TECHNICAL EFFICIENCY OF TABLE SIZE CATFISH PRODUCTION IN KAINJI LAKE BASIN, NIGERIA

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ABSTRACT

The study investigated the technical efficiency of catfish table size production under intensive system among cluster fish farmers in Kainji Lake Basin. Multistage sampling procedure was deployed to select 120 respondents for the study from three clusters namely Monai, Fakun and New Bussa in 2020. Primary data were collected with semi structured questionnaire and analyzed using descriptive statistics and Cobb-Douglas regression analysis to determine technical efficiency of table size catfish production in the study area. Findings showed that the catfish table size entrepreneurs are mostly men (86%) with mean age of 38 years. Majority (96%) are marriedand educated (72.5%) with 40.83% having household size of 4-5 persons with good fish farming experience ($\bar{x}$=5years). Majority (99%) use earthen ponds while 94% farm hybrid (hetero-clarias) species. Total number of fingerlings was 970,600 stocked in a 47,493m^2 size of ponds and fed with 741,060kg feed. The significant production efficiency factors were type of ponds, farming experience, household size, years of education, marital status, age, size of ponds and labour. Therefore, improving production efficiency in the area requires adherence to stocking density, mentoring young fish farmers, and adoption of best aquaculture practices. In addition, post fingerlings should be stocked in earthen ponds supported with technical knowledge through training, embracing agribusiness management and marketing principles to ensure profitable return on enterprise and sustainability as well as cooperative approach to overcome common issue.

INTRODUCTION

Practitioners' business orientation towards commercial fish farming in the production value chain activity is the driving force on visible impact of catfish culture to the economy in terms of job and wealth creation, gross domestic product, food nutrition security as well as good image as a leader in sub-Saharan region. Aquaculture contributes up to 30% of total domestic fish production in the country with 316,727 metric tonnes in 2021(Global Panel on Agriculture and Food Systems for Nutrition (2022). According to Food and Agricultural Organization (FAO) reported in Daily Trust Newspaper, (2021), Nigeria's aquaculture industry monetary value has risen from ₦23 billion investment in 2006to ₦261.8 billion in 2022, contributing about one million direct jobs in the value chain. Also, ECOWAS report (2020) showed that aquaculture production in Nigeria rose from 143.21 metric tonnes in 2008 to 291.32 metric tonnes in 2018 and now 316,727 metric tonnes in 2021 (Global Panel on Agriculture and Food Systems for Nutrition, 2022). All these indicate positive change and increase in production with more capacity to meet domestic fish need.

As aquaculture production intensify, practitioners of catfish farming sought for cost effective production techniques to leverage on at minimal cost. In Kainji Lake basin, particularly in New Bussa and surrounding communities with concentration of fish clusters, aquaculture activities in catfish production has been nurtured and grown with visible impact on life of aquapreneurs. Recent study in New Bussa, Kainji Lake basin on aquaculture performance cited by Olaosebikan (2021) showed that between July 2019, and February 2020, a total of 32,340 cartons of smoked fish worth ₦1,746,360,000.00 billion were transported to Onitsha market in Anambra state from New Bussa, Niger state, whereas another investigation of 12 middlemen showed an estimated 7,680 tonnes of live table size catfish worth ₦5,030,400,000.00 billion were sold from Kainji lake basin at the market price of ₦655/kg. On

profitability of enterprise, Omeje *et al.* (2021a) empirically established that catfish farming in Kainji lake basin is a viable business with high return on investment of 71.81%, 51.05% and 109.27% for the men, women and youths respectively implying that to every ₦ 1.00 invested in table-size fish farming, about 77.38 kobo (average value) will be realized as profit ceteris paribus. Above evidence indicates that aquaculture farmers are to an extent technically efficient in utilizing production inputs and their human capital, but not yet to the maximum potential.

Efficiency implies the ability of a firm to realize maximum output from the given set of inputs. It is the ratio of output to input and the greater the ratio, the more the magnitude of technical efficiency (Girei *et al*., 2014; Ohen *et al*., 2014). Hence, a production process is technically inefficient if it does not produce maximum output from a given set of inputs and is therefore operating below its production frontier. According to Jarzebowski (2013), efficiency studies help countries to determine the extent to which they can raise productivity by improving efficiency with the existing resource base and available technology. In this direction, Onoja and Achike (2011) asserted that fish production system in Nigeria is faced with low technical efficiency. In South-West zone with active aquaculture entrepreneurs, Esobhawan and Reuben (2010) pointed out that fish farms operate below optimal frontier production level, of whose efficiency level can be improved by a range of 20-40%. Also, Ifejika *et al.* (2022) noted that fish farmers manage to produce table size catfish more efficiently at lower cost with farm made pelletized feed. On production system, Oluwatayo and Adedeji (2019) study concludes that the most efficient and profitable construction designs among earthen, cage culture and plastic tank is the earthen pond.

According to Ebukiba *et al*. (2022), the acute shortage of production inputs has been complicated by gross inefficiency in resource use. In spite of the growing number of Catfish farmers in Kainji Lake Basin, Catfish production in Nigeria is not efficient. This is because the demand for fish still outweighs its supply in Nigeria (Liverpool-Tasie *et al*., 2021). This led to the spending of over 288 billion naira annually on fish importation in Nigeria (Central Bank of Nigeria, 2017). This implies that much need to be done on the technical efficiency of Catfish production. Also, the limited information on the prevailing circumstances on technical efficiency pre-empted the study on technical efficiency of catfish production in Kainji Lake Basin, Nigeria. Specifically, the study described the socio-economic variables; examined the table size Catfish production inputs and determined the technical efficiency of table size catfish production.

MATERIALS AND METHOD

Study Area, Data Collection and Analysis

This study was carried out in Kainji Lake basin on coordinates $10^0$22'N $4^0$33'E. Fishing is one of the attributes of the lake basin which is on decline for some decades. The Kainji lake axis of Borgu local government area is the center for aquaculture hub in Niger state with two federal fisheries institutions on research and human capital training, clusters of fish farm, more than 30 farm-made pelletizing fish feed producers, and recent multimillion tilapia cage culture on the lake by private investor. In the past 15years, catfish farming has risen as a flourishing rural enterprise in New Bussa and environ contributing to fish food supply to cities, job creation, wealth in the value chain, and training of fisheries undergraduates on practical field experience as documented by Ifejika *et al.* (2007; 2021), and Omeje *et al.* (2021b).

The study used a three-stage sampling technique. The first stage is the purposive selection of Borgu local government area based on the availability of clusters of fish farms in the Niger state axis of the lake. Second stage was purposive selection of New Bussa, Monai, and Fakun communities based on the concentration of clusters of fish farms in those communities. Third stage was the random selection of 120 respondents from the three clusters of fish farm communities thus; 30 table size fish farmers were selected from New Bussa, 60 from Monai and 30 fish farmers from Fakun the population of 185 table size fish farmers. Primary data were collected using semi structured questionnaire which were administered to the respondents through face to face interview. Collected data were on the socioeconomic characteristics and production inputsused to determine technical efficiency. Analytical tools deployed were descriptive statistics of mean and percentages to describe socio-economic variables of age, experience, household size, membership of association, gender, education, and marital status. For technical efficiency, the model is expressed below:

Technical Efficiency Model Specification

There is an assumption that farmers maximize expected profits. Following this, Cobb-Douglas stochastic production model was used in a single equation below to analysis technical efficiency of catfish farmers. The appropriateness of Cobb-Douglas model for testing efficiency of catfish production system is based on the assumption that Cobb-Douglas model methodology has self-duality of choice.

$\text{In } Y_i = \beta_0 + \Sigma^5_{i=1} \beta \ln X_i + (v_i . \mu_i)$

Where;

Y_i= quantity of catfish output in kilogram (kg)

X_1= total numbers of labour used measured in man days (family and hired labour)

X_2= size of pond used (m^2)
X_4= cost of other materials: such as hormones, fuel, farm land rent, additives and depreciation costs, cost of chemicals, and electricity (₦)
X_5= quantity of fingerlings stocked (kg)
μ= a non-negative random variable associated with farm-specific factors which contribute to farms not achieving maximum efficiency
V = a stochastic error term (including extreme weather, measurement errors; and other noise errors such as misspecification problems; poaching industrial action) βo= constant parameter
X_3= quantity of feed used (kg)
βi= coefficients to be estimated; ln= natural logarithm

RESULTS

Presented below are the results and findings of the study on respondents' socioeconomic characteristics, and technical efficiency of catfish table size production.

Table 1: Socio-Economic Characteristics of Table Size Fish Farmers (N= 120)

Variables	Percentage (%)	Mean
Age		39
Less than 30	25.00	
31-40	28.00	
41-50	38.00	
Above 51	9.00	
Gender		
Male	86.00	
Female	14.00	
Marital Status		
Single	4.17	
Married	95.83	
Educational Level		
Educated	72.50	
Non-educated	27.50	
Household Size		5
Less than 4	33.33	
4 - 5	40.83	
6 -7	22.50	
Above 7	3.33	
Years of Fish Farming Experience		5
Less than 6	69.17	
6 - 10	24.17	
11 - 15	5.00	
16 above	1.67	
Membership of Fish Farmers Group		
Yes	37.70	
No	62.30	

Source: Field Survey, 2020

Socio-Economic Characteristics Variables

The result of socio-economic characteristics is presented in Table 1. Result on gender showed involvement of men and women in catfish production activities, however, men (86%) are the dominant gender with high level of investment in catfish farming than the women (14%). On the age distribution, mean age was 39 years which signifies high involvement of young people (19-40 years) in catfish farming enterprises. The most dominant active age group were people in middle adulthood between 41-50 years (38%) followed by young age category 31-40 years (28%) and youths below 30 years (25%). Information on marital status of respondents showed that 95.83% were married while 4.17% are single. On household size, the mean household size was 5 persons whereas 40.83% have household size of 4-5 persons, while

22.5 % had 5-6 household size, and 3.33% had household size of more than 7 persons. Respondents' education showed that 72.5% have the ability to read and write as educated respondents compared to uneducated (27.5%) without formal education. Responses on years of experiences indicated that most of the sampled farmers (69%) have less than 6 years of experience followed by 24% with 6-10years experience, while 7% had at least11years experience. Less than half (37.7%) belong to fish farmers' association against 62.3% as none members in the area. Low membership of cooperative association affects formidable cooperative activities on monitoring and price control of fish for profitable enterprise in the area.

Production Inputs of Table Size Fish Farmers

Adequate production inputs ensure high survival rate, productivity and profit venture, hence the verification on choice of pond type and size, quantity of fish stocked, feed type and quantity used. As shown in Table 2, earthen pond was the most preferred pond type used by respondents (99%) followed by concrete ponds (1%). On pond size, 47,493m^2 was the size of the entire ponds used by the fish farmers (120 fish farmers). Response on fish species cultured and quantity of fish stocked revealed that *hetero-clarias was* the major (94 %) fish species cultured by the fish farmers followed by *Clarias gariepinus species* (5%) called butch. On stocking density, respondents stocked 970,600 fingerlings with an average of 6,560 fingerlings per pond measuring 147.95m^2. The result on feed type revealed intensive usage of both extruded and pelletized feed by all respondents. Whereas on feed quantity, it shows the usage of 741,060kg of both feeds (extruded feed =18,855kg and pelletized feed =722,235kg) till maturity which is usually 6 months.

2: Table Size Catfish Production Inputs

Variables	Value	Mean
Type of ponds (%)		
Earthen	99%	
Concrete	1%	
Total pond size (m^2)	47,493m^2	147.95m^2
Catfish Species stocked (%)		
Hybrid (*hetero-clarias*)	94%	
Clarias garipinus	5%	
Heterobranchus bidorsalis	1%	
Total number of Fingerlings stocked (number)	970,600	6,560
Fish Feed Types Used (Kg)	722,235	6018.62
Pelletized farm made feed	18,855	157.12
Extruded feed		

Technical efficiency of catfish production

The results presented in Table 3 shows the OLS regression estimate offactors that affect catfish production. The Cobb-Douglas functional form was used given that the data analyzed was a production data. The results showed that the F-statistic of 73.16 was statistically significant at 1% level of significance. The R-square of 0.8914 implies that about 89% of the variation of the dependent variable is accounted for by the independent variables included in the model. The remaining 10.86% not explained could be attributed to factors beyond the farmers' control as well as variables not included in the model. The estimated coefficients of the pond type and size were positive and significant at 1% and 5% levels of significance respectively. Further results showed that labour was positively and significant in increasing the efficiency of the table size catfish farmers at 5% level of significance. For the production inefficiency variables, the results revealed that fish farming experience, household size and educational level had negative signs and were significant at 1% levels of significance in influencing the efficiency of the farmers in catfish production in the area. More years of farming experience means more perfection in application of skills and allocation of scarce resources; whereas, large farming household size could provide cheap source of labour thereby reducing cost of production. Formal education on the other hand, encouragesfarmers to accept agricultural innovations that could increase their level of efficiency. Contrarily, results showed that marital status and ages of farmers had positivesigns and were significant at 1%, levels of significance influencing the efficiency of the farmers in catfish production in the area. Similarly, the result for age implies that the farmers are less likely to improve in catfish production efficiency as they become older.

Table 3: Factors determining the efficiency of catfish production

Variables	Coefficient	Standard Error	T-value	P> t
Production Variables				
Type of ponds	0.0889	0.0170	5.24***	0.000
Total size of ponds	0.0345	0.0137	2.52**	0.013
Skill labour in month	0.0442	0.0186	2.38**	0.019
Pelletized local feed used	0.0090	0.0222	0.41	0.685
Extruded foreign Feeds used	-0.0055	0.0160	-0.34	0.731
Number of fingerlings stocked	-0.0092	0.0258	-0.36	0.722
Inefficiency Variables				
Years of fish farming experience	-0.0661	0.0098	-6.72***	0.000
Household size	-0.2570	0.0192	-13.41***	0.000
Educational level	-0.0839	0.0154	-5.44***	0.000
Marital status	0.1485	0.0349	4.25***	0.000
Gender	0.0307	0.0200	1.54	0.127
Age	0.5255	0.0273	19.23***	0.000
Constant	-1.6312	0.2464	-6.62***	0.000
Diagnostic Statistics				
F-statistic	73.16***			
R-squared	0.8914			

Source: Field data analysis 2020

** =significant at 0.05, ***=significant at 0.01

DISCUSSIONS

On gender involvement, finding justify that men (86%) are harnessing the economic opportunities more than women in table size value chain of aquaculture, probably due to access to capital for investment, stamina to carryout daily tasking job activities, and perseverance to wait for 4-6 months before fish harvest and high return as profit and income. This finding was consistent with Ifejika *et al*. (2007) finding on men as active fish farmers, thus confirming that the status quo has not changed after 18years on men domineering pond fish culture in the Kanji lake basin. From the result, youth (25%) involvement in catfish enterprise has recorded remarkable improvement compared to only 7% recorded 18years ago in the area (Ifejika *et al*., 2007). Profitability of enterprise is the driving force for men folk to engage in table size catfish farming to meet family responsibilities and argument income by actors like traders, pensioners, civil servants, health workers, housewives and politicians. It has been established that most catfish farmers use family labour which serves as source of learning and induction into fish farming enterprise (Ifejika, 2015). In agreement with finding were Omeje *et al*. (2021b) on the mean household size of 5 persons which can be of great importance in meeting the labour requirements of fish farming such as feeding, environmental sanitation and the like. Most respondents are educated (72.5%) in the area. A high literacy level in aquaculture has been established to enhance the management of fish farms through the adoption of improved farm practices (Agboola, 2011). Therefore, educational status of catfish farmers is a necessary pre-requisite to support adoption of innovations and techniques to increase productivity, economic benefit and interaction with digital tools for technical knowledge and management. In this study, about 31% had over six years of experience which can be attributed towealth of knowledge gained over the years which can be used to navigate challenges as well asshare with others during meetings, mentor beginners, and take informed technical decisions in the enterprise. Baruwa and Omodara (2019) agreed that fish farming experience is a vital human capital for productivity growth in catfish production as found in Oyo state.Respondents' membership of local association of fish farmers is low as few (37.7%) joined existing Borgu Fish Farmers' Cooperative Society and Borgu Catfish Association of Nigeria, New Bussa branch. This is seen as a challenge for them to enjoy economy of scale to tackle issue of high cost of feed, unstable fish price, insecurity, theft and government interventions.

Also, the result on production inputs of table size fish farmers showed a high adoption and preference of earthen pond. This is due to its rich source of natural fish food of zooplanktons which adds to fish growth and productivity as well as the availability of land with water retention capacity near river banks. This finding agrees with earlier results of Ifejika *et al*. (2007) on the high adoption of earthen ponds for fish farming in the area. This is also justified by Oluwatayo and Adedeji (2019) that the most efficient and profitable construction

designs among earthen, cage culture and plastic tank is the earthen pond method. Because of this, the demand for land for aquaculture has increased as well as cost of land by 250% in most communities like Monai, Old Awuru, Yuna, New Bussa, Sabo Pegi, within the area in the past 10 years (Ifejika *et al*., 2022). The finding on the fish species stocked agrees with Ifejika *et al*. (2007) that most fish farmers stock hybrid catfish (*Hetero clarias*). The choice of adoption and stocking of hybrid catfish is because *Hetero clarias* grows bigger over time and gives processors more "fish cuts" to sell compared to pure *Clarias* species. The result on stocking density implies that the fish farmers over stock their ponds with fingerlings. The stocking density did not conform to standard of10/$m^2$for *Clarias species* as recommended by Ovie and Ovie (2014). The overstocking of ponds usually results to cannibalism, poor growth, unhealthy competition for feed and space, fish death, water quality issues and loss of revenue. Adequate input and management practices ensure high survival rate, productivity and profitable venture.

Findings on production efficiency established that the model has strong explanatory power, that is, there was a significant relationship between the dependent variable and the independent variables included in the model. It also showed that the coefficient of multiple determinations (R-squared) was 0.8914. This implies that 89.14% variation in the table size catfish farmers' production was explained by the explanatory (production and inefficiency) variables included in the model. This suggests that the level of production among the catfish farmers is being influenced by the high use of earthen ponds and size of their ponds in relation to stocking density. The variable (pond type) and (size of ponds) were significant at ($p<0.01$) and ($p<0.05$) respectively which implies that a unit increase in the type and size of the ponds will likely lead to improvement in the quantity of output of the catfish farmers in the area. This agrees with Oluwatayo and Adedeji (2019) that the most efficient and profitable construction designs for fish farming is the earthen ponds. Also, the variable (labour) was significant at ($p<0.05$) whichimplies that a unit increase in labour utilization by one man-day will increase the likelihood of observing an increase in the farmers' technical efficiency. The quality and quantity of labour input represents the care given to the catfish farm which could enhance the productivity of the farmers. Earlier studies in the area attest to high use of family and hired labour in carrying out fish farm activities such as feeding, sampling and harvesting (Ifejika, 2005; and Omeje *et al*., 2021a). For the production model, it means that an increase in these explanatory variables will likely reduce the level of production inefficiency among the catfish farmers in the area. This implies that these independent variables included in the production model have the potentials to improve the technical efficiency of the farmers. For the inefficiency model, the variables such as years of farming experience, household size and years of education had negative signs and were significant at ($P<0.01$). This implies that a unit increase in these variables will result to a decrease in inefficiency of fish farmers; hence, an increase in the efficiency of fish farmers. Variables such age and marital status had positive signs and were significant at ($P<0.01$) which means that an increase in age will result to inefficiency of farmers whereas, fish farmers that are married are more likely to be more efficient in catfish production than their single counterparts.

CONCLUSION

Empirical evidence from the study showed positive changes and progress over the years in the multi-million catfish table size enterprise. As revealed, there is remarkable increase in active involvement of youths in fish farming. Also, practices showed the use of improved technologies and inputs like fingerlings, extruded and pelletized feeds, and earthen ponds to increase production and yield. However, over stocking of ponds with fingerings practices undermine technical efficiency which should be replaced with best practices on stocking density for better productivity. Notwithstanding, the study showed high technical efficiency among fish farmers even though there is room for improvement with best technical and agribusiness aquaculture practices.

RECOMMENDATIONS

Based on the emerging evidence from the study, there is need for continuous capacity building through sensitization and technical training to upgrade knowledge, business orientation and management practices among practitioners for better yield and profit to sustain aquaculture enterprises. Fisheries institutions like National Institute for Freshwater Fisheries Research (NIFFR), Federal College for Freshwater Fisheries Technology (NIFFR) and farmers' groups like Catfish Farmers Association of Nigeria (CAFAN) and Fisheries Society of Nigeria (FISON) operating in the area should form synergy on capacity building to help improve technical efficiency. Also, catfish farmers

should adopt the stocking of juvenile and post-juvenile fingerlings, avoid overstocking and improve quality of pelletized feed for better results and return on investment.

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