

Utilization of Irrigation farming technique as Panacea to Farmers' Output Improvement in Mai'Adua LGA, Katsina State

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ABSTRACT

The study examined the impact of irrigation farming technique on the output of farmers in Mai'Adua LGA, Katsina state, Nigeria with output of farmers disintegrated into three dimensions of the output of farmers along the output of maize, cowpea and millet. The study utilized Yamane's formula to draw the sample of two hundred and eighty-six (286) respondents from the irrigation farmers around two major dams (Sabke and Koza dams) in Mai'Adua LGA, Katsina state and used questionnaire instrument to collect information from the sampled respondents. Subsequently, the study adopted multinomial logistic regression as technique of analysis. Essentially, the found that, irrigation farming portends positive and significant impact on millet output, maize output and cowpea output being the three dimensions of farmers' output examined in the study. Consequently, the study concludes that irrigation farming is a veritable means of addressing the problem of dwindling output of farmers, thereby incentivising the agricultural activities, which in turns, enhances living standard among farmers in Mai'Adua LGA, Katsina state. On this note, the study suggested the following recommendations to include among others, the act of disseminating awareness on utilizing irrigation farming technique, applying adequate fertilizer and improved seeds, among farmers, must be promoted through the services of agricultural extension workers in Mai'Adua LGA for entrenching and improving the output of farmers by its all dimensions. This would not only boost the farmers's output but also make the farming attractive to the youth in Mai'Adua LGA, Katsina State, Nigeria.

Keywords: Farmer's Output; Irrigation Farming; Katsina State; Mai'Adua LGA and Multinomial logistic regression

INTRODUCTION

The output of farmers is one of the metrics of measuring agricultural productivity for growth and development of any economy in the world. This is essentially so in the area of output optimization that allows for supplying of food to the citizens, raw materials to industries, employment and income generation for farmers as well as enhances societal well-being (Food and Agriculture Organization [FAO], 2024; World Bank, 2019). Similarly, output of farmers stimulates realization of enhanced socioeconomic wellbeing that entails income generated from the sales of output and physical access to the right quality and quantity of diet food for consumption, which are one among other cardinal aspiration of every individuals in life (World Bank, 2019; Economic Commission for Africa, 2009).

Admittedly, developed countries such as China, United States of America (USA), Russia, France, Mexico, Japan and Germany are among the top ten (10) agricultural productive countries in the World with remarkable produced output by the farmers that contribute to the growth and development of these countries in terms of employment and income generation for the farmers as well as food security of farmers at the country at large (FAO, 2024). In this direction, Nigeria and her rural areas like Mai'Adua LGA, Katsina state is blessed with abundance and large expanse of arable land for cultivation with potentiality of optimizing output for the farmers and agricultural production in the country if well harnessed. Subsequently, the output of farmers that cut across the outputs of maize, rice and cowpea, among others, can be produced optimally by the farmers in the country and Mai'Adua LGA, Katsina state in particular. However, this goal of optimal production of farmers' output in Mai'Adua LGA, Katsina state has not actualized due to a number of factors that include weather condition (shortage rainfall), insecurity and obsolete system of farming.

In this view, Wasiu (2024) asserted that, lower output of farmers in northern states like Zamfara, Sokoto, Kebbi, Kaduna and Katsina that is attributed to the state of insecurity in form of banditry, kidnapping and cattle rustling, among others, thus, resulted to the lingering cases of hunger and starvation of the population in the aforementioned states. However, Gain and Harvestplus (2019) maintained that, crude system of agricultural practices in Mai'Adua LGA, Katsina state that depends largely on traditional farm implements like use of hoes, cutlass and axes as farming tools and the practice of only raining season farming are among other reasons that impedes optimum agricultural production, hence, farmers in Mai'Adua LGA, Katsina state like in major part of the north and the country at large continued to recorded lower agricultural output.

Importantly, Suleiman (2013) stressed that, Mai'Adua LGA as one of the thirty-four (34) local government areas of Katsina state, is located along Northern part of the state, which also bordered Niger Republic often characterized by low rainfall during the raining season due to desert encroachment. As a result, the area is mostly affected by climate change, which left aspiration of farmers in Mai'Adua LGA, Katsina state to have a bumper harvest far from reach. Consequently, the growth aspiration of farmers to boost their output produced is hindered. On this account therefore, Moukhtar, Alhassan and Ahmad (2021); Alhassan, Salis and Sulu-Gambari (2020); Gain and Harvestplus (2019) and Ogunniyi, et al. (2018), among others, opined that, until agricultural practice in local areas like Mai'Adua local government area of Katsina state and Nigeria at large, is revamped and transformed with introduction modernized system of farming the utilizes agricultural technologies like irrigation and mechanized system of farming to augment crop cultivation during the raining season, the output of farmers would remained insignificant to improve the livelihood of farmers in Mai'Adua local government area of Katsina state, and Nigeria as whole, thereby discouraging participation and investment into agricultural activities by farmers in the Mai'Adua LGA, and the country generally.

In view thereof, Tijani, Abba and Dandela (2022), Ibrahim, Yusuf and Adefila (2018) and Sulaiman (2013) expressed the significant roles of irrigation farming on socioeconomic wellbeing of the rural farmers in Jibia, Faskari and Mallunfashi local government areas of Katsina state and so if irrigation farming technique is adequately utilized in Mai'Adua LGA, similar impact in the Jibia, Faskari and Mallunfashi would be replicated on the farmers' output in Mai'Adua LGA, Katsina state. However, the choice of Mai'Adua LGA, Katsina state as the study area is owed to its geographical position being a bordering LGA in Katsina to Niger Republic that is mostly affected by adverse effect of climatic challenges that include erratic rainfall and prolonged dry season that affects land cultivation by the farmers in the area. Hence, the needs to undertake study relating irrigation farming to farmers' output in Mai'Adua LGA becomes imperative for lending significant contribution to literature and to the immediate society of the study, which could also serve as basis of policy measures to the local authorities in mitigating the problems of poor output harvests by the farmers due to the shortfall in rainfall in the area. From the foregoing, this study investigates into the impact of irrigation farming on output of farmers in Mai'Adua local government area of Katsina state, Nigeria.

LITERATURE REVIEW

Conceptual Literature

Irrigation is a system of farming that has been in existence for over 5,000 years and practiced in many countries of the world (Siebert, Hoogeveen, Faurès & Frenken, 2006). Importantly, irrigation aids growing of crops, maintaining landscapes, revegetates the distressed soils nutrient in a dry areas particularly, during the times of low rainfall that is below the average and protect crops from frost. Therefore, the concept of irrigation is defined with conscious to its vital roles in the process of land cultivation and food production. However, the concept of irrigation farming is in general sense means the system of applying regulated quantity of water on land surface in order to aid growing of crops, landscaping the plants and lawns (Elshaikh, et al., 2018; Snyder, & Melo-Abreu, 2005). Similarly, irrigation is man-made application of regulated amount of water on plants for aiding agricultural production with aim of promoting food production, poverty reduction and enhancing the contribution of agricultural sector towards economic development (Elshaikh, et al., 2018). Consequently, this study adopts the combined conceptualization of irrigation farming by Elshaikh et al. (2018) and Snyder and Melo-Abreu (2005) for highlighting the purposes of utilizing irrigation farming like welfare enhancement, poverty reduction and boost agricultural sector's contribution to the societal and national development.

Farmers' Output

Generally, the concept of Farmers' output can be deduced from the conceptualization of agricultural output. Therefore, the concept of Farmers' output can be viewed to mean the total yield in monetary term from cultivated farmland by the farmers (Tijani, et al., 2022). This then, refers the yield to the total quantity or volume of all types of crops harvested from the cultivated agricultural land. According to Siebert, Hoogeveen, Faurès and Frenken (2006), Farmers' output is the total monetary value of all species of crops produces by farmers on a given space of farmland land during a particular period of time. This thus stresses that, Farmers' output covers both cultivation of both cash and food crops harvested from farmland with the primary aim of producing wealth necessary to satisfy the basic needs of life. In the same vein, Kindineh (2023) refers to farmers' output as the value of final products produced from cultivated farmland by the farmers in a particular geographical location during a particular period of time. In other word, it is a yield from farming activities by farmers for meeting and satisfying the basic needs of life like household consumption, and income generation. From the foregoing, this study adopts the conceptualization of agricultural output by Kindineh (2023) as the operational definition for outlined the "final products" from Farmers' output, "time and geographical location of cultivation and harvest" in their conceptualization because, that differentiate the product between final and intermediate products in this context and save the conceptualization of output from being taking as "intermediate product". While, time and location of production is equally necessary in the conceptualization because of distinct in endowment between locations and time variances from location to location.

THEORETICAL LITERATURE

The reviewed theory of total factor productivity was the framework upon which this study was built.

Total Factor Productivity

The total factor productivity (TFP) theory otherwise known as Solow residuals was developed by Robert Solow in 1956 which was an attempt to measure the ratio of the aggregate output to the aggregate inputs (Sickles & Zelenyuk, 2019). The theory was built on some basic assumptions that, through the production technology, the growth in TFP is a portion of growth in output not expressed in the traditionally measured inputs of labour and capital utilised in production which is thus represented by technical know-how (Robert, 2017). Consequently, the total factor productivity is a measure of production efficiency that measure the quantity of output that can be produced from a given units of inputs is measured by technological know-how in the production process which can be algebraically expressed as:

$$Y = AK^{\alpha}L^{\beta} \dots\dots\dots (2.2)$$

Where Y is total output, A is total factor productivity which is the representation of technology, K is capital input and L is labour input, α and β are the share of contribution of K and L to the total output. And so, an increase in either of K or L will results in increase in total output.

Empirical Literature Review

Generally, there is plethora of empirical studies centered on the impact of irrigation farming on agricultural output from the Global, national and state perspectives with dearth of such empirical studies in Mai'Adua LGA, Katsina state, however, the selected studies reviewed include a study by Kindineh (2023) that investigated the impact of irrigated agriculture on households' income and food security in South-west region of Ethiopia. The study employed both descriptive statistics and logit regression model to analyzed the 200 sample households that adopts irrigation schemes and 219 households that refused to adopts irrigation scheme and discovered that age of the household head, education level of the household head, distance of land from the irrigation source, land size, off-/nonfarm income, distance from the nearest market, slope of the land and access to irrigation services are the variables that were found to significantly affect participation in irrigation. Consequently, on the account of significance of irrigation schemes, households' income and food security of those households that adopted small-scale irrigation is significantly enhanced through the output enhancement because, it increases the accessibility of households that utilized the scheme to intake of calories and diets.

Additionally, Tijani, et al. (2022) studied the awareness on the effects of irrigation farming on farmers' yield and income: evidence from Jibia irrigation scheme in Katsina state, Nigeria. The study adopted descriptive statistics as technique of analysing the obtained data from the field survey to found that, food security through the output of crop production under irrigation farming, crop yield and crop income is significantly enhanced. This thus points to the necessities of adopting irrigation farming that subsequently allow for all year-round farming as viable option of boosting crop production, hence, food security in Jibia local government area of Katsina State and Nigeria at large. Likewise, Employing descriptive statistics and Product Moment Correlation on the 379 irrigation farmers sampled from two registered and functional irrigation Farmers' Association in Kafur and Mahuta districts of Kafur local government area of Katsina State, Nigeria, Ibrahim, Yusuf and Adefila (2018) investigated the effect of irrigation farming on socioeconomic development of Kafur local government area of Katsina state. The findings revealed that, 70%, 44% and 39% of respondents shown improvement in housing condition, improvement in education of children and better-quality diet, respectively are excellent through output improvement. This thus points to the attainment of relative wellbeing of the irrigated farmers in kafur local government area of Katsina state and concluded that irrigation schemes play an important role in ensuring and assuring overall wellbeing that include higher output to the individual households or farmers who practiced it.

Similarly, Ogunniyi, et al. (2018) examined the impact of irrigation technology use on crop yield, crop income and households' food security. The study adopted logistic regression as a tool of analysis on the number of employed explanatory variables using the data retrieved from the sampled respondents to reveals that years of education, household size, rainfall information, access to credit, regional dummies are the main drivers of usage decision. Consequently, the estimated regression model revealed that irrigation technology use is positively related to crop yield, crop income and household food security. This implied that, crop yield, crop income and household food security is significantly enhanced with the adoption of irrigation technology in Nigeria. More so, using descriptive statistics, Musa, Baba and Beli (2014) examined the economic analysis of the crop production under Jibiya irrigation project and found that, the irrigated famers enjoyed net investments of 1.01% while exercising farming activities under irrigation-fed system in Jibiya LGA, Katsina state, Nigeria. More so, applying descriptive statistics and logistic regression on the 166 sampled respondents that participated in irrigation farming in Jibiya LGA, Katsina state, Sulaiman (2013) studied the impact of Jibia dam irrigation project on wheat production and livelihood of benefiting farmers adopted irrigation farming mechanism in Katsina state, Nigeria to discovered that, farming experience, farm size, labour, extension contact, cooperative association were the factors that collectively influence 75% of the participation of the respondents in Jibia dam irrigation project. Furthermore, it is revealed that, Jibia dam irrigation project had significant impact on participants' output, yield, income and living standard at 1% levels of probability. However, 25% of the sampled respondents point to the insufficient farm inputs like fertilizer and agrochemical as the principal constrain confronting the irrigation farmers that hinders them from harvesting the expected level of output on the irrigated farms.

More so, Tekana and Oladele (2011) studied the impact analysis of Taung irrigation scheme on household welfare among farmers in North-west province of South Africa. The study drawn the sample size of 137 from the targeted population and subsequently employed OLS as a method of analyzing the obtained data to revealed that explanatory variables like level of education attainment, access to financial capital and human capital, and income as well as socioeconomic status of the farmers portend positive effect on the output of farmers, which in turns translate to positive effect on the welfare of the farmers that practiced taung irrigation scheme in North-west province of South Africa while, access to physical capital, household size, household head, number of dependent of the farmers and access to natural capital have negative effect on the output of farmers that in turns, exert negative effect on the welfare of the farmers that practiced taung irrigation scheme in the North-west province of South Africa.

Therefore, from the above reviewed studies, it is evident that, attempt to study the relationship between irrigation farming and agricultural production in Mai' Adua LGA was not made in the literature in addition to the absence of studies that employed multinomial logistic regression as the technique of analysis. Consequently, lack of empirical study in the area of investigation in Mai' Adua LGA, Katsina state and absence of studies that utilized multinomial logistic regression leaves both spatial and methodological gaps that this study bridged in the literature.

METHODOLOGY

Research Design

In order to achieve the stated objectives of the study, both survey and quantitative research design was adopted. This is because, survey research enables the researcher to gain a greater understanding about individual or group of individuals' perspectives pertaining the particular subject under investigation, which in this case, is the impact of irrigation farming on farmers' output in Mai'Adua LGA, Katsina state while, quantitative research allows for the analysis of the cause and effect of the explanatory variables, that is, irrigation farming on the dependent variable, that is, the output of farmers in Mai'Adua local government area of Katsina state (Selltitz, 1959).

Study Area

Mai'Adua local government area of Katsina state is one of the thirty-four (34) local government areas in Katsina state chosen as the study area. This is owed to fact that, Mai'Adua LGA, Katsina state is located along Northern part of the state that is bordered by Niger Republic often characterized by low rainfall during the raining season due to desert encroachment and prolonged dry season which does affect the soil fertility of the area and subsequently, the agricultural output from cultivated farmland. Hence, the need to augment the erratic rainfall with irrigation farming technique and fertilizer application on the farmland to support the poor fertility of soil of the area is imperative.

Mai'Adua LGA, Katsina state is located in the extreme north of the state that has its local government headquarters situated in the city of Mai'Adua on the A2 highway. It has an area of 528 km² and estimated population of 360,700 with male occupying 51.1% and female occupying 48.9% of the population thus, male dominates the population of Mai'Adua local government area of the state (National Population Commission [NPC], 2022).

The climatic state of the Mai'Adua LGA has temperature of 37°C on average annually; approximately 653 mm of rainfall in a year; 263 dry days; and a 30% of average humidity and Mai'Adua has a semi-arid climate (Kankara, 2009). Mai'adua LGA, katsina state has ten (10) electoral wards; namely, Mai'Adua A, B and C, Koza, Bumbum A and B, Danyashe, Mai-Koni A and B, and Natsalle.

It has a very huge historical International and rural market located at Mai'Adua town (the local government headquarters) that does operates on Sundays with livestock such as cattle, sheep, goats, camels, donkeys, and horses as the major live commodities supplied from Niger Republic, whereas, grains like maize, sorghum, millet, and soybean are commodities supplied in the market from Nigeria. Consequently, the market is an international one that serve as exchanging point between Nigeria and Niger Republic.

However, there are two formal dams (Sabke and Koza) in Mai'Adua local government area that serves as sources of water to most part of the local government area to ease the supply of water to the cultivating farmlands in the area, while Daberam dam is interlocked between the territorial boundary of Daura local government area and Mai'Adua local government area but more occupied by Daura local government area.

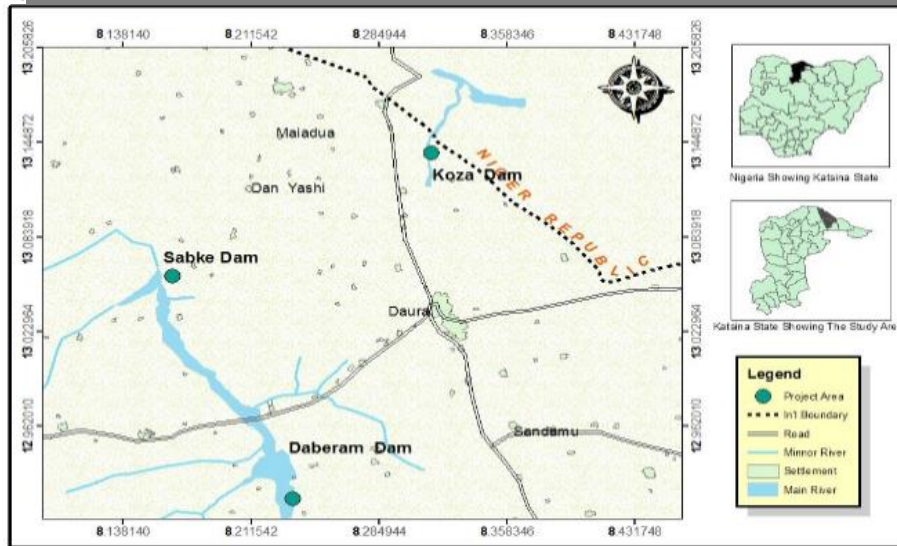


Figure 3.1: Mai'Adua Local Government Area with available Dams

Source: Adapted from Usman, Rilwanu and Usman (2018)

The population of the study is the population of irrigation farmers in Mai'Adua local government area of Katsina state who are active participant in irrigation farming most especially, during the dry season. Based, on the adapted statistics of irrigation farmers in Mai'Adua local government area of Katsina state contained in the surveyed work of Usman, Rilwanu and Usman (2018), the total number of irrigation farmers surrounding the two major dams in the area were 1,050 with Sabke dam has number of seven hundred (700) and Koza has three hundred and fifty (350) number of irrigation farmers.

Sampling and Sample Size

A probability sampling using a simple random sampling technique were utilized to select the sampled respondents for the study. Consequently, sample size of the population of Mai'Adua LGA was determined using Yamane formula of sample size determinations. Thus, according to Jacqueline (2022), Yamane specified the formula for sample size determination as:

$$n = \frac{N}{1 + Ne^2}$$

Where; n is the sample size; N is the total targeted population and; e^2 is the square of the percentage of the error of tolerance and in this study, it is assumed at 5 per cent level of error tolerance.

Recall that N, which is the total population is given as 1,050. Hence, Yamane for this study is explicitly expressed as:

$$n = ?; N = 1,050; e = 5\%$$

$$n = \frac{N}{1 + Ne^2}$$

$$1 + Ne^2 = 1,050$$

$$1 + 1,050(e)^2$$

$$= \frac{1,050}{1 + 1,050(0.05)^2}$$

$$= \frac{1,050}{1 + 1,050(0.05)^2}$$

$$1+1,050(0.0025)$$

$$= 1,050$$

$$1+2.625$$

$$= 1,050$$

$$3.625$$

$n = 289.6551 \sim 290$ therefore, sample size of the total population of the study which is the representation of the entire population of Mai'Adua LGA, Katsina state. Hence, the breakdown of the sample size for the respective dams in Mai'Adua LGA, Katsina is derived by the percentage composition of population in each of the two major dams in the local area as thus, represented in the Table 3.1.

Table 3.1: Breakdown of the Sample Size

S/N	Name of Dam	Population	Sample size	Percentage
1.	Sabke	700	193	66.6%
2.	Koza	350	97	33.4%
Total		1,050	290	100%

Source: Researcher's computation (2026).

Method of Data Collection

The data for the study was generated from primary source and the study used questionnaire method as an instrument of collecting data. And the questionnaire contained structured questions relating to the study variables like size of farmers' farmland for irrigation farming, level of output of the irrigated farmers and generated income of the irrigated farmers, among others, in Mai'Adua LGA, Katsina state. The questionnaire was designed in English language to enable the respondents to fill the questionnaire more appropriately.

Model Specification

Based on the literature particularly, the total factor productivity (TFP) model which expresses input-output relationship; hence, the model of the study is expressed as:

$$Q = Af(L, K) \dots\dots\dots (3.1)$$

Where Q is output level, L is labour, K is capital and A is total factor productivity which is the representation of technological progress in the production function. Therefore, the study adapted the model of Tijani, et al. (2022), Ibrahim, et al. (2018) with some modifications to capture and reflect the variables of the study. The modification to the adapted questionnaire were made along the disaggregation of output of Farmers into its main components like millet output, maize output, rice output and cowpea output. However, the output of Farmers is tantamount to the quantity of components of Farmers' output produced by the irrigated farmers; hence, output in the original TFP model remains the output of Farmers, labour was proxy by the number of workers used by irrigation farmers while, capital (K) was proxy by adoption of irrigation farming technique. Thus, the model of the study was built around single equations model which is specified as:

$$QF = f(L, irr.f.p) \dots\dots\dots (3.2)$$

Where QF is output of farmers, L is unit of labour proxy by the number of people hired by irrigation farmers working in farmland, irr.f.p is irrigation farming technique. Subsequently, the farm size, improved agricultural

seed is introduced and fertilizer application into the model as the control variable because of their ability to induce the output farmers. Consequently, the model in equation (3.2) is reinstated with the farm size, improved agricultural seed and fertilizer as control variable as:

$$QF = f(L, IRR.F.P, FS, IS, FAPP) \dots\dots\dots (3.3)$$

Where QF is output of farmers, L is unit of labour proxy y the number of people hired by irrigation farmers working in farmland, IRR.F.P is adoption of irrigation farming technique as supplementary input, fs is farm size, IS is improved agricultural seed and FAPP is fertilizer application. Therefore, the composite equation of farmers' output in relation to the examined explanatory variables and control variable specified in equation (3.3) is restated in both mathematical and econometric form as:

$$QF = L + IRR.F.P + FS + IS + FAPP \dots\dots\dots (3.3a)$$

$$QF_i = \beta_0 + \beta_1 L_i + \beta_2 IRR.F.P_i + \beta_3 FS_i + \beta_4 IS_i + \beta_5 FAPP_i + e_i \dots\dots\dots (3.3b)$$

Where β_0 is the intercept, $\beta_1, \beta_2, \beta_3, \beta_4$, and β_5 are the parameters (coefficients) to be estimated and e_i is the stochastic error term which takes into account all the unobservable factors affecting farmers' output. Nonetheless, it is imperative to state that in this study, the regressand, that is, farmers' output has numerous dimensions though, this study adopted the four of such dimensions because of the peculiarity of the study area regarding factors other than the lower rainfall and shortage of water needed for plant germination. The adopted dimension of the farmers' output includes rice output, millet output, maize output and cowpea output: hence, the dependent variable has three responses. Consequently, output of farmers is further decomposed into its various dimensions like rice output millet output, maize output and cowpea output, and as such, the dependent variable (output of farmers) stated in equation (3.3) is disaggregated and expressed as:

$$RQ = f(L, IRR.F.P, FS, IS, FAPP) \dots\dots\dots (3.5)$$

$$MTQ = f(L, IRR.F.P, FS, IS, FAPP) \dots\dots\dots (3.6)$$

$$MZQ = f(L, IRR.F.P, FS, IS, FAPP) \dots\dots\dots (3.7)$$

$$CPQ = f(L, IRR.F.P, FS, IS, FAPP) \dots\dots\dots (3.8)$$

Therefore, the multiple responses of the response variable QF_i is written as:

$QF_i=1$ stand for rice output of farmers

$QF_i=2$ stand for millet output of farmers

$QF_i= 3$ stand for maize output of farmers

$QF_i= 4$ stand for cowpea output of farmers

Thus, the choice pattern of Multinomial logistic regression models expressed in the composite model presented in equation (3.2) can take the following forms:

$$QF_i = X_{RQ} \beta_{RQ} + e_{RQ} \dots\dots\dots (3.9)$$

$$QF_i = X_{MTQ} \beta_{MTQ} + e_{MTQ} \dots\dots\dots (3.10)$$

$$QF_i = X_{MZQ} \beta_{MZQ} + e_{MZQ} \dots\dots\dots (3.11)$$

$$QF_i = X_{CPQ} \beta_{CPQ} + e_{CPQ} \dots\dots\dots (3.12)$$

Where: RQ = Rice output of farmers; MTQ = Millet output of farmers; MZQ = Maize output of farmers; CPQ = Cowpea output of farmers and e_{RQ} , e_{MTQ} , e_{MZQ} and e_{CPQ} are error terms or other factors affecting QF_i

However, if

$$X_{RQ}\beta_{RQ} + e_{RQ} > \max (X_{MTQ} \beta_{MTQ} + e_{MTQ} + X_{MZQ} \beta_{MZQ} + e_{MZQ} + X_{CPQ} \beta_{CPQ} + e_{CPQ}) \text{ then, } RQ_i = 1 \quad (3.13)$$

$$X_{MTQ} \beta_{MTQ} + e_{MTQ} > \max (X_{RQ} \beta_{RQ} + e_{RQ} + X_{MZQ} \beta_{MZQ} + e_{MZQ} + X_{CPQ} \beta_{CPQ} + e_{CPQ}) \text{ then, } MTQ_i = 2 \quad (3.14)$$

$$X_{MZQ} \beta_{MZQ} + e_{MZQ} > \max (X_{RQ} \beta_{RQ} + e_{RQ} + X_{MTQ} \beta_{MTQ} + e_{MTQ} + X_{CPQ} \beta_{CPQ} + e_{CPQ}) \text{ then } MZQ_i = 3 \quad (3.15)$$

$$X_{CPQ} \beta_{CPQ} + e_{CPQ} > \max (X_{RQ} \beta_{RQ} + e_{RQ} + X_{MTQ} \beta_{MTQ} + e_{MTQ} + X_{MZQ} \beta_{MZQ} + e_{MZQ}) \text{ then } CPQ_i = 4 \quad (3.16)$$

The above equations (3.13) through (3.16) depicts that when $QF_i = 1$ the irrigation farming has impact on rice output dimension of farmers' output, when $QF_i = 2$ the irrigation farming has impact on millet output dimension of farmers' output, for $QF_i = 3$, the irrigation farming has impact on maize output dimension of farmers' output and lastly when $QF_i = 4$ irrigation farming has impact on cowpea output dimension of farmers' output.

Data Presentation and Analysis

Data Presentation

The report of the field survey showing the number of administered questionnaires, returned questionnaire, valid questionnaire and invalid questionnaire is presented in the Table 4.1.

Table 4.1: Data Reporting

Panel A: Questionnaire Distribution		
Variables	Frequency	Percentage (%)
Administered Questionnaire	290	100
Returned Questionnaire	282	97.24
Not Returned Questionnaire	8	2.76
Total	290	100
Panel B: Distribution of the Returned Questionnaire		
Returned Questionnaire	282	100
Valid Questionnaire	267	94.68
Invalid Questionnaire	15	5.32
Total	267	100

Source: Researcher's compilation (2026).

As shown in the Table 4.1, a total number of two hundred and ninety (290) copies of questionnaires were distributed to the sampled irrigation farmers in Mai'Adua local government area of Katsina State, of which two hundred and eighty-two (282) representing approximately 97.24% of the administered questionnaire were returned while, eight (8) representing 2.76% were not retrieved during field work as thus, presented in Table 4.1 (Panel A). However, panel (B) of the Table 4.1 shows that, of the two hundred and eighty-two (282) returned questionnaire, two hundred and sixty-seven (267) representing 94.68% were correctly filled; hence, declared valid for this research use. While, fifteen (15) of two hundred and eighty-two (282) representing 5.32% of the returned questionnaire were invalid and rejected due to the problem of inadequate responses to the list of schedules in the questionnaire, choosing more than one responses to some of the schedules or questions in the questionnaire among the provided options and non-response to some questions on the questionnaire list, among others.

Summary of Descriptive Statistics

In the light of the various statistics criteria of the variables specified in the model of the study, the descriptive statistics is presented in the Table 4.2.

Table 4.2: Summary of Descriptive Statistics

Statistics Criteria	QF	L	IRR.FP	FRMS	IS	F/App
Observations	267	267	267	267	267	267
Mean	2.45	1.66	1.64	1.66	1.53	1.81
Variance	1.25	0.36	0.47	0.62	0.41	0.60
Standard Deviation	1.12	0.60	0.69	0.79	0.64	0.80
Skewdness	0.07	0.40	1.03	1.20	0.81	0.82
Kurtosis	1.65	2.93	4.35	4.15	2.60	3.50
Minimum	1	1	1	1	1	1
Maximum	4	3	4	4	3	4

Source: Researcher's computation (2026).

The Table 4.2 revealed that, all the variables under investigation have positive and non-zero mean that range between 1.53 as the least and 2.45 being the highest value of mean shown in the Table 4.2. Thus, the output of farmers in Mai'Adua LGA, Katsina state have highest mean of 2.45; while, the improved agricultural seed used by the irrigation farmers have minimum mean of 1.53. This shows that on average, the sampled irrigation farmers in Mai'Adua LGA, Katsina state have the perception that the utilization of irrigation farming is moderately helpful in enhancing output of farmers in Mai'Adua LGA, Katsina state, and that the variability between the mean and the individual responses is relatively low. Similarly, the variances and standard deviations of all the variables are positive with output of farmers (QF) having the highest values of variance and standard deviation while, unit of labour used by irrigation farmers (L) have the least variance and standard deviation values. Also detailed in the Table 4.2, all the variables are positively skewed while, the Kurtosis statistics indicated that, all the series for the variables falls within the region of one 1.65 and 4.35 indicating seemingly symmetric distribution of random variable in the model. Furthermore, the minimum value across the variables is one (1) indicating that one (1) is least weight for the responses to the questions for all the variables while, four (4) is the maximum value across all the variables indicating that four (4) is the highest weight for the responses to the questions of all the variables as detailed in the Table 4.2.

Pearson's Correlation Matrix

The study employs Pearson's correlation test to access the degree of relationship between the output of farmers in Mai'Adua LGA, Katsina state in one hand, and the explanatory variables like unit of labours working in irrigation farms (L), the irrigation farming adoption (IRR.FP) by the farmers in Mai'Adua LGA, Katsina state, farm size of irrigation farmers (FRMS), use of improved agricultural seeds (IS) and the fertilizer application in irrigation farming (F/APP) and the result of Pearson's Correlation is presented in the Table 4.3.

Table 4.3: Results of Pearson's Correlation

Variables	QF	L	IRR.FP	FRMS	IS	F/APP
QF	1.000					
L	-0.008	1.0000				
IRR.FP	0.057	-0.0496	1.000			
FRMS	0.175	0.0425	-0.068	1.0000		
IS	-0.007	0.044	0.045	0.2485	1.000	
F/APP	-0.002	0.269	-0.0003	0.102	0.225	1.000

Source: Researcher's computation (2026).

the result of correlation coefficients between the variables under examination presented in the Table 4.3 revealed that, the unit of labour employed in the irrigation farmland by the irrigation farmers in Mai'Adua LGA, Katsina state portends negative and very weak correlation with output of farmers (QF) in Mai'Adua LGA, katsina state. This is because, the coefficient of correlation (0.008) between the unit of labour in the irrigation farm and the output of farmers is far from one (1) signifying that, the two variables in the model are not auto-correlated. Similarly, the Table 4.3 shows that, the irrigation farming adoption (IRR.FP) by the farmers in Mai'Adua LGA, Katsina state is positively but weakly correlated with the output of Farmers (QF) because, the correlation coefficient (0.057) between IFF.FP and QF is not approximatable to one (1). This thus, indicated that, there is absence of autocorrelation between the IRR.FP and QF specified in the model of the study. The Table 4.3 shows that, the farm size (FRMS) of the farmers in Mai'Adua LGA, Katsina state is positively but weakly correlated with the output of farmers (QF) because, the correlation coefficient (0.175) between FRMS and QF is not approximatable to one (1). This thus, indicated absence of autocorrelation between the FRMS and QF specified in the model of the study. More so, the improved agricultural seed used in irrigation farming (IS) in Mai'Adua LGA, Katsina state is negatively and weakly related to the output of Farmers (QF) in Mai'Adua LGA, Katsina state. This is because, the coefficient of correlation (0.007) between IS and QF is farther from one (1) thus, presenting no presence of autocorrelation between the said variables specified in the model of the study. The correlation between fertilizer application (F/APP) in irrigation farmland and Farmers' output (QF) in Mai'Adua LGA, Katsina state negative and very weak because, the coefficient of correlation (0.002) between F/APP and QF is farther from one (1) thus, presenting absence of autocorrelation between the variables specified in the model of the study as thus, detailed in the Table 4.3.

Reliability Test

Based on the critical conditions of the convergent validity, internal consistency, discriminant validity and multicollinearity, it is imperative to evaluate the adequacy of the model using the scale of Crombach's alpha reliability test. According to Hair, et al. (2010), the convergent validity of the scales can be verified by two different criteria: firstly, all standardized factor load must surpass 0.70, and secondly, average variance extracted (AVE) of every construct should surpass 0.5. the result of reliability test is presented in Table 4.4.

Table 4.4: Reliability Test

Item-Total Statistics				
	Scale Mean	Scale Variance	Corrected Item	Cronbach's Alpha
QF	8.30	3.541	.088	0.834
L	9.09	4.252	.221	0.627
Irr.FP	9.11	3.980	.257	0.632
frmS	9.09	4.157	.120	0.622
IS	9.22	4.428	.120	0.620
F_App	8.94	3.977	.190	0.724
Test Scale mean (Standardized Items)				0.70

Source: Researcher's computation (2026). The Table 4.4 shows the statistics of cronbach's alpha with the approximate scale of reliability equal to 0.70 threshold of the scale reliability. This follows the principle of testing the reliability of the questionnaire instrument of data collection indicating that, there is internal consistency among the variables of the study specified in the model. Thus, the collected data through the use of questionnaire instrument is reliable and the collected data by implication is valid for policy usage.

Estimation of Model of the Study

The model evaluating the impact of irrigation farming on the output of Farmers Followed the presentation of the data obtained from the field survey, cleansing of the obtained data and testing the statistical properties of the data using various statistical criteria like mean, variance, standard deviation and correlation coefficient (Pearson's correlation) as well as testing the reliability of the questionnaire instrument of data collection using cronbach's alpha,. The dependent variable of the study, that is, farmers' output is disaggregated into its various dimensions like rice, millet, maize and cowpea output, respectively being motive behind the objective of this study. Hence, the results of the estimated multinomial logistic regression is presented in the Table 4.5.

Table 4.5: Results of Multinomial Logit Regression

D/Variables	Coeff.	Std. err.	Z –cal.	Probability
1 (base outcome)				
Millet Output				
L	-0.6771	0.3238	2.09	0.037
IRRF	0.8750	0.2987	2.93	0.003
FRMS	0.3156	0.2570	1.23	0.220
IS	0.3590	0.2865	1.25	0.210

F/APP	0.5326	0.2438	2.18	0.029
Const.	-4.6660	0.9397	-4.97	0.000
Cowpea Output				
L	-0.0280	0.3305	-0.08	0.932
IRR.FP	0.5588	0.3066	1.82	0.068
FRMS	0.6930	0.2400	2.89	0.004
IS	-0.0612	0.3021	-0.20	0.839
F/APP	0.1490	0.2446	0.61	0.543
Const.	-2.2250	0.8460	-2.63	0.009
Maize Output				
L	0.1274	0.3222	0.40	0.693
IRRF	0.6035	0.3047	1.32	0.015
FRMS	0.3845	0.2460	1.56	0.118
IS	0.2360	0.2869	0.82	0.041
F/APP	-0.1094	0.2559	-0.43	0.669
Const.	-1.6640	0.8203	-2.03	0.043

Source: Researchers' computation (2026).

The results of multinomial logit regression model presented in the Tale 4.5 shows that, the output of farmers (QF) in Mai'Adua LGA, Katsina state being the dependent variable with multiple responses such as rice, millet, maize and cowpea output while, unit of labour employed by the irrigation farmers on the irrigation farmland in Mai'Adua LGA, Katsina state, irrigation farming adoption (IRR.FP), farm size (FRMS), improved agricultural seed (IS) and fertilizer application (F/APP). The Table 4.5 presents the results of only three models, that is, the one with respect to millet output, maize output and cowpea output, without presenting the result of rice output due to possibility of dummy variable trap that trapped–in the rice output and thus, excluded such dimension of dependent variable (farmers' output) from the estimated result of multinomial logistic regression. Furthermore, in order to test the significance and ensure the consistency of the result, the study considered two major statistics, of the logistic regression; namely, coefficient and probability value. In the case of probability value, it is expected to satisfy the necessary and sufficient conditions, i.e., it must be significant at specified level of statistics (i.e. 5%) for the null hypothesis to stand rejected, otherwise the null was consider accepted.

Hence, the Table 4.5 shows that, labour size is negatively related with the both millet and cowpea dimensions of farmers' output but positively related to maize dimension of farmers' output in Mai'Adua LGA, Katsina state. As such, more unit labour in irrigation farmland contribute to the decreasing units of millet and cowpea dimension of farmers' output while, more unit of labour contribute an increasing unit of maize dimension of farmers' output thus, negating wide held view of more unit of labour increases output. However, more unit of labour being variable input in a production is conditioned by the principle of diminishing returns which often set-in after the production has reached the pick. Hence, employing additional unit unit of labour is always done with caution of efficiency because, not all additional unit of labour brings efficiency in the production.

Though, the result of relationship between labour and farmers' output is significant for millet dimension while, insignificant for cowpea and maize dimensions of farmers' output in Mai'Adua LGA,

The Table 4.5 revealed positive relationship between utilization of irrigation farming technique with all dimensions of farmers' output, that is millet, cowpea and maize in Mai'Adua LGA, Katsina state conforming to the theoretical postulations underpinning this study and wide held believe that irrigation farming increase output of the farmers. That is, a unit rise in the level of utilization of irrigation farming produces corresponding increase in farmers' output in Mai'Adua LGA, Katsina state. Impressively, the result of positive relationship between utilization of irrigation farming technique with the farmers' output is statistically significant at 5% and 10% levels of statistical significance.

Similarly, the result of multinomial logit presented in the Table 4.5 shows that farm size has a positive relationship with the farmers' output in Mai'Adua LGA, Katsina state corroborating theoretical principles anchoring this study. That is, a unit rise in the size of cultivated irrigation farmland leads to a corresponding increase in the unit of farmers' output by its all dimensions (millet, cowpea and maize) in Mai'Adua LGA, Katsina state. However, the result of positive relationship between farm size and the farmers' output is significant for cowpea dimension while, insignificant for the millet and maize dimensions of farmers' output in Mai'Adua LGA, Katsina state.

Also, the result of multinomial logit depicted in the Table 4.5 shows that application of improved agricultural seed has a positive relationship with millet and maize dimensions of the farmers' output while bears negative relationship with the cowpea dimension of farmers' output in Mai'Adua LGA, Katsina state corroborating the theoretical principles anchoring this study. That is, a unit rise in the rate of applying improved agricultural seed leads to a corresponding increase in the unit of farmers' output by its two dimensions (i.e. millet and maize) but decrease in the cowpea dimension of farmers' output in Mai'Adua LGA, Katsina state. However, the result of positive relationship between application of improved agricultural seed and maize dimension of the farmers' output is significant statistically while, insignificant statistically for the millet and cowpea dimensions of farmers' output in Mai'Adua LGA, Katsina state.

Likewise, the results of multinomial logistic regression presented in the Table 4.5 shows positive relationship between fertilizer application and the millet and cowpea dimensions of the farmers' output while bears negative relationship with the maize dimension of farmers' output in Mai'Adua LGA, Katsina state corroborating the theoretical fertilizer in the irrigated farmland leads millet and cowpea dimensions of farmers' output to increase but lead maize dimension of farmers' output in Mai'Adua LGA, Katsina state to decrease. However, the result of positive relationship between application of fertilizer on irrigated farmland and millet dimension of the farmers' output is significant statistically while, insignificant statistically for the maize and cowpea dimensions of farmers' output in Mai'Adua LGA, Katsina state.

Post Estimation Diagnostic Tests

Pseudo R-Squared

The Pseudo R-square producing the summary of the proportion of variance in the explained (depended variable) that is associated with the explanatory variables that is, the independent variables is measured in three different ways that includes Cox and Snell, Nagelkerke and McFadden. However, Nagelkerke is more preferred to the Cox and Snell and McFadden because, it is a normalized form of Cox and Snell, and offer more interpretable and comparable measure of model fit than the Cox and Snell, and McFadden. Therefore, the results of Pseudo R-squared presented in the Table 4.10 shows the level of variation in the explained variable, that is, farmers' output (QF) that is associated to the explanatory variables like unit of labour (L) employed by the irrigation farmers on the irrigation farmland in Mai'Adua LGA, Katsina state, irrigation farming adoption (IRR.FP), farm size (FRMS), improved agricultural seed (IS) and fertilizer application (F/APP).

Table 4.6: Pseudo R-Square Measures

Cox and Snell	0.571
Nagelkerke	0.717
McFadden	0.605

Source: Researcher's computation (2026).

From the reported results of Pseudo R-squared presented in the Table 4.6, the study considers Nagelkerke with 0.717 which signifies that about 71.7% of variation in the farmer's output (QF) is explained by the predictor variables the unit of labour (L) employed by the irrigation farmers on the irrigation farmland in Mai'Adua LGA, Katsina state, irrigation farming adoption (IRR.FP), farm size (FRMS), improved agricultural seed (IS) and fertilizer application (F/APP) as compared to both Cox and Snell, and McFadden. The implication of this evidence is that, there are many factors other than the examined explanatory variables that determines the farmers' output in Mai'Adua LGA, Katsina state such factors include the market price of output of farmers and pesticide applied on the farm, among others (Moukhtar, et al., 2021) but this study considers only technological factor such as irrigation farming. Hence, the study considers Nagelkerke with 0.717 which is greater than both the Cox and Snell (0.571) and McFadden (0.605) as thus presented in the Table 4.6.

DISCUSSION OF FINDINGS

The impact of irrigation farming on farmers' output by its all millet output dimensions (i.e. millet, cowpea and maize) is positive in Mai'Adua LGA, Katsina state, Nigeria as depicted in the Table 4.6. This finding is in agreement to the findings in a study by Kindineh (2023); Tijani, Abba and Dandela (2022) and Ogunniyi, et al. (2018) in their respective study that irrigation farming enhances yield of cultivated crop of farmers like millet, cowpea and maize dimension of farmers' output which in turns boost the welfare of the irrigated farmers in their respective location of the study like Mai'Adua LGA, Katsina state. This is so because, when all year-round farming is practiced that is aided by the adoption and utilization of irrigation farming, the output of farmers particularly, the millet cowpea and maize are enhanced thus, encouraging land cultivation by farmers, thereby enhancing their wellbeing.

CONCLUSION AND RECOMMENDATIONS

Irrigation farming is a veritable means of addressing the challenges confronting farmer's output for the entrenchment of enhanced agricultural output in Mai'Adua LGA, Katsina State. Importantly, the influential impact of irrigation farming adoption and utilization is too enamous that it bears positive and significant impact on the millet, maize and cowpea outputs, which are the examined dimensions of farmers' output in the study, thus, mitigating the rate of poor output havest among irrigation farmers in Mai'Adua local government area of Katsina state. In a nutshell, the study draws its conclusion that, irrigation farming has significant impact on output of Farmers in Mai'Adua LGA, Katsina state. In the light of findings emanating from this study, the following recommendations are made:

- Irrigation farmers must pay focused attention to the expanssion plan of their cultivated irrigation farmlands both through using the part of output harvests that is not immediately utilized on the expansion plans of their farms and acquire facility like agricultural credit scheme of the government for the expansion purposes.
- Irrigation farmers are encourage to look out for utilization of improved agricultural seeds and fertilizer application on their irrigation farmland so as to complements the supply of water to the farmland through irrigation farming technique.
- The irrigation farmers must also give priority to the particular crop that needs not much water like rice and maize, thereby encourages cultivation of crops that is most compatible with climatic condition and soil fertility of the area rather than cultivating any type of crop using irrigation technique.

- The irrigation farmers must thread with caution on the unit of labour to be engaged in the irrigation farming since, the irrigation farming is more technologically inclined than the labour intensive so as not to gives room to inefficiency and decreasing marginal poductivity of labour as a results of unproductive unit of labour employed on the farmland.

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