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**PROFITABILITY AND TECHNICAL EFFICIENCY OF CULTURED FISH FARMING IN KAINJI LAKE BASIN, NIGERIA**

Ibeun, B. A., Ojo, O. A., Mohammed, U. S. and Adewumi, A.

National Institute for Freshwater Fisheries Research, P. M. B. 6006, New Bussa, Niger State, Nigeria
[2]Department of Agricultural Economics and Farm Management, Federal University of Technology, P. M. B. 65, Minna, Niger State, Nigeria
*Corresponding author: adewumiadeoluwa@gmail.com, +2347063155051

**ABSTRACT**

The study analysed the profitability and efficiency of cultured fish farming in Kainji Lake Basin, Nigeria. A two-stage sampling procedure was used to select a total of 204 respondents from the three main strata of Kainji Lake Basin. Data were collected through interview schedule and structured questionnaire administered to the sampled fish farmers. Data analysis was done using descriptive statistics, farm budgeting technique and stochastic production frontier approach. A total of 88.2% of the respondent were males, 87.8% married, 92.65% had formal education and 64.2% had no extension contacts. An average cultured fish farmer in the study area was 41 years old, had 8 years of fishing experience and household size of 8 persons. The costs and returns analysis revealed a net farm incomes of ₦349.40/kg and ₦1,385.08/$m^2$, gross ratios of 0.57 and 0.44 and return on investment of ₦0.73 and ₦1.23 per kilogram of fish and per meter square pond size respectively. The farmers were not technically efficient with a mean efficiency score of 0.7367. The quantity of feed at 1%, stock density at 1%, fertilizer at 1% and capital input at 10% probability level respectively were efficiency factors while education at 10%, farming experience at 1%, credit access at 5% and extension service at 5% probability level respectively were the inefficiency factors. The study recommended that the research institute with freshwater mandate should collaborate with extension agents in the area to constantly educate the cultured fish farmers on innovations that will improve their profit and level of efficiency.

**Key words;** profitability, efficiency, cultured fish, farmers and Kainji Lake

## INTRODUCTION

Fish farming is a sub-set of aquaculture that focuses on rearing of fish under controlled or semi-controlled conditions for economic and social benefit (Oladejo, 2010). Globally, fish production has grown steadily in the last five decades with food fish supply increasing at an average annual rate of 3.2%, which is more than the world population growth standing at 1.6% (Food and Agriculture Organization (FAO), 2014). In accordance with the world fish centre report 2012 as documented by FAO, Africans rely on fish for an average of 22% of their consumption of animal protein and provides essential vitamins, minerals, fatty acids and other nutrients crucial to a healthy diet. FAO (2014) reported that African countries as at 2012 contributed 1,485,367 metric tonnes to world aquaculture production of 66,633,253 metric tonnes representing 2.23%. Nigeria as one of the leading fish producing country in sub-Saharan Africa produced over 400,000 metric tonnes of culture fish in 2013 (Mohammed *et al.*, 2014). The government has attempted several efforts over the years to boost fish production via institutional reforms, creation of research institutes and colleges, and different economic measures which include tax waver for fish farmer and subsidy for inputs among others. However, there is still shortage in supply with increasing demand for fish by the populace (Dada, 2004).

In Kainji Lake Basin, fish farming is an emerging enterprise supporting the livelihood of the riparian communities who largely depend on near collapse capture fisheries. Fish farming however has not been fully explored as a strategy to reduce poverty levels and malnutrition despite its potential to improve livelihoods in riparian communities (Ibeun, 2017). Due to the shortfall of fishes from the wild (artisanal), fish farmers along Lake Kainji has been encouraged to adopt other sources of fish production like aquaculture so as to get improved and sustainable standard of living. The emergence and adoption of aquaculture in Kainji Lake Basin Area and Nigeria in the last decade has led to a geometric increase in production ranging from less than 50,000 Metric tonnes to more than 100,000 metric tonnes between 2004 and 2010 (Chilaka *et al.*, 2014 ).

The National Institute for Fresh Water Fisheries, New Bussa has been enlightening the communities along the Lake Basin on the benefits and importance of augmenting production with aquaculture. But there are only a few studies done on the factors affecting farmers' efficiency in fish farming in the Kainji Lake Basin so as to gear up policy actions towards improving domestic production by providing solution to factors militating against fish farming efficiency in the area. It is against this background that this study attempted to analyse the profitability and technical efficiency of cultured fish farming in Kainji Lake Basin, Nigeria. Specifically, it described the socio-economic characteristics of cultured fish farmers; estimated the costs and returns and analysed the farmers' technical efficiency in cultured fish farming in the study area.

The outcome of this study will therefore provide information that will be useful in enlightening fish farmers on better ways of producing efficiently in order to minimize cost and maximize profits hence, increasing the marginal output of fish. This study will reveal the return to capital invested by the farmers. The information derived from the costs and returns analysis will serve as a guide for prospective investors into fish farming to guide investment decisions.

## METHODOLOGY

### Study Area

Kainji Lake is a reservoir on the Niger River, on the border between Niger and Kebbi States in the Northern Nigeria. Moreover, Kainji dam is built across the Niger River. The Lake covers an area of 1250km$^2$ with a maximum depth of 60m and extends for 136.8km upstream of Kainji beyond Yelwa with total volume of 13.97km$^3$ (Olokor, 2011). It is 24.1km at its widest point (Adegbiji, 2001). According to German Technical Corporation (GTZ) (2002), the Lake is located between Latitudes 9°50′N to 10°55′N and Longitudes 4°23′E to 4°45′E. It was primarily to generate hydro-electricity. However, it opened way for other opportunities such as irrigation farming, fisheries activities and water transportation. According to Adegbiji (2001), the dam is 1,030km from the sea, 8.3km long and 65.5m high .Thus, the birth of the dam led to the emergence of Kainji Lake Basin. The annual drawdown of water level on Lake Kainji is between 10m and11m while the catchment area is 1.6x 10$^6$ km$^2$ and the mean annual water temperature is 27.85°C. The number of fishing localities in the area has steadily increased since 1993 as recorded by Tafida *et al.* (2011). Fishing communities along the lake is altogether 297 fishing localities. The area is also the most productive lake for fishing. German Technical Cooperation (2002) reported that 61% of the fishing localities were recorded in Niger State while 39% was recorded for Kebbi State. Kebbi State has more permanent fishing camps than Niger, particularly at Foge Island, which was an important beach seining area and has large floodplain areas (GTZ, 2002).

### Sampling Technique

A two-stage sampling procedure was adopted in the selection of respondents for this study. Kainji Lake Basin is divided into three strata by the Kainji Lake Management and Conservation Unit. The first stage involved random selection of five fishing communities from each of the three strata of Kainji Lake Basin. The second stage involves the proportionate selection of 80% of the fish farmers from each of the selected fishing communities. This gave a total of 204 cultured fish farmers for the study.

### Method of Data Collection

Primary data was utilized in this study. The data were collected with the use of structured questionnaire designed to address the objectives of the study. This also was complemented with interview schedules.

### Data Analytical Techniques

Various analytical tools were used to analyse the data for this study. Descriptive statistics such as means, percentages, and frequency distributions were used to describe the socio-economic characteristics of the cultured fish farmers. The farm budgeting technique and stochastic production frontier were also used for analysis.

**Farm budgeting technique:**

The net farm income was computed to measures the difference between the Gross Farm Income (GFI) and the Total Costs (TC) of production. The formula used was adopted from Adewumi (2017) and modified by the researchers. It is mathematically expressed as:

$$NFI = \sum_{i=1}^{n} P_{yi} Y_i - \sum_{j=1}^{m} P_{xj} X_j - \sum_{k=1}^{o} F_k$$

Where:
NFI = Net Farm Income,
$P_{yi}$ = Unit price of output in Naira
$Y_i$ = Quantity of output produced
$P_{xj}$ = Unit price of variable input in Naira
$X_j$ = Quantity of variable input used
$P_{yi}Y_i$ = Gross farm income
$P_{xj}X_j$ = Total variable cost
$F_k$ = Total Fixed cost

**Stochastic production frontier analysis:**

The Stochastic Production Frontier (SFA) model was used to analyse the technical efficiency of the farmers.

The theoretical framework of the stochastic frontier production function is specified as follows:

$Y_i = f(X_i\ \beta) \exp (V_i – U_i), 1 = 1, 2 \ldots.n$

Where:
$Y_i$ = Output of the $_i$-th farm
$X_i$ = the vector of input quantities used by the $_i$-th farm (explanatory variables)
$\beta$ is a vector of unknown parameters to be estimated
f represents an appropriate function (such as Cobb Douglas and translog).
The term $V_i$ is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer while the term $U_i$ is a non-negative random variable representing inefficiency in production relative to the stochastic frontier. The random error $V_i$ is assumed to be independently and identically distributed as N (O, б$_2$) random variables independent of the $U_i$ which are assumed to be non-negative truncation of the N (O, б$_2$) distribution (*i.e.* half-normal distribution) or have exponential distribution. The stochastic frontier was independently proposed by Aigner *et al.,* (1997) and Meeusen & Vander Broeck (1977). The technical efficiency of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology (Onyenweaku and Effiong, 2006).

Technical Efficiency (TE) = $Y/Y_i$*

This is expressed as;

$Y_i = [(X_i\ \beta) \exp (V_i - U_i) (X_i, \beta) \exp (V_i)] = \exp (-U_i)$
Where:
$Y_i$ = Observed output and $Y_i$* = the frontier output. The parameter of the stochastic frontier production function was estimated using the Maximum Likelihood method.

For this study, the production technology of the culture fish farmers in Kainji Lake Basin, Nigeria was assumed to be specified by the Cobb Douglas frontier production function. The function was defined as follows:

$$\ln Q = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + v_i - u_i$$

Where;
Q = Output of fish (kg)
$X_1$ = Quantity of feed (in kg)
$X_2$ = Stock density (Number of fingerlings)
$X_3$ = Labour (Man-day)
$X_4$ = Lime (kg)
$X_5$ = Fertilizer (kg)
$X_6$ = Capital input (₦)

In order to determine the inefficiency factors contributing to the observed technical efficiency, the following model was formulated and estimated jointly with the stochastic frontier model in a single stage Maximum Likelihood Estimation procedure using the computer software Frontier Version 4.1 (Coelli, 1996).

$$-U_i = a_0 + a_1 Z_1 + a_2 Z_2 + a_3 Z_3 + a_4 Z_4 + a_5 Z_5 + a_6 Z_6$$

Where,
$-U_i$ = Technical infficiency of the i-th fish farmers
$Z_1$ = Age (Years)
$Z_2$ = Sex (male = 1, female= 0)
$Z_3$ = Education (Years)
$Z_4$ = Farmer‘s experience in fishing (Years);
$Z_5$ = Credit access (₦)
$Z_6$ = Frequency of contact with extension agents,
$a_1 \ldots\ldots a_{ij}$ are parameters to be estimated.

## RESULTS AND DISCUSSION

### Socio-economic Characteristics of Cultured Fish Farmers

The socio-economic characteristics of cultured fish farmers which included; age, gender, marital status, educational qualification, year spent in school, fish farming experience, involvement in fish farming, household size, membership of cooperative and extension agent visitation were presented in Table 1. The results showed that 40.2% of the respondents were within the age range of 31-40 years with the mean age of 41 years which indicated that fish farmers in the study area were young, active and energetic and, could easily key-in to new innovation. This corroborates the finding of Adewuyi *et al.* (2010) that most of the fish farmers in Ogun State, Nigeria were within the age range of 31-40 years.

The results in Table 1 revealed that an overwhelming majority 88.20% of the cultured fish producers in the study area were males. The low percentage of women involved in fish production in the area could be as a result of cultural and religious belief which limited the outdoor activities of women. This agrees with Nwabeze and Erie (2013) who reported that 97.0% of fish farmer in Jebba Lake Basin, Nigeria were males, revealing the preponderance of the male folks in fishing business. It was also found that 87.8% of the fish farmers in the study area were married and 11.8% were single while only 0.40% was divorced. The predominance of married fish farmers in the study area could translate into increased availability of family labour for fish farming operations. This could help boost farm income thereby increasing productivity.

Finding in Table 1 showed that 92.65% of the farmers had formal education while 5.39% and 1.96% had Quranic and adult education, respectively. The relevance of education in agricultural production in the view of Onuabugu and Nnadozie (2005) is that high educational attainment can help farmers to produce efficiently. Results further showed that 75.50% of the fish farmers had between 1 – 10 years of fish farming experience with the mean fish farming experience of 8 years in the area. The number of years one has spent as a cultured fish farmer helps to build practical knowledge in fish production, though fish farming is still a nascent enterprise in the study area.

**Table 1: Distribution of farmers according to their socio-economic characteristics**

| Variable | Frequency (n=204) | Percentage | Mean |
|---|---|---|---|
| **Age** | | | |
| 21-30 | 26 | 12.80 | 41 |
| 31-40 | 82 | 40.20 | |
| 41-50 | 68 | 33.30 | |
| 51-60 | 26 | 12.80 | |
| >60 | 2 | 0.90 | |
| **Sex** | | | |
| Male | 180 | 88.20 | |
| Female | 24 | 11.80 | |
| **Marital status** | | | |
| Married | 179 | 87.80 | |
| Single | 24 | 11.80 | |
| Divorced | 1 | 0.40 | |
| **Education level** | | | |
| Adult | 4 | 1.96 | |
| Primary | 54 | 26.47 | |
| Secondary | 70 | 34.32 | |
| Tertiary | 65 | 31.86 | |
| Quranic | 11 | 5.39 | |
| **Fish farming experience** | | | |
| 1 – 10 | 154 | 75.50 | 8 |
| 11 – 20 | 47 | 23.03 | |
| >20 | 3 | 1.47 | |
| **Household size** | | | |
| 1-5 | 62 | 30.40 | |
| 6-10 | 95 | 46.60 | |
| 11-15 | 34 | 16.70 | |
| 16-20 | 11 | 5.39 | |
| >20 | 2 | 0.98 | 8 |
| **Extension visit** | | | |
| Yes | 73 | 35.80 | |
| No | 131 | 64.20 | |

Source: Field Survey, 2017

The result in Table 1 further revealed that 46.6% of the farmers had household size of between 6-10 persons while only 0.98% of the fish farmers in the study area had above 20 household members. The result showed that the mean household size of the fish farmer in the study area was 8 persons which implies that family labour is ready available in the study area due to the large household size. This is in consonance with the findings of Nwabeze and Erie (2013) that the mean household size of fish farmers in Jebba Lake, Nigeria was 9 persons.

Majority (64.2%) of the fish farmers had no contact with extension agent while 35.8% of the fish farmers in the study area had contacts with extension agent. The frequency of visit by extension agent is expected to expose the fish farmers to new findings and better approaches to efficient and effective cultured fish production as well as increased access to timely and adequate information for sustainable fish farming practices.

**Costs and Returns Analysis of Cultured Fish Enterprise**

The result of the costs and returns analysis of cultured fish farmers in the study area is presented in Table 2. It showed that the total variable cost per kilogram of fish produced was ₦442.14. The cost of feed was highest at ₦351.14/kg while the cost of fingerlings was at ₦45.38/kg. Cost of liming, fertilizer and cost of transportation were infinitesimally low at ₦1.96/kg. Transportation cost was very low in the variable cost components because buyers usually come to purchase the fish at the pond site during harvest unlike in crop production where the farmers have to transport the output from their farms to desired destinations. The labour cost was also small because aside from the initial cost of labour for site preparation, labour was mainly required to feed the fish daily and to assist during harvest-this drastically reduced the labour cost.

Among the fixed cost components, cost of water gulped the bulk (₦32.99/kg) of the total fixed cost of ₦38.72kg. This was because fish is an aquatic animal and as such requires constant supply of water for its survival. Summarily, the total cost of producing 1kg of fish in the area was ₦480.86 while the total revenue was ₦830.26/kg. The gross margin and net farm income values of ₦388.12/kg and ₦349.40/kg respectively showed that cultured fish farming was a profitable enterprise in the study area. The gross ratio of 0.57 further affirmed that fish farming was profitable in the study area; this implied that 57% of the total revenue was sufficient to cover the total cost of producing a kilogram of fish in the study area. In addition, the return on investment per kilogram of fish produced in the study area was ₦0.73 which implied that for every ₦1 invested a profit of ₦0.72/kg was made. This result was similar to the work of Okwu and Acheneje (2011) that reported that fish farming was profitable in Benue State. It also compared favourably with Emakoro and Ekunwe (2009) on the efficiency of resource-use among catfish farmers in Kogi State.

The results further revealed that the total variable cost per metre square of fish produced was ₦1,001.93. The cost incurred on feed, fingerlings, and labour were ₦726/$m^2$, ₦138.97/$m^2$ and ₦80.85/$m^2$, respectively. The total fixed cost incurred was ₦119.84/$m^2$ while the total cost of production and total revenue were estimated to be ₦ 1,121.77/$m^2$ and ₦2,506.85/$m^2$, respectively. The net farm income was ₦1504.92/ $m^2$ and ₦1385.08/ $m^2$. The gross ratio of 0.44 implied that 44% of the total revenue was sufficient to cover the total cost of producing a metre square of fish in the study area. The finding revealed that aside the fact that cultured fish farming was profitable in the area, it also showed that it is very economical to start up a cultured fish farming as a business and hence, could serve as a source of employment opportunity and livelihood to teeming population of unemployed youths in the country.

**Table 2: Cost and return analysis of cultured fish farmers in the study area**

| Items | Amount (₦/kg) | Amount (₦/m$^2$) | % of total cost |
|---|---|---|---|
| Variable Cost (VC) | | | |
| Fingerlings | 45.38 | 138.97 | 13.35 |
| Feed | 351.14 | 726.50 | 61.83 |
| Labour | 27.10 | 80.85 | 7.97 |
| Liming | 0.60 | 1.87 | 0.18 |
| Fertilizer | 0.41 | 1.30 | 0.12 |
| Fuelling/Lubrication | 4.92 | 14.73 | 1.45 |
| Pond maintenance | 11.66 | 34.82 | 3.43 |
| Transportation | 0.95 | 2.90 | 0.28 |
| Total Variable Cost (TVC) | 442.14 | 1,001.93 | 88.61 |
| Fixed Cost (FC) | | | |
| Land rent | 4.58 | 17.72 | 1.35 |
| Depreciation | 0.88 | 2.79 | 0.26 |
| Interest on credit | 0.28 | 0.91 | 0.08 |
| Water facility | 32.99 | 98.42 | 9.71 |
| Total Fixed Cost (TFC) | 38.72 | 119.84 | 11.39 |
| Total Cost (TC) | 480.86 | 1,121.77 | 100.00 |
| Total Revenue (TR) | 830.26 | 2,506.85 | |
| Net Farm Income (NFI) | 349.40 | 1,385.08 | |
| Gross Ratio (GR) | 0.57 | 0.44 | |
| Return on Investment (RoI) | 0.73 | 1.23 | |

**Source: Field Survey, 2017**

**Technical Efficiency of Cultured Fish Farmers in the Study Area**

**Summary statistics of production variables in stochastic production frontier analysis**

Analysis of summary statistics of the various inputs used was as revealed in Table 3. The result showed an average 4093.13kg of feed used per farmer. The average stock density of 4,260.34 fingerlings indicated high stock density in the study area. The average labour of 76.37 man-day showed that fish farmer in the study area relied heavily on human labour to do most of the fish farming operations. The analysis also showed that lime, fertilizer and capital input had mean values of 1.53kg, 2.99kg, and ₦4537.00, respectively.

**Table 3: Summary statistics of the variables in stochastic frontier model**

| Variables | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|
| Feed (Kg) | 4,093.13 | 2,413.39 | 21.00 | 480.00 |
| Stock density(No) | 4,260.34 | 2,342.37 | 500.00 | 1500.00 |
| Labour(Man-day) | 76.37 | 73.89 | 3.00 | 501.00 |
| Lime (Kg) | 1.53 | 6.09 | 0.00 | 50.01 |
| Fertilizer (Kg) | 2.99 | 11.19 | 0.00 | 75.01 |
| Capital input(₦) | 4,573.00 | 2,768.82 | 0.00 | 18,660.00 |

**Source: Field Survey, 2017**

**Technical efficiency estimates of the cultured fish farmers**

The technical efficiency indices were derived from the MLE results of the stochastic production function, using computer programme FRONTIER 4.1. The indices in Table 4 showed that the technical efficiency of all the sampled fish farmers was less than 100%, which implied that all the culture fish farmers in the study area were producing below the maximum efficiency frontier. However, the mean technical efficiency of 0.7367 (73.67%) implied that on the average, farmers in the study area were able to obtain about 74 percent of cultured fish output from a given mix of production inputs. The average efficiency level of 73.67% for the fish farmers in the study area was lower than the 83.62% and 82.99% reported by Akanbi (2014) for cultured fish production by fish farmers in Kwara and Kogi States of Nigeria respectively. The result further indicated that the highest efficiency class index was between the ranges of 0.71-0.90 and accounted for 63.23% while the lowest efficiency index was 0.31-0.40 (3.43%). No farmer operated at the index of between 0.10-0.30. The maximum value of 93.01% showed that some farmers operated very close to the optimum frontier level while the minimum of 32.53% showed that there was still room for the improvement of the technically inefficient farmers. The overall result showed that an average cultured fish farmer in the area would enjoy input saving of 20.43% [(1-0.74/0.93)*100] if he attains the technical efficient level of the most efficient farmer in the area. Also, the most inefficient farmer would also have an efficient gain of 64.52% [(1-0.033/0.93)*100] for the farmer to attain the efficiency level of the most efficient farmer.

**Table 4: Distribution of technical efficiency indices among cultured fish farmers**

| Efficiency Index | Frequency (n = 204) | Percentages |
|---|---|---|
| $\leq$ 0.40 | 7.00 | 3.43 |
| 0.41 – 0.50 | 10.00 | 4.90 |
| 0.51 – 0.60 | 12.00 | 5.88 |
| 0.61 – 0.70 | 38.00 | 18.62 |
| 0.71 – 0.80 | 62.00 | 30.39 |
| 0.81 – 0.90 | 67.00 | 32.84 |
| 0.91 – 1.00 | 8.00 | 3.92 |
| Mean | 0.7367 | |
| Maximum value | 0.9301 | |
| Minimum value | 0.3253 | |

**Source: Field Survey, 2017**

**Maximum Likelihood Estimates of stochastic production function**

The result in Table 5 showed the maximum likelihood estimates (MLE) of the stochastic production frontier of cultured fish farmers in the study area. It revealed that the estimated value of the sigma squared ($\delta^2$) was 0.441 and statistically significant at 1% probability level. This also indicated a good fit and the correctness of the specified distributed assumption of the composite error term. It was also an indication that 44% of the observed variation in the output of cultured fish in the study area was explained by the included explanatory variables. The gamma ratio (ɣ) was 0.79.3 and also statistically significant at 1% level of probability which implied that about 79.3 percent variation in the output of cultured fish farmers was due to differences in their technical inefficiencies.

For the efficiency model, results showed that the coefficients of quantity of feed ($X_1$), stock density ($X_2$), and fertilizer ($X_5$) were positive and significant at 1% level of probability respectively while the coefficient of capital input ($X_6$) was positive and significant at 10% level of probability. This implied that, the likelihood that cultured fish farmers would be technically efficient increased with an increase in these variables. That is, any increase in the use of these production inputs led to increase in fish output during the period.

Furthermore, the result of the technical inefficiency model as presented in Table 5 revealed that the coefficient of fish farming experience ($Z_4$) and extension visit ($Z_6$) were negative and significant at 1% and 5% level of probability, respectively while the coefficient of access to credit ($Z_5$) was positive and significant at 5% level of probability. The coefficients of educational level, farming experience and frequency with extension agent in the study area were negative indicating that an increase in these variables decreased their technical inefficiency in cultured fish production in the area. This is in line with the a priori expectation that educational level, fish farming experience and frequent contact with extension agent will enhance level of efficiency in their fishing enterprise. The positive coefficient of access to credit showed that an increase in this variable led to an increase in the technical inefficiency of the farmers. This was contrary to the *a priori* expectation that an increase in access to credit should increase production efficiency of farmer.

**Table 5: Maximum likelihood estimates of parameters of the Cobb Douglas frontier function for cultured fish farming in Kainji Lake Basin**

| Variables | Parameters | Coefficient | Standard deviation | t - value |
|---|---|---|---|---|
| Constant | $\beta_0$ | 3.523 | 0.877 | 4.014*** |
| Quantity of feed (kg) | $\beta_1$ | 0.550 | 0.067 | 8.137*** |
| Stock density (No) | $\beta_2$ | 0.032 | 0.087 | 3.697*** |
| Labour (Man-day) | $\beta_3$ | 0.361 | 0.036 | 1.000 |
| Lime (Kg) | $\beta_4$ | 0.000 | 0.014 | 0.012 |
| Fertilizer (kg) | $\beta_5$ | 0.057 | 0.018 | 3.122*** |
| Capital input (₦) | $\beta_6$ | 0.038 | 0.020 | 1.858* |
| **Inefficiency Model** | | | | |
| Constant | $\delta_0$ | 0.973 | 0.398 | 2.445** |
| Age ( years) | $\delta_1$ | -0.009 | 0.008 | -1.161 |
| Sex | $\delta_2$ | 0.035 | 0.377 | 0.918 |
| Education level (years) | $\delta_3$ | -0.026 | 0.012 | -1.742* |
| Farming Experience (years) | $\delta_4$ | -0.074 | 0.016 | -4.573*** |
| Credit Access (₦) | $\delta_5$ | 0.000 | 0.000 | 2.114** |
| Extension agent | $\delta_6$ | -0.016 | 0.008 | -2.518** |
| Sigma square $\delta^2$ | | 0.441 | 0.052 | 4.580*** |
| Gamma $\gamma$ | | 0.793 | 0.136 | 4.337*** |
| Log likelihood function | | -100.013 | | |
| Mean technical efficiency | | 0.736 | | |
| LR test | | 25.17 | | |

**Source: Field Survey, 2017**

***, ** and * = Significant at 1%, 5% and 10% probability level respectively

**CONCLUSION AND RECOMMENDATIONS**

Based on the findings of the study, it was concluded that the cultured fish farmers were not technically efficient as they were producing below the frontier level. The significant determinants of cultured fish yield in Kainji Lake Basin were quantity of feed, stock density, labour, capital input, fish farmer experience, access to credit and extension contact.

It was therefore recommended that; extruded feed and other production inputs should be subsidized and made available by the government through relevant agricultural and financing institutions to the cultured fish farmers. The Research Institute with Freshwater mandate in collaboration with skilled extension agents should constantly educate the fish farmers on innovations in cultured fish production that will improve their level of efficiency. The farmers should participate actively in extension trainings in order to improve their knowledge and skills on how to produce fish more efficiently. And further research on cultured fish farming particularly in Kainji Lake Basin should focus on deriving optimum production plans for the farmers towards efficient allocation of available production inputs which will enhance increased yield and income generation.

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