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ANALYSIS OF TECHNICAL EFFICIENCY AMONG SMALL-SCALE IRRIGATED CROP FARMERS IN TARABA AND GOMBE STATES, NIGERIA

[1]Umaru, I. I. and [2]Maurice, D. C.
[1]Department of Agricultural Economics, University of Nigeria, Nsukka
[2]Department of Agricultural Economics and Extension, Modibbo Adama University of Technology PMB 2076 Yola, Adamawa State, Nigeria
Corresponding Authors' E-mail: dmchinda2003@yahoo.com **Tel:** 08036554382

ABSTRACT
The study determined the technical efficiency of small-scale irrigated crop farmers in Taraba and Gombe States, Nigeria. Data were collected from a cross section of 337 irrigated crop farmers in five Local Government Areas of Taraba State and eight Local Government Areas of Gombe State using purposive and simple random sampling techniques. Structured questionnaire was the main instrument for primary data collection. The analytical tools employed were descriptive statistics and stochastic frontier production function model. The socio-economic characteristics of the respondents revealed that majority (92.28%) of them were males, with mean age of 44 years and had some form of formal education. Most (59.05%) of them cultivated an average of 2.54 hectares using personal savings. On their cropping systems, fourteen cropping systems were identified with mixed cropping system accounting for 61.12% of the cropping systems and 83.56% of the total hectares allocation, an indication that mixed cropping was the dominant cropping system among the irrigated farmers. The result of the maximum likelihood estimates of the stochastic frontier production function revealed that the coefficients of farm size ($p = 0.01$), seed ($p = 0.01$) and agrochemicals ($p = 0.05$) were all significant and positively related to crop output among the respondents. The technical efficiency indices of the sampled farmers ranged from 0.44 - 0.96 with a mean of 0.78, indicating that crop farmers in the study area were technically efficient in their production systems although were operating below the frontier output. The inefficiency model revealed that age, gender, farming experience and extension contact were found to increase technical efficiency of the farmers. The study recommends more subsidies on farm inputs, more extension services and the training of farmers on farm management among others.

Keywords: Cropping systems, Irrigation, Small-scale farming, Technical efficiency.

INTRODUCTION
Irrigation has been described as the artificial application of water to the soil for the purpose of supplying moisture needed for plant growth mostly in the dry season. It is regarded as a powerful factor in increasing crop productivity, more stable incomes, employment and for increasing prospects for multiple cropping and crop diversification where there is virtually little or no precipitation (Oruonye, 2011; Oladimeji and Abdulsalam, 2014).

Globally, massive investments have been made in the development of irrigation schemes (Dauda *et al*., 2009). Through irrigation, countries bring otherwise useless land into production, increase yields by facilitating the introduction of more productive and high-valued crops and promoting crop intensification by reducing the fallow period and allowing farmers grow several crops throughout the season (Moigne, 1991).

Irrigation has the potential to play an important role in helping Nigeria achieve its goal of food security through increased food production and poverty reduction (Takeshima and Edeh, 2013). Investment in small-scale irrigation schemes has a positive impact on consumption and overall assets accumulation. It enables the participants to increase wealth, take varied diet and consume own food instead of depending on food handouts from the government (FAO, 2011). Small-scale farmers use water pumps to draw water from streams/rivers, lakes, boreholes, tube wells and ponds for irrigation and take responsibility for investment and management of their farms.

The achievement of food self-sufficiency therefore has been the policy thrust of successive governments in Nigeria. In view of the growing gap between the demand for and supply of food in the country against the background of an increasing population, the efficiency with which available resources and technology are used by farmers becomes a priority subject of investigation (Maurice *et al*., 2014). It is no surprise therefore, that considerable effort has been devoted to the analysis of farm level efficiency in developing countries. Efficiency studies are important in that they serve as reliable guidance in formulating policies, especially when it comes to the search for the primary causes of inefficiency and improvement potentials (Ogundari and Brummer, 2011). Efficiency analysis is an issue of interest given that the overall productivity of an economic system is directly related to the efficiency of production of the components within the system.

The Food and Agriculture Organization (FAO) listed Nigeria among nations that are technically unable to meet their food needs from rain fed production (Folayan, 2013). Thus, there is a need to increase the productivity of the abundant irrigable land in the country and that of the few smallholder farmers engaged in irrigation farming system. Also, analyzing the present level of efficiency of smallholder irrigation farmers and the factors influencing their level of efficiency is necessary. An increase in efficiency in arable crop production could present a ray of hope and could lead to an improvement in the welfare of the farmers and consequently a reduction in their poverty level and food insecurity. Specifically, the objectives of the study includes to:

i). describe the socio-economic characteristics of the small-scale irrigation farmers in the study area;
ii). identify the various cropping systems practiced by the farmers;
iii). analyze the determinants of crop output among the farmers;
iv). determine the technical efficiency of the farmers; and
v). identify the socio-economic factors responsible for technical inefficiency among the farmers.

Conceptual Framework and Empirical Reviews

According to Farrell (1957), technical efficiency (TE) is the ratio of the physical output to the factor input. TE or production efficiency is defined as the ability of making use of implement to bring about measure of a farm success in producing maximum output from a given set of inputs (Ohajianya and Onyenweaku, 2002). In a similarly definition by Rahman (2003), TE is the ability of a farmer to produce at the frontier technology. The greater the ratio of the output to inputs, the greater the magnitude of technical efficiency and vice versa. Technical efficiency is attained when the best available technology is used (Chavas *et al.,* 2005; Bokusheva and Hockmann, 2006). It therefore, implies that the frontier output varies with the level of technology employed by the farm. On the other hand, technical inefficiency arises when less than maximum output is obtained from a given bundle of factors (Russell and Young, 1983).

Aboki *et al*. (2013) evaluated the technical efficiency of cassava production in Taraba State, Nigeria, using the stochastic frontier production function. It was found that level of education; household size and source of fund were negatively and significantly related to technical inefficiency. The results also showed that farmers with the best practice had a technical efficiency of 0.984 while the least had 0.489. Return to scale was found to be 0.94, meaning that the cassava farmers in the study area were on stage II of the production curve.

Ogbanje *et al*. (2014) used the stochastic frontier production function to estimate the technical efficiency of *fadama* II farmers in Taraba State of Nigeria. The minimum technical efficiency estimate was 2.59 with maximum of 0.86. The coefficients of farm size and fertilizers were positive and statistically significant at 1% level. However, the coefficients of herbicide and labour were negative and significant at 5% level. In the inefficiency model, the coefficients of education, age and sex were all negative and significant indicating that increase in these variables decreases technical inefficiency.

Oladimeji and Abdulsalam (2014) used the stochastic frontier production function to carry out economic analysis of dry season irrigated farming in Asa River Kwara State, Nigeria. The mean technical efficiency estimate was 0.85. Technical inefficiency coefficient of farming experience (-0.540), adjusted household size (-0.184) and training (-0.342) revealed that these variables increased technical efficiency.

Maurice *et al.* (2015) examined the technical inefficiency in food crop production systems among small-scale farmers in selected Local Government Areas of Adamawa State, Nigeria. They found the elasticity coefficient of farm size, inorganic fertilizer, family labour, Seed, agrochemicals were positive and statistically significant at 5% level. Technical efficiency indices spread observed across the sample farms was large. The best farm had a technical efficiency of 0.96 (96%), while the worst farm had a technical efficiency of 0.26 (26%). The mean technical efficiency was 0.66 (66%) implying that in the short run, the farmers would increase their technical efficiency in food crop production in the study area by 34 percent. Education, extension contact, crop diversification and credit availability were found to decrease technical inefficiency of the farmers.

Adamu *et al.* (2015) analyzed the technical efficiency of rain-fed rice farmers in Taraba State, Nigeria using the stochastic frontier production function. The result revealed that farm size, quantity of seed, quantity of fertilizer, family labour and hired labour were all significant at varying levels. The inefficiency model reveals that level of education, farming experience and family size were the major determinants of technical efficiency (TE) of rain-fed rice farmers in the area. The mean technical efficiency was 0.78 with minimum and maximum of 0.41 and 0.97, respectively.

MATERIALS AND METHODS

The Study Area

The study was carried out in Taraba and Gombe States, Nigeria. Taraba State lies between Latitudes $6^0$30' and $9^0$36'North of the equator and between Longitudes $9^0$10' and $11^0$50' east of the Greenwich meridian (Taraba State Ministry of Economic Planning, TSMOEP, 2014). The state has a land area of 54,473 km^2 with a population figure of 2,300,736 people (NPC, 2006). The projected 2015 population figure is 2,886,733.46 people using 2.83% annual population growth rate (Aboki *et al.*, 2013). The state has boundary with Bauchi State to the north, Gombe State to the north east, Adamawa State to the east, Plateau State to the north west, Nasarawa and Benue States to the west and the Republic of Cameroun to the south east (TADP, 2014).

Taraba State has a tropical climate marked by dry and rainy seasons. The rainy season starts in April and ends in October, while the dry season starts in November and ends in March. The mean annual rainfall ranges from 800 mm in the north to 1800 mm in the southern part. The mean minimum daily temperature recorded is 14.8^{0}C and the mean maximum daily temperature recorded is 34.4^{0}C (TADP, 2014).

The vegetation of Taraba State is the guinea savannah type with the state being predominantly agrarian and some of the major crops produced are cassava, yams, maize, rice, soybeans, oil palm, mangoes, citrus, bananas, dry season production of maize, rice, sugarcane and vegetables. Other economic activities include livestock rearing, fishing, trading and tailoring. The ethnic groups include Mumuye, Jukuns, Kutebs, Ichens, wurkuns, Chambas, Jenjo and the Tivs.

Gombe State lies between latitudes 9^{0}30' and 12^0 30' north of the equator and between Longitudes 8^{0}45' and 11^{0}45' east of the Greenwich meridian. It shares boundaries with Bauchi State to the west, Taraba and Adamawa States to the south west, Borno State to the east and Yobe State to the north (Gombe State Ministry of Economic Planning (GSMOEP), 2014). The state has a land area of 20,265km^2 with a population figure of 1.85 million people (NPC, 2006). The projected 2015 population figure is 2,321,195.69 people using 2.83% annual population growth rate.

Gombe State is characterized by two distinct wet and dry seasons. The wet season begins from April and ends in October, while the dry season starts in November and lasts up to March. The mean annual rainfall ranges from 600 mm to 1200 mm with the minimum and maximum temperatures of 22.7^{0}C and 33.5^{0}C respectively (Gombe State Economic Empowerment Strategies(GOSEEDS), 2006). The vegetation of the State is open savannah woodland with trees occurring singly or in clusters. The state is traversed by river Gongola and numerous tributaries that are seasonal. There are also facilities for irrigation which include Dadin Kowa multipurpose Dam, Balanga Dam and Cham Dam. The major ethnic groups are Fulani, Tangale, Waja, Tera, Pero, Bolawa, Tula, Chamawa, Lunguda, Dadiya, Kamo and Awak Kanuri. The income activities of the people include farming, livestock rearing, trading, and civil service. Maize, millet, cowpea, groundnuts, fruits and dry season production of maize, rice, wheat and vegetables are among the major farming activities in the state (GOSEEDS, 2006).

Source and Nature of Data

Primary data was mainly used for the study. The data were collected from small-scale irrigation farmers with the aid of structured questionnaires. Trained enumerators from the Agricultural Development Programme (ADP) of Taraba and Gombe States were used for the primary data collection, and the data covered 2013/2014 and 2014/2015 irrigation farming.

Sampling Procedure and Data Collection

A multi-stage purposive sampling and simple random sampling techniques were used in the selection of respondents for the study. In the first stage, 5 Local Government Areas in Tarable State notable for irrigation farming were purposively selected. These are Ardo Kola, Jalingo, Bali, Gassol and Ibi. Similarly, in Gombe State, 8 Local Government Areas were also purposively selected notable also for irrigation farming. These are Dukku, Kwami, Nafada, Funakaye, Akko, Yalmatu/Deba, Balanga, and Kaltungo in Gombe State. The second stage sampling involved the purposive selection of 15 farming communities in Taraba State and 24 farming communities in Gombe State based on the availability of flood plains that encourages dry season irrigation farming. Finally, 337 farmers were randomly selected from the two States in proportion to the size of the farming communities from the existing sampling frame obtained from Taraba Agricultural Development Programme (TADP) and Gombe Agricultural Development Programme (GADP).

Analytical Techniques

Descriptive and inferential statistics were used in the analysis of the data. Descriptive statistics involving frequency counts, means, and percentages was used to describe the socio-economic characteristics of the respondents and the various cropping systems. The stochastic frontier production function on the other hand was used to analyze the determinants of crop output among the farmers, determine the technical efficiency of the farmers and to identify the socio-economic factors responsible for technical inefficiency among the farmers.

Model Specification

The specification of the stochastic frontier production function model used for study in explicit form is thus:

$$\ln Y_{ij} = \beta_0+\beta_1 \ln X_{1ij}+\beta_2 \ln X_{2ij}+\beta_3 \ln X_{3ij}+\beta_4 \ln X_{4ij}+\beta_5 \ln X_{5ij}+\beta_6 \ln X_{6ij}+V_{ij}-U_{ij} \quad \ldots(1)$$

where;

Y_i = Output of food crops (measured in kilogram grain-equivalent weight)
X_1 = Farm size (ha)
X_2 = Family labour (man days)
X_3 = Hired labour (man days)
X_4 = Quantity of agrochemicals (litres)
X_5 = Quantity of inorganic fertilizer (kg)
X_6 = Quantity of seed (kg)
ln = Logarithm to base e
V_i = Statistical noise such as the effects of measurement error and external sources out of the farmers' control.

$$U_{ij} = \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 \quad \ldots(2)$$

where;

U_{ij} = Technical inefficiency of the i^{th} farmer
Z_1 = Sex (1=male and 2= female)
Z_2 = Age (years)
Z_3 = Level of education (number of years spent in formal school)
Z_4 = Farming experience (years)
Z_5 = Household size (number of persons in household)
Z_6 = Extension contact (number of contacts)
Z_7 = Cooperative membership (dummy, membership = 1, Non members =0)
δ_1- δ_7 = Coefficients to be estimated.

The maximum likelihood estimates (MLE) and the technical efficiency estimates would be simultaneously estimated using the computer program FRONTIER version 4.1 (Coelli, 1994). The outputs of the crops were measured in kilogramme (kg) and were adjusted to kilogram grain-equivalents for homogeneity and aggregation by using indices as given by Clark and Haswell (1970).

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents

The socio-economics of the respondents as presented in Table 1 reveals that majority (92.28%) of them were male, implying that small scale irrigation farming in the study area was mostly undertaken by the males. A similar result was obtained by Oladimeji and Abdulsalam (2014) in Kwara State, Nigeria who reported that the male dominated small-scale irrigation farming.

The age distribution reveals that majority (70.7%) of the respondents were within the age range of 20-49, with mean age of 44 years. This indicates that the farmers were in their active and productive age bracket, and they will be willing to adopt and practice new technology effectively (Kefas, 2012). The study is in consonance with the finding of Nwalieji and Ajayi (2009) who reported a higher proportion of younger people in adoption of improved production practices among *fadama* farmers in Anambra State.

The distribution of the marital status of the respondents reveals that majority (94.07%) were married. Family labour supply is expected to be more among respondents that are married than unmarried. The educational level of the respondents reveals that majority (62%) had attained various forms of formal education, an indication that literacy level was high among the farmers. Thus, adoption of new technologies that will increase crop productivity will be easier and faster among the respondents.

The household size of the respondents reveals a mean household size of 14 persons. This indicates that household size in the study area is large, hence, family labour supply for execution of important farm activities such as clearing, weeding, planting and harvesting will be more. The primary occupation of the respondents was mostly farming. A comparable result was obtained by Tshoho *et al.* (2012) in Sokoto state who found that about 90% of dry season vegetable farmers were farmers.

The distribution of respondents by farming experience reveals that majority (68%) had between 1-10 years of farming experience, while 32% had farming experience of more than 11 years. The mean years of farming experience was 10 years. This shows that the farmers are well experienced in irrigation farming. The distribution of their farm size reveals that majority (59.1%) cultivated up to 2.0 hectares (ha) of land, while 40.9% cultivated between 2.1-5.9 hectares. The mean farm size was estimated at 2.5 ha, an indication that irrigation crop farming in the study area is mostly undertaken on a small scale. A similar result were obtained by Usman and Bakari (2013) in Adamawa State among small scale dry season tomato farmers where 60% of the farmers had farm sizes ranging from 0.5 – 2.0 ha.

On the basis of extension contact, majority (76%) of the respondents had contacts with extension agents at different times in the last cropping season. By implication, it will afford them the opportunity of utilizing new technology that could improve their skills and technical knowhow, which will increase their productivity. On membership of cooperative society, the distribution reveals that 49% belonged to cooperative associations, while 51% do not. The farmers' main source of finance for irrigation farming is personal savings as indicated by 88% of the respondents. This indicates that they may lack the capacity to purchase necessary inputs that will expand production.

Crop Combination Patterns of Irrigation Farmers

Cropping systems are the yearly sequence and spatial arrangement of crops on a given area. The objective of any cropping system is efficient allocation of all resources (Panda, 2007). The distribution of cropping system of irrigated farmers in the study area is presented in Table 2. The result revealed fourteen (14) cropping systems, namely; sole tomato, sole pepper, sole maize, sole rice, tomato/pepper, tomato/maize, tomato/rice, pepper/maize, maize/rice/, tomato/pepper/maize, tomato/pepper/rice, tomato/maize/rice, pepper/maize/rice and tomato/pepper/maize/rice. It implies that the farmers were involved in both sole and mixed cropping system. The total hectares allocation to irrigated crop production among the respondents was estimated at 854.6 ha with sole cropping accounting for 140.45 hectares representing 16.43%, while mixed cropping accounting for 714.15 hectares and representing 83.57%. On the cropping systems, sole cropping accounted for 39% of the cropping systems, while mixed cropping system accounted for 61% of the cropping systems. From the result, tomato-based enterprise was the highest cropping combination being practiced by the respondents which accounted for 55% of the cropping systems and 75% of the total hectares allocation. The consideration for risk minimization, stable income and adaptability to a particular season are the reasons for farmers' involvement in cropping systems (Sani and Haruna, 2010; Maurice *et al*., 2015).

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Table 1: Socio-economic Characteristics of Irrigated Crop Farmers in Adamawa and Gombe States (n=337)

Sex	Frequency	Percentage
Male	311	92.28
Female	26	7.72
Marital status		
Single	13	3.86
Married	317	94.07
Divorced	1	0.30
Widow/er	6	1.78
Age (years)		
20-29	14	4.15
30-39	76	22.55
40-49	148	43.92
50-59	77	22.85
Mean = 44.2		
Farming Experience (years)		
1 – 10	229	67.95
11- 20	68	20.18
21- 30	28	8.31
≥31	12	3.56
Mean = 10		
Household Size		
1- 5	39	11.57
6 – 10	84	24.93
11- 15	108	32.05
16 – 20	63	18.69
≥ 21	43	12.76
Mean = 13.5		
Educational Level		
No formal education	128	37.98
Primary education	70	20.77
Secondary education	86	25.52
Tertiary education	53	15.73
Primary Occupation		
Farming	306	90.80
Civil service	24	7.12
Trading	5	1.48
Artisanship	2	0.59
Farm Size (ha)		
≤ 2.0	199	59.05
2.1- 3.9	55	16.32
4.0 – 5.9	61	18.10
≥ 6.0	22	6.53
Mean = 2.54		
Extension Contact		
Non	82	24.33
Once yearly	31	9.20
Twice yearly	70	20.80
More than twice yearly	154	45.69

Source: Field Survey, 2015

Table 2: Distribution of Respondents according to Crop Combination Patterns

Crop Combination	Number of farmers	% of farmers	Total area (Ha)	% Total area	Average farm size (Ha)
Sole tomato	16	4.75	15.5	1.81	0.97
Sole pepper	13	3.86	14.5	1.7	1.12
Sole maize	64	18.99	59.2	6.93	0.93
Sole rice	38	11.28	51.25	6.0	1.35
Tomato/pepper	4	1.20	8.5	1.0	2.13
Tomato/maize	14	4.15	16.45	1.92	1.18
Tomato/rice	2	0.59	3.0	0.35	1.50
Pepper/maize	9	2.67	17.25	2.02	1.92
Maize/rice	24	7.12	58.0	6.79	2.42
Tomato/pepper/maize	22	6.53	69.55	8.12	3.16
Tomato/pepper/rice	1	0.30	2.5	0.3	2.50
Tomato/maize/rice	5	1.48	13.0	1.52	2.60
Pepper/maize/rice	4	1.20	14.3	1.67	3.58
Tomato/pepper/maize/rice	121	35.91	511.6	59.9	4.23
Total	337	100	854.6	100	
Average			2.54		

Source: Field Survey, 2015

Stochastic Frontier Production Function for Irrigation Farmers

The maximum likelihood estimates of the stochastic frontier production function for irrigated crop farmers in the study area are presented in Table 3. The estimated coefficients of all the parameters of production function were positive except family labour which is negative. This means that total output increases by the value of each coefficient as the quantity of each variable input increases by 1%. The estimated elasticities of the explanatory variables of the general model shows that all the coefficients except that of farm size have positive decreasing function (<1), an indication that the inputs allocation was in stage II of production function. All the inputs used in the model, namely; farm size, agrochemicals, inorganic fertilizers and seed with the exception of family labour and hired labour were statistically significant at varying levels. The sigma square (0.096) was statistically different from zero at 1% level. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term. The variance ratio also defined as Gamma (γ), is estimated as 0.833 suggesting that systematic influences that are unexplained by the production function were the dominant sources of random errors. This means that the existence of technical inefficiency among the farmers accounted for about 87% of the variations in the output levels of the farmers. This indicates the presence of one-sided error component in the specified model. This also implies that the effects of technical inefficiency is significant and that a classical regression model of production function based on ordinary least square estimates would be an inadequate representation of the data. Thus, the diagnostic statistics confirm the relevance of the stochastic production function.

The coefficient of farm size is 1.447 and statistically significant at 1%. This means that a 1% increase in the hectares of land put into cultivation would increase the output of crops under irrigation by 1.447% in the area. Thus, farm size is a major factor of production which suggests that land is a significant factor associated with changes in crop output. A comparable

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result was obtained by Adamu *et al*. (2015) who found a positive relationship between farm size and rice output under rain-fed condition in Taraba State. Agrochemical which includes herbicides and pesticides has an elasticity coefficient of 0.243 and statistically significant at 5% level. This means that a 1% increase in the quantity of agrochemicals used in crop production under irrigation will increase crop output by 0.243%. The use of agrochemicals help farmers to save time and money that would have been spent on weeding and manual control of pest and diseases. It also raises the productivity of seed, and enables farmers to cultivate large hectares of land which ultimately increases crop output.

The coefficient of inorganic fertilizer is 0.155 and significant at 5% level. Inorganic fertilizer raises the fertility status of farm lands leading to increase output. A 1% increase in the quantity inorganic fertilizers in crop production under irrigation will increase crop output by 0.155%. A comparable result was obtained by Maurice *et al*. (2015) in Admawa State who found a positive correlation between inorganic fertilizers and output of food crops.

The coefficient of seed is also significant at 5% with an elasticity of 0.274. This implies that 1% increase in quantity of seed used in crop production under irrigation *ceteris paribus* will increase crop output by 0.274%. A similar result was obtained by Benjamin *et al*. (2011) who found a positive and significant relationship between seed and output of farmers.

The inefficiency parameters were specified as those relating to farmers' specific socio-economic characteristics and were examined by using the estimated δ coefficients These include sex, age, education, farming experience, household size, extension contact and cooperative membership. A negative *Z* coefficient indicates that the parameter has a positive effect on efficiency and vice versa. The results of the inefficiency effects are also presented in Table 3.

Sex as a variable was specified as a dummy. A negative sign on the coefficient referred to male while a positive sign referred to female. The coefficient of sex was estimated at 0.211 (positive) and statistically significant at 1% level. This indicates that as more female farmers get involved in irrigated crop farming technical inefficiency increases. This may be because the involvement of women in domestic chores and to look after the children, could affect time they devote on irrigated farms, thereby leading to technical inefficiency. Also, the proportion of female irrigation farmers to the male in the sample was small and may be responsible for this scenario.

The coefficient of age was negative and statistically significant at 1% level. This implies that as the farmers increase in age, they gain more experience in irrigation farming and make better production decisions thereby reducing technical inefficiency in production. Similarly, the coefficient of farming experience is negative and statistically significant at 1%. This implies that technical inefficiency decreases as farmers become more experience in farming presumably due to their ability to acquire technical knowledge through learning on the job. This result agrees with the findings of Oladimeji and Abdulsalam (2014) who established that increase in farming experience decreases inefficiency among farmers.

The coefficient of extension was negative and statistically significant at 5% level. This indicates that increase in extension services to farmers tend to decrease technical inefficiency among crop farmers under irrigation. A similar result was obtained by Tsoho *et al*. (2012) where they found a positive relationship between technical efficiency and output of small scale vegetable farmers in Sokoto State, Nigeria.

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Table 3: Maximum Likelihood Estimates of the Parameters of Stochastic Frontier Production Function

Variables	Parameter	Coefficient	Standard Error	t-ratio
Constant	β_o	4.141	0.075	5.530***
Farm size (X_1)	β_1	1.447	0.038	3.772***
Family labour (X_2)	β_2	-0.033	0.056	-0.582
Hired labour (X_3)	β_3	0.004	0.055	0.074
Agrochemicals (X_4)	β_4	0.243	0.104	2.34**
Inorganic fertilizer (X_5)	β_5	0.155	0.076	2.06**
Seed (X_6)	β_6	0.274	0.090	3.03***
Inefficiency effects				
Sex (Z_1)	δ_1	0.211	0.066	3.201***
Age (Z_2)	δ_2	-0.187	0.066	-2.848***
Educational level (Z_3)	δ_3	0.009	0.012	0.821
Farming experience (Z_4)	δ_4	-0.235	0.075	-3.13***
Household size (Z_5)	δ_5	-0.062	0.071	-0.881
Extension contact (Z_6)	δ_6	-0.492	0.174	-2.837***
Cooperative membership (Z_7)	δ_7	-0.027	0.017	-1.637
Diagnostic statistics				
Likelihood ratio		59.963		
Sigma squared	(σ^2)	0.096	0.017	5.794***
Gamma	(γ)	0.833	0.049	17.180***

*** Significant at 1% level; ** Significant at 5% level
Source: Computer output from Frontier 4.1c.

Technical Efficiency Estimates of the Farmers

The distribution of farmers' technical efficiency indices derived from the analysis of the stochastic production function is presented in Table 4. The technical efficiency of the sampled farmers was less than 1.00, indicating that the farmers in the study area were producing below the frontier output. A range of technical efficiency was observed across the sampled farms and the spread was large. The best farm had a technical efficiency of 0.96 (96%), while the worst farm had a technical efficiency of 0.44 (44%). It means that the least efficient farmer is 56% less efficient than the best practice farmer. The mean technical efficiency was 0.78 (78%) implying that on the average, the respondents were able to obtain about 78% of optimal output from a given mix of production inputs. This indicates that in the short run there is a scope for increasing technical efficiency among the farmers in the study area by about 22%. The distribution of technical efficiency of the farmers revealed that 4% had technical efficiency of less than 50%, while 26.41% had technical efficiency of 50-69% and 72.40% of the respondents had technical efficiency of 70% and above. This indicates that the farmers are fairly efficient in the allocation of resources. The results corroborates with that of Adamu *et al.* (2015) and Maurice *et al.* (2015) who in their separate studies reported similar efficiency estimates.

Table 4: Technical Efficiency Estimates of the Respondents

Efficiency level	Frequency	Percentage
0.40 - 0.49	4	1.19
0.50 - 0.59	42	12.46
0.60 - 0.69	47	13.95
0.70 - 0.79	58	17.21
0.80 - 0.89	140	41.54
≥ 0.90	46	13.65
Total	**337**	**100**
Mean 0.78		
Minimum 0.44		
Maximum 0.96		

Source: Field Survey, 2015

CONCLUSION AND RECOMMENDATIONS

The study concludes that irrigated crop farmers in the study area are more into mixed cropping system because it permits higher yield than sole cropping and ensures efficient utilization of environmental resources as well as insurance against crop failure. The farming was mostly undertaken by smallholders who cultivated an average farm size of 2.5 ha and the most dominant cropping system as observed is tomato-based. The efficiency estimates reveals that though the farmers were operating below the frontier output (mean technical efficiency of 78%), they have the scope of technical efficiency improvement by about 22% in the short run under the existing technology through efficient allocation of inputs especially the ones the study found to be significant. The study therefore recommends that government and non-governmental organizations should provide farming inputs such as inorganic fertilizers, improved seeds, and tractor hiring services at subsidized rate in order to boost their farming activities. The government and non-gornmental organizations should strengthen the extension arm of the ADPS whose primary role is to educate farmers on fundamental farm management practices.

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