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Economics of Cage Aquaculture Operations in Oyan Reservoir, Ogun State, Nigeria

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ABSTRACT

Background and Objective: Cage culture contributions to domestic fish supply in Nigeria are abysmally low currently due to the low level of adoption. An in-depth study of the economic indices of cage aquaculture is key to improving its adoption and consequently enhancing its contribution to food fish security in Nigeria. Hence, the economic viability of cage culture operations at the Oyan Reservoir was investigated. **Materials and Methods:** Stratified sampling technique was used to administer structured questionnaires to the three cage culture operators in the Oyan Reservoir. Information on the socioeconomic characteristics of cage operators and production indices, income and expenditure was exclusively collected from the producers (A, B and C). Data generated were analyzed using descriptive statistics, farm budgetary analysis, profit function and multiple regression analysis at a 95% confidence limit. **Results:** The cage fish operators (A, B and C) were male (100%) in the productive age (31-50 years). Years of cage culture operator experience (0.792) as well as production area (0.304), had the highest impact on fish output. Investor A supplies an average of 50,000 kg of *Oreochromis niloticus* annually with revenue of ₦19,125,000 while investments B and C had annual production range and revenues of 101,000-150,000 kg, ₦124,015,000 and 51,000-100,000 kg, ₦62,641,666, respectively. Investors A, B and C recorded negative net present values of -₦6,400,132.727, -₦213,540, 807.3 and -₦51,004,361.5, respectively. Also, the rates of returns on each investment and profit index were 22.2 and 0.79%, 6.09 and 0.84%, 8.59 and 0.63% for A, B and C, respectively. **Conclusion:** It is therefore, safe to conclude that cage culture operators in Oyan are yet to recover the initial investment. Cage fish farming is capital intensive with probable 4, 16 and 12 years for investors A, B and C, respectively to generate returns on investment.

KEYWORDS

Oreochromis niloticus, socio-economic, fish production, profit index, Oyan reservoir

INTRODUCTION

Fisheries being a renewable resource contribute significantly to the nutritional and economic euphoria of a nation. Nigeria is a coastal state with full capacity for marine, brackish and freshwater aquaculture. These resources constitute a major drive that makes Nigeria one of the leading aquaculture fish producers with huge marketing and consumption potentials. Olaoye and Ojebiyi[1] noted that the fisheries sub-sector contributes an average of 3.0-5.0% to the agriculture share of the Nigerian economy and provides an

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important livelihood source to several communities in riverine villages, coastal and hinterland areas. Moreover, it supplies a crucial source of animal protein that improves the quality of food and nutrition security of the Nigerian people. Thus, fisheries in Nigeria are critical to social and economic development and peace in the country.

In recent years, the rearing of fish has become an important and expanding part of the economy, particularly as far as the production of protein is concerned in rural and urban settings. Olanrewaju *et al.*[2] had earlier noted that the catfish aquaculture industry which is a private-driven sub-sector with vast investment has today become a formidable economic venture in Nigeria. Moreover, the rise in Nigeria's aquaculture growth is borne out of various factors including dwindling capture fishery resources, population explosion, awareness of fish nutritional values, marketing opportunities, fisheries research and advancement[2].

Consequently, aquaculture in Nigeria has developed into a remarkable and popular sector in the last few years, especially in the catfish aquaculture industry, which targets both domestic and international markets. However, Nigeria still trails behind with her annual national fish demand of about 2.7 million metric tons and domestic fish production of about 1.02 metric tons[3]. Hence, this sector is expected to become more successful by increasing efforts towards producing more fish by using less land, water and financial resources.

Cage aquaculture has therefore continued to garner increased recognition as a system of aquaculture capable of utilizing the vast water resources available in the country. This flexible system of aquaculture allows various commercially important species of fish, such as *Clarias gariepinus* and *Oreochromis niloticus* to be raised in a floating mesh immersed in open water bodies which otherwise would not have been possible[4]. Given its potential to support the culture of a larger number of fishes per square meter compared to another system of production, various cage aquaculture pilot project has been initiated in Nigeria. The Oyan Dam in Ogun State under the management of the Ogun-Osun River Basin Development Authority has provided the site for one of such projects.

Although a cage culture is now a serious option for addressing the shortage of fish supply in the country, there is a dare need to better understand the economic subtlety. The economic characteristic of aquaculture is a delicate aspect of the industry and this is more pronounced in the cage system of aquaculture which is an emerging activity in Sub-Saharan Africa with only a handful of successful examples[5]. As stated by Lakhwani *et al.*[6] the success of the adoption of any innovation or new technology lies in its economic performance. Therefore, the economic analysis of cage aquaculture provides a basis not only for decision-making by the individual farmers but also for formulating aquaculture policies. Potential investors are encouraged to develop the business if they are availed of crucial data that is genuinely convincing of the economic viability of cage aquaculture. This study, therefore, investigated the economics of cage culture operations in the Oyan Reservoir.

MATERIALS AND METHODS

Study area: Oyan River Dam located in Abeokuta North local government area of Ogun State, is about 20 km Northwest of the state capital Abeokuta. Oyan River lies between Latitudes 7°15'30''N and 3°15'20''E and Longitudes 7.25833°N and 3.25556°E. The dam was created by damming of Oyan and Ofiki Rivers. It is also abstracted by the Ogun-Osun River Basin Development Authority (OORBDA) for the supply of water to the cities of Abeokuta and Lagos for irrigation and domestic uses. Further, the dam covers an area of 4000 hectares and has the potential capacity to generate 9-megawatt of hydroelectric power for distribution to Abeokuta and its environs discussed by Ofoezie and Asaolu[7]. The rural dwellers are predominantly farmers, most of whom engage in the cultivation of arable crops like cassava, cocoyam plantain and maize, while some engage in livestock. Some of the settlers around the lake engage in fishing activities and farm vegetables along the fertile shoreline as the lake recedes in the dry season[8]. People in the area are also involved in quarry business, artisan work and handicrafts such as tie and die making and pottery.

Data collection: The study was conducted for three months (July to September, 2017) at the fish culture facilities at Oyan Reservoir. This study made use of both primary and secondary data. As 100 structured questionnaires were used for collecting primary data on cage operations from all three cage culture operators at Oyan Reservoir.

Economic analysis: The net farm income calculated as described by Okoth *et al.*[9] as follows:

$$\pi = TR\text{-}TC$$

$$TR = PQ$$

Where:

π = Net farm income (₦)
TC = Total variable cost+total fixed cost (₦)
P = Unit price of output (₦)
Q = Total quantity of output (₦)

For:

$$\text{Profitability index (PI)} = \frac{\text{Net present value}}{\text{Initial investment required}}$$

$$\text{Net present value (NPV)} = \sum_{i=1}^{T} \frac{C_i}{(I+r)^i} - C_o$$

Where:

C_o = Initial investment
C = Cash flow (year)
r = Discount rate
T = Time

Statistical analysis: The data obtained were analyzed using descriptive statistics, budgetary techniques and multiple regression. Statistical significance was tested at a 5% significant level ($p<0.05$).

RESULTS

All cage fish culture investors at Oyan Reservoir were male (100%), in the productive age which ranges from 31-50 years. About 33.3% of the respondents were in the age bracket 31-40 years, while 66.7% were between 41-50 years as shown in Table 1. All cage culture operators at Oyan Reservoir were married (100%) and had formal education up to tertiary school. Among the cage operators, 66.7% use the imported fish cage model while 33.3% make use of the local fish cage model. In terms of surface area (in square meters) of operation, 33.3% of cage culture operators at Oyan reservoir operate at 1000 square of fish cage area, followed by 33.3% who operate between 1001-2000 m^2 and 33.3% on a water area of about 3001-4000 m^2. As shown in Table 2, two investors (66.7%) operate 21-40 unit cages, while one (33.35%) uses between 81-100 unit cages. Two investors (66.7%) had just between 1-3 years of cage culture experience while one (33.3%) had between 4-6 years of experience. All cage fish operators at Oyan Reservoir had no contact yet with aquaculture extension agents. Tilapia is the sole fish species cultured among cage fish operators at Oyan Reservoir.

Table 1: Socio-economic characteristics of fish cage operators

Socio-economic variables	Frequency	Percentage
Gender		
Male	3	100.0
Female	0	0.0
Age		
21-30	0	0.0
31-40	1	33.3
41-50	2	66.7
51-60	0	0.0
>61-above	0	0.0
Marital status		
Single	0	0.0
Married	3	100.0
Widow/widower	0	0.0
Divorced	0	0.0
Educational qualification		
No formal education	0	0.0
Primary	0	0.0
Secondary	0	0.0
Tertiary	3	100.0
Types of cage models used		
Imported model	2	66.7
Local model	1	33.3
Fish cage area (m^2)		
Up to 1000	1	33.3
1001-2000	1	33.3
2001-3000	0	0.0
3001-4000	1	33.3
>4000	0	0.0

Table 2: Operational characteristics of fish cage operators

Operational variables	Frequency	Percentage
Number of unit cages		
≤20	0	0.0
21-40	2	66.7
41-60	0	0.0
61-80	0	0.0
81-100	1	33.3
Years of cage culture		
1-3	2	66.7
4-6	1	33.3
7-9	0	0.0
≥10	0	0.0
Number of contacts with extension agents		
1	0	0.0
2	0	0.0
3	0	0.0
None	3	100.0
Species of fish cultured		
Clarias	0	0.0
Heterobranchus	0	0.0
Tilapia	3	100.0

As shown in Table 3, the regression equation was:

$$LnY = 0.064+0.304X_1-0.326X_2+0.168X_3+0.792X_4+0.349X_5$$

All the socio-economic factors considered were not significant since their significant value is greater than the p-value (0.05). Also, years of cage culture experience have the highest impact on the annual average fish output while the factor with the lowest impact is the number of unit cages since their standardized coefficients (Beta) were 0.482 and -0.595, respectively.

Table 3: Multiple regression estimates of socio-economic determinants of fish output from cage culture system in Oyan Reservoir

Model	B	Standard error	Beta	t	Significance level
Constant	0.064	1.392	-	0.046	0.966
Fish cage area (in square meters)	0.304	0.439	0.464	0.691	0.539
Number of unit cages	-0.326	0.379	-0.595	-0.859	0.453
Amount of start-up capital (million naira)	0.168	0.275	0.429	0.612	0.584
Years of cage culture experience	0.792	0.934	0.482	0.848	0.459
Age	0.349	0.936	0.212	0.373	0.734

Dependent variable: Annual average fish output, R^2 =0.374, B: Regression coefficient, Beta: Standardized coefficient, t: t-value and R^2: Coefficient of determination

The fish cage area was 0.304. This showed that for every unit change, there will be about a 30.4% increase in the annual average fish output. This implied that securing a larger water area will promote fish production at Oyan Reservoir. Operators were required to pay a yearly permit per meter square for the use of the reservoir for cage culture. Therefore, there is a tendency of increasing fish production for every additional area of cage culture. The number of the unit cage was -0.326, which showed that for every unit change, there will be about a 32.6% decrease in the annual average fish output.

The negative relationship observed could be due to the relatively high cost of the fish cage and other inputs (fixed and variable) hence, judicious use of resources is advised when acquiring this asset. It is important to maximize the use of the current cage facility before adding an extra unit as this may not be economically sound. The amount of start-up capital was 0.168, this showed that for every unit change, there will be about a 16.8% increase in the annual average fish output. This suggested that investors might enjoy economies of scale in cage fish farming. Therefore, it is advisable to seek a greater scale of operation as this could mean higher returns.

Years of cage culture experience was 0.792, this showed that for every unit change, there will be about a 79.2% increase in the annual average fish output. This is not surprising as would-be investors could be advised to seek guidance from those already in the business in other to mitigate against risk which may surface at the onset. Age was 0.349 this showed that for every unit change, there will be about a 34.9% increase in the average monthly expenses on fish. It suggested that as operators advance in the active age bracket, their productivity increases coupled with better cage fish farming experience and there is a greater tendency to maximize output.

The estimate of costs and returns on cage fish farming were made using the annual average cost (fixed and variable) from the data generated from all three fish cage culture operators at Oyan Reservoir. The cost and return analysis in Table 4 revealed that the variable cost accounted for the largest proportion (68.38%) of the total cost of cage fish farming investment, while the proportion of fixed cost was 31.62% in investment A. Individually, the cost of feed was the highest at 39.49%, followed by the cost of the fish cage (local model) at 25.55%. Cost of fish seeds (13.06%), labor (10.50%), motorized boat (5.91%), depreciation (4.93%) water use permit (0.39%), canoe (0.32%) and harvesting gears (0.16%) came in that order. This shows that the bulk (65.04%) of money spent on this investment was majorly on the purchase of fish feeds and fish cages (local model). Therefore, it is important to pay more attention to how and why these inputs are used as they may tell on the productivity of the enterprise. Also, the result showed that a total cost (TC) of N25,363,066 was incurred on the investment, while total revenue (TR) of ₦17,342,266 was generated annually. Adjusted net farm income was ₦1,782,734 per annum.

In investment B, the fixed costs accounted for the largest proportion (69.84%) of the total cost of cage fish farming, while the proportion of variable costs was 30.16%. Individually, the cost of a fish cage (imported model) was the highest at 69.37%, followed by the cost of fish feed at 23.00%. Cost of fish seeds (4.33%), labor (1.39%), depreciation (1.02%) motorized boat (0.42%), water use permit (0.11%), canoe (0.022%) and harvesting gears (0.028%) came in that order. This shows that the bulk (92.37%) of money spent on this investment was majorly for the purchase of fish cages (imported model) and fish feeds. Also, the result shows that a total cost (TC) of ₦360,358,666 was incurred for the investment, while total revenue (TR) of N124,015,000 was generated annually. Adjusted net farm income was ₦15,336,334 per annum.

Also, for investment C, the fixed costs accounted for the largest proportion (59.45%) of the total cost of cage fish farming while the proportion of variable cost was 40.55%. Individually, the cost of a fish cage (imported model) was the highest at 58.30%, followed by the cost of fish feed (34.99%), cost of fish seeds (2.47%), labor (2.04%), motorized boat (1.09%), depreciation (0.89%), water use permit (0.14%) and harvesting gears (0.03%) came in that order. This shows that the bulk (93.29%) of money spent on this investment was majorly for the purchase of fish cages (imported models) and fish feeds. Also, the result showed that a total cost (TC) of ₦360,358,666 was incurred for the investment, while total revenue (TR) of ₦124,015,000 was generated annually. Adjusted net farm income was ₦15,336,334 per annum.

For profitability analysis, Table 5 reveals that the profitability index in investment A was lesser than one. This ratio is one of the concepts of the discount method of project evaluation. Since the profitability index= 0.79, it implied that this cage fish farming investment is yet to either break even or become profitable. The Net present value (NPV) for this investment, which is in the 1st year is -₦6,400,132.727. This shows that the investment is still undergoing a payback period (4 years), at the rate of 22.2% per annum. The analysis of profitability ratios in investment B reveals that the profitability index was lesser than one. Since the profitability index = 0.85, it implies that this cage fish farming investment is yet to either break even or become profitable.

Table 4: Cost and returns of investments

	Investments					
	A		B		C	
Items	Amount (₦)	Total cost (%)	Amount (₦)	Total cost (%)	Amount (₦)	Total cost (%)
Fixed cost (FC)						
Fish Cage (local/Imported model)	6,480,000	25.55	250,000,000	69.37	80,000,000	58.30
Motorized boat	1,500,000	5.91	1,500,000	0.42	1,500,000	1.09
Canoe	80,000	0.32	80,000	0.022	-	-
Harvesting gears	40,000	0.16	100,000	0.028	45,000	0.03
Total fixed cost (TFC)	8,020,000	31.62	251,680,000	69.84	81,545,000	59.45
Variable cost (VC)						
Water use permit	100,000	0.39	400,000	0.11	200,000	0.14
Fish seeds	3,312,000	13.06	15,606,000	4.33	3,398,955	2.47
Labour	2,664,000	10.50	5,000,000	1.39	2,800,000	2.04
Fish Feed	10,017,000	39.49	84,000,000	23.00	48,000,000	34.99
Depreciation	1,249,266	4.93	3,672,666	1.02	1,230,355	0.89
Total variable cost (TVC)	17,342,266	68.38	108,679,666	30.16	55,629,310	40.55
Total cost (TC)	25,363,066		360,358,666		137,174,310	
Total revenue (TR)	19,125,000		124,015,000		62,641,666	
Adjusted net farm income						
(TR-TVC)	1,782,734		15,336,334		7,012,356	

Table 5: Profitability ratios for investments

	Investments values		
Ratios	A	B	C
Profitability index (PI)	0.79	0.85	0.63
Net present value (NPV)			
1st year	-₦6,400,132.727	-₦237,737,878.20	-₦75,170,130.91
2nd year	-	-₦225,063,222.00	-₦69,374,795.37
3rd year	-	-₦213,540,807.30	-₦64,106,308.52
4th year	-	-	-₦59,316,775.02
5th year	-	-	-₦54,962,653.65
6th year	-	-	-₦51,004,361.50
Rate of return (ROR)	22.2%	6.09%	8.59%
Payback period	4 years	16 years	12 years

The net present value (NPV) for this investment which is in the 3rd year was -₦237,737,878.2, -₦225,063,222 and -₦213,540,807.3, respectively. This showed that the investment is still undergoing a payback period (16 years), at the rate of return of 6.09% per annum. Also, in investment C, the profitability index was 0.63. This implied that this investment is yet to either break even or become profitable. The Net present value (NPV) for this investment which is in the 6th year was -₦75,170,130.91, -₦69,374,795.37, -64,106,308.52, -₦59,316,775.02, -₦54,962,653.65, -₦51,004,361.5, respectively. This showed that the investment is still undergoing a payback period (12 years), at the rate of return of 8.59% per annum.

DISCUSSION

In the present study, cage culture is dominated by literate married male individuals (100%), within the age bracket of 41-50 years (66.70%). The study has also revealed that the imported fish cage model is mostly used (66.70%) by cage operators. The socio-economic characteristics of cage culture operators at Oyan reservoir follow the trend obtained by Adewuyi *et al.*[10]. They found that male fish farmers constituted the majority (87.7%) as compared to the female farmers represent 12.3%. The dominance of males in fish farming could be due to its high level of management which demands time and resources. The result also coincided with the report of Mohammed[11] that women were not major players in agricultural production in Nigeria. This could also be because gender plays a very important role in fish farming and agriculture, in terms of property acquisition, for example, fixed assets like land and machines.

Age is an important socioeconomic characteristic that affects productivity and output as well as the adoption of innovation. Ofuoku *et al.*[12] corroborated the result obtained in this study. They also noted that respondents within these age groups are more innovated and better adapted to deal with the stress of fish farming. Hence, there exists a greater potential for increasing fish output in the area. The high level of literacy among cage fish producers in the area was similar to the observation of Adewuyi *et al.*[10] and Omeje *et al.*[13] as they reported high literacy levels among fish farmers in Oyo and Ogun States, Nigeria. This means that cage fish farming at Oyan Reservoir is dominated by the educated class, who are well-armed with the technical and scientific knowledge required for a successful cage fish farming business.

The cost of fish cages is high either for the imported model or the local model, therefore cage culture operators have to make economic decisions on the model of the fish cage to be used. This study revealed that 66.7% of respondents are using the imported model of the fish cage which is made of High-density polyethylene (HDPE). A similar observation has been reported in cage farming of Asian seabass in the coastal waters of Kerala[14]. The HDPE is also used in the production of plastic bottles because of its corrosion resistance and high strength-to-density ratio. Although expensive compared to the local model has a far better life span. Only 33.3% make use of a local model of fish cage which has a limited life span.

The cost and returns analysis revealed that variable costs in investments A, B and C accounted for a total cost of production at 68.38, 69.84 and 59.45%, respectively. It was observed that the percentage cost of the imported fish cage model was by far the highest of total cost in investment 2 (69.37%) and 3 (58.3%), while in investment A, (25.55%) with the local model of the fish cage was relatively inexpensive. The imported model of the fish cage which is made of High-density polyethylene (HDPE) is more expensive than the local model which consists of nettings made using multifilament fibers such as polyester. In support of this view, Orinda *et al.*[15] reiterate that Galvanized iron (GI) cages are more cost-effective than High-Density Polyethylene (HDPE) cages and thus expand the lucrativeness of the trade. Consequently, the idea of developing a low-cost cage for the business will go a long way to minimize the cost of production and raise profitability. The pay-back period of 4 years in local model cages from investment A is encouraging and shows that tilapia cage aquaculture can provide a significant return on investment. These results corroborate the findings of Lan *et al.*[16], who report a pay-back period of 3.55 years for 24-unit large submersible cage aquaculture in Taiwan.

However, the characteristics of each of these netting materials dictate their life span, which will determine how often they are replaced. It could be observed that investments, currently recorded negative NPV values (-₦6,400,132.727, -₦213,540,807.3 and -₦51,004,361.5, respectively) which shows that the investments are still very much at the initial stages. Also, the rate of returns for investments A, B and C were 22.2, 6.09 and 8.59%, while the profitability index was 0.79, 0.85 and 0.63, respectively, showing that these investments are not yet profitable at these current stages. As a rule of thumb, any business with a benefit-cost ratio greater than one, equal to one, or less than one indicates profit, break-even, or loss, respectively[17]. These results however differ from the findings of Otubusin and Olaitan[18], who report 34.10 and 53.34% RRI in small-scale tilapia farming in floating net cages from Lake Kainji, Nigeria. Also, Lan *et al.*[16] found a higher profit index of 2.15 for Snubnose Pompano (*Trachinotus anak*) and Cobia (*Rachycentron canadum*) in large submersible cage cultures in Taiwan.

The study has provided crucial information on the economic viability of cage culture technology in the Oyan Reservoir. It has also revealed that cage fish farming is highly capital-intensive and the returns on investments come after several years. However, there is a high prospect for this eco-friendly technology once it passes the pilot stage and achieves wide adoption. The limitation in this study is essentially the shortage of funds to broaden the study to cover more operation areas like Lagos State to reflect different results. Thus, studies on the comparative economic performance of cage culture from different parts of the country are necessary.

CONCLUSION

Unlike other systems, the fish cage culture system is still at its trial stage in Nigeria at sites such as the Oyan Reservoir. Findings from this study revealed that cage fish culture at Oyan Reservoir is predominantly for *Oreochromis niloticus* production, with an annual average output ranging between 50,000-150,000 kg among the three investments. Years of cage culture experience (0.792), as well as fish cage area (0.304), had the highest impact on fish output. The economic analysis of investments revealed that cage fish farming is highly capital-intensive and the returns on investments in this study may occur after several years.

SIGNIFICANCE STATEMENT

The study provides crucial information on the economic viability of cage aquaculture in Oyan Reservoir, Nigeria where the pilot project is taking off. The project revealed that cage fish farming is highly capital-intensive and the returns on investments in this study may occur after several years. More so, the study will assist the potential investors of cage aquaculture systems with the needed data, skills and resources for profitable investment.

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