Assessment of Resource-Use Efficiency in Catfish Production in Akure North and South Local Government Areas, Ondo State, Nigeria

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Abstract
The study assessed resource-use efficiency in catfish production in Ondo State, Nigeria. The study examined the socio-economic, resource and institutional characteristics of catfish farmers; and determined the factors influencing resource use efficiency in catfish production in the study area. To achieve these objectives the study used a multi-stage sampling procedure to select a hundred (100) catfish farmers in two Local Government Areas (LGAs) and the data were collected through a well-structured questionnaire. Descriptive statistics and Stochastic Frontier Production Function (SFPF) of the Cob-Douglas functional form and ordinary least square regression analysis were used to analyse the data collected. The findings shows that the mean age of the fish farmers was 48 years and 78% of the farmers were males. It also indicated that most (99%) of the farmers were educated and majority (91%) were new in the business. The resource information of the farmers shows that more than average of them accessed land through purchase and mostly relied on underground water for their farming, fifty-eight percent (58%) sourced their fingerlings and juveniles from private farms and 60% solely rely on family labour for their production. The Stochastic Frontier Production Function showed that feed consumed and fishing equipment were statistically significant determinants of resource-use efficiency of the catfish farmers at 1% level of significance. The elasticity of production and return to scale showed that catfish farmers in the study area were in stage II of production. Therefore, the study concluded that resource factors like feed, fingerlings and fishing equipment were factors that influenced catfish production efficiency among catfish farmers in the study area. It was recommended that catfish farmers should carefully consider an economic reduction in the number of ponds/tanks to reduce cost of production and raise the existing gross margin of respective farms.

Introduction

Clariid Catfish majorly cultured in Nigeria include *Clarias gariepinus*, *Heterobranchus bidorsalis* and Clarias heterobranchus hybrid (heteroclarias) (Imade and Egbodon, 2023). *Clarias gariepinus* is regarded as an excellent aquaculture species because it grows fast and feeds on a variety of agricultural by-products, it is hardy and can tolerate extreme temperature, easy to produce in captivity with high annual production and good feed conversion rate (Ahmadu and Egbodion, 2017). Catfish as a species of fish is healthy for human consumption and Fishery is an important sector in the economic development of many developed and developing countries. It is impossible to farm meat to meet the protein requirement of everyone in the world due to the large resource consumption for its production (Imade and Ahmadu, 2022). Catfish is a source of high-quality protein that can be produced more cheaply than any other animal protein for human consumption. It is also medically recommended for pregnant women, children and adults because of its high-level protein, digestibility and lack of cholesterols, and constitutes a preventive resource for heart attack or failure and stroke (Kareem, 2011). In effect, meeting the demand for fish using catfish production under different ponds system (concrete pond, earthen pond and plastics tank pond) offers a profitable, ecologically viable and increased production in the catfish industry (Quintero *et al.*, 2021). Catfish has the potential to contribute to sustainable development and poverty reduction in Nigeria as a whole by generating income and employment (Imade and Ahmadu, 2022).

Nigeria needs about 2.66 million metric tons of fish annually to meet the dietary requirement of her citizens. Regrettably, the total aggregate domestic fish supply from all sources (capture and culture fisheries) is <0.7 million metric tons per annum (Oyewole *et al*., 2023; Ogbe *et al*., 2018; Federal Ministry of Agriculture and Rural Development, 2011). Nigeria has to import about 1.96 million metric tons of fish valued at about $500 million annually to augment the shortfall. This colossal importation of frozen fish into the country has ranked Nigeria the largest importer of frozen fish in Africa (Oyewole *et al*., 2023; Ogbe *et al*., 2018; Federal Ministry of Agriculture and Rural Development, 2011). It has been observed that Nigeria can be self-sufficient in fish production if domestic capacity is greatly enhanced so as to transform the country from being a net importer of fish into a net exporter of fish. To reverse this negative trend of huge fish importation with its attendant drains on the nation's economic reserve, it is pertinent to ensure that resources being used in fish farming are allocated efficiently. This is to produce fish that will not only reach market weight within the shortest period but also meet local demand. It will also ensure that fish farmers can make quick returns from their investment of money, time, energy, and resources.

Therefore, in order to reduce waste and redeploy resources to new or expanded ventures, knowledge of resource use efficiency would be helpful. In the study area, research on the efficient use of resources in catfish production is still quite limited. This study seeks to describe the socio-economic, resource and institutional characteristics of catfish farmers; and determine the factors influencing resource use efficiency in catfish production in the study area.

Materials and Methods

Area of Study

Akure, the capital and largest city of Ondo State, Nigeria, stands as a vibrant hub of cultural, economic, and environmental diversity within the southwestern region of the country (Geoinfotech, 2024). Akure is strategically located on latitude 7°15′0″N and longitude 5°11′42″E in southwestern Nigeria, bordered by Ekiti State to the north, Kogi State to the northeast, Edo State to the east, Delta State to the southeast, Ogun State to the southwest, Osun State to the northwest, and the Atlantic Ocean to the south (Geoinfotech, 2024). This central position within the region positions Akure as a pivotal gateway for trade, commerce, and cultural exchange between neighboring states and the coastal regions (Olamiju, *et al.*,2017). The natural landscape surrounding Akure is characterized by its diverse ecological features, ranging from mangrove-swamp forests near the Bights of Benin to the iconic Idanre inselberg hills, which stand as the highest geographical point in the western half of Nigeria, soaring over 1000 meters in elevation (Akinluyi *et al.*, 2020). The city of Akure pulsates with life, driven by a dynamic blend of economic activities that fuel its growth and development. With a population that surged to prominence with 403,000 inhabitants during the 2006 census (Ondo State Ministry of Economic Planning and Budget, 2018), Akure is a melting pot of diverse communities, languages, and traditions (Geoinfotech, 2024). The city's economy is underpinned by a mix of industries, including the petroleum sector, cocoa production, asphalt mining, and agricultural activities (Akinluyi *et al*., 2020). The annual trade fair organized by the Ondo State Agricultural Commodities Association underscores the city's vital role as a trading avenue for the surrounding farming region, where crops such as cocoa, yam, cassava, maize, cotton, and tobacco, livestock farming and aquaculture are practiced (Geoinfotech, 2024). According to WorldFish (2024), the total fish production per year in Nigeria is about to 1.2 million metric tons, 90% which consumed domestically, while about 10% is exported.

Sampling Techniques

A two-stage sampling procedure was used for this study. First stage involves the purposive selection of two Local Government Areas (LGAs) out if the three LGAs of the capital city (Akure North and South) because of its high-profile aquaculture status in the state (Abbas and Ahmed, 2018). In the second stage, a random selection of fifty (50) fish farmers each from the two LGAs was carried out using snowball sampling technique, making a total of one hundred (100) catfish farmers for the study.

Method of Data Collection

Structured and pretested survey instruments were used to collect information on such relevant variables as feeds, fingerlings, labour among others from catfish farmers. Data were collected with the use of questionnaire and Focus Group Discussion (FGDs) on socio-economic features, extension services, number of pond and fishing equipment associated with catfish farming in the State.

Analytical Technique

The following analytical models were employed for the objective of this study to be realized.

Objective (i): descriptive statistics, such as mean, standard deviation, tables and percentages were used for the accomplishment of this objective.

Objective (ii): Stochastic Frontier Production Function (SFPF) of the Cob-Douglas functional form, elasticity of production with respect to resource factors were all used to accomplish the objective.

Model Specification

The Technical Efficiency (TE) of an individual farmer is defined in terms of the ratio of observed output to the corresponding frontier output, conditional on the level of input used by the farmer as used by Imade and Egbodon (2023)

The Cobb-Douglas Stochastic Production Function is defined by

$Yi = f(X_i; \beta) + e_i$ ……………………(1)

$ei = V_i - U_i$ ………………………… (2)

where:

Y_i = Output of the ith farm in kg

X_i = Vector of the inputs used by the ith farm

β = Vector of the parameters to be estimated

ei = Composed error term

Vi = Random error outside the farmer's control

Ui = Technical inefficiency effects

f (Xi) = A suitable function of the vector

The explicit function of the model is stated as:

$$LnY = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + (V_i - U_i) \quad (3)$$

Y= output (in kg) of catfish / annum

X_1 = No of ponds

X_2 = Fingerlings stocked in kg / annum

X_3 = Feed consumed in kg/annum

X_4 = Labour in man-day/annum

X_5 = Fishing equipment in naira value / annum

vi = Random variability in the production that cannot be influenced by the farmer.

ui = Deviation from maximum potential output attributable to technical efficiency.

The farm technical efficiency was estimated using the equation above and summation of β_i (i=1…5) gives the return to scale. Furthermore, elasticity of production with respect to resource factors was also computed.

Results and Discussion

This chapter deals with the analysis of data obtained in the field. Here, the characteristics of catfish farmers were grouped into three namely: Socio-economic, resource and institutional characteristics.

Socio-Economic Characteristics of Respondents

The result on Table 1 presents the socioeconomic characteristics of catfish farmers in the study which involves the age, sex, marital status, educational background, farming experience, farm size among others. The result indicates the mean age of the fish farmers was 48 years. This is similar to Oyewole *et al*. (2023) who reported a mean age of 48 years among fish farmers in Kogi State. The reported mean age shows an aging farming population in the catfish enterprise, and the sector may face challenges in the future due to the aging of the current generation of catfish farmers. This may result in a decline in the number of active catfish farmers and a reduction in production levels if younger farmers do not enter the sector to replace those who retire. seventy-eight percent (78%) of the respondents were male while only 22% constitute the female gender and this is in line with Ogunnaike *et al*., (2021) findings that men dominate catfish production in Oyo State. This implied that more men were engaged in catfish production than women in the study area. This may be attributed to the fact that women are more involved in processing and marketing.

The result further revealed that 89% of the respondents in the study area were married while 11% were still unmarried and their education status shows that 10% of the respondents in the study area had only primary education while 17% stopped at the secondary school level. The highest percentage of the respondents (72%) attended tertiary education. This corroborate the findings of Usman *et a*l. (2023) that majority of catfish farmers in Nigeria were educated. Consequently, catfish farmers in Ondo State are educated and able to cope with the challenges of new (improved) technology among others. The table further revealed that 35% of the respondents take catfish farming as their major occupation while 31% combine catfish farming with public service. The rest combine catfish farming with other forms of businesses like trading, consultancy service, clergy, construction and maintenance services. This is in variance to Oyewole *et al.* (2023) that sole catfish fish farming overarches other livelihood combinations in the catfish business in Nigeria. The years of experience serve as a basis for making more precise production decisions and taking appropriate actions, the more the years of experience the more precise the decision making. Table 1 showed that farming experience of the respondents indicated that majority (91.0%) of the respondents were new in the business with 1-10 years of experience. This implies that majority of catfish producers have not been in production for quite long period of time. The study finally revealed that the average number of ponds in control of the respondents was 4 ponds with mean volume of $60m^3$ per pond.

Resource Information

The sources of the land used by the respondents for the ponds or tanks are of various kinds. The results in Table 2, show that majority (54%) of the respondents acquired their land through purchase. This aligns with findings of Zanna and Musa (2023) who reported that land acquisition methods varied, with a most proportion of farmers using purchased land for aquaculture, reflecting a trend where ownership and access to land are critical for aquaculture development. Source of water is an important factor in fish farming as water represents the medium through which they breathe, grow and reproduce. Most (62.0%) of the respondents depend on underground water such as Borehole and Well water for their fish farming. This agrees with the findings of Ayisi, et al. (2016) that most fish farms relied on boreholes and wells. Fingerlings and juveniles are the young catfish that are raised in ponds / tanks to market weight. Most (58.0%) source their fingerlings and juveniles from private farms and (16.0%) of the respondents in the State have hatchery which means they produced the fingerlings/juveniles for breeding themselves while the remaining 26% purchased their fingerling/juveniles from the government (at cheaper rates). The Table further revealed that 60.0% of labour were sourced from the family labour. The various activities carried out by family

Table 1: Distribution of the Respondents based on their Socio-economic Characteristics

Socio-economic Characteristics	Frequency	Percentage
Age		
Mean	48	
Sex		
Male	78	78.0
Female	22	22.0
Marital Status		
Married	89	89.0
Unmarried	11	11.0
Educational Status		
No Formal Education	1	1.0
Primary Education	10	10.0
Secondary Education	17	17.0
Tertiary Education	72	72.0
Type of Job		
Catfish only	35	35.0
Catfish with public service	31	31.0
Catfish with trading	21	21.0
Catfish with consultancy service	7	7.0
Catfish with clergy	4	4.0
Catfish with construction and maintenance services	2	2.0
Farming Experience (Years)		
1 -10	91	91.0
11 – 20	7	7.0
21 – 30	1	1.0
31 – 40	1	1.0
Number of Pond		
Mean	4	
Pond Size		
Mean Volume	$60m^3$	

Source: Field Survey, 2024

labour, casual (hired) labour or permanent worker could be grouped into fish feeding, fertilization and liming, periodic stocking and filling of ponds (with water), pond clearing and general maintenance, harvesting and sales of fish. Finally, most (60.0%) of the respondents do not receive a single extension visit throughout the year while the remaining percentage had access to extension services. This is in line with the assertion of Olaoye *et al.,* (2014) that most fish farmers do not have access to extension services through out production cycle.

Table 2: Resource and Institutional Characteristics of Catfish Farmers

Resource Information	Frequency	Percentage
LAND SOURCE		
Gift	26	26.0
Tenancy	3	3.0
Purchase	54	54.0
Inheritance	17	17.0
WATER SOURCE		
Spring	11	11.0
Stream	19	19.0
Borehole	43	43.0
Rainfall	4	4.0
Tap	1	1.0
Well	22	22.0
SOURCES OF FINGERLINGS/ JUVENILES		
Hatchery	16	16.0
Private Farms	58	58.0
Government Farms	26	26.0
SOURCE OF LABOUR		
Family Labour	60	60.0
Hired labour	40	40.0
ACCESS TO EXTENSION SERVICE		
Yes	40	40.0
No	60	60.0
TOTAL	100	100

Source: Field survey, 2024.

Stochastic Production Function

The result of the maximum likelihood estimates of the Cobb- Douglas stochastic frontier model is as shown in Table The estimates of lambda (1.815) and sigma (0.653) are large and significantly different from zero at 1 percent level indicating a good fit and the correctness of the specified distribution assumption of functional forms. The gamma estimate of 0.328 indicate that 32.8% variation in output for catfish is due to the inefficiency factor (u).

The results of the estimated parameters show that the coefficients of number of ponds/tank and labour are negative. This implies that both variables contributed negatively to the output of catfish farmers, which may be due to overspreading of resources across too many ponds which could dilute management efforts, poor water quality, disease outbreaks, and suboptimal stocking densities. Also, overstaffing, use of unskilled labour, may be the contributing factors to the negative effect of labour to output of the catfish farmers. On the other hand, variables such as fingerlings, feed consumed and fishing equipment contributed positively to catfish output. This may be due to availability of healthy and fast-growing fingerlings, high-quality feed that improves growth rates, weight gain, and overall fish health, and appropriate fishing equipment which lead to higher survival rates and better yields. The analysis show that feed consumed and fishing equipment were statistically significant at 1% level of significance. The result compares favorably with the findings of Usman *et al.* (2023) who applied the stochastic Frontier Production function to measure determinants and resource-use efficiency of catfish production in Kumbotso Local Government Area of Kano State, Nigeria in which some of the coefficient of the estimated parameters i.e. fingerlings, feed and fish equipment had positive signs and significant in MLE functions.

Table 3: Stochastic Production Frontier Estimates Maximum Likelihood Estimates (MLE) of Parameters of Cobb- Douglas Frontier Function

Variable	Estimates
Primary index equation for model.	
Number of ponds	-0.183(-1.982)
Fingerlings	0.262***(4.515)
Feed	0.533***(7.400)
Labour	-0.660 (-0.644)
Fishing equipment	0.346***(7.663).
Variance Parameters for Compound Error	
Lambda	1.815 (3.021)
Gamma (7)	0.328
Sigma	0.653 (11.356).
Log likelihood function (11f)	-65.230

Source: field survey, 2024.

In parentheses is the t- ratio *** estimate are significant at 1% level.

Elasticity of Production and Return to Scale

Estimates of the independent variables for the general model presented in table 4 show that fingerlings, feed consumed and fishing equipment were positive decreasing functions to the factor, indicating that the allocation and utilization of the variables was in the stage of economic relevance of the production function, i.e. stage II**.** The elasticity of production with respect to pond/tank and labour was however a negative decreasing function to the factor, indicating over utilization of these resource inputs that characterized stage III of the production process. The return to scale was 0.316 signifying a positive decreasing return to scale and that catfish production in the study area was in stage II of production. The productivity of the factor can be improved by either reducing the number of ponds/tanks, reduce man-days of labour usage or by increasing the quantity of feeds, fingerlings and fishing equipment at the existing level of ponds/tanks and labour in order to move the duo (ponds/tanks and labour) back to stage II of the production process. The result of the elasticities of production was in consonance with Ogunnaike *et al* (2021) who reported both negative and positive signs in the study of resource-use efficiency and elasticity of production among catfish farmers in Nigeria are in a decreasing return to scale.

Table 4: Elasticities of Production and Return to scale

Variables		Elasticities
Fingerlings	-	0.262
Labour	-	-0.660
Feed Consumed	-	0.533
Number of Ponds	-	-0.183
Fishing Equipment	-	0.364
RETURN TO SCALE		0.316

Source: Field Survey, 2024

Conclusion and Recommendations

The following conclusion could be drawn from the findings of this study. Most farmers' socio- economic and institutional characteristics like age, level of education, organizational participation, extension shows that they are in their productive age, educated and do not have access to extension services. Resource factors like feed, fingerlings and fishing equipment are factors that influence catfish production ~~efficiency~~ among catfish farmers in the study area. A positive decreasing return to scale of 0.316 indicated that catfish farmers are in stage II of the production process and this suggests that each extra input will produce an extra unit during the production process of catfish farmers in the study area.

Based on the findings of this study, any policy that is directed at the following recommendations has the likelihood of promoting catfish production. Catfish farmers should carefully consider an economic reduction in the number of ponds/tanks to reduce cost of production and raise the existing gross margin of respective farms. Credits facilities should be made available to catfish farmers to expand their enterprise and tackle the challenge posed by inadequate supply and high cost of table catfish in the State once and for all. Government should implement its policy on the production of 5 million fingerlings per annum and construction of a feed mill for the production of local fish feeds at the Sunshine Fisheries Limited.

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