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*Research Article*

# Profitability Analysis of Small-Scale Cage Aquaculture Farms in the Volta Lake of Ghana

**Emmanuel Kaboja Magna**,[1] **Emmanuel Tetteh-Doku Mensah**,[2] **Franklin Nantui Mabe**,[3] **Mercy Johnson-Ashun**,[1] **Lilly Osei Konadu**,[1] **and Ebenezer Koranteng Appiah**[1]

[1]*CSIR-Water Research Institute (ARDEC), Akosombo, Ghana*
[2]*CSIR-Water Research Institute, Tamale, Ghana*
[3]*Centre for Agricultural Productivity and Policy Studies (CAPPS), UDS, Tamale, Ghana*

Correspondence should be addressed to Emmanuel Kaboja Magna; egmagna@yahoo.co.uk

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In Ghana, aquaculture offers acceptable opportunities for generating income. Cage aquaculture has a lot of potential for growth in Lake Volta. In this region, cage aquaculture farmers perform aquaculture in a variety of ways that fall into three major groups: commercial, medium scale, and small scale. In this study, the profitability and production economics of small-scale aquaculture operations in Lake Volta were examined. The average total revenue accrued and the average total costs of production were GhȻ395231.25 and GhȻ267970.15, respectively. The overall gross margin and net return for all the farms were GhȻ130294.02 and GhȻ127,261.10 per cycle, respectively. The overall assessment of the profitability performance indicators such as the benefit-cost ratio (BCR), the return on investment (ROI), the net present value (NPV), the operating expense ratio (OE), the operating profit margin (OPM), and the gross margin ratio (GMR) were 1.47, 47.49%, GhȻ407625.47, 0.77%, 32.20%, and 33.00%, respectively. These indicators showed that small-scale cage fish farming in the study area is profitable. The sensitivity analysis further demonstrated that small-scale cage fish production was robustly profitable. In light of this, the study suggests that stakeholders educate small-scale cage aquaculture farmers on the profitability of the business and make a concerted effort to teach and equip farmers with best management practises (BMPs), water quality management, feeds, and feeding management.

## 1. Introduction

In Ghana, fish is the most popular animal protein, with a per capita consumption of about 26 kilogrammes per annum, which significantly exceeds the global and African sub-regional averages of 20 kg and 10 kg, respectively [1]. The fishing sector is critical to Ghana's economic development and livelihood opportunities. Local consumption provides about 60% of total protein consumption and accounts for about 80% of total domestic fish production [2]. The relevance of fisheries to household food security increased from 2.2 to nearly 2.4 million people between 2011 and 2015 [3]. The domestic fish production industry, including aquaculture, earns about US$1 billion annually [4]. Profits in the fishing industry increased from $165.7 million in 2010 to $309.7 million in 2015, representing a 9.3% increase in gross fish output by proportion [2]. With a 5% GDP growth rate, Ghana's fisheries stock contributes 4.5% of GDP annually [5]. Overall annual fish demand is predicted to be 1 million tonnes, whereas national fish production is 420 000 tonnes on average, meaning a shortfall of 580,000 tonnes, covered by fish imports [6]. Ghana, therefore, spends at least US$200 million per year on fish imports to supplement the indigenous supply [7]. Overfishing of inland fish stocks, decreases in marine fisheries stocks, and a rapid population growth rate of 2.13% [8], with accompanying increased demand for fish, have prompted Ghanaians to consider aquaculture as a viable option.

In Ghana, different cultural systems are employed in the culture of fish. These include earthen ponds, cages, and concrete tanks. Cage production systems account for the vast majority (90%) of cultured fish, with the remaining 10% being other holding systems [9]. The mainstay of cage farming is Lake Volta, and it witnessed a growth rate of about 73% per year between 2010 and 2016, making it the leading aquaculture business industry. The cage type of aquaculture represents about 2% of farms in terms of the total number; however, production is substantially greater [9]. The Nile tilapia (*Oreochromis niloticus*) is the most popular fish species, producing over 52,000 metric tonnes per year and accounting for more than 80% of the farmed fish harvest [10]. In 2018, the sector obtained 76,600 metric tonnes of farmed fish, mainly tilapia, valued at US$200 million [11]. Ghana has been the second largest tilapia producer in sub-Saharan Africa (SSA) since 2018, after Egypt. According to [11], Ghana's aquaculture surged at the quickest pace among African countries, at 28% per year from 2006 to 2019. This is due to cage aquaculture farming along Lake Volta, well-established breeding procedures, the existence of suitable sites, and significant research and development programmes [12, 13]. Unfortunately, in late 2018, the infectious spleen and kidney necrosis virus (ISKNV) emerged across tilapia farms in Lake Volta, resulting in substantial fish mortality in cage systems [14] and hence a decline from 76,000 to 52,000MT in 2018 and 2019, respectively [15]. In furtherance, the COVID-19 pandemic and its accompanying restrictions and security measures started to disrupt the cage aquaculture supply chain when the industry was beginning to recover.

Commercial floating feeds, which are used on cage farms, account for about 70% of the total cost of aquaculture production [10]. In respect of this development, the majority of feed sold by vendors is substandard [16]. Commercial tilapia feeds typically include 28–45% crude protein; however, due to the high cost of fish meal and other ingredients, fish farmers commonly employ feeds with lower protein levels to maximise profit [17].

Aquaculture production's capacity to earn a profit will determine its continued expansion and development. As a result, potential entrepreneurs and prospective financiers place a high value on assessing historical, current, and future profitability and its associated risks. In improving food security, growth, and poverty alleviation for present and future generations of Ghanaians, it is vital to examine the profitability of aquaculture and identify possible areas for development. However, due to several persistent risks, Ghana's aquaculture is burdened with inadequate financial investment [18]. Climate change [19], floods, droughts, and the prevalence of parasitic, viral, fungal, and bacterial infections are notable risks [20]. Because of these dangers, fish producers are more likely to go bankrupt. Fisheries are Ghana's primary source of animal protein and account for 4.5% of the country's GDP [21]. However, aquaculture contributes a minimal proportion to Ghana's GDP, which is blamed on the industry's exposure to the aforementioned residual risks and unfavourable climate variations. Gustin [22] estimated that 20–40% of fish production may be lost to climate change despite a number of successful interventions. Therefore, it is not unexpected that the availability of agricultural credit, which includes fish farmers, has grown problematic in Ghana [18]. Lack of adequate protection against aquaculture risk, which recurs in Ghana, has also resulted in monetary losses for aquaculturists, lowering profitability and the rate of growth in the economy. Consequently, farmers are not motivated to consider taking on an additional financial risk by making investments in their farms. Nunoo et al. [7] focused on the economics of the pond and pen culture systems, while other researchers, such as [9, 23, 24], have reported the levels of pesticides and heavy metals and the impact of cage culture activities on the lake's water quality, respectively. Findings from these previous studies have implications for the profitability of the cage industry. Inadequate information, however, exists on the profitability of the cage culture industry on Lake Volta. Therefore, the current study aimed at assessing the profitability of the small-scale cage aquaculture farms on Lake Volta to ensure growth and the sustainability of the industry.

## 2. Materials and Methods

*2.1. Description of Study Area.* Volta Lake is located at longitude 0°7′ and latitude 6°58′. The majority of the nation's rivers flow via the 8,480 km$^2$ Lake Volta, which is part of the Volta River basin. Of Ghana's overall inland fishery productivity, Lake Volta fishing accounts for about 90%. Lake Volta, which originated about forty years ago, is the second-biggest artificial lake in the world and the largest in Africa. It is estimated that a total of 300,000 people rely on the lake for their livelihood, of which 80,000 are fishers and 20,000 are fish processors and traders [25]. The fishery is entirely artisanal, with about 17,500 canoes actively fishing in the lake, operating out of about 2,000 fishing villages. The emergence of the lake provided a tremendous opportunity for fishing, and a large number of fishermen from different parts of Ghana migrated into the lake's geographical region.

About 90% of the farmed fish in Ghana are produced in cage culture systems, while only 10% are from ponds and other holding systems [9]. The Nile tilapia (*Oreochromis niloticus*) is the main fish species cultured in the cages. The documents reveal that Ghana's first cage fish farm opened its doors in 2001 on Volta Lake [10]. The cage aquaculture system is divided into small-scale, medium-scale, and large-scale commercial farms, characterised by their size of cages, stocking density, and produce. The Water Research Institute, Aquaculture Research and Development Centre at Akosombo (WRI-ARDEC), and other suppliers, such as large-scale cage farmers, are typically where small-scale and medium-scale cage farmers purchase fingerlings [10].

*2.2. Data Collection.* Since some farmers do not register with the fishery commission (FC) and some of those who did have abandoned their operations due to the emergence of the infectious spleen and kidney necrosis virus (ISKNV) and other operational issues, it is unknown how many small-scale cage aquaculture farms are present throughout the lake. In accordance with [26], farmers were chosen at random from a list that had been produced. From the compiled list of

256 caged tilapia farms, 80 farmers volunteered to participate in the investigation. These farmers were selected using continuous randomised numbers produced in Excel. Farm visits and studies were conducted between June 2022 and August 2022. Small-scale cage fish farms selected for this study were farms that have 1–10 cages each of dimensions $5\,\text{m} \times 5\,\text{m} \times 5\,\text{m}$, production below two tonnes per year, a minimal income level, and relatively little or no public data on the economics of fish farming. Additionally, the ideal stocking density for cage culture of monosex tilapia practised by the cage farmers is 50 fish/m$^3$.

Primary data from the small-scale cage aquaculture farms were collected using structured questionnaires and interview schedules. While the questionnaire solicited answers to questions about problems that had been documented in literature on the economics of aquaculture, the interview schedules attempted to learn about the primary obstacles facing farmers while allowing them the chance to comment on their own methods of operations. The questionnaire was developed to gather data on household demographics and the economic status of the farms. The survey also gathered information on the farms' revenue, variable costs, and fixed costs. The variable cost (VC) included the cost of labour, fingerlings, the manager's salary, the cost of preparing cages, and the cost of transportation. The fixed cost (FC) included the cost of equipment, the cost of boats and canoes, the cost of land use, and the cost of repairs. To confirm the appropriateness and applicability of the questions and anticipated replies from the respondents, a pilot test was conducted prior to the data collection. Following the completion of the pilot questionnaires, the questionnaire was revised in light of the mistakes uncovered.

*2.3. Returns and Profitability Ratios.* A well-executed profitability analysis offers incredibly helpful information about a company's earning potential and managerial efficiency. The estimated profitability was determined using a straightforward economic analysis that includes costs and returns. The following information is needed in order to determine profitability: total revenue; fixed costs, which are unaffected by output; and variable costs, which are actual expenses that change with the volume of fish produced. The profitability analysis was conducted using project appraisal indicators such as net revenue (NR), gross margin (GM), benefit-cost ratio (BCR), return on investment (ROI), net present value (NPV), and other ratios.

*2.3.1. Net Revenue and Gross Margin (GM).* Net revenue (NR) is defined as total revenue less total cost. The sum of all fixed and variable costs was regarded as the total cost of cage aquaculture. The quantity of fish produced and the unit price were multiplied to obtain the total revenue. Based on the analysis, the profitability of aquaculture in terms of NR was determined by deducting the total cost from the total revenue. The estimation was done using the following formulas:

$$\begin{aligned} \text{TC} &= \text{TFC} + \text{TVC}, \\ \text{TR} &= Q \times P, \\ \text{NR} &= \text{TR} - \text{TC}, \end{aligned} \tag{1}$$

where TC is the total cost (Gh¢); TFC is the total fixed cost (Gh¢); TVC is the total variable cost (Gh¢); TR is the total revenue (Gh¢); $Q$ is the quantity of fish (kg); $P$ is the unit price of fish (Gh¢); and NR is the net revenue (Gh¢). The total variable cost of aquaculture production was calculated by adding the costs of labour and all other inputs, such as fingerlings, feed, and transportation costs. The amount of labour was calculated based on the number of days a person works, the typical number of hours they work each day, and the daily wage they receive.

The straight-line approach was used to determine the depreciation value for all depreciable assets since it is a popular and simple method and estimates the same yearly depreciation for each full year of an item's lifespan.

$$\text{Depreciation} = \frac{\text{cos t of asset} - \text{salvage value}}{\text{useful life}}. \tag{2}$$

The fixed costs were calculated using the amount of depreciation rather than the asset cost since the asset cost probably overestimated the current cost for any given year because the asset has a longer useful life.

Similarly, gross margin (GM) is a financial indicator used to assess how effectively and efficiently a farm manages its operations. The sales revenue that a cage farm keeps after paying the direct expenses related to growing the fish it sells and the services it offers constitutes its gross margin. It is estimated as follows:

$$\text{Gross margin (GM)} = \text{TR} - \text{TVC}. \tag{3}$$

*2.3.2. Benefit-Cost Ratio.* An investment's benefit-cost ratio (BCR) can be used to determine its profitability. BCR is a measurement tool or indicator that depicts the relationship between a project's or intervention's relative benefits and costs. It is the proportion of project benefits to costs. BCR is a suitable indicator to be utilised to determine the profitability of small-scale cage aquaculture since fish production involves cost and benefit over a specific period of time. The production dynamics were examined using the following equations:

$$\text{BCR} = \frac{\text{TR}}{\text{TC}}. \tag{4}$$

If $\text{BCR} > 1$, then the benefits exceed the costs implying that cage aquaculture is profitable and viable for small-scale farmers.

If $\text{BCR} = 1$, costs equal the benefits implying that small-scale cage aquaculture production has broken even value or normal profit.

If $\text{BCR} < 1$, then the costs exceed the benefits, and therefore, small-scale cage aquaculture production is not profitable for aquaculturists.

*2.3.3. Return on Investment (ROI) and Ratios.* The return on investment (ROI) is an investment performance indicator as it can give an investor an indication of whether it is worth spending money on a particular investment project [27]. In this study, it is the percentage of net revenue to the total cost.

$$\mathrm{ROI} = \frac{\mathrm{TR} - \mathrm{TC}}{\mathrm{TC}} \times 100. \tag{5}$$

Other ratios such as the operating expense (OE), operating profit margin (OPM), and the gross margin ratios (GMR) were calculated as shown in equations (6)–(8), respectively.

$$\text{Operating expense (OE) ratio} = \frac{\mathrm{TFC}}{\mathrm{TR}}, \tag{6}$$

$$\text{Operating profit margin (OPM) ratio} = \frac{\mathrm{TR} - \mathrm{TC}}{\mathrm{TR}} \times 100, \tag{7}$$

$$\text{Gross margin ratio (GMR)} = \frac{\mathrm{TR} - \mathrm{TVC}}{\mathrm{TR}} \times 100. \tag{8}$$

These were conducted in order to cover a broad range of economic assessment and financial performance [28].

*2.3.4. Net Present Value.* Another important indicator for profitability analysis is net present value (NPV). To account for the time value of money and extrapolate the long-term profitability of cage aquaculture, this study used NPV. With NPV, we were able to consider the distribution of costs and benefits over time, which is important in determining the sustainability of cage aquaculture agribusiness. The NPV was estimated by deducting the sum of the present value of cash outflows from the present value of cash inflows for a period of $t$ years. The present value of the cash inflows is the sum of discounted benefits, while the present value of the cash outflows is the sum of discounted costs. NPV is given as follows:

$$\begin{aligned} \mathrm{NPV} &= \sum_{t=0}^{t=n} \text{PV Cash Inflows} - \sum_{t=0}^{t=n} \text{PV Cash Outflows}, \\ \mathrm{NPV} &= \frac{\sum^{B_t}}{(1+\delta)^n} - \frac{\sum^{C_t}}{(1+\delta)^n}, \end{aligned} \tag{9}$$

where $t$ is the lifespan of the project in years, beginning from $t = 0$ to $t = n$. $B_t$ = the benefit (Gh¢) obtained from cage aquaculture produced in year $t$, where $t = 0$ to $n$ years. $C_t$ = the cost (Gh¢) incurred on cage aquaculture production in year $t$, where $t = 0$ to $n$ years. $n$ = the total number of years that the floating cage can last/life span. $\delta$ = the discount rate (29%) which is taken as the cost of capital recorded by the Bank of Ghana in 2022.

The lifespan of the cage was a major fixed input; thus, the cage was used $t$. Farmers were asked to state the lifespan of the cage.

*2.4. Statistical Analysis.* All the data gathered were entered and analysed in a statistical package for social sciences (SPSS) version 21. Descriptive statistics such as the mean and standard deviation (SD) were estimated. All data and estimations were based on a single production cycle, which is mostly seven to eight months.

## 3. Results and Discussion

*3.1. Demographic Characteristics of Fish Farmers.* The results presented in Table 1 show the socioeconomic characteristics of the fish farmers. The farmers' average age was 37 years, with the majority being between the ages of 30 and 39. Small-scale cage aquaculture farming was dominated by men, with approximately 95% male representation and only 5% female representation. This finding is similar to that of [29], who discovered that the majority of farmers were men between the ages of 35 and 40 in their study. This is most likely because fish farming requires a lot of capital and is fraught with risk and uncertainty, and women are generally regarded as being risk-averse.

Twelve percent of small-scale farm operators had more than a decade of experience raising cage-grown tilapia, compared to the majority (84%) of small-scale farmers, of whom 42% had fewer than five years. Experienced farmers have better farming techniques and are better able to comprehend the market, which allows them to get higher rates for their produce. Small-scale farming is characterised by a number of newcomers, some of whom may lack substantial aquacultural expertise. As a result, they are exposed to several dangers that they may not be capable of handling in their initial periods. Many of the fish farmers were married (65%) and 20% of them were single.

The level of education among fish farmers was remarkable: 20% had completed junior high school, 45% had completed senior secondary school, and 10% had completed a bachelor's degree programme at a university. This finding contrasted with that of [30], who revealed that only 1.5% of participants had attended university and that 56.1% of respondents were in primary school. This proves that Ghana intermediate schools' leavers rely on income from the fish farming industry.

Apart from the price of feed, all the farmers surveyed during the research period lamented the lack of access to loans and the high interest rates charged by the banks. This makes it more difficult for smallholder fish farmers to cover their production costs, compelling them to use their own savings as seed money. Again, interviewees noted difficulties with the marketing of fish.

The distance between farm locations and the local market, the high costs associated with "middlemen," and a dearth of suitable transportation options for getting products to customers all potentially contribute to marketing difficulties. The orderly and quick development of the aquaculture venture had been hampered, according to [31], due to insufficient government assistance rates charged by the banks. This makes it more difficult for smallholder fish farmers to cover their production costs, compelling them to use their own savings as seed money. Again, interviewees noted difficulties with the marketing of fish. The distance between farm locations and the local market, the high costs associated with "middlemen," and a dearth of suitable transportation options for getting products to customers all potentially contribute to marketing difficulties. The orderly and quick development of the aquaculture venture had been hampered, according to [31], due to insufficient government

Table 1: Demographic characteristics of respondents ($N = 80$).

| Category | Frequency (%) |
|---|---|
| Age group (years) | |
| 20–29 | 12 (15) |
| 30–39 | 28 (35) |
| 40–49 | 8 (10) |
| 50–59 | 8 (10) |
| 60–69 | 24 (30) |
| Gender | |
| Male | 76 (95) |
| Female | 4 (5) |
| Marital status | |
| Single | 20 (25) |
| Married | 52 (65) |
| Widow/widower | 4 (5) |
| Divorced | 4 (5) |
| Education | |
| JHS | 16 (20) |
| SHS | 52 (65) |
| Diploma | 4 (5) |
| Bachelor degree | 8 (10) |
| Main occupation | |
| Fish farmer | 64 (80) |
| Trader | 4 (5) |
| Retired | 12 (15) |

assistance. The farmers acknowledged that Ghana's small-scale cage aquaculture production was hindered by the government's insufficient support (financially, in terms of training and equipment provision).

*3.2. Costs and Returns Analysis.* The inputs and outputs, along with incomes and expenditures, were collected from each respondent in a production cycle and used to determine the costs and benefits of the fish farming operation. Table 2 shows the analysis of the costs and revenues of cage aquaculture in Volta Lake of Ghana. The cost estimations were given in Ghanaian Cedis (1 US dollar = GhȻ15.00; average exchange rate used over the research period) [32]. All of the farms' combined average costs amounted to GhȻ267970.15.

The farms' variable costs constituted 98.86% of the overall cost of production. Others have similarly shown high variable costs, ranging from 88% to 94% [28, 33, 34]. For small-scale farms, feed costs constituted 76.84% of total costs. The cost of cage preparation came in second with about 9.70% of the total cost. The choice of fish farming feed could have a significant impact on overall productivity. While some farmers choose to supplement with agro-based materials like groundnut and maize husk, most farmers prefer using commercial feed because it is more palatable, has a higher nutritional value, and can float. However, commercial feed is also comparatively expensive. Due to a high reliance on foreign manufacturers and the consequent rise in the cost of aquaculture, investors, governmental organisations, and researchers have not given local feed production the attention it needs to become competitive with that produced abroad. According to reports, the cost of feed makes up the largest amount of the production cost in Nigeria; in Oyo State, [35] estimated that feed contributed 75% of the overall production cost, and in Borno State, [28] estimated that feed contributed 66%. An investigation of the pangasius catfish industry in India revealed that small-scale farms' feed expenses accounted for a significant amount of their overall costs—roughly 76% [36]. Few other studies [10, 11, 37] reported that in Ghana, the cost of fish feed accounts for almost 70% of the entire cost of fish production. The fisheries commission (FC) in Ghana has therefore trained farmers on how to manufacture local feed to overcome this galloping cost, but because there is no set protocol, farmers have to experiment with different components, which leads to bad performance of the feed and the fish they culture.

A few small-scale farms spent more than GhȻ110000 on fingerlings, with the average cost of a fingerling being GhȻ17752.27 representing about 6.62% of the total cost. It was observed in the field that the fish farmers frequently overstock their cages because they act on the recommendations of the fingerling producers, which elevates the cost per unit output.

The findings indicate that the assets' costs for equipment and boats were GhȻ1361.67 and GhȻ139.58, respectively, (See Table A1 of the supplementary file attached). None of the assets have salvage value, and their useable lives were about ten years. About 1.13% of the entire cost of production was made up of overall fixed costs. The depreciated cost of equipment for the farms was greater than any other variable contributing to fixed assets. In terms of percentage of total production costs, equipment costs were on average GhȻ1361.67, about 0.51%.

The majority of farmers in the area (80%) undertake cage aquaculture, with only a small number engaging in other enterprises. It was shown that the size of the cage affected the stocking density and fish productivity. Fish production ranges from 5,600 to about 41,500 kg, with an average production of 18608.33 ± 10119.46 kg per cage. The study's findings show that the average total revenue was GhȻ 395,231.25 ± 217,580.59. Total revenue was computed by multiplying fish farm output by the real price farmers were paid. The total revenue varied from 123200 to GhȻ 910000 from the study.

Overall GM and NR for all farms were GhȻ 130294.02 and GhȻ127261.10, respectively. The GM represents the farm's profit before deducting all fixed costs, whereas the NR represents the farm's profit after deducting all fixed costs. The initiative is profitable based on the average of the profit indices for all farms, and this appears to be consistent with other observations made in Nigeria [35, 38–40]. According to [21], the profitability of Ghana's aquaculture is mostly hampered by restrictions such as exorbitant feed prices, low output levels, and low fish pricing, which might be improved through better farming practises. Growing profitability indicates that fish farms should run well and deliver high-quality catch at competitive prices.

### *3.3. Profitability Indicators and Ratios*

*3.3.1. BCR, ROI, and Ratios.* The profitability of fish culture farms was assessed using the benefit-cost ratio (BCR). However, it serves as a metric for initiatives to be evaluated

Table 2: Return (GhȻ) and economic indicators of small-scale cage fish farms.

| | Average | SD | Max | Min | % of TC |
|---|---|---|---|---|---|
| Total revenue (TR) | 395231.25 | 217580.59 | 910000 | 123200 | |
| *Fixed cost (FC)* | | | | | |
| Cost of equipment | 1361.67 | 829.19 | 3000 | 170 | 0.51 |
| Cost of boat/canoe | 139.58 | 84.52 | 400 | 50 | 0.05 |
| Cost of land use | 1091.67 | 613.55 | 2000 | 200 | 0.41 |
| Cost of repairs | 440.00 | 192.72 | 700 | 100 | 0.16 |
| Total fixed cost (TFC) | 3032.92 | 1719.98 | 6100 | 520 | 1.13 |
| *Variable cost (VC)* | | | | | |
| Cost of labour | 6491.07 | 2399.53 | 11220 | 3720 | 2.42 |
| Cost of feed | 205917.81 | 117298.62 | 513562.50 | 57540 | 76.84 |
| Cost of fingerlings | 17752.27 | 26854.72 | 120000 | 2700 | 6.62 |
| Manager's s salary | 7250 | 3608.32 | 15000 | 3600 | 2.71 |
| Cost of preparation of cages | 26000 | 13934.91 | 65000 | 6000 | 9.70 |
| Cost of transportation | 1526.08 | 1132.56 | 6000 | 250 | 0.57 |
| Total variable cost (TVC) | 264937.23 | 165228.66 | 730782.5 | 73810 | 98.86 |
| Total cost (TC) = TFC + TV | 267970.15 | 166948.64 | 736882.5 | 74330 | 100 |
| Net revenue (NR) = TR–TC | 127261.10 | 50631.95 | 173117.5 | 48870 | |
| Gross margin (GM) = TR–TVC | 130294.02 | 64521.12 | | | |
| ROI = (NR/TC) ∗ 100 | 47.49% | | | | |
| GMR = [(TR − TVC)/TR ∗ 100 | 33.00% | | | | |
| OE = (TFC/TR) ∗ 100 | 0.77% | | | | |
| OPM = [(TR − TC/TR)] ∗ 100 | 32.20% | | | | |
| BCR = TR/TC | 1.47 | | | | |

SD, standard deviation; BCR, benefit-cost ratio; OE, operating expense; OPM, operating profit margin.

[41]. According to the profitability analysis, small-scale cage aquaculture had a BCR of 1.47, which is greater than one. The findings show that this kind of aquaculture in the study area is both viable and profitable. Internationally, [42] estimated a BCR of 1.05 in carp polyculture; a BCR of 2.73 was reported by [43] in a pond used for carp production in the Rajshahi district; and [41] in a study in Egypt revealed a BCR value of 1.82. Their findings are consistent with the current study.

As a whole, the BCR was greater than 1, indicating a profit, and the rate of return on investment (ROI) was positive but low (47.49%), suggesting that only Gh¢47.49 will be made for every Gh¢100 of invested capital. The positive ROI value means that the returns or profits of the small-scale cage project exceed the total costs. The farmers can therefore accept and/or continue with the small-scale cage aquaculture project. The cage farm average expenditure (OE) ratio was 0.0077, which meant that 0.77% of the total production cost was made up of fixed expenses. However, given that variable costs increase total revenue at faster rates when total fixed costs are smaller, this low value is actually beneficial for cage farm operations.

The operational profit margin (OPM) data similarly revealed that small-scale farmers had an average OPM of 32.20%, suggesting that the income realised can cover the operating costs. An excellent OPM often ranges from 10 to 12 percent and the higher the percentage, the more financially viable the investment [44]. According to OPM's findings for this study, small-scale cage aquaculture investment is viable, but not as viable as that of [44], who reported it to be 57% in the northern region of Nigeria.

Similar to the OPM, the GMR showed a positive 33% result for small-scale cage farms. Accordingly, out of every Gh¢100.00 in sales, Gh¢33.00 is returned, while 67% is used to cover the cost of producing that product. A higher GMR shows that the farm is selling the product at a higher profit margin, which is often attained by raising the sales price or lowering the cost of production [45].

*3.3.2. Net Present Value (NPV).* The discounting rate used in this study is 29%. The lifespan of the cages, according to the surveyed farmers, is five years. Therefore, 5 years was used as the time length for the NPV analysis. Depreciation of both variable and fixed costs is one of the cost factors taken into account in this study. Only the revenue made from selling the fish that was captured was taken into account when calculating the benefits. The NPV of the small-scale cage aquaculture business operation is shown in Table 3.

The NPV was positive (Gh¢407625.47) despite the five-year investment period. This demonstrates that small-scale cage aquaculture production investment is feasible and profitable because the amount invested is less than the net cash flow's present value. Therefore, the investment is approved because it generates a profit greater than its opportunity cost [46].

*3.3.3. Sensitivity Analysis of Profitability of Small-Scale Cage Aquaculture Production.* Every project may have various uncertainties that may have an impact on the project's profit margin. The sustainability of aquaculture operations may also be influenced by these uncertainties. A sensitivity analysis was carried out in this study, taking the facts into

Table 3: Net present value (NPV) for small-scale cage aquaculture investment.

| Year | Cash inflow (Gh¢) | Cash outflow (Gh¢) |
|---|---|---|
| 0 | 395231.25 | 267970.15 |
| 1 | 306380.81 | 207728.80 |
| 2 | 237504.51 | 161030.08 |
| 3 | 184112.02 | 124829.52 |
| 4 | 142722.50 | 96767.07 |
| NPV = 407625.47 | ∑ cash inflow = 1265951.09 | ∑ cash outflow = 858325.62 |

Table 4: Sensitivity analysis of the profitability of small-scale cage fish production.

| Scenarios | Cost and revenue lines | Total values |
|---|---|---|
| 10% decrease in output price | Present value of cash inflow (Gh¢) | 355708.13 |
| | Present value of cash outflow (Gh¢) | 267970.15 |
| | Net present value (Gh¢) | 87737.98 |
| | Benefit-cost ratio | 1.33 |
| | Return on investment | 32.74 |
| 10% increase in the cost of production | Present value of cash inflow (Gh¢) | 395231.25 |
| | Present value of cash outflow (Gh¢) | 294767.17 |
| | Net present value (Gh¢) | 100464.08 |
| | Benefit-cost ratio | 1.34 |
| | Return on investment | 34.08 |
| 10% increase in the discount rate | Present value of cash inflow (Gh¢) | 1392546.20 |
| | Present value of cash outflow (Gh¢) | 944158.18 |
| | Net present value (Gh¢) | 448388.02 |
| | Benefit-cost ratio | 1.47 |
| | Return on investment | 47.49 |
| 10% decrease in fish produced due to disease and environmental variables | Present value of cash inflow (Gh¢) | 355708.13 |
| | Present value of cash outflow (Gh¢) | 267970.15 |
| | Net present value (Gh¢) | 87737.98 |
| | Benefit-cost ratio | 1.33 |
| | Return on investment | 32.74 |
| 10% decrease in output price, 10% increase in production cost, and 10% increase in the discount rate | Present value of cash inflow (Gh¢) | 2143485.58 |
| | Present value of cash outflow (Gh¢) | 1506895.50 |
| | Net present value (Gh¢) | 636590.08 |
| | Benefit-cost ratio | 1.42 |
| | Return on investment | 42.25 |

account, to establish the viability of fish cage farming. The low market pricing and high production expenses of fish cause farmers to be very demoralised about growing it [47]. As a result, the sensitivity analysis was carried out to show how the farmer's financial reward varied with the adjustment of present value of cash inflow, present value of cash outflow, NPV, ROI, and BCR in order to make fish farming sustainable and profitable. Five alternative scenarios relating to normal business operations were used in the assessment (Table 4).

*(1) Scenario 1: Sensitivity Analysis for a 10% Reduction in Small-Scale Cage Fish Output Price*. In this case, it was estimated that the price of caged fish was going to be 10% lower. According to the results presented in Table 4, a BCR value of 1.33 and a net present value per cage of Gh¢ 87737.98 are, respectively, more than 1 and Gh¢0.00. Aquaculture production can still generate a return on investment per cage of 32.74%, *Ceteris paribus*, despite a 10% drop in output price. This suggests that the small-scale cage aquaculture venture remains profitable and financially feasible even if fish output prices drop by 10%.

*(2) Scenario 2: Sensitivity Analysis for a 10% Increase in the Total Cost of Production*. According to what was previously reported, the second scenario aimed to ascertain whether or not fish production would be profitable in the event of a 10% increase in overall production costs. According to Table 4, the per cage net present value of Gh¢100464.08 and BCR of 1.34 were higher than Gh¢0.00 and 1, respectively. A per cage return on investment of 34.08% was achieved in this situation. This suggests that even with a 10% rise in overall costs, fish production is still profitable.

*(3) Scenario 3: Sensitivity Analysis for a 10% Increase in the Discount Rate*. The discount rate, often known as the cost of

capital, is another aspect that affects aquaculture's financial feasibility. According to the farmers, cages last for 5 years, so discounting is necessary to determine their present worth. According to Table 4, a 10% increase in the discount rate led to a marginal rise in the net present value per cage to Gh¢ 448388.02. This scenario resulted in a BCR of 1.47 per cage while keeping all other variables constant. Additionally, a return on investment of 47.49% per cage is less than 100%. As a result, a 10% rise in the discount rate is insufficient to significantly affect the profitability or feasibility of fish production financially.

*(4) Scenario 4. Sensitivity Analysis for a 10% Decrease in Fish Produced due to Diseases and Unfavourable Environmental Variables*. Certain diseases, pathogens, and unfavourable environmental conditions may pose risk parameters that threaten the profitability of cage culture. The sensitivity analysis was performed to examine how these factors may affect cage aquaculture on Volta Lake. According to the model, the per cage net present value of Gh¢87737.98 and BCR of 1.32 were higher than Gh¢0.00 and 1, respectively. A per cage return on investment of 32,74% was achieved in this situation. This suggests that even with a 10% decrease in fish production due to fish diseases and weather conditions, fish production is still profitable.

*(5) Scenario 5. Sensitivity Analysis for a 10% Decrease in Output Price, 10% Increase in Production Cost, and 10% Increase in the Discount Rate*. The fifth scenario examined the cumulative effects of the first three scenarios on the profitability of fish production. It is possible to still generate a net present value of Gh¢636590.08 per cage, as indicated in the table, even with a 10% rise in the discount rate, total cost, and a 10% fall in the price of fish. A BCR of 1.42 and a net return rate of 42.25% per cage were also obtained. Simply put, producing fish on a small scale is highly profitable.

## 4. Conclusion

This study used profitability analysis to evaluate the economic performance of Ghana's small-scale cage aquaculture in Volta Lake. The results found from the profitability analysis in this study showed positive net revenue, ROI, NPV, and BCR. The overall assessment of the performance indicators portrayed small-scale cage fish farming to be profitable in the study area. Furthermore, the sensitivity analysis still demonstrated the robust profitability of small-scale cage fish production. The majority of small-scale farmers were facing difficult challenges exacerbated by a lack of access to loans and the high interest rates charged by the banks, difficulties with the marketing of fish, and insufficient government assistance. In light of this, the study suggests that stakeholders involved in small-scale cage aquaculture production educate farmers and fish traders about the nutritional worth of the business as well as other benefits of investing in it from a return perspective. In order to equip farmers with the business skills they need to run aquaculture operations as successful enterprises; it is also recommended that a concerted effort be made to teach and equip farmers with best management practises (BMPs), water quality management, feeds and feeding management, and business skills. The geographic coverage and sample size of the present research, which evaluates the performance of fish producers in the study area, are both constrained. To evaluate the performance of the sector and formulate recommendations with broad national implications, a more comprehensive analysis is needed.

## Data Availability

The data that support the findings of this study are available upon reasonable request to the corresponding author.

## Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

## Supplementary Materials

The straight-line approach was used to determine the depreciation value for all depreciable assets. The salvage value was zero, and the lifespan of the assets was 10 years. (*Supplementary Materials*)

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