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Resource Use Efficiency and Profitability Analysis of Catfish (*Clarias gariepinus*) Production in Kogi State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SJI and BOO designed the study. Author PEA performed the statistical analysis. Author SJI wrote the protocol and wrote the first draft of the manuscript. Author FOO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Understanding the resource use efficiency and profitability in catfish production is essential for maximizing productivity, minimizing environmental impact, and ensuring sustainable economic growth in the aquaculture industry. This study assessed the resource use efficiency and profitability analysis of catfish (*Clarias gariepinus*) production in Kogi State, Nigeria. Primary data obtained through questionnaire administration to one hundred and sixty (160) catfish farmers in the State

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were analysed using descriptive statistics, Cobb-Douglass production function, efficiency ratio, gross margin, and mean score from the Likert type of scale. The result showed that 68.12 percent of catfish farmers in the State were males in a productive age of 48 years. The major catfish farming practices/enterprise combination include; sole catfish farming (78.75 percent), fish cum vegetable (44.38 percent) and fish cum poultry (40.63 percent). Analysis of the resource use efficiency showed that fingerlings, labour and vaccines were underused while feed, pond and fuel were overused by catfish farmers in the State. The calculated gross margin among catfish farmers is N2, 110,136.01k with a profit of N1, 333,910.54k, indicating the net financial gain from the catfish production after deducting all costs. The benefit-cost ratio (BCR) is 1.32, suggesting that for every unit of cost invested in catfish production, there is a return of 1.32 units in revenue. The serious constraints faced by catfish farmers include; inadequate finance (mean score = 2.88), high cost of feed (mean score = 2.87), inadequate power supply (mean score = 2.66), cannibalism (2.42), inadequate processing experience (mean score = 2.32), and low market price (mean score = 2.21). Among others, the study recommended that, the State government should: implement policies that promote access to quality inputs, provide technical assistance and training to catfish farmers, facilitate market access, and create an enabling business environment.

Keywords: Catfish; cobb-douglas; overused; resource; underused.

1. INTRODUCTION

Fish are more important than ever and continue to gain importance. According to statistics, a large portion of the essential protein food required to feed Nigeria population, which is always growing and of which perhaps half are undernourished even now, will come from marine (saltwater) fisheries. Nigeria's fish demand is 2.66 million metric tons (MT), while domestic supply is 0.76 million MT, with a per-capita consumption of 15.46 kilograms [1]. According to the Food and Agriculture Organization, FAO [2], Nigeria has a 400 000 ton fish supply compared to an 800 000 ton demand; as a result, the country as a whole, including Kogi State, needs to close this gap. This demonstrates the significant disparity between the supply and demand for animal protein.

Diverse institutions have recognised the detrimental consequences of fish imports on the country's foreign reserve [3,4]. According to FAO [5], between 1995 and 2020, the need for protein-based meals climbed globally by 58%, and consumption will continue to rise. This should pique people's interest and spur more catfish study.

Despite the country's domestic need for fish not being met locally, local fish production has tremendous potential for growth [6]. As a result, Nigeria now has a demand-supply mismatch of at least 0.7 million metric tons. According to FAO (2022b), increased catfish production in the country can aid in closing the alarming demand-supply fish gap. According to Ugwumba and Chukwuji [7], further improvements in catfish production may be made with thorough analysis that reveals the profitability level of catfish farming as well as the socio-economic characteristics of catfish farmers that limit maximum profitability.

Therefore, issues concerning the knowledge of the venture's financial feasibility and production sustainability will be addressed through profitability analysis. Such a discovery will highlight the amount of profit that may be realized from the business and assist businesspeople in making well-informed decisions about fish farming.

In order to reduce waste and redeploy resources to new or expanded ventures, knowledge of allocative efficiency and optimal resource usage would be helpful. In the study area, research on the efficient use of resources in catfish production is still quite limited. The majority of the scant studies that are accessible were conducted outside of Kogi State. This study seeks to examine the resource use efficiency and profitability analysis of catfish in the state in light of this and other unsupported claims about catfish production in Kogi State.
The specific objectives are to:

i. Describe the socio-economic characteristics of catfish farmers in the study area
ii. Describe the catfish farming practices in the study area
iii. Estimate resource use efficiency of catfish production in the study area;

iv. Analyse the cost and returns of catfish production in the study area?
v. Identify the constraints confronting catfish farmers in the study area.

2. METHODOLOGY

2.1 Study Area

The study was conducted in Kogi State in North Central, Nigeria. Kogi State was created on the 27th day of August 1991. The State is headquartered at Lokoja, a city located on the confluence of the two major rivers in the country – Niger and Benue and is bordered by the States of Nassarawa to the Northeast; Benue to the East; Enugu, Anambra, and Edo to the South; Ondo, Ekiti, and Kwara to the West; and Niger to the North. Abuja Federal Capital Territory also borders Kogi to the North. Geographically, State is located between latitude $6^0$30'N and $8^0$5'N and longitude $5^0$51'E and $8^0$00'E. For the purpose of agricultural development, especially in the area of extension delivery, the State is delineated into four agricultural zones namely; Zone A which comprises of Ijumu, Kabba/Bunu, Mopamuro, Yagba-East and Yagba-West local government areas with headquarters in Aiyetoro-gbede. Zone B, comprises of Dekina, Bassa, Ankpa, Olamaboro, and Omala local government areas, with zonal headquarters in Anyigba. Zone C, comprises of Adavi, Ajaokuta, Lokoja, Kogi, Okene and Okehi local government areas with zonal headquarters in Koton-Karfe. Zone D, comprises of Idah, Ofu, Ibaji, Olamaboro, and Igala-Mela local government areas with zonal headquarters in Aloma.

2.2 Sources of Data Collection

For the purpose of this study, primary data was used and information was obtained through the use of a well-structured questionnaire. The questionnaire was administered to the respondents. Personal discussions, interview schedule and observations were also used to complement the data for accuracy and reliability.

2.3 Sampling Procedure and Data Collection

Kogi State was purposively selected because fish farming has gained prominence. The sampling frame comprised of all the Catfish farmers in the State.

The respondents for the study were selected through a multistage sampling technique. The first stage involved purposive selection of two Agricultural zones from the four agricultural zones in Kogi State. The two zones selected were zones B and D. They were selected because about 70% of Catfish production occurred in these two zones [1]. Similarly, in stage two, purposive sampling method was used to select two Local Government areas from each of the two selected agricultural zones based on their involvement in fish farming. The four Local Government Areas selected include Omala, and Bassa from zone B and Idah and Ibaji from zone D. The third stage involved the random selection of 2 communities from each of the four selected Local Government Areas. In all a total of 8 communities were selected for the study. The final stage involved the random selection of 20 Catfish farmers from each of the selected communities. The research instrument was administered to a total of 160 respondents.

Trained enumerators in collaboration with the researchers were used to administer the questionnaire to 160 selected Catfish farmers within the selected communities. Required data included those on personal characteristics of the respondents, the production technologies in use, various resources used in production, cost of production, volume and returns from production.

Respondents (catfish farmers) in this study were required to provide informed consent prior to their inclusion. The consent process involved explaining the purpose, procedures, risks, and benefits of the study to potential participants. Participants were assured of the confidentiality and anonymity of their responses, and they were informed that their participation was voluntary. The following consent statement was presented to the respondents:

“By participating in this study, you voluntarily agree to provide information and consent to its use for research purposes. Your participation is entirely voluntary, and you have the right to withdraw at any time without consequence. Any information collected will be kept confidential and used solely for the purpose of this study. Your anonymity and privacy will be protected, and the data will be reported in aggregate form without revealing individual identities. If you have any questions or concerns about the study or your participation, please feel free to contact the research enumerator. Your decision to participate or not will not affect your current or future relationship with the researchers or the institution".

2.4 Validity and Reliability of the Instrument

Content validity of this research instrument was determined by experts in social science, applied science and aquaculture research through proper scrutiny. The instrument was pilot tested using catfish farmers (n=30) in the Federal Capital Territory, Abuja, Nigeria. The farmers used were not part of the main study. Changes was made as necessary, to improve the clarity and reliability of the instrument. Cronbach's alpha was measured to estimate the reliability. A coefficient of 0.895 was obtained, which confirms the reliability of the instrument.

2.5 Method of Data Analysis and Model Specification

Objectives 1 and 2 were analysed using descriptive statistics like frequency distribution, objective 3 was attained using Cobb-Douglas production function following the methods mentioned by Rahman and Lawal (2003), while gross margin analysis was used to achieve objective 4. Objective 5 was achieved using mean score from a 3-point likert type of scale. The models were specified as follows;

2.5.1 Cobb-Douglas production function

The Cobb-Douglas production function employed in this study is given as:

$$Y = aX_1^{b1}\, X_2^{b2},\, X_3^{b3},\, X_4^{b4},\, X_5^{b5},\, X_6^{b6},\, e^u \qquad (1)$$

Explicitly, this is expressed as:

$$Y = \alpha + \partial_1 X_1 + \partial_2 X_2 + \partial_3 X_3 + \partial_4 X_4 + \partial_5 X_5 + \partial_6 X_6 + e_i \qquad (2)$$

Where:

Y = Total return from catfish production (₦)
X_1 = Total cost of fingerlings ((₦))
X_2 = Total cost of feed (₦)
X_3 = Total cost of pond (₦)
X_4 = Total labour cost (₦)
X_5 = Total cost of fuel (₦)
X_6 = Total cost of vaccines (₦)
A = the intercept
∂ = the function coefficients, and e_i = error term.

Both dependent and explanatory variables were transformed to natural logarithm.

The level of resource use efficiency was calculated using the formula:

$r = \frac{MVP}{MFC}$ where, r = efficiency ratio; MVP = Marginal Value Product – which is the value of incremental unit of output resulting from the additional unit of inputs; MFC = Marginal Factor Cost which is equal to 1 (because both the dependent and independent variables are converted to monetary value) – the increase in the cost of inputs due to the purchase of additional unit of inputs.

$MVP = \frac{\partial_{i*} y_i}{x_i}$ where, ∂_i = estimated regression coefficient of input X_i; y_i and x_i represent the geometric mean value of output and ith resource used, respectively.

2.5.2 Decision rule

r= 1; Efficient use of resource
r>1; Underused of the resource
r<1; Overused of the resource

The relative percentage change in MVP was calculated using:

$D = 1 - \frac{MFC}{MVP} * 100$ Or, $D = 1 - \frac{1}{r} * 100$; D= absolute value of percentage change in MVP of each resource [8].

2.5.3 Profitability analysis

To determine the cost and returns in catfish production for each respondent, a partial Gross Margin was employed to determine Net Farm Income (NFI). This analysis elucidates the profitability of the venture.

Gross Margin = TR – TVC

Where TR = Total Revenue (total receipts from the sales of cropped fish in naira).

Gross Margin – Fixed Costs = Net Farm Income (NFI)
(Fixed Cost = costs of all assets e.g. fish tank, pumps, pipes, etc)

2.5.4 Mean Score

The mean score from a 3 point likert scale is stated as;

$$X = \frac{F_i A_i}{N}$$

X = ∑ FiAiN

Where,

X = mean response
F_i = number of respondents choosing a particular scale point
A_i = numerical value of the scale point
N = total number of respondents to the items
∑ = summation

Decision rule: very severe (VS) = 3 points with real limit of 2.5 and above, severe (S) = 2 points with real limits of 2.00 – 2.40, not severe (NS) = 1 point with real limit less than 2.00.

Any constraint with mean score of above 2 and above is a very severe constraint.

3. RESULTS AND DISCUSSION

We presented the results and discussion for this report in line with the stated research objectives. These include; socioeconomic characteristics of fish farmers in the study area, catfish farming practices, resource use efficiency in catfish production, costs and return in catfish production, and constraints faced by catfish farmers in Kogi State.

3.1 Socioeconomic Characteristics of Catfish Farmers

The relevant socioeconomic indices considered in this study include; sex, age, marital status, household size, educational level, fish farming experience, credit access, and extension visit. The outcome of the statistical analysis on these variables of interest is as presented in Table 1.

3.1.1 Sex of the respondents

Table 1 shows that most (68.12 percent) of the respondents were males while the remaining 31.88% were females. The result on sex agrees with Aminu et al. [9] who reported that 68.1 percent of catfish farmers in Lagos are males. The findings of this study suggests that catfish farming is still a male-dominated field, and there may be social and cultural factors that prevent or discourage women from participating in this occupation. However, there is a growing number of female catfish farmers in Nigeria.

3.1.2 Age of the respondents

The reported mean age among catfish farmers in the study area was 48 years. This is similar to Aminu et al. [9] who reported a mean age of 41 years among fish farmers in Lagos. Regardless of the impressive percentage of youth (23.12%) participation in catfish production, 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.

3.1.3 Marital status of the respondents

The distribution of respondents according to marital status as presented in Table 1 shows that 88.75 percent of the catfish farmers were married while the remaining 11.25 percent were unmarried. This finding has important implications for understanding the social and economic characteristics of catfish farmers in the study area. Marriage is often associated with stability and social support, which can be beneficial for individuals engaged in farming activities. The high percentage of married catfish farmers suggests that this may be a relatively stable population, which can have positive implications for the sustainability of the catfish farming sector. This result is in tandem with the findings of Ugwuja et al. [10] that majority of the catfish farmers in Rivers State were married.

On the other hand, the relatively low percentage of unmarried catfish farmers may suggest that the sector is less attractive to younger people or those who are not yet established in their personal lives. This could potentially limit the growth and vibrancy of the catfish farming sector if there are not enough younger farmers entering the sector to replace those who retire or leave the sector for other reasons.

3.1.4 Household size of the respondents

The mean household size as presented on Table 1 is 7 members. The distribution reveals that, only 24.38 percent of the catfish farmers had household size of 1 - 5 members, while the remaining 75.62 percent had household size of 6 – 20 members. This finding could positively influence catfish production in the study area as catfish farming is a labour-intensive activity that requires the participation of all family members. This finding further highlights the important role that catfish farming plays in supporting livelihoods and providing economic opportunities for extended families in the study area.

3.1.5 Educational level of the Respondents

The distribution of respondents according to highest educational qualification as presented in Table 1 shows that, all (100 percent) the catfish farmers are expected to be able to read and write, *all else equal*. Specifically, 8.13 percent had primary educational qualification, while 36.88% and 55% had secondary and tertiary educational qualification, respectively. This finding suggests that catfish farmers are relatively well-educated. Education can play an important role in promoting the adoption of new technologies and practices, improving productivity and profitability, and enhancing the overall competitiveness of the catfish farming sector. The high percentage of catfish farmers with tertiary education may therefore be a positive factor for the future growth and development of the sector in the study area. However, the relatively low percentage of catfish farmers with primary educational qualifications (8.13%) may suggest that there is still a significant proportion of the population that may face challenges in accessing and adopting new technologies and practices. This could potentially limit the growth and competitiveness of the catfish farming sector in the study area if there are not enough farmers with the necessary skills and knowledge to drive innovation and growth.

3.1.6 Fish farming experience of the respondents (years)

The mean years spent in catfish production among the respondents was 12 years. This result suggests that catfish farming is a relatively established activity in the study area. Farmers with more experience may be better equipped to navigate the challenges and risks associated with catfish farming, such as disease outbreaks, market fluctuations, and production variability. This experience may also enable farmers to adopt more sophisticated production methods and technologies, leading to higher productivity and profitability. Furthermore, the finding suggests that there may be a strong community of practice around catfish farming in the study area. This community of practice may facilitate the exchange of knowledge, skills, and best practices among farmers, leading to further improvements in productivity and profitability.

3.1.7 Access to credit by of the respondents

Table 1 shows that only 35 percent of the catfish farmers have access to credit for catfish production, while the remaining 65% have not. The low access to credit facilities among catfish farmers in the State has important implications for the growth and sustainability of the catfish farming sector. Access to credit can be an important factor in promoting investment in catfish farming, as it can enable farmers to purchase inputs such as fingerlings, feed, and equipment, as well as to invest in infrastructure such as ponds and tanks. The low percentage of catfish farmers with access to credit in the study area may therefore be a limiting factor in the growth and development of the sector.

Lack of access to credit can also limit the ability of farmers to adopt new technologies and practices that may improve productivity and profitability, such as the use of high-quality feed, improved genetics, and advanced production systems. This may further constrain the growth and competitiveness of the sector in the study area.

3.1.8 Extension visits

The result (Table 1) shows that, majority (81.88 percent) of the catfish farmers have no access to extension agents while only 18.12 percent experienced extension visit in the last production cycle. Furthermore, of the percentage that had extension visit, 12.50 percent were visited on a monthly basis. This finding suggests a potential limitation in the dissemination of information and knowledge related to catfish production.

Extension agents play a critical role in disseminating information and knowledge related to best practices in catfish farming, including topics such as pond management, feeding, and disease prevention and control. The low percentage of farmers who have access to extension agents in the study area may therefore limit their ability to adopt best practices, which may ultimately impact the productivity and profitability of their operations.

The low percentage of farmers who have experienced extension visits during the last production cycle may also be a cause for concern. Extension visits provide an opportunity for farmers to receive hands-on training and technical assistance on specific aspects of catfish farming. Without regular extension visits, farmers may miss out on important information and updates on new technologies and practices that may improve their operations.

3.2 Catfish Farming Practices

This study considered eleven (11) enterprise and enterprise combination among catfish farmers in the study area. The descriptive analysis of the data obtained among the respondents is presented in Table 2.

Table 1. Distribution of respondents according to socioeconomic characteristics
n = 160

Socioeconomic Variables	Frequency	Percentage	Mean
A. Sex			
Male	109	68.12	
Female	51	31.88	
B. Age (years)			
20 – 40	37	23.12	48 years
41 – 60	112	70.00	
61 – 80	11	6.88	
C. Marital Status			
Single	8	5.00	
Married	142	88.75	
Divorced	3	1.88	
Widow	7	4.38	
D. Household Size (number)			
1 – 5	39	24.38	
6 – 10	97	60.63	7 members
11 – 15	20	12.50	
16 – 20	4	2.50	
E. Educational Level			
Primary education	13	8.13	
Secondary education	59	36.88	
Tertiary education	88	55.00	
F. Fish Farming Experience (years)			
1 – 5	15	9.38	
6 – 10	52	32.50	12 years
11 – 15	65	40.63	
16 – 20	28	17.50	
G. Credit Access			
Access	56	35.00	
No Access	104	65.00	
H. Extension Visit			
No Visit	131	81.88	
Weekly	5	3.13	
Every Three Weeks	4	2.50	
Monthly	20	12.50	

Source: Field Survey, 2023

Table 2. Catfish farming practices among catfish farmers in Kogi State n = 160

Enterprise/Enterprise combination	Frequency	Percentage	Ranking
Sole catfish farming	126	78.75	1st
Fish cum rice	36	22.50	5th
Fish cum maize	24	15.00	7th
Fish cum cassava cum maize	49	30.63	4th
Fish cum cassava	24	15.00	7th
Fish cum yam	7	4.38	9th
Fish cum vegetable	71	44.38	2nd
Fish cum poultry	65	40.63	3rd
Catfish cum Margot	4	2.50	10th
Catfish cum piggery	0	0	-
Fish cum sheep and goat	30	18.75	6th

Source: Field Survey, 2023

Sole catfish farming ranked first among the eleven enterprise and enterprise combination considered in this study. The finding that 78.75% of the catfish farmers practiced sole catfish farming indicates that this is the most common catfish production practice in the study area. Sole catfish farming involves the production of catfish in a single pond or tank, without any other species. This practice is typically easier to manage and may be more profitable compared to mixed farming systems, as farmers can focus on optimizing the conditions for catfish growth and production without having to manage different species with potentially different requirements. The high percentage of farmers practicing sole catfish farming may also suggest a lack of access to resources or knowledge required to implement more complex mixed farming systems, which require more technical knowledge and resources to manage successfully.

The second farming practice which is the most common enterprise combination catfish farmers in the study area is fish cum vegetable. Fish cum vegetable farming, also known as aquaponics, is a sustainable integrated system where fish and vegetables are produced together in a closed recirculating system. The fish provide nutrients for the plants, and the plants purify the water for the fish. The popularity of fish cum vegetable farming among catfish farmers may be due to the potential for increased yields and profitability as well as environmental sustainability. The system allows farmers to produce fish and vegetables in the same space and with fewer inputs than traditional production systems, which can increase productivity and efficiency. However, the percentage of farmers practicing fish cum vegetable farming is still relatively low compared to sole catfish farming, suggesting that this practice may be more challenging to implement or require more technical knowledge and resources.

The finding also shows that 40.63% of catfish farmers practiced fish cum poultry farming as their production practice, and this ranks third in the study area. Fish cum poultry farming is an integrated system where fish are produced alongside poultry, typically in the same space or system. The waste from the poultry provides nutrients for the fish, and the fish waste can be used to fertilize the poultry feed. The popularity of fish cum poultry farming among catfish farmers may be due to the potential for increased productivity and profitability, as well as the ability to use resources more efficiently. The system allows farmers to maximize the use of available space and resources, and can also help to reduce waste and environmental impacts. However, the percentage of farmers practicing fish cum poultry farming is still relatively low compared to sole catfish farming.

The finding that fish cum maggot and piggery farming ranked last with a percentage of 2.50 and 0, respectively, indicates that these production practices are not widely adopted among catfish farmers in the study area. Fish cum maggot farming involves the use of maggots as a source of protein for fish, while fish cum piggery farming involves the production of both fish and pigs in the same system. The low adoption rate of these practices may be due to various factors such as technical know-how, limited resources, and market demand. Fish cum maggot farming may require specialized skills and equipment for the production and processing of maggots, which may not be readily available or affordable for many catfish farmers. Similarly, fish cum piggery farming may require additional resources and expertise, such as knowledge of pig husbandry and the construction of appropriate housing facilities, which may not be feasible for all catfish farmers.

3.3 Resource Use Efficiency in Catfish Production

The estimated resource use efficiency in catfish production is presented in Table 3. The coefficients used for calculating the Marginal Value Product (MVP) was obtained from the estimates of a double-log functional form where the value of return from catfish production were used as the dependent variable while selected inputs served as the explanatory or independent variables. The major inputs used in catfish production as adopted in this study include; fingerlings, feed, pond, labour, fuel, and vaccines. The coefficients from a double-log functional form are usually interpreted as elasticities. Consequently, the positive sign of all the included variables in the model is an indication that a percentage increase in any of the explanatory variables will lead to a percentage increase in the return from catfish production.

The efficiency ratio (r) represents the relationship between the actual input used and the optimal input required to achieve a desired output level. Table 3 shows that fingerlings, labour and vaccines were underused in catfish production in Kogi State, while feed, pond, and fuel were overused. It was clear from the result that, none of the considered inputs was efficiently used by catfish farmers in the State. In the case of overutilization, the actual input usage exceeds the optimal level required to achieve the desired output. Overutilization can result from inefficient practices beyond what is necessary for optimal fish output. This can lead to negative environmental impacts, increased production costs, and potential harm to soil, water, and ecosystems. There is underutilization when the actual input usage is lower than the optimal level required to achieve the desired output. Underutilization can occur due to factors such as limited access to resources, inadequate knowledge or technology, or suboptimal decision-making. It can result in lower productivity, reduced output, and missed opportunities for maximizing profitability.

The efficiency ratio for fingerlings as presented in Table 3 was greater than 1. This implies that there is underutilization of fingerling resource by catfish farmers in the study area. It indicates that the actual input usage is lower than the optimal level required to achieve the desired output. There is need for a 90.71 percent adjustment for optimum utilization of this resource. The underutilization of fingerlings may lead to: slow growth and development, reduced productivity, and missed production potential.

Table 3 further shows that feed resource was overused by catfish farmers in the study area. This means that the amount of feed being used is insufficient to meet the optimal or necessary level for achieving the desired outcomes. This interpretation aligns with the notion that increasing the utilization of the input by over 5,000 percent can lead to improved profitability. Accordingly, more feed resources are needed to enhance fish growth, achieve better feed conversion ratios, and ultimately improve profitability. By increasing the feed input to an optimal level, the fish can maximize their growth potential and potentially increase the economic returns.

The over-utilization of pond is an indication that their usage exceeds the optimal or sustainable level for the intended purpose. For optimal utilization, there is the need for about 136 percent adjustment in the pond space for catfish production among the farmers. Overutilization of pond can have several implications: environmental impacts, decreased productivity and increased management challenges. Fuel was also over-utilized, and this implies that the consumption of fuel in the catfish production system exceeds the optimal or necessary level.

Underutilization of labour as shown in Table 3 suggests that the available workforce is not being fully utilized or assigned to productive tasks. This can result in reduced efficiency and productivity in various aspects of the production process, such as feeding, pond maintenance, and harvesting. By optimizing workforce allocation, ensuring that tasks are adequately assigned, and maximizing the skills and capabilities of the labour force, catfish producers can enhance productivity and overall production efficiency. This optimization can be achieved by the catfish farmers through 99.89 percent adjustment. Additionally, the underutilization of vaccines in catfish production indicate that the available vaccines are not being used to their maximum potential. For optimal allocation, there is the need for a 99.80 percent adjustment.

Table 3. Estimated resource use efficiency in catfish production

Inputs	Coeff.	MVP	MFC	r = MVP/MFC	D-value	Remarks
Ln_Fingerlings	0.2447	10.7585	1	10.7585	90.71	Underused
Ln_Feed	0.00367	0.0184	1	0.0184	5,334.78	Overused
Ln_Pond	0.06484	0.4226	1	0.4226	136.63	Overused
Ln_Labour	0.25862	956.543	1	956.543	99.89	Underused
Ln_fuel	0.01269	0.1608	1	0.1608	521.89	Overused
Ln_vaccines	0.14966	510.2947	1	510.2947	99.80	Underused

Source: Field Survey Data, 2023; Ln = Natural Logarithm; No. of Obs. = 160
NOTE: Marginal Factor Cost (MFC) is equal to one since both dependent and explanatory variables are converted to monetary value; and is defined as the increase in the cost of inputs due to purchase of additional unit of inputs [11]

3.4 Costs and Returns Analysis

From Table 4, the total costs represent the sum of variable costs and fixed costs. In this case, the total costs amount to 4,116,089.46 NGN, reflecting the combined expenses incurred in the production process, including both variable and fixed costs. The fixed costs include expenses related to infrastructure and equipment, such as ponds, tanks, bowls, nets, buildings, and various tools. These costs, totaling 776,225.47 NGN, are considered fixed because they do not vary with the level of production. It's important to note that these costs are depreciated, meaning they account for the wear and tear of the assets over time.

The gross margin represents the difference between total revenue and total variable costs. In this case, the gross margin is calculated as 2,110,136.01 NGN. It indicates the profitability of the catfish production after accounting for the variable costs associated with inputs such as fingerlings, water, feed, fuel, drugs, and other variable expenses.

Profit is calculated by subtracting total costs from total revenue. In this analysis, the profit is determined as 1,333,910.54 NGN, indicating the net financial gain from the catfish production after deducting all costs. This represents the surplus generated by the business. The benefit-cost ratio (BCR) is a measure of the profitability and efficiency of an investment. It is calculated by dividing the total benefits (total revenue) by the total costs. In this case, the BCR is 1.32, suggesting that for every unit of cost invested in catfish production, there is a return of 1.32 units in revenue. A BCR greater than 1 indicates a positive return on investment.

The gross margin analysis and profitability assessment provide valuable insights into the financial performance of catfish production. The positive gross margin and profit indicate that catfish production is financially viable and has the potential to generate a surplus. This suggests that farmers can generate income and sustain their operations by engaging in catfish farming. The profit generated from catfish production signifies the potential for financial sustainability in the sector. This can attract investments, encourage entrepreneurship, and contribute to the economic growth of the local communities and the agricultural sector as a whole.

3.5 Constraints Confronting Catfish Farmers

The major constraints to catfish production in the study area are presented in Table 5.

Catfish farmers' perception on the seriousness of the various constraints were obtained from the three point Likert type of scale and the mean score calculated accordingly. From the analysis, the serious constraints faced by catfish farmers include; inadequate finance (mean score = 2.88), high cost of feed (mean score = 2.87), inadequate power supply (mean score = 2.66), cannibalism (2.42), inadequate processing experience (mean score = 2.32), low market price (mean score = 2.21), high rate of evaporation (mean score = 2.18), lack of government support (mean score = 2.06), scarcity of viable seed (mean score = 2.04), high water resources (mean score = 2.01), and high temperatures (mean score = 2.01).

The result on inadequate finance is an indication that catfish farmers in the study area face significant challenges in accessing financial resources. This is a common constraint in agriculture, and it can have a major impact on the productivity and profitability of farmers. Inadequate finance can limit farmers' ability to invest in essential inputs such as improved fingerlings, conventional feeds, and equipment, which can ultimately affect their yield and income. Addressing the issue of inadequate finance could go a long way in improving the productivity, profitability, and sustainability of catfish farming in the study area [12].

The result on high cost of feed could also be associated with the significant financial challenge faced by catfish farmers in the study area. The high cost of feed could be due to a variety of factors such as fluctuations in the cost of raw materials, transportation costs, and market forces. Furthermore, the high cost of feed may also have implications on the profitability and sustainability of catfish farming in the study area. Farmers who are unable to afford the high cost of feed may be forced to cut corners, which could negatively impact the quality of their produce and their overall productivity.

Inadequate power supply can negatively affect the productivity and profitability of catfish farming by limiting the use of machinery and equipment, which can increase efficiency and productivity. Furthermore, it can also impact the quality of the feed, which is essential for the growth and health of the fish. Inadequate processing experience was also reported as a major constraint for catfish farmers, as it can limit their ability to add value to their products and access higher-value markets. Cannibalism was also reported as a

Table 4. Costs and Return Analysis in Catfish Production in Kogi State n = 160

Items	Total Value (₦)
Returns	5,450,000.00
Total Revenue	5,450,000.00
Variable Costs	
Fingerlings	124,940.502
Water	190419.4
Feed	2,464,223.2
Other feed	20,030.13
Fuel	38,860.45
Drugs	37,230.40
Lime	3500.55
Fertilizer	126720.13
Agrochemical	16,680.55
Vaccines	7,120.00
Labour	272,648.00
Transportation	37490.68
Total Variable Costs	3,339,863.99
Gross Margin	2,110,136.01
Fixed Costs (Depreciated)	
Pond	140098.7
Tanks	66590.13
Bowl	850
Net	2836
Bags	324
Hoe	734
Cutlass	2136
Sprayers	4500
Wheelbarrow	16468.47
Buildings	529134.1
Shovel	2875.40
Weight balance	9678.67
Total Fixed Costs	776,225.47
Total Costs	4,116,089.46
Profit	1,333,910.54
Benefit Cost Ratio	1.32

Source: Field Survey Data, 2023

Table 5. Constraints faced by catfish farmers in Kogi State n = 160

Constraints	VS	S	NS	TSS	MS	Remark
Inadequate finance	144	13	3	461	2.88	Serious
High cost of fish feed	145	10	5	460	2.87	Serious
Inadequate power supply	109	48	3	426	2.66	Serious
Inadequate processing facilities	69	73	18	371	2.32	Serious
Predators	13	48	99	234	1.46	Not Serious
Low Market price	33	127	0	353	2.21	Serious
Poor storage facility	20	101	39	301	1.88	Not Serious
Lack of government support	51	67	42	329	2.06	Serious
High cost of Transportation	57	43	60	317	1.98	Not Serious
Disease	9	42	109	220	1.38	Not Serious
High cost of vaccine	14	21	125	209	1.31	Not Serious
Inadequate drug supply	15	30	115	220	1.38	Not Serious
Poor road network	35	57	68	287	1.79	Not Serious
Challenges of water sources	43	76	41	322	2.01	Serious
High Temperature	59	44	57	322	2.01	Serious
High rate of evaporation	74	41	45	349	2.18	Serious
Poor water quality	44	59	57	307	1.92	Not Serious
Seasonal storms and flooding	17	57	86	251	1.57	Not Serious
Scarcity of viable seed	52	63	45	327	2.04	Serious
Small pond size	40	68	52	308	1.92	Not Serious
Cannibalism	100	27	33	387	2.42	Serious
Lack of access to extension services	12	56	92	240	1.50	Not Serious
Lack of experience	10	54	96	234	1.46	Not Serious
Poor expertise	22	48	90	252	1.57	Not Serious
Theft	6	17	137	189	1.18	Not Serious

Source: Field Survey, 2023

major constraint to catfish production in the study area. Cannibalism refers to the act of catfish eating their own kind. It can lead to significant losses in the catfish production process and was identified as a major constraint in the study [13].

High water resources, high evaporation, and high temperatures were reported as serious constraints in the study area. These factors can affect the growth and survival of catfish, as well as the quality and quantity of the water in which they are raised. High evaporation can lead to reduced water levels and increased salinity, while high temperatures can lead to decreased oxygen levels and increased risk of disease.

4. CONCLUSION

This study examined the resource use efficiency and profitability analysis of catfish production in Kogi State, Nigeria. The results suggest that although there are increasing numbers of female catfish producers, the industry is still dominated by men. The current generation of catfish farmers are getting older, which could result in fewer farmers being active and lower output levels. The most popular method of producing catfish is sole catfish farming, which is simpler to control and more lucrative.

Further analysis reveals that feed, ponds, and fuel were overused while fingerlings, labour, and vaccines were underutilized in Kogi State's catfish production. The profit and gross margin showed that catfish production is economically feasible and has the potential to produce an excess. Benefit-cost ratio (BCR) data point to a profitable investment. The study area's catfish growers encountered substantial obstacles when trying to acquire funding. Other significant obstacles to catfish production in the study area include high feed costs, insufficient power supplies, a lack of processing expertise, and cannibalism.

5. RECOMMENDATIONS

The following policy recommendations are made in line with the findings from this study:

1. To address underutilization in fingerlings production, it is important to focus on improving feeding practices, providing adequate and balanced nutrition,

optimizing water quality parameters, and ensuring optimal environmental conditions for fingerling growth. Implementing proper management techniques, such as regular monitoring, adjusting feeding regimes, and ensuring appropriate stocking densities, can help enhance resource utilization and improve the overall efficiency of fingerlings production.

2. Policymakers can support catfish production by implementing policies that promote access to quality inputs, provide technical assistance and training to farmers, facilitate market access, and create an enabling business environment. This can help stimulate growth in the catfish farming sector, enhance productivity, and contribute to food security and rural development.
3. The presence of significant fixed costs indicates the importance of infrastructure and equipment in catfish production. Policymakers and farmers should consider investing in modern and efficient infrastructure, such as improved ponds, tanks, and tools, to enhance productivity and reduce long-term costs.
4. The study found inadequate finances. Addressing this constraint will require interventions such as improving access to credit, providing financial education to farmers, and encouraging the development of financial institutions that can provide tailored financial products and services to catfish farmers.
5. Cannibalism was reported as a major constraint to catfish production in the study area. Consequently, catfish farmers need to take measures to prevent cannibalism, such as providing adequate feed and managing the stocking density of the fish.
6. Government and relevant agencies should provide adequate training and support to catfish farmers to improve their processing skills, as well as developing linkages between farmers and processors to enable them to access processing facilities.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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