

# Comparative Analysis between Canal and Tube Well Irrigation on Food Security, Farmer's Income and Resource Use Efficiency in Kano State, Nigeria: A Case of Rice Farmers

Abdulazeez Hudu Wudil<sup>1,\*</sup>, Asghar Ali<sup>2</sup>, Mortala Boye<sup>3</sup> and Salihu Musa<sup>4</sup>

<sup>1,4</sup>Department of Agricultural Economics and Agribusiness, Federal University Dutse, Ibrahim Aliyu Bye-Pass Dutse, Nigeria

<sup>2</sup>Institute of Agricultural and Resource Economics, University of Agriculture Faisalabad University Road, Faisalabad, Pakistan

<sup>3</sup>Institute of Business and Management Studies, University of Agriculture Faisalabad University Road, Faisalabad, Pakistan

azeezhud4real@gmail.com<sup>1,\*</sup>, asghar.ali@uaf.edu.pk<sup>2</sup>, mortalaboye@gmail.com<sup>3</sup>, bappa.girei@gmail.com<sup>4</sup>

\*Corresponding Author

## Abstract

*The federal government of Nigeria has invested millions of naira to develop irrigation schemes across the country to stimulate employment, poverty reduction, and food security. However, more attempts need to be made to analyze whether these investments have achieved their objectives. Therefore, this study was conducted to: evaluate the impact of the Kano River Irrigation Project on resource use efficiency, food security, and farmers' income. The samples of 216 and 167 canal water users and tube well users were examined, respectively. The samples were drawn using multi-stage sampling techniques, and data were analyzed using descriptive statistics, t-tests, and average treatment effect. It was found that the average household size, experience, and educational level of the canal water users were higher than their counterparts. The average annual income of the canal users was also significantly higher than that of tube well users. Meanwhile, the result further indicated that the project (canal water users) has no impact on water use efficiency, technical efficiency, and food security in the study area. For large-scale irrigation to impact food security and resource efficiency, efforts should be geared towards training, infrastructural development, farmers' inclusion in operation, and managing irrigation projects in the country.*

**Keywords:** Food security; Water use efficiency; Average treatment effect; Irrigation, Tube well water users, Canal water users.

## 1. Introduction

To stabilize agricultural output and lessen the effects of inadequate rainfall, irrigation is essential. Mudzielwana et al. (2022) asserted that irrigation is a key tool for guaranteeing global food security and market-driven production. Ahmed (2019) also reported that greater irrigation-based food production is crucial for rural and economic development of sub-Saharan Africa. If efforts are made to improve and support access to input supply, output marketing, and extension, irrigation investments may have broader impacts on food security and poverty reduction. Similarly, Darko et al. (2016) outlined that irrigation can help with agricultural diversification, improve food self-sufficiency, raise rural incomes, provide foreign exchange, and create job possibilities. Given adequate investments in research and infrastructural development, irrigation has the most potential short to medium term for achieving poverty reduction and food security improvement in sub-Saharan Africa (SSA) (Takeshima & Adesugba, 2014). Small-scale and large-scale irrigation, if widely adopted, could revolutionize farming in Nigeria (Bashir & Kyung-Sook, 2018). Similarly, increasing agricultural output would benefit rural Nigeria, where food insecurity and child malnutrition are widespread (Pawlak & Kołodziejczak, 2020). Irrigated farming not only helps

ensure the safety of our food supply but also plays a crucial role in the economy of rural areas, providing jobs and helping to keep people from starving (Adebayo et al., 2021a). Ulsido & Alemu (2014) claimed that global food insecurity and reducing income poverty, especially among rural households, are two areas where the irrigation system has significantly contributed. The Federal Government of Nigeria has prioritized food security and poverty reduction as central policy goals (Modi, 2019). Most of the policymakers agreed that increasing agricultural output and alleviating poverty required primarily agricultural intensification and technologies that improve soil moisture (Lalani, Dorward, Holloway, & Wauters, 2016). Soil moisture is crucial for the efficiency and productivity of other inputs like fertilizer and high-yielding varieties (Aluoch et al., 2022).

Consequently, the Federal government of Nigeria has prioritized investment in both small- and large-scale irrigation to increase agricultural production, reduce poverty, enhance food security, and generate employment for the teeming population (Adebayo et al., 2021b). For example, the country has 148 registered dams, of which 59 are owned by the federal government, 81 by the states, and 9 by private companies (Ofoezie, 2002). Despite these efforts, most government irrigation programs, projects, and policies still need to achieve the goals of self-sufficiency in food production, poverty reduction, and food security (Sanusi, Ebukiba, & Peter, 2020). For instance, Kano state has 17 dams with a total capacity of 1,438,000 hectares of cropland. Regrettably, less than 15.65% of irrigated croplands were developed, leaving 84.35% of irrigated land farmland unutilized, contributing to the state's low rice productivity (Tanko et al., 2019). One of the causes of the inefficiencies of irrigated cropland is the lack of drainage channels that connect dams to farmland (Kaugama & Ahmed, 2014).

Furthermore, the conventional approach of continuous inundation, which quickly depletes available irrigation water, contributed to the idealization of a large area of farmland (Tanko et al., 2019). According to Ovwigho and Ifie (2009), poor databases for policy formulation, insufficient monitoring, and lack of impact assessment led to the continuous failure of multiple governments' agricultural development programs. Sani et al. (2010) reported that Nigeria's private irrigation systems' diversity is greater than that of public irrigation systems. This is because farmers design private irrigation systems to meet their unique needs within their local agro ecological and socioeconomic environments. One example of this diversity is their ability to obtain and transport water to their plots. To this end, impact assessment is very crucial because one must be sure of the success of a program or intervention with appropriate evaluation. Our primary goal is to analyze the Kano River Irrigation Project (KRIP) effect on food security and poverty reduction in Kano State so that policymakers can make smarter financial decisions for the current and subsequent interventions to improve farmers' livelihood and food security.

There is a plethora of empirical studies on the connections between irrigation, food security, and poverty (Malana & Malano, 2006; Burney & Naylor, 2012; Zewdie et al., 2020; Xiong et al., 2021). Moreover, (Burney & Naylor, 2012; Mwendera & Chilonda, 2013; Schuenemann, Thurlow, Meyer, Robertson, & Rodrigues, 2018; F. A. Adela, Aurbacher & Abebe, 2019) claimed that due to the relatively low level of irrigated agriculture in the Sub-Saharan Africa (SSA) countries compared to the rest of the world, little is known about the impact of irrigated agriculture on increasing incomes, ensuring food security, and decreasing poverty in the continent. Specifically, the study is designed to find the answers to the following questions;

- (i) What is the food security status of canal and tube well water users in the study area?
- (ii) Does the irrigated rice annual income of the canal water users significantly higher than the tube well rice farmers?
- (iii) Are canal water users more efficient than tube well users in technical and irrigation water use in the study area?
- (iv) In what circumstances does large-scale irrigation impact food security and resource use efficiency?

Different approaches were used in the impact assessment analysis depending on the data availability and the need of the researchers. Some studies (Giordano, Samad, & Namara, 2007; Sam-Amoah & Gowing, 2001; Yercan, Dorsan, & Ul, 2004) relied on before and after situation analysis in the irrigation sector, while other studies (Kumar, Bandyopadhyay, Raghuwanshi, & Singh, 2008; Raza, Ashfaq, Zafar, & Baig, 2009; Culas & Baig, 2020;

Wudil, Ali, Hassan, & Mushtaq, 2021) used with and without approach. Another approach that was adopted in a few other studies was the comparison of the performance of two or more transferred systems (Kloezen, Garcés-Restrepo, & Johnson, 1997; Culas & Baig, 2020; Raza et al., 2009; Baig et al., 2009). The structural and treatment effect approaches are two different theoretical frameworks typically used to evaluate the effects of any initiative, change, or reform (Hamilton et al., 2017). The structural approach (before and after situation analysis) can be used in situations where everyone participates in the project. In contrast, the treatment effect approach can be used in cases where there are two groups: (a) the treatment group (canal water users) and (b) the comparison group (tube well water users) (Eisenhauer, Heckman, & Vytlačil, 2015).

Considering the unavailability of baseline survey data and the limitations of before and after not considering the counterfactual effect, the present study adopted with and without the project approach.

### 1.2 Irrigation, Food Security, and Poverty Nexus

There were contradictory findings about the significance of irrigation agriculture on food security and poverty alleviation from empirical research (Adela et al., 2019). There is a plethora of studies that investigate the nexus between irrigation and poverty. Still, most do so indirectly, as by-products of more comprehensive studies of rural development and economic growth (Saleth, Samad, Molden, & Hussain, 2003). Moreover, the existing empirical studies oppose one another, giving detailed results. For instance, government spending on irrigation in India has been shown (Hussain & Hanjra, 2004) to have a minimal effect on agricultural output growth and an even more negligible effect on rural poverty and inequality. A study by (Gebregziabher & Namara, 2008; Adela & Aurbacher, 2018) concluded that no connection exists between irrigation, agricultural productivity, and poverty reduction in Asia, China, and India.

Similarly, a study by Omilola (2009) found that modern agricultural technology, including irrigation facilities, does not significantly reduce poverty among rural farmers in Nigeria. For modern irrigation, Ehui and Pender (2005) argue that returns on investment in irrigation schemes have been low so far. On the contrary, many studies have found that irrigated farming significantly increases crop yield and food security and reduces rural poverty and inequality (Bacha et al. (2011), Sinyolo et al. (2014) and Wichelns (2014). Similar findings by (Namara et al. (2005; Mangisoni, 2008) shows that farmers whose households successfully adopted small-scale irrigation were relatively better off than the non-adopters. (Adeniyi & Dinbabo, 2020) also found a positive correlation between irrigation agriculture, resource use efficiency, income, and food security.

### 1.3 Conceptual Framework

There are numerous, multifaceted ways in which irrigation can help alleviate poverty and improve food security. The intermediate variables, such as the size of irrigated areas, land and water productivity, cropping intensity, and labor productivity, all contribute to irrigation's impact on rural poverty and food security. Irrigation performance could result either from the input use effect or the external shock-minimizing effect of irrigation. The shock-minimizing impact of large-scale irrigation is mainly related to farm location (head, tail, or middle), significantly affecting water supply across areas. At the same time, the shock related to small-scale irrigation is the high fuel cost for water withdrawal and, in some instances drying of the wash bore or tube wall. Under unreliable water supply, farmers are skeptical about investing in fertilizer and other inputs due to the risk of crop failure. So, we assumed that production, income, and food security differences between canal water users and groundwater users (tube wall) could be perceived even if there is no dissimilarity in input use.

An alternative way of conceptualizing irrigation benefits is according to where the benefit incidence occurs and to whom the benefits accrue. The benefit of irrigation can be direct and indirect, mainly to the broader economy. The indirect benefit is due to the demand for additional inputs (fertilizer, labor, and agrochemical). Another tertiary layer of use is irrigation's spillover effect, which results from income and employment due to increasing land productivity. The spillover and indirect effects of irrigation are beyond the scope of the present study. In the present study, we are concerned only with the direct impact of irrigation between the canal water users and groundwater users (tube walls) of the KRIP.

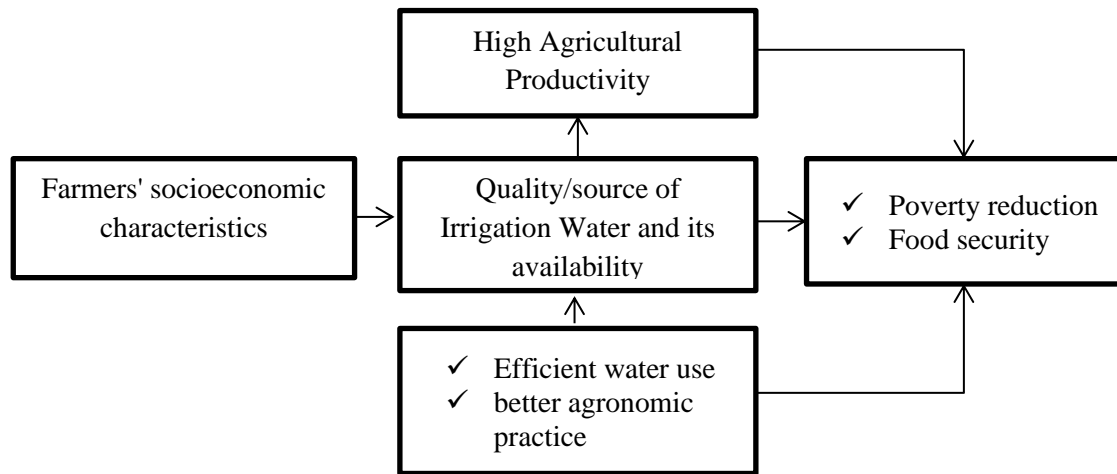


Fig 1: Conceptual Framework

Fig. 1 demonstrates how increased productivity, decreased poverty, and guaranteed long-term food security can result from the widespread use of good irrigation water and its availability, along with proper water management and improved agronomic techniques. It is indisputably agreed that a rise in productivity leads to greater profits for agricultural production, increased wages for employees, lower or stabilize food prices for consumers, and overall economic expansion. The Sustainable development goals (SDG) 1, 2, and 13 are to reduce poverty and food insecurity while protecting ecological health can be realized through better management of natural resources and environmental protection brought about by this.

## 2. Methodology

The tendency to attribute differences in income, resource use, and food security between canal water users and tube well households is a common methodological issue in studies of the impacts of large-scale (canal water) irrigation projects. There is a catch, though A particular farm cannot simultaneously be part of the project (canal water users) and outside of it (tube wall). For this reason, it is logically impossible to simultaneously measure results for a personal farm existing in two different states of nature (participating in a project (canal) and not participating (groundwater)). As a result, the evaluation of an impact has long been understood to be a problem of incomplete information. A control group (tube well water users) serves as a counterfactual by simulating the participants without benefiting from the large irrigation project. This study uses the Average Treatment Effect (ATE) and propensity score matching (PSM) method, part of the more prominent non-experimental impact evaluation techniques. The mean difference of a few socioeconomic variables between canal water users and groundwater users was also tested using an independent sample t-test.

### 2.1 Study Area

The Kano River Irrigation Project (KRIP) is located between latitude 11045` and 12005` North of the equator and longitude 08045` and 09005` East of the Greenwich mean. It is situated in a vast area of over 25km south of Kano city and is one of the functional irrigation schemes in the country. It is designed to provide irrigation facilities to about 22,000 hectares of land utilizing water release from the Tiga dam (through the Ruwan Kanya reservoir). The scheme operates in three local government areas: Kura, Garum Mallam, and Bunkure. The climate of the area is characterized by relatively varied and rapid changes in temperature and humidity. Humidity at times could rise to 100 % in an area considered typically dry. The mean daily minimum and maximum temperatures are 140 C and 350 C, respectively. The state has an estimated population of 15 million in 2020.

### 2.2 Average Treatment Effect

The term 'treatment effect' is the causal effect of a binary (0–1) variable on a result of interest (scientific or policy or intervention). The principal econometric shortcomings of the valuation of ATE is selection bias, which

occurs when treated individuals differ from the non-treated for reasons outside the treatment status. Treatment effects can be measured. Average Treatment Effect (ATE) is an analysis that shows the mean variation in outcome between units allocated to the participants and units assigned to the non-participant (Lokshin & Sajaia, 2011; Sadiq, 2020; Wang, Nianogo, & Arah, 2017).

The equation is given below;

Project beneficiaries' households are given by:  $E\left(\frac{y_{1i}}{I} = 1; X\right)$

Non-beneficiaries are given by:  $E\left(\frac{y_{2i}}{I} = 0; X\right)$

Project beneficiaries if there were no project:  $E\left(\frac{y_{2i}}{I} = 1; X\right)$

Non-beneficiaries if there were no projects:  $E$

Where;

$E(.)$  expectation operator

$y_{1..ni}$  = Beneficiaries' dependents variables (IWUE, Technical efficiency, Yield, Food security, and Income (farm and off-farm))

$y_{2..ni}$  = Non-beneficiary's dependents variables (IWUE, Technical efficiency, Yield, Food security, and income (farm and off-farm))

$I$  = dummy variable (1 = beneficiaries, 0 = non-beneficiaries) households

$X$  = explanatory variables common to both beneficiaries' and non-beneficiaries' household

$$ATT = E\left(\frac{y_{1i}}{I} = 1; X\right) - E\left(\frac{y_{2i}}{I} = 1; \left(\frac{y_{1i}}{I} = 0; X\right)\right) \quad (1)$$

$$ATU = E\left(\frac{y_{2i}}{I} = 1; X\right) - E\left(\frac{y_{2i}}{I} = 1; X\right) \quad (2)$$

$ATT$  = Average treatment effect on treated

$ATU$  = Average treatment effect on untreated

These two equations were further simplified as follows;

$$ATT = \frac{1}{N_1} \sum_{i=1}^{N_1} P(y_{2i}|1 = 0; X) - P(y_{2i}|1 = 1; X) \quad (3)$$

$$ATU = \frac{1}{N_2} \sum_{i=1}^{N_2} P(y_{2i}|1 = 0; X) - P(y_{1i}|1 = 1; X) \quad (4)$$

Where  $N_1$  and  $N_2$  are the numbers of beneficiaries and non-beneficiaries and  $P$  = probability

### 2.3 Independent sample T-test

The mean differences of some socioeconomic variables between canal and tube well water users were estimated using a t-test. The test could be used as specified in an equation, according to (Zupancic et al., 2006)

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S_{X_1 X_2} \sqrt{\frac{1}{n}}} \quad (5)$$

Where;  $S_{X_1 X_2} = \sqrt{S_{X_1}^2 + S_{X_2}^2}$

### 2.4 Data sources and sample selection procedure

The data used in this paper are obtained from a survey to study the impact of KRIP (canal irrigation) on food security, income, and poverty reduction. The respondents for the study comprised both canal water users and

tubed well water users within the same catchment in the study area. Tube well water users in the non-sector regions were used as a control for the study. Multi-stage sampling procedure was used in the data collection. In the first stage, all the local government areas of the KRIP were selected for the field study, representing the first stratum. The second stratum of the sampling technique took place at the village level. Twenty-four (24) villages were selected for the study, twelve from the irrigation command area (canal) and twelve from the non-command area (tube well water users) Table 1. The third phase of the fieldwork component was the central survey in which in-depth data collection took place from March 2020 – February 2021. Due to varying population sizes, proportionate random sampling of (217) canal water users and 165 groundwater users were employed. Thus, three hundred and eighty-two (382) respondents were interviewed as the study's sample size. However, after removing questionnaires that were not correctly filled and those with doubtful information, 360 questionnaires comprising 208 from the canal water users and 152 from the groundwater users were used for the analysis. Information on socio-demographics, crop water use, irrigated area, crop water productivity, farm income, and food security were all included in the questionnaire. Data was gathered on individual households and then polled respondents to understand their farm operation and food security status.

Table 1: Sample size and population of the respondents (Canal water users and Tube well users)

Local Government	Canal water users' villages	Sample frame	Sample size (5%)	Tube well users' villages	Sample frame	Sample size (5%)
<b>Kura</b>	Karfi	650	28	Gundutse	342	15
	Kura	840	36	Danhassan	397	17
	Bugau	280	12	Kudani	420	18
	Kosawa	590	26	Kosawa	384	17
<b>Garun Mallam</b>	Mudawa	274	12	G/Mallam	164	7
	Chiromawa	337	15	Kwarin bototo	592	26
	Yada kwari	196	8	Garin Babba	174	8
	Kadawa	207	9	Kwanar Gafan	269	11
<b>Bunkure</b>	Bunkure	724	31	Barkun	369	16
	Lautaye	323	14	Kumurya/Daba	228	10
	Gafan	404	17	Karwan Kwari	324	14
	Turba	209	9	Luran	149	6
<b>Total</b>		<b>5034</b>	<b>217</b>		<b>3812</b>	<b>165</b>

Source: KRIP Water Users Association and HJRDA, Kura Head Officer

## 4. Result and Discussion

### 4.1 Household Socioeconomic Characteristics

The result in Table 2 indicates some differences between canal water users and groundwater users regarding household demographic characteristics. The canal water user's households have larger mean household size, years of formal education, more land size, and more mean years of experience. However, the result of paired sample t-test shows no significant difference in the mean age, farm size, and non-farm income between the two groups. The result further indicates significant difference prob. < 5%, in the mean years of experience, years in formal education, farm income, and total annual income. This indicates the labor absorption capacity of the canal water users relative to their counterparts.

Table 2: Socioeconomic Characteristics of the Respondents

Variables	Mean (Canal water users)	Mean (tube well users)	t-value	P-value
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Age of the farmers (years)	41.8	41.60	-1.483	.140 <sup>NS</sup>
Farming experience (years)	19.14	16.66	5.638	.000**
Formal education (years)	8.4	6.03	-2.663	.009**
Household size (number)	12	10	3.640	.000**
Total Farm size (ha)	3.95	2.97	1.195	.234 <sup>NS</sup>
Farm income (₦)	551,669.85	236,390.73	8.483	.000**
Non-farm income (₦)	287,234.45	279,311.25	.707	.481 <sup>NS</sup>
Total Annual Income (₦)	847,133.97	515,701.98	6.575	.000**

Source: Field survey, 2021

#### 4.2 Technical and Water Use Efficiency Score of the Canal Water Users and Ground Water Users

Fig 2 shows that the mean technical efficiency for beneficiaries and non-beneficiaries was 72.8 and 70 %, respectively. This result indicates that there were possibilities for the rice output to increase by 27.2 and 30 % for canal water users and tube well users, respectively, at a given input level. The minimum efficiency score for canal water users was 38 %, while the maximum efficiency score was 94 %. For the groundwater users, the minimum efficiency score was 3 %, with a maximum efficiency score of 90 %. Fig 3: shows a significant gap that needs improvement in irrigation water use efficiency between the two groups. The average Irrigation Water Use Efficiency (IWUE) score for canal and groundwater users was 76.2 % and 70.2 %, respectively. In other words, the findings showed that canal and groundwater users might save 23.8% and 30 % of current irrigation water usage in rice cultivation, respectively, without reducing their present output levels. The findings of the study revealed a link between technological efficiency and IWUE. Improvements in irrigation water use efficiency could improve the overall technical efficiency of rice farming in the research area, considering the association between technical efficiency and irrigation water use efficiency.

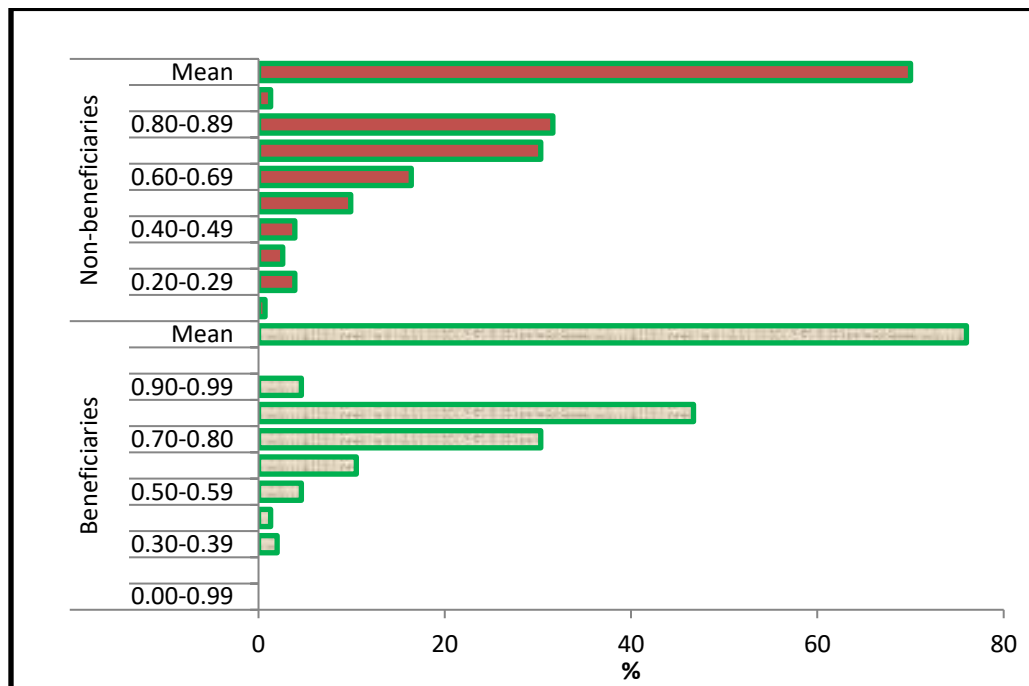


Fig 2: Water Use Efficiency Score

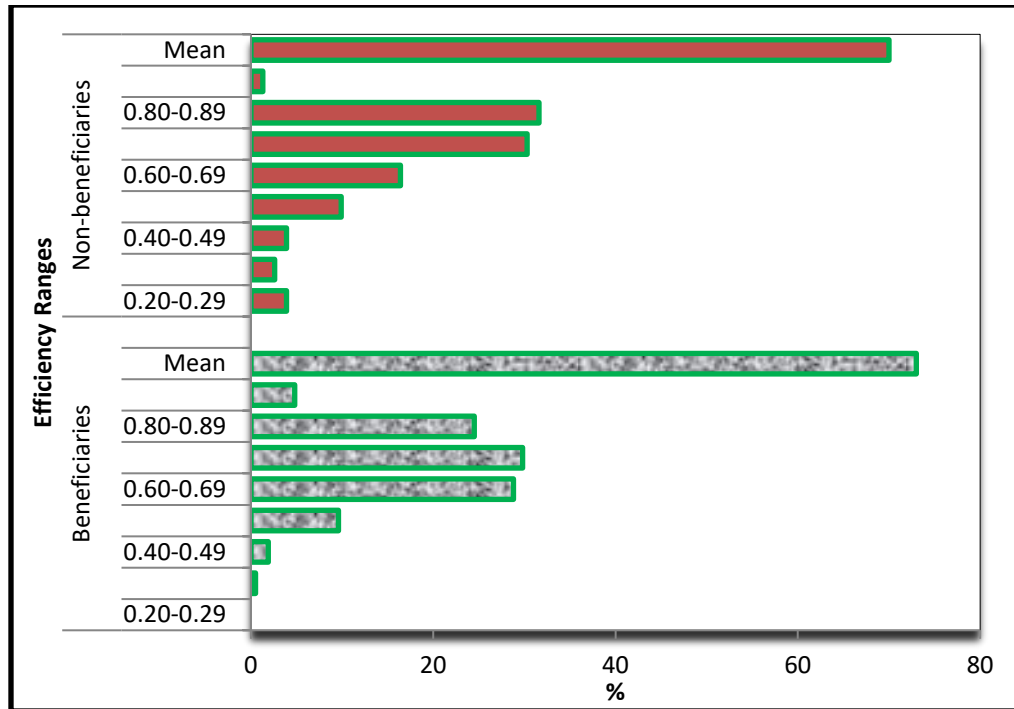


Fig 3: Technical Efficiency Score

### 4.3 Impact of KRIP on Water Use Efficiency in Rice Production

Presented in Table 3 is the result of the impact of KRIP (canal irrigation) on water use efficiency; the Average treatment effect (ATE) estimations, viz. propensity-score matching and regression adjustment, show that the project had no significant impact on the efficiency of the irrigation water use in the study area. The ATE indicates these estimated coefficients, which were not different from zero at a 5% probability level. The ATE coefficients of propensity-score matching and regression adjustment for IWUE were 0.03 and 0.01, respectively, although these coefficients were positive but statistically insignificant. The result can further be interpreted to mean that the IWUE of canal water users is only 1 to 3 % better than their counterparts. Similarly, within the treatment group (canal water users), ATET of the regression adjustment showed that their mean difference is not statistically different from zero. The mean regression adjustment of the untreated group ATEU was also not statistically different from zero. The propensity score matching of the ATET/ATEU also showed that the coefficients were not different from 0 at a 5% probability level.

Table 3: Impact of KRIP on Water Use Efficiency in Rice Production

Items	Coefficient	t-stat	Coefficient	t-stat
<b>Irrigation water use efficiency</b>				
	<b>Regression adjustment</b>		<b>Nearest-neighbor marching</b>	
ATE	0.01416 (0.02525)	0.56 <sup>NS</sup>	0.02037 (0.02743)	0.743 <sup>NS</sup>
ATET*	0.00855 (0.01939)	0.44 <sup>NS</sup>	0.03400 (0.02732)	1.245 <sup>NS</sup>
ATEU	-0.02185 (0.04826)	-0.45 <sup>NS</sup>	-0.00173 (0.0469)	-0.036 <sup>NS</sup>
Mean (B)	0.74542 (0.02251)	33.12***		
Mean (N)	0.73125 (0.01164)	62.81***		
<b>Propensity- score matching</b>				
ATE	0.032346 (0.04695)	0.69 <sup>NS</sup>		
ATET*	0.019895 (0.01235)	1.61 <sup>NS</sup>		
ATEU	-0.04938 (0.10447)	-0.47 <sup>NS</sup>		

Source: Field survey, 2021



#### 4.4 Impact of KRIP on Technical Efficiency in Rice Production

Concerning technical efficiency, the result in Table 4 indicated that the ATE estimations, viz. propensity-score matching and regression adjustment were not statistically different from 0, as indicated by the ATE of the estimated coefficients. The regression adjustment's negative ATE coefficient (-0.007) showed a loss of TE of about 1% for the canal water users compared to the control group (groundwater users). Contrary to the ATE of the regression adjustment, the coefficient of the ATE of the propensity score matching, which is adjusted to sampling bias, shows a positive (0.01). Furthermore, within each stratum, the regression adjustment showed no significant difference within the two groups as indicated by the probability of their respective average treatment effect on treated/untreated (ATET/ATEU). The propensity score matching of the ATET/ATEU also showed similar results. This is probably due to the extension gap and the withdrawal of the government from all technical assistance apart from water since 1985. This finding is consistent with (Higginbottom et al., 2021), who reported that most irrigation projects in Africa produce below their potential due to mainly institutional problems, project size, and climate. The finding is also in line with (Sangari, 2007) in his analysis of the "Evaluation of Water and Land Uses in the Kano River Project," which outline that the project's performance was below its productivity level. However, this finding is contrary to that of (Umar, 2019; Umar & Haruna 2019), who reported that surface water irrigation (canal) farmers were more efficient in terms of farm income and poverty status than their counterparts. However, many studies advocated that lack of augmenting input or credit is an impediment to the use of proper input mix, which could negatively affect the efficiency of a farm, especially small-scale farmers who are constraints by capital necessitating them to operate below the global profit or output maximization level as the case may be.

Table 4: Impact of the KRIP on Farmer's technical efficiency

Items	Coefficient	t-stat	Coefficient	t-stat
<b>Technical Efficiency</b>				
	<b>Regression adjustment</b>		<b>Nearest-neighbor marching</b>	
ATE	-0.00742 (0.01537)	-0.48 <sup>NS</sup>	0.00623 (0.02064)	0.30 <sup>NS</sup>
ATET	-0.02546 (0.01947)	-1.31 <sup>NS</sup>	-0.0255 (0.01947)	1.31 <sup>NS</sup>
ATEU	-0.01727 (0.02337)	-0.74 <sup>NS</sup>	-9.35e-06 (0.0271)	-0.00 <sup>NS</sup>
Mean(B)	0.72383 (0.00971)	62.81***		
Mean(N)	0.73123 (0.01164)	74.54***		
<b>Propensity- score matching</b>				
ATE	0.01492 (0.01596)	0.94 <sup>NS</sup>		
ATET	-0.0141 (0.01099)	-1.28 <sup>NS</sup>		
ATEU	-0.0547 (0.03312)	-1.65 <sup>NS</sup>		

Source: Field survey, 2021

#### 4.5 Impact of KRIP on Food Security

Presented in Table 5 is the analysis of the project's impact on the food security status of the canal water users. The coefficient of the ATE of the regression adjustment and propensity score matching were (-0.155 and -0.183) respectively. This indicated that the canal water users were less food secure by about 15 to 18 % than their counterpart. The probable reason for this result is that the canal water users have more household sizes, which could mean they might have more dependence. Households with many individuals are likely to see an increase in household spending on food and non-food items, putting additional strain on household disposable income. Many empirical studies affirm a positive correlation between food insecurity and household size. In other words, they attested that food insecurity increases with an increase in family size (Olayemi, 2012; Maxwell, Coates, & Vaitla, 2013; Agboola, 2016; Jabo, Ismail, Abdullah, & Shamsudin, 2017).

Table 5: Impact of KRIP on Food Security of the Canal Water Users

Items	Coefficient	t-stat	Coefficient	t-stat
<b>Food Security</b>				
	<b>Regression adjustment</b>		<b>Nearest-neighbor marching</b>	
ATE	-.15579 (.05349)	-2.91**	-.11389 (.06433)	-1.77

Table 5 Cont'd

ATET*	-.17496 (.04229)	-4.14**	-.20192 (.05665)	-3.56***
ATEU	.129561 (.10341)	1.25 <sup>NS</sup>	-.00658 (.11145)	-0.06
Mean(B)	.636963 (.04986)	12.77***		
Mean(N)	.792760 (.02985)	26.56***		
<b>Propensity- score matching</b>				
ATE	-.18333 (.05183)	-3.54***		
ATET	-.12019 (.04824)	-2.49**		
ATEU	.26974 (.10289)	2.62**		

Source: Field survey, 2021

#### 4.6 Impact of the Project on the Income of the Canal Water Users

Table 6 shows that the income of the canal water users significantly differs from that of groundwater users. This is indicated by their respective ATE estimated coefficients, which varied from zero at a 5% probability level. Thus, the ATE coefficients of propensity-score matching and regression adjustment, respectively, being N250,864, and N269,031, imply that canal water users had their rice production annual incomes significantly above their counterparts. This result confirmed the result of the descriptive test, which reported a difference in mean annual income of about N431,441 against the groundwater users Table 1. Furthermore, within the stratum of the canal water users, the result shows significant differences in the mean income among the canal water users prob. <0.05% as indicated by the ATET of the regression adjustment and ATET of propensity score matching (4.47 and 3.77), respectively. This finding is in line with the conclusions of (Kirby et al. (2015), who argued that participation in irrigation projects improved the living standard of the beneficiaries (canal water users) through increased farm income.

Table 6: Impact of the Project on the Income of the Beneficiaries

Items	Coefficient	t-stat	Coefficient	t-stat
<b>Income</b>				
	<b>Regression adjustment</b>		<b>Nearest-neighbor marching</b>	
ATE	250864 (86883.8)	2.89**	361926 (107749)	3.36***
ATET*	335062 (74880.6)	4.47***	420182 (76834)	5.47***
ATET	135647 (155939)	0.87 <sup>NS</sup>	-282207 (208733)	-1.35
Mean(B)	758668 (75239.5)	10.8***		
Mean(N)	507803 (42866.3)	11.85***		
<b>Propensity- score matching</b>				
ATE	269031 (74803.9)	3.60***		
ATET*	358798 (94984.3)	3.77***		
ATET	-146191 (102454)	-1.43 <sup>NS</sup>		

Source: Field survey, 2021

#### 4.7 Circumstances under which Large Scale Irrigation has an Impact on Food Security and Increase Resource use Efficiency (empirical evidence)

Although research conducted by Hussain & Hanjra (2003) found that irrigation can improve cropping intensity by up to 242%, compared to only 100-168% in rain-fed agriculture, a large number of studies (Bashir & Schilizzi, 2013; Matemilola, 2017; Adeyeye & Idowu-Adebayo, 2019) have shown that the accessibility and availability of irrigation water are not sufficient to ensure food security in large-scale irrigation (canal). The ultimate result depends on the linkages between water and non-water sector issues and processes, which could either lessen or exacerbate food insecurity depending on their direction. A few general prerequisites must be met before access to irrigation may be considered effective in fighting poverty. These include:

Table 7: Conditions under Which Large Scale Irrigation Improve Rural Livelihood, Food Security and Enhance Resource Use Efficiency of Irrigated Farmers

1	<u>Training</u> Frequent technical training on efficient water use and the use of improved cultivars	(Burney, Davis, & Lobell, 2010); (Misra, 2014)
2	<u>Fairness in the Allocation of resources and Management of Irrigation Facilities</u> Proper allocation of resources, couple with good management of irrigation facilities in large scale irrigation systems is essential for maintaining diversified infrastructure. This enables long-term sustainability, increase productivity and reduce food insecurity.	(Molle & Mollinga, 2003; Hussain & Hanjra, 2003)
3	<u>Development of Practical Irrigation Policy</u> Irrigation water allocation/distribution policies, procedures, and practices with good and applicable policy framework.	(Sarwar et al., 2010)
4	<u>Agronomic Practices</u> Better production technology, different patterns of cropping, and the diversification of crops	(Hussain & Hanjra, 2003; Adebayo & Oluwamayowa, 2021)
5	<u>Better Output Marketing Strategy and Value addition</u> Input- and output-marketing information value addition and post-harvest lost management	(Girabi & Mwakaje, 2013)
6	<u>Participatory Extension Teaching Method</u> Farmers' participation in planning and decisions related to production, marketing, and technology transfer.	(Hussain & Hanjra, 2004; Plusquellec, 2009)
7	<u>Research and Development</u> Research and development, as well as regulations that are beneficial to water management and policies for social protection, aimed at protecting farmers against the shock and danger connected with agriculture.	(Omotesho, Ogunlade, Akinrinde, & Omotayo, 2017; Osabohien, Osabuohien, & Urhie, 2018)

## 5. Conclusion

The low use of irrigation's potential for food production in Nigeria is due to a number of factors. This necessitates a review of the current situation in order to pinpoint the extent of success and failures of the large-scale irrigation systems that are currently in place throughout the country. It will be necessary to evaluate Nigeria's irrigation projects to identify what went wrong, suggest potential fixes, and develop potential future plans. The evaluation procedure must also be focused on gathering the information required to improve the development and management of water resources in order to develop strategies address the predicted national food crisis.

This study was conducted to investigate the impact of the Kano River Irrigation Project (KRIP) (canal water users) on farmers' incomes, resource use efficiency, and food security. The study estimated controls for observable household variables between the canal and tube well water users using descriptive statistics, average treatment effect, propensity score matching, and t-test. It aimed to contribute to the existing literature by showcasing the silence issue about the contribution of large-scale irrigation towards food security, income and resource use efficiency. The study also established some path ways essential for stake holders and policy makers through which large scale irrigation scheme could achieve its target objectives.

The analysis demonstrates that canal water users' income was significantly higher than groundwater's. The result also found conflicting findings depending on the examined variable. Our findings indicate that KRIP positively affects farmers' income but has no impact on technical or water usage efficiency and a negative effect on food security as measured by calorie availability per capita. This shows that further study is needed better to

understand the adoption dynamics of the two irrigation systems. However, less market integration in tube well water communities compared to markets in large-scale irrigators' communities may account for the income disparity between canal and tube well water users. Also, it may be because the people who benefit from the project (canal water users) have relatively cheap access to irrigation water.

These findings suggest that large-scale irrigation systems are not significantly superior to those used by individual smallholder farmers. However, the discussion for scale may need to be simplified. This study finding only provides an empirical finding of on irrigation scheme. More evidence in other regions of the country is necessary to create an evidence base outcome. In conclusion, there is growing demand for panel datasets that observe both canal water users and groundwater irrigators across time to understand the dynamics of irrigation better and provide the chance to utilize econometric tools to adjust for household or individual fixed effects. Increase the effectiveness of irrigation investments and their impact on household welfare by learning more about the mechanisms by which the scale of irrigation influences benefits and costs in future studies. More studies are required to recognize the nexus between efficiency in water use, food production and food security; to develop prognostications of water supply and demand in the country; and to evaluate the effects of investments in water and irrigation management and development on food security, macro-economic policies and rural livelihood.

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