



**EFFECTS OF POLICY FACTORS ON TECHNICAL EFFICIENCY OF IRRIGATED
RICE PRODUCTION UNDER DIFFERENT LAND ADMINISTRATION
INSTITUTIONS DADIN KOWA IRRIGATION SCHEME, NIGERIA**

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ABSTRACT

The study was conducted to determine the effects of policy factors of land administration on the technical efficiency of irrigated rice production in the Dadin Kowa Irrigation Scheme (DKIS) area. A structured questionnaire was used for data collection. Three hundred and twenty irrigated rice farmers were selected using multi-stage sampling technique drawn from five land administration institutions in the DKIS area. Descriptive statistics, stochastic frontier, and multiple regression models were used to analyze the data. The technical efficiency (TE) analysis revealed that for the sample, farm size ($P < 0.01$), fertilizers ($P < 0.05$), herbicides ($P < 0.05$), and pesticides ($P < 0.01$) were all significant and negative while labour was positive ($P < 0.01$). The inefficiency model for TE revealed that for the sample, four variables education, household size, access to improved seeds, and distance to market were each statistically significant at 5% probability level and negative (except for education which was positive). The effects of five policy factors of land administration (land governance, partnership in land use, socio-economic factors, gender and inclusiveness, institutional and environmental factors) on TE revealed that for the aggregate sample, only land governance ($P < 0.01$) and socio-economic factors ($P < 0.05$) were significant. The study recommended that the five policy factors of land administration should be accorded priority in strategic policy planning and implementation of programme for improving the productivity of irrigated agriculture and the livelihoods of people in the study area.

Keywords: Efficiency, Factors, Governance, Institutions and Land

INTRODUCTION

Irrigated agriculture has been an important aspect of agriculture for a long time. But it has increasingly become globally crucial in the effort to overcome hunger and food insecurity as well as to satisfy other industrial demands (Tushaar *et al.*, 2020; World Bank, 2019; Takeshima *et al.*, 2017). This has become inevitable given the increasing menace of climate change and the concomitant variations in rainfall regimes, making dependence on rain-fed agriculture more precarious than ever for sustainable agriculture and livelihoods (Balasubramanya and Lele, 2022). Irrigation is a pathway for both agricultural intensification, and adaptation to climate change especially for the poor vulnerable farmers (Shah *et al.*, 2020; World Bank, 2019).

Rice was ranked in the year 2019 as the third most produced crop in the world with a global output of 0.8 million tonnes (FAO, 2021). Nigeria has an average rice yield of 2 tonnes/ha (Thrive-Agric, 2020; Price house water Cooper [PwC], 2018) and the potential of achieving the world average yield of 4.1 tonnes/ha on the 630,000 ha irrigated segment of its production can be increased by 1.7 million tonnes (paddy) or 1.1 million tonnes (milled rice). At this level of productivity, the country will require an additional 214,000 ha of irrigated rice production in order to achieve self-sufficiency (Babatunde *et al.*, 2017). This therefore necessitates not just expanding the irrigated area for rice production but also the efficiency and productivity of the mass of small-scale farmers involved in the production process.



Land administration is essentially an embodiment of the rules of land tenure as applied and practised in any given society based on policies, laws, customs and practices. Effective land administration must be fit-for-purpose, appropriate and adequate, interoperable and sustainable, flexible and inclusive, and able to accelerate efforts to document, record and recognize people land relationships in all its forms. Land institutions are central to effective and efficient land administration as they are expected to provide security of property rights and equitable access to economic resources across all segments of the society. This makes the land resource an essential instrument for asset and wealth redistribution (Gnedenko, 2020).

Land is an integral factor of agriculture production, and good land administration systems are required to promote productivity and efficiency of agriculture. Most studies on production efficiency have often examined the interplay of socio-economic factors as causes of inefficiencies. But, the extent to which land administration policy factors contribute to inefficiency has not been given due attention. Zaman (2024) identified five factors of land administration (namely land governance, partnership in land use, socio-economic factors, gender and inclusiveness, institutional and environmental factors) from an array of twenty land issues in the Dadin Kowa Irrigation (DKIS) area. This study therefore examined the effects of these five policy factors of land administration on the technical efficiency of irrigated rice production in the DKIS area. The broad objective of this study was to analyze the effects of five policy factors of land administration on technical efficiency of rice (*Oryza sativa*) production under different land administration institutions in the Dadin Kowa irrigation Scheme area.

The specific objectives of the study were to:

- i. determine the technical efficiency of irrigated rice production under the various land administration institutions in the study area; and
- ii. examine the effects of policy factors of land administration on the technical efficiency of irrigated rice production under the various land administration institutions in the study area.

MATERIALS AND METHODS

The study Area

The study was conducted in the Dadin Kowa Irrigation Scheme (DKIS) communities which fall within Borno and Gombe States. Dadin Kowa town which hosts the irrigation scheme is about 37 km to the east of Gombe town in Yamaltu-Deba Local Government Area of Gombe State, North-eastern Nigeria. The people in the area are mostly small-scale farmers who produce rice, maize and vegetables as major crops (Alhassan *et al.*, 2016; Hassan *et al.*, 2015).

Sampling Procedure and Sample Size

The respondents were irrigated rice farmers. Multi-stage sampling technique was applied for the data collection. In the first instance, the study area was purposively selected to cover areas or communities adjoining the Dadin-Kowa Irrigation Scheme (DKIS). In line with this, the sampling frame was drawn from Yamaltu-Deba, and Bayo Local Government Areas from Gombe and Borno State, respectively, because of their contiguity to the DKIS. Respondents who were irrigated rice farmers were randomly sampled from four (4) formal institutions which administered land, namely; Dadin Kowa Irrigation Scheme (DKIS), Federal College of Horticulture (FCoH), National Institute of Horticulture (NIHORT), all in Dadin-Kowa, and Savanna Integrated Farms (or Vegfru) located in Garga-Shehu (or Yadi), Bayo Local Government Area of Borno State. The fifth group of irrigated rice farmers were drawn from outside the above four formal institutions. Hence, this fifth group belonged to the non-formal

land institution (hereafter referred to as traditional institution). They were randomly selected from four communities around the DKIS drawn from both Yamaltu-Deba and Bayo Local Government Areas of Gombe and Borno States respectively. In essence, irrigated rice farmers from each of these five (5) groups (institutions) were randomly selected from the list provided by the Water Users Association (WUA) in conjunction of the Dadin Kowa Irrigation Scheme (DKIS) office.

The sample size was determined using the Yamane (1967) model which is given by:

$$n = \frac{N}{1 + Ne^2} \quad \dots (1)$$

Where, n = sample size

N = Population size

e = margin error (5%).

Based on the application of equation (1) to the sampling frame (of 1,569 irrigated rice farmers) a sample size of three hundred and twenty (320) respondents was drawn. The study used primary data collected at the household level using structured questionnaire. The questions (5-point Likert scale) made up of twenty policy issues which were identified from literature review and from the participatory action research (PAR) policy workshops conducted in Gombe and Borno States by Ayoola *et al.* (2021).

Method of Data Analysis

Data were analyzed using the stochastic frontier and the multiple linear regression models.

The Stochastic Frontier Technical Efficiency Model

The stochastic frontier was proposed by Aigner, Lovell and Schmidt (1977). The model has been applied in several studies to estimate production efficiency of the farm (Sani *et al.*, 2023; Houngue and Nonvide, 2020; Kazeem, 2020; Mohammed *et al.*, 2019; Rapu, 2016; Ahmadu and Alufohai, 2012).

Technical efficiency was measured as a ratio of actual to potential output (Abdulai *et al.*, 2017; Aigner *et al.*, 1977). The Cobb-Douglas functional form used for measuring the technical efficiency of rice farmers for the study was explicitly of the form:

$$\ln Y_i = \beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4 + \beta_5 \ln x_5 + \beta_6 \ln x_6 + V_i - U_i \quad \dots (2)$$

where,

Y_i = Rice output (kg) of the i^{th} farmer per hectare

x_1 = Farm size (ha)

x_2 = Seed quantity (kg)

x_3 = Fertilizer (kg)

x_4 = Herbicides (litres)

x_5 = Pesticides (litres)

x_6 = Labour (man-days)

V_i = random variable which is assumed to be independently distributed (such as errors of measurement, and unfavourable weather conditions).

U_i = Non-negative random variable (associated with inefficiency)

The Inefficiency Model

The inefficiency model was measured by:

$$\mu = \delta_0 + \delta_1 w_1 + \delta_2 w_2 + \delta_3 w_3 + \delta_4 w_4 + \delta_5 w_5 + \delta_6 w_6 + \delta_7 w_7 + \delta_8 w_8 + \delta_9 w_9 + \delta_{10} w_{10} \quad \dots (3)$$

Where,

μ = Inefficiency effect

w_1 = Age of rice farmer (years)

w_2 = Sex of farmer (male = 1; female = 0)

w_3 = Educational level (years of schooling)

w_4 = Household size (number)

w_5 = Rice farming experience (years)

W_6 = Extension contact (Yes = 1; No = 0)

W_7 = Membership of farmers' cooperative society (Yes = 1; No = 0)

W_8 = Access to improved/hybrid seeds (Yes = 1; No = 0)

W_9 = Average distance of the nearest rice plot to home (km)

W_{10} = Distance to the nearest marketplace (km)

Multiple Linear Regression Model

The regression model is a widely applied instrument in modeling cause-effect relationships between variables with one termed the dependent variable and the other(s) referred to as the independent or explanatory variables (Greene, 2018; Kumbhakar *et al.*, 2015). The study examined four functional regression models to determine the effects of the five policy factors of land administration on technical efficiency in the study area as follows:

Linear Regression model:

$$\hat{E} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon \quad \dots (4)$$

Where,

\hat{E} = Technical efficiency estimate;

β_0 = intercept or constant;

β = coefficients of the independent variables;

x_1 = Land Governance;

x_2 = Partnership in land use;

x_3 = Socio-economic factor;

x_4 = Gender and inclusiveness; and

x_5 = Institutional and environmental factors of land administration.

ϵ = error or disturbance term.

Logarithmic Regression Model

$$\hat{E} = \beta_0 + \beta_1 \log(X_1) + \beta_2 \log(X_2) + \beta_3 \log(X_3) + \beta_4 \log(X_4) + \beta_5 \log(X_5) + \epsilon \quad \dots (5)$$

Quadratic Regression Model:

$$\hat{E} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_1^2 + \beta_7 X_2^2 + \beta_8 X_3^2 + \beta_9 X_4^2 + \beta_{10} X_5^2 + \epsilon \quad \dots (6)$$

Cubic Regression Model:

$$\hat{E} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_1^2 + \beta_7 X_2^2 + \beta_8 X_3^2 + \beta_9 X_4^2 + \beta_{10} X_5^2 + \beta_{11} X_1^3 + \beta_{12} X_2^3 + \beta_{13} X_3^3 + \beta_{14} X_4^3 + \beta_{15} X_5^3 + \epsilon \quad \dots (7)$$

The linear regression model was chosen over the other (three) models because on the overall it had the best values for adjusted R^2 , better significance for the model (F), and statistically significant coefficients for independent variables. Furthermore, it satisfied theoretical assumptions of the linear model.

RESULTS AND DISCUSSION

Technical Efficiency Parameter Estimates

The parameter estimates of the stochastic frontier production (Table 1) for the respondents revealed that almost all the factors of production were statistically significant except for seed which was not for the aggregate sample ($n=320$) and all the institutions (excluding FCoH and NIHORT). Fertilizers and pesticides too were not statistically significant for DKIS and traditional institutions respondents.



The findings revealed that only labour as an input had a positive coefficient and statistically significant at various probability levels for both the aggregate sample and across all the institutions, meaning that a unit increase in labour (man-day) would increase output of irrigated rice in the study area. Taking the aggregate sample for example, 1% increase in labour (man-day) increased rice output by 0.83 units. Seeds and fertilizers were only positive and statistically significant ($P < 0.01$) for farmers under FCoH and NIHORT.

But contrary to *a priori* expectations, all the other statistically significant inputs (farm size, seeds, fertilizers, herbicides and pesticides) had negative coefficients, meaning that any unit increase in the inputs was accompanied by reduction in the marginal rice output by their respective coefficients. The negative coefficient for farm size may reflect diminishing marginal returns and managerial inadequacies. So, as farm size increased, the farmers were unable to manage efficiently, leading to lower productivity per unit of land (Coelli *et al.*, 1998). Similarly, the negative coefficients for fertilizers, seed, and pesticides may have been due to overuse or inefficient use of these inputs, because beyond an optimal level, additional inputs may lead to diminishing returns or even negative effects on crop yield (Pretty, 2008). The findings of this study contrasted with that of Sani *et al.* (2023) who reported that farm size was significant for farmers at DKIS ($P < 0.05$), Vegfru ($P < 0.01$); labour at DKIS ($P < 0.01$), and traditional ($P < 0.05$); while seed was only significant for traditional ($P < 0.01$). Even though Banseka (2023) reported positive statistically significant coefficients for these inputs (farm size, seeds, fertilizers, herbicides and pesticides), except labour which was not significant.

Determinants of Technical Inefficiency

The findings about the inefficiency components (Table 1) revealed that for the aggregate sample, four of the ten variables in the model were statistically significant. Education has positive and significant ($p < 0.05$) coefficient, which was similar to the findings by Banseka (2023) who also reported a positive and significant coefficient ($p < 0.01$). This meant that education increased inefficiency or negatively affected irrigated rice production in the area. This contrasted with the negative significant coefficients for education found by Tenaye (2020), and Abate *et al.* (2019) at various probability levels. This finding was also not in line with the *a priori* expectation, which holds that by increasing literacy, education enhances skills, problem-solving abilities as well as the propensity for adopting better production technologies. This finding may be attributed to the diversification of livelihood options which usually accompanies increasing level of education (Haughton and Khandker, 2009) which may have reduced the direct and regular involvement of the more educated farmers in supervising and managing the rice production process, which explained the inefficiency.

Household size was found to be negative and significant ($P < 0.05$) which was similar to the findings of Aboki *et al.* (2020) and Mohammed *et al.* (2019) who both found it to be negative and significant ($P < 0.01$). This was consistent to the characteristic prevalence of family-farms in developing countries like Nigeria where the bulk of labour requirement on the farm is provided by family members who have a personal commitment to ensure its success (Athukorala, 2017; Rahman *et al.*, 2012).

Finally, a significant negative effect ($P < 0.05$) existed between the distance farmers traveled from their homes to the markets and their technical efficiency implying that farms with longer distance from home are more efficient technically than those with shorter distance. This finding was incongruous to *a priori* expectation which stipulates that increase in farmers distance from home would decrease farm productivity, because, distance of farms from markets determines travel time, and cost of transporting inputs and the ease selling their farm products (Wickramaarachchi and Weerahewa, 2016). The finding differed from that of Ayoola *et al.* (2022) and Tenaye *et al.* (2020) who independently found significant positive effect of the variable on technical inefficiency ($P < 0.01$).



The decomposition of the inefficiency effects according to the land issuing institutions in the study area showed that only three variables (age, sex and education) were significant at various probability levels. Age was negative and significant ($P < 0.05$) at FCoH and NIHORT, meaning that a unit increase in age reduced inefficiency because, age usually associated with farming experience and mastery of farming skills which contribute to higher yields. The result for the age variable was similar to what Addison *et al.* (2016), and Adeniyi and Dinbabo (2020) reported ($P < 0.01$) and ($P < 0.05$), respectively. But, Ayedun and Adeniyi (2019) found that the effect of age on TE was positive ($P < 0.01$).

In contrast to the positive coefficient associated with education for the aggregate sample, education was negative and significant ($P < 0.05$) for respondents under FCoH and NIHORT, meaning that improvement in education was instrumental to reducing inefficiency. This was in harmony with theoretical expectations as well as the findings of Aboki *et al.* (2020), Osawe *et al.* (2017) and Tenaye *et al.* (2016) whose coefficients were negative and significant ($P < 0.01$), ($P < 0.05$) and ($P < 0.05$) respectively.

Sex was only significant ($P < 0.05$) and positive for Vegfru, meaning that women were more inefficient than their male counterparts and this was in harmony with Umaru and Maurice (2019) who also found the positive effect ($P < 0.01$). The findings was in contrast with Addison *et al.* (2016) found a negative effect for females ($P < 0.01$). The coefficient of sex actually represents gender roles and how it contributes to inefficiency in irrigated rice production in this context. The positive sign in the case of this study means more of women were associated with increasing inefficiency. This could be due to gender-based discrimination reflected by limited land tenure access, rights, and security, and other socio-cultural biases and resource limitations against them which are prevalent in traditional societies (Ayoola *et al.*, 2023; Rahman, 2009).

An examination of the diagnostic statistics (sigma squared, gamma, and likelihood ratio test) of the model under consideration (on Table 1) all confirmed appropriateness of the adopted stochastic production model.



Table 1: Summary of parameters (maximum likelihood estimates) of the stochastic frontier production function

| Institution | DKIS | | FCoH and NIHORT | | Vegfru | | Traditional | | Aggregate | |
|---|----------------|----------|-----------------|----------|----------------|----------|----------------|----------|----------------|----------|
| Variables | Coeff. T-Ratio | | Coeff. T-Ratio | | Coeff. T-Ratio | | Coeff. T-Ratio | | Coeff. T-Ratio | |
| Constant (x_0) | 3.42 | 8.45*** | 3.30 | 6.27*** | 3.59 | 5.85*** | 4.80 | 4.89*** | 5.22 | 15.39*** |
| Farm size (x_1) | -0.71 | -8.54*** | -0.75 | -3.86*** | -0.58 | -4.38*** | 0.33 | 1.98 | -0.23 | -3.66*** |
| Seed (x_2) | 0.02 | 0.51 | 0.33 | 4.44*** | 0.01 | 0.12 | 0.04 | 0.39 | 0.01 | -0.01 |
| Fertilizer(x_3) | -0.05 | -0.71 | 0.54 | 3.82*** | -0.21 | -2.10** | -0.28 | -1.40 | -0.20 | -2.76** |
| Herbicides (x_4) | -0.67 | -1.10 | -0.46 | -5.37*** | -0.30 | -4.69*** | -0.21 | -1.26 | -0.12 | -2.77** |
| Pesticides (x_5) | -0.16 | -3.27*** | -0.17 | -3.34*** | -0.26 | -3.90*** | -0.28 | -3.13*** | -0.25 | -6.62*** |
| Labour (x_6) | 0.97 | 10.76*** | 0.37 | 2.73** | 1.20 | 11.68*** | 1.07 | 6.86 *** | 0.83 | 12.75*** |
| Inefficiency model | | | | | | | | | | |
| Constant (w_0) | 0.65 | 3.48*** | 2.86 | 2.50** | -2.02 | -1.74 | 2.50 | 1.66 | 1.72 | 2.41** |
| Age (w_1) | -0.10 | -0.59 | -0.06 | -2.04** | 0.02 | 1.52 | -0.01 | -0.58 | -0.01 | -0.79 |
| Sex(w_2) | -0.01 | -0.13 | 0.49 | 1.37 | 0.64 | 2.34** | -0.26 | -0.40 | -0.08 | -0.44 |
| Education(w_3) | -0.01 | -0.26 | -0.03 | -1.88 ** | 0.01 | 0.31 | 0.03 | 0.74 | 0.04 | 2.06** |
| Household size(w_4) | -0.01 | -1.04 | -0.02 | -1.36 | 0.01 | 0.03 | 0.01 | 0.18 | -0.06 | -2.48** |
| Rice farming experience (w_5) | 0.01 | 1.83 | 0.02 | 0.61 | -0.01 | -0.80 | -0.13 | -1.78 | -0.01 | -0.40 |
| Extension contact (w_6) | -0.04 | -1.18 | 0.22 | 1.25 | 0.04 | 0.63 | -0.15 | -0.86 | -0.21 | -1.78 |
| Coop society membership (w_7) | -0.04 | -0.87 | -0.33 | -0.87 | 0.11 | 0.44 | -0.51 | -1.18 | -0.27 | -1.77 |
| Access to improved/hybrid seeds (w_8) | -0.04 | -1.68 | -0.13 | -1.56 | -0.13 | -1.58 | -0.08 | -0.67 | -0.32 | -2.22** |
| Distance to farm (w_9) | -0.03 | -1.57 | -0.47 | -1.38 | 0.12 | 0.71 | 0.04 | 0.09 | -0.11 | -0.74 |
| Distance to market (w_{10}) | -0.03 | -1.57 | -0.01 | -0.05 | 0.01 | 0.06 | -0.04 | -0.86 | -0.07 | -2.10** |
| Diagnostic statistics: | | | | | | | | | | |
| Sigma-square | 0.07 | 6.72*** | 0.08 | 3.66*** | 0.12 | 5.92*** | 0.63 | 2.97*** | 0.45 | 3.57*** |
| Gamma | 0.01 | 0.07 | 0.96 | 54.97*** | 0.17 | 1.96 | 0.92 | 18.67*** | 0.70 | 6.75*** |
| LR test | 15.37 | | 25.53 | | 10.16 | | 29.77 | | 16.12 | |

Source: Field Survey (2022)

Note: *** = (P<0.01); ** = (p<0.05)



Effects of Policy Factors of Land Administration on Technical Efficiency

The effects of five policy factors of land administration (land governance, partnership in land use, socio-economic factor, gender inclusiveness, institutional and environmental factors of land administration) on technical efficiency of irrigated rice production are examined here. The effects of these factors on the aggregate sample ($n=320$) as well as on the four institutions was analyzed using the multiple linear regression model as discussed below.

The institutional analysis revealed that land governance was significant at DKIS ($p<0.05$), FCoH and NIHORT ($P<0.010$), and Vegfru ($P<0.05$). Good land governance is central to land access, tenure security and invariably agricultural productivity. The findings were in tandem to the recommendations of the African Union Commission (AUC), Economic Commission for Africa (ECA) and African Development Bank (AfDB) Consortium (2010) on the urgent need for reform of land governance institutions in Africa. The recent pronouncement by the President Bola Ahmed Tinubu-led government of an emergency in the agricultural sector and food security in particular in Nigeria (Daily Trust, 2023) must be anchored and driven by a policy thrust that emphasizes not just the central role of good land governance policies in the management of land institutions, but most importantly their actualization through implementation.

Poor partnership in land use was significant at FCoH and NIHORT ($P<0.01$), Vegfru ($P<0.05$) and traditional ($P<0.05$). Multi-stake holder approaches are central to evolving productive and sustainable land use. This necessitates partnerships such as: farmer-herder, private-public, research-extension, community-government partnership and improving farmers participation in cooperatives (World Bank, 2017).

The socio-economic factor was significant ($P<0.01$) at FCoH and NIHORT just like with the sample, Poverty, ethnicity, corruption, limited access to legal services, particularly for lower-income individuals, can hinder efficient land administration (Eboh and Olomoda, 2012) and technical efficiency. For the aggregate sample ($n=320$), only land governance ($P<0.01$) and socio-economic factors ($P<0.05$) were found to be statistically significant in affecting technical efficiency (Table 2). For example, poor land governance as a factor was found to negatively affect technical efficiency such that 1% decrease in the score for land governance was capable of reducing irrigated rice output by 0.237 units.



Table 2: Effects of land policy factors of land administration on technical efficiency

| Land Admin Factors | DKIS | | | FCoH and NIHORT | | | Vegfru | | | Traditional | | | Aggregate | | |
|-----------------------------|--------|-------------|----------|-----------------|-------------|----------|--------|-------------|----------|-------------|-------------|----------|-----------|-------------|----------|
| | Coeff. | Std. Err | t- ratio | Coeff. | Std. Err | t- ratio | Coeff. | Std. Err | t- ratio | Coeff. | Std. Err | t- ratio | Coeff. | Std. Err | t- ratio |
| Constant | 0.960 | 0.049 | 19.64*** | -0.016 | 0.045 | -0.37 | 1.050 | 0.141 | 7.43*** | 0.806 | 0.159 | 5.09*** | 0.933 | 0.028 | 33.91*** |
| X ₁ | -0.145 | 0.066 | -2.20** | 0.072 | 0.047 | 1.54 | -0.265 | 0.131 | -2.02** | -0.390 | 0.238 | 1.64 | -0.237 | 0.039 | -6.09*** |
| X ₂ | -0.001 | 0.049 | -0.02 | 0.062 | 0.059 | -1.04 | -0.295 | 0.126 | -2.34** | -0.361 | 0.153 | -2.34** | 0.052 | 0.028 | 1.77 |
| X ₃ | -0.016 | 0.045 | -0.37 | -0.520 | 0.140 | 3.73*** | -0.044 | 0.126 | -0.35 | 0.031 | 0.162 | 0.19 | 0.045 | 0.027 | 1.99** |
| X ₄ | 0.072 | 0.047 | 1.54 | 0.060 | 0.126 | 0.48 | 0.194 | 0.102 | 1.89 | -0.279 | 0.152 | -1.84 | -0.026 | 0.034 | -1.65 |
| X ₅ | 0.062 | 0.059 | -1.04 | -0.066 | 0.102 | -0.64 | 0.098 | 0.116 | 07.43 | -0.062 | 0.165 | -0.38 | 0.043 | 0.041 | -0.75 |
| Sample size (n) | | 126 | | | 26 | | | 86 | | | 82 | | | 320 | |
| F-ratio | | 1.914 | | | 6.83*** | | | 2.90** | | | 2.28 | | | 8.56*** | |
| R ² | | 0.075 | | | 0.631 | | | 0.153 | | | 0.13 | | | 0.122 | |
| R ² Adj. | | 0.036 | | | 0.538 | | | 0.100 | | | 0.073 | | | 0.108 | |
| Durbin- Watson Index. | | 1.997 | | | 1.987 | | | 2.167 | | | 1.928 | | | 1.729 | |

Note: x₁ = Land governance; x₂ = partnership in land use; x₃ = socio-economic factor; x₄ = gender and inclusiveness; x₅ = and institutional and environmental factors of land administration.

*** = 1% and ** = 5%, levels of significance.

Source: Field Survey (2022)



CONCLUSION AND RECOMMENDATIONS

The potentials of irrigated rice production in the Dadin Kowa Irrigation Scheme (DKIS) are enormous given the vast undeveloped irrigation land area and the abundant water supply at the Dadin Kowa dam for all-year irrigation. Closing the existing gaps in technical efficiency due to inadequate factor use and substantial improvements will depend on deploying policy instruments that will transform socio-economic factors which are sources of inefficiencies into drivers of efficiency in the DKIS area.

Similarly, the five extracted policy factors (land governance, partnership in land use, socio-economic factor, gender and inclusiveness, and institutional and environmental factors) exerted varying effects on technical efficiency of irrigated rice production under the land issuing institutions in the study area require attention. This should be accorded priority in strategic policy planning and implementation of programmes aimed at improving the productivity of irrigated agriculture and the livelihoods of people in the study area.

There is need for increased multi-sectoral approach in policy development and implementation so that agricultural, land, environmental, and national security issues are not treated in isolation. This is because, policy factors of land governance, partnership in land use, gender and inclusiveness in land administration do not just affect food productivity and security, but impact substantially on poverty, national security and economic development. Land policies must therefore strategically ensure that land institutions are operated within globally acclaimed good land governance principles of transparency and equity. Policies on peace-building and peace-sustainability must promote inclusiveness, and partnership in the use of land resources within the framework of sustainable development.

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CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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