient utilization of existing resources. Even the most technically efficient farmers in the sample achieve an efficiency score of only 22.8%, suggesting that the potential for efficiency improvement is widespread rather than confined to a small group of poorly performing farmers. The distribution of efficiency scores further supports this interpretation: 23% of respondents fall within the efficiency interval of 0.0785–0.1084, while 35% fall within the 0.1085–0.1384 interval. Thus, approximately 58% of the sampled farmers operate below an efficiency score of 13.84%. This pattern suggests that low technical efficiency represents a structural challenge within the HYV-based irrigated rice production system in the study area. The estimated 77.2% efficiency gap relative to the optimum level is particularly noteworthy. Economically, such a large gap suggests that substantial productivity gains may be achieved through improvements in production practices and resource management without relying exclusively on additional inputs or expansion of cultivated land. This implication is especially relevant given that 94.74% of the sampled farmers cultivate less than two hectares, indicating that land expansion may face considerable structural constraints. The finding also differs markedly from the result reported by Obianefo et al. (2020), who estimated a mean technical efficiency of 84.76% among rice farmers in Anambra State. Such a substantial difference highlights the context-specific nature of agricultural efficiency, which may be shaped by differences in production technologies, irrigation systems, farmer capabilities, institutional arrangements, and local production environments.

Nisab of Zakah has a coefficient of -3.214 and is statistically significant at the 1% level, while education level has a coefficient of -7.493 and is significant at the 5% level. Within the inefficiency-effect specification employed in this study, the negative coefficients indicate that increases in these variables are associated with lower technical inefficiency and, consequently, higher technical efficiency. The finding concerning Nisab of Zakah is particularly noteworthy because it extends the analysis of agricultural efficiency beyond conventional production economics by incorporating an Islamic economic dimension. The negative and statistically significant relationship suggests that farmers' awareness of, or attention to, the zakah threshold associated with agricultural production may be related to more effective farm management behavior. Nevertheless, this result should not be interpreted as evidence that zakah payment directly causes higher technical efficiency,

because the cross-sectional research design and the estimated model primarily establish an empirical association rather than a definitive causal mechanism. More cautiously, the finding suggests that religious and economic considerations may be interconnected in the production behavior of Muslim farmers. The significant effect of education, meanwhile, provides a more direct explanation from a human-capital perspective. Education may enhance farmers' ability to understand technical information, select appropriate inputs, follow recommended cultivation practices, manage production risks, and adapt to technological changes. This finding is particularly relevant given the socio-economic characteristics of the respondents, among whom 64.56% possess only O-Level education and 24.91% have an Islamic educational background. Limited formal educational attainment may therefore constitute an important contextual factor underlying the relatively low utilization efficiency of HYV technology. The result reinforces the proposition that agricultural modernization requires not only the provision of physical technologies but also sustained investment in farmers' knowledge, skills, and decision-making capabilities.

Interestingly, years of farming experience and frequency of extension contacts have negative coefficients but are not statistically significant, with p-values of 0.426 and 0.236, respectively. The negative signs are theoretically consistent with the expectation that greater experience and more frequent interaction with extension agents may reduce inefficiency; however, the empirical evidence from this study is insufficient to conclude that either factor is a statistically significant determinant of technical efficiency among the sampled farmers. This result requires careful interpretation because the descriptive findings reveal a considerable limitation in farmers' access to extension services. Approximately 60.35% of respondents reported having no extension contact, while only 21.40% reported frequent extension contact. Consequently, the issue may not simply concern whether extension services exist, but also the intensity, quality, timing, and relevance of the knowledge transferred to farmers. The statistical insignificance of extension-contact frequency should therefore not be interpreted to mean that extension services are unimportant. Rather, it may indicate that the quantitative frequency of contact alone is insufficient to generate measurable improvements in technical efficiency when the content, timing, or practical relevance of extension interventions does not adequately correspond to farmers' production needs. This interpretation is broadly consistent with Zoogah and Nakuja (2020), who found that farmers benefiting from modernized extension services achieved higher productivity than non-beneficiary farmers. For Kano State, the implication is that agricultural extension should move beyond a purely administrative emphasis on the number of visits and instead provide more intensive, timely, technically relevant, and problem-oriented support at the farm level, particularly concerning HYV management. Such an approach would enable extension services to address the practical constraints that prevent farmers from fully realizing the productive potential of improved rice varieties. This interpretation is also consistent with the study's recommendation that HYV utilization should be strengthened through effective and timely extension visits.

Overall, the findings demonstrate that the central challenge in HYV-based irrigated rice production in Kano State is not simply technology adoption, but the effective utilization of technology. The mean technical efficiency score of 12.8% and the 77.2% efficiency gap indicate considerable potential for increasing rice production through the reduction of existing technical inefficiencies. From this perspective, policies aimed at improving rice productivity should not focus exclusively on distributing improved varieties but should

adopt an integrated strategy combining farmer education, technical capacity building, stronger extension services, improved access to production information, and greater awareness of agricultural zakah obligations. The finding concerning Nisab of Zakah also creates an important opportunity to integrate Islamic economic perspectives into agricultural development policies by recognizing that religious obligations may form part of the broader socio-economic environment within which Muslim farmers make production decisions. Nevertheless, this relationship warrants further investigation using research designs capable of establishing the underlying mechanisms and stronger causal relationships. From a policy perspective, the very low level of technical efficiency suggests that capacity building and extension-based interventions should receive greater attention before assuming that additional inputs or land expansion will automatically generate proportional increases in output. Improving the productivity of HYV cultivation should therefore involve not only increasing production volumes but also promoting more efficient, sustainable, and context-sensitive resource utilization. In this regard, the study's recommendations for more effective and timely extension visits, together with stronger dissemination of information regarding agricultural zakah thresholds through extension mechanisms, provide a practical pathway for addressing the observed inefficiencies among HYV irrigated rice farmers in Kano State.

Conclusion

The findings of this study demonstrate that irrigated rice farmers adopting Higher-Yielding Varieties (HYVs) in Kano State experience substantial levels of technical inefficiency, indicating that the adoption of improved rice varieties alone does not necessarily translate into efficient production. The Stochastic Frontier Model confirms the presence of systematic technical inefficiency, as reflected by the statistically significant Lambda coefficient of 0.369. The estimated mean technical efficiency score of 0.128 indicates that, on average, farmers operate at only 12.8% of the attainable production frontier, leaving a substantial efficiency gap of approximately 77.2%. The relatively narrow range between the minimum efficiency score of 7.9% and the maximum of 22.8% further suggests that low technical efficiency is not confined to a small group of farmers but represents a broader structural challenge within the study area.

The results of the inefficiency model further indicate that the Nisab of Zakah and education level are statistically significant factors associated with technical inefficiency, with coefficients of -3.214 and -7.493, respectively. Their negative coefficients imply that higher levels or stronger conditions associated with these variables are related to lower technical inefficiency and, consequently, greater technical efficiency. In particular, the significant role of the Nisab of Zakah provides an important dimension from the perspective of Islamic economics, suggesting that the institutional and socioeconomic environment surrounding Zakah may be relevant to farmers' productive capacity. Meanwhile, the significant contribution of education highlights the importance of human capital in enabling farmers to understand, manage, and effectively utilize improved agricultural technologies. In contrast, years of farming experience, frequency of extension contacts, household size, and age were not statistically significant in explaining technical inefficiency. These findings imply that accumulated farming experience or the frequency of extension contact, by themselves, may not be sufficient to improve productive efficiency unless accompanied by relevant knowledge, effective technology transfer, and appropriate institutional support.

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