

## Review Article

# A Mini-Review of the Economic Aspects of Fish Cage Farming In Lake Victoria

Jimmy Brian Mboya<sup>1,2\*</sup> and Kevin Okoth Ouko<sup>3</sup>

<sup>1</sup>Kenya Marine and Fisheries Research Institute (KMFRI), Sangoro Aquaculture Research Center P. O. Box 136-40111, Pap Onditi, Kenya

<sup>2</sup>Department of Animal and Fisheries Sciences, Maseno University, P.O. Box Private Bag, Maseno, Kenya

<sup>3</sup>Department of Agricultural Economics and Agribusiness Management, Jaramogi Oginga Odinga University of Science and Technology, P.O. Box 210-40601, Bondo, Kenya

### Abstract

In recent years, governments, researchers and policy makers have encouraged the use of net cages for fish production in an effort to increase aquaculture production by utilizing the enormous natural waters on the planet. As a result, fish cage farming has seen a rapid growth in different oceans, lakes, and reservoirs across the globe. The cost and availability of inputs, as well as the demand and sales value of the farmed fish, all have important roles towards the success of fish cage farming. However, there is a dearth of information on the economics of the fish cage farming industry, especially in Lake Victoria. In light of this, researchers are increasingly emphasizing more studies on the economics of fish cage farming towards improving food security and alleviating poverty in the Lake Victoria region. To ensure its success and boost investments in the sector, the fish cage farming industry should abide by economic principles. In this review, we highlight the important economic aspects including capital and operating costs, revenue, marketing, and profitability indicators that influence management choices in fish cage farming.

**Keywords:** Costs; Fish cage farming; Fish marketing; Profitability; Revenue

\*Corresponding author: Mboya JB, Kenya Marine and Fisheries Research Institute (KMFRI), Sangoro Aquaculture Research Center, Department of Animal and Fisheries Sciences, Maseno University, P.O. Box Private Bag, Maseno, Kenya, Tel: +254716785854, E-mail: jimmybrianmboya@gmail.com

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### Introduction

Production and consumption of aquatic foods has been on an upward trend in recent years, driven by the increasing global demand for food [1]. Both capture fisheries and aquaculture provide the much needed protein-rich aquatic foods, thus contributing significantly to the sustainable development goal number 2 of improving global food and nutrition security [2,3]. However, the recent decades have seen a decrease in yields from capture fisheries due to the decline in fish stocks in the natural waters, majorly caused by overfishing and deterioration of the functional integrity of the aquatic ecosystems due to climate change and environmental factors [1,4]. Aquaculture has grown as a remedy to the declining wild fish stocks to keep the supply and demand of fish and fish products at an equilibrium [5,6]. It is the fastest growing food production sector, accounting for more than 50% of the global fish production [1]. Mainstreaming aquaculture into the global food system strategies and policies has been promoted, a move aimed at making it a major “game changer” towards sustainably meeting future food demand. Developing nations are the major fish producers with more than half of the world’s aquaculture output coming from low to middle income countries [1,5,7].

The use of net cages for fish production has been promoted in the recent years to enhance aquaculture production by making use of the vast natural waters in the world [8,9]. Consequently, there has been a sporadic growth of fish cage farming in various lakes and reservoirs in many parts of the world [10]. The East African region has taken advantage of Lake Victoria, the largest freshwater lake in the world, to grow fish cage farming in the region, with Nile tilapia being the dominant species. Recent studies have demonstrated the potential of fish cage farming in Lake Victoria in improving food and nutrition security, and livelihoods in the region [11-14]. Remarkably, little is known regarding the economic aspects of fish cage farming industry, notwithstanding the fact that a business’s success is mostly dictated by economic viability [13,15]. Due to lack of economic indicators in the industry, an absence of economic knowledge on cage fish farming may deter potential investors from engaging in the cage culture business. Additionally, it might prevent financial institutions like banks and insurance companies from providing cage fish farmers with credit and insurance.

The acceptance and viability of a novel aquaculture practice or technology will largely depend on its likelihood of yielding profit. As a result, research initiatives are beginning to put more emphasis on the economics of fish cage farming [13,16-18]. Just like in any other commercial enterprise, the cage farming business should adhere to the economic principles, both at microeconomic and macroeconomic levels. The microeconomic level entails all the economic implications of production at the farm level including farm input costs and operation costs, whereas the macroeconomic level entails the economic implications beyond the control of the farmer, for instance, the domestic and international market, government regulations, variations in climatic conditions, among others [17,19]. Any variations in the external environment are just as important as the variations in the farm level environment, implying that the availability and cost of farm inputs is just as significant as the price and demand of the cage farmed fish.

The economic parameters that need to be taken into account while assessing the production from fish cage culture systems include the costs (capital costs and operating costs), gross income/revenue and profitability, variation in costs and revenue, and marketing of fish and fish products [20,21]. Management decisions pertaining to these parameters take into consideration the uncertainties involved in the input supplies and the demand for the produced fish [22]. Several econometric studies on aquaculture have been undertaken in the past, highlighting various economic parameters that are considered when evaluating the production from fish culture systems [16,23-26]. This mini-review summarizes the key economic parameters and their significance in fish cage farming within Lake Victoria.

## Key Economic Elements in Fish Cage Farming

### Costs

The primary concern of a farm manager should be cost and cost structure. This section will highlight the significance of having a basic knowledge of how costs determine profitability and will go over management tactics for increasing profitability. Aquaculture is basically a commodity business, and because of this, product diversification strategies are challenging to execute [27,28]. As a result, the majority of farmers must establish a competitive advantage through cost leadership. Because it is a commodity business, it would not be an overstatement to say that the fish farmer with low-cost production will be the most likely to survive. It is therefore essential to assess the impact of cost and cost structure on farm management strategies by doing a cost structure analysis.

### Cost structure analysis

The cost structure of a business is the measure of the weight of each form of cost on the total cost of production [29]. The term "cost structure" refers not only to the division of costs needed to produce a commodity, but also considers the financial resources used throughout the production and marketing chain [24,29]. Like several manufacturing and other businesses that do not involve farming, the cost structure in fish cage farming is marked by low fixed costs, accounting for a low percentage of total costs, and a high percentage of variable costs [18]. This makes fish cage farming a low-fixed-cost business. This cost structure significantly impacts management decisions in fish cage culture. One implication is that conventional "cost control" methods work better in low-fixed-cost businesses [16]. Strategies that by definition target variable costs have a higher likelihood of succeeding when a significant proportion of the costs are variable since variable costs make up a larger portion of the total cost. Variable costs should be the primary focus of cost control in fish cage culture since they make up a bigger fraction of the total and have a strong probability of affecting profitability [18]. Another aspect is that a business with low fixed costs is more adaptable and versatile [30]. Such a business finds it simpler to adapt to shifting economic situations, new market situations, or new technology and business concepts [13,18]. A business that has a greater ability to respond to change, adjust, and be flexible has a higher chance of surviving in the ever changing aquaculture industry.

In fish cage farming, the major components of capital costs (fixed cost) include the cost of cage construction (including labour and construction materials), harvesting nets and bird nets [18,30,31]. The variation in fixed costs among different farms in a production cycle are mainly due to the difference in cage sizes, and the number of harvesting and bird nets used. Fixed costs make up a negligible

proportion of the total cost of production. However, they cannot be ignored when a farmer is doing cost control by minimizing costs. Fixed costs can be controlled by sourcing each cost item from reliable suppliers, in terms of price, quality and logistical issues. Operating costs (variable costs) primarily consist of cost of feeds, fingerlings, labour, extension and marketing [13,18]. Cost of feeds and cost of fingerlings account for a large proportion of the total costs. Just like in various aquaculture production systems, cost of feeds alone takes up more than 50% of the total cost of production in cage fish farming. Therefore, differences in variable costs in cage fish farming are mainly due to cost of feeds and cost fingerling, costs which vary according to stocking rate, quality (in terms of crude protein content) and unit price of feeds, size and unit price of fingerlings at stocking, and the duration of a production cycle [16,32]. In order to achieve profitability in fish cage farming, these cost items should be given focus when controlling costs since they are the major component of total production costs.

### Revenue and profitability

Revenue, also known as gross income, is comprised of recurring income and/or sales earnings at the completion of a given production period [33,34]. It is computed by multiplying the product's unit price by its overall quantity (the number of units produced) [35], as illustrated in equation (1).

$$TR = P * Q \quad (1)$$

where TR is the total revenue; P is the unit price of fish and Q is the quantity of fish sold.

Profitability can be determined from gross income since it is the difference between gross income and total costs. Net farm income, gross margin analysis, and profitability ratios are frequently used methods for profitability analysis in fish farming [36-38].

### Net farm income

Profitability is assessed using both enterprise budget and income statements (also referred to as a profit and loss statement), although income statements, whose key metric is net farm income, are preferred when evaluating farm profitability or losses [18,37]. A positive net farm income indicates a profit, while a negative net farm income indicates a loss. The total cost is subtracted from the total revenue to determine net farm income [39,40], as illustrated in equation (2).

$$NFI = TR - TC \quad (2)$$

where NFI is the net farm income; TC is the total cost

### Gross margin analysis

Gross margin is a profitability metric that uses data from a single point in time to examine a business's gross profit in relation to its revenue [41-43]. Gross profit is calculated by subtracting the cost of product sold from the gross income [18,44]. Fish cage farming is a low-fixed-cost business and therefore its gross margin is calculated by subtracting the total variable cost from the gross income, and is expressed as a percentage [39,43]. The percentage is computed by dividing gross margin by revenue. The bigger the gross margin, the more capital the fish cage farming enterprise retains, as illustrated in equation (3).

$$GM = TR - TVC \tag{3}$$

where GM is the gross margin; TR is the total revenue and TVC is the total variable cost

### Profitability ratios

Profitability ratios are also used to gauge the profitability of fish cage farming. They are financial analyses that compare the cost incurred with the revenue for a given time period to determine if a business can generate a profit [16,45]. Profitability ratios offer insight into a business’s potential to produce an adequate profit and return on investment by measuring the business’s financial performance and how well it controls its resources [18,45]. Therefore, a profitability ratio is a tool for measuring whether or not a business is making enough profit. Because long-term investors care about profitability appraisal, investors are drawn to businesses with high profitability ratios [38,46]. The commonly used profitability ratios in fish farming are benefit cost ratio (BCR), return on investment (ROI), gross revenue ratio (GRR) and expense structure ratio (ESR) [21,40,47].

The expense structure ratio (ESR) analyzes the percentage of total cost that is fixed cost to calculate the profitability of an investment. It is calculated by dividing the fixed cost by the total variable cost, as illustrated in equation (4).

$$ESR = \frac{FC}{TVC} \tag{4}$$

The gross revenue ratio (GRR) is used to determine the percentage of the profits that is spent. It is calculated by dividing the total cost by the total revenue, as illustrated in equation (5).

$$GRR = \frac{TC}{TR} \tag{5}$$

The return on investment is a profitability ratio that indicates the amount earned for each unit of capital invested. It is calculated by dividing the profit by the total cost of investment, as illustrated in equation (6).

$$ROI = \frac{P}{TC} \tag{6}$$

where P is the profit, which is the difference between the total revenue and the total cost, as illustrated in equation (7).

$$P = TR - TC \tag{7}$$

### Break-even analysis

Break-even analysis, which is an important aspect of revenue and profitability analyses, uses BCR [20]. The break-even point is reached when the gross income is equivalent to the total cost of production. A business operates at a profit above the break-even point. A BCR below one indicates that the business is operating at a loss, a BCR of one indicates that the business is at the break-even point, while a BCR of more than one indicates profit [18,33]. BCR is determined by comparing the overall revenue from fish sales to the total cost of producing fish over the duration of the production cycle, as illustrated in equation (8).

$$BCR = \frac{TR}{TC} \tag{8}$$

Break-even analysis is important in fish cage farming business since it can be used in the early stages of the farming business in order to assess how accurate the initial projections were and to keep track of whether the firm is headed in the correct direction or not [13]. The efficiency and efficacy of the fish marketing techniques used by a farmer can also be evaluated using this analysis as an extra management decision support tool [20,33].

### Revenue in relation to costs

A production model that can be used to ascertain the link between income and costs is input-output analysis [48,49]. Inputs and outputs play a major role in its linkages in production systems. To evaluate how changes in other variables, which are the input variables, affect the output variables, sensitivity analysis, feasibility testing, and consistent forecasting all require input-output analysis [27,50].

Production output in fish cage farming is influenced by a variety of aspects, including general management practices and production-related costs [19,35,51]. Regression model can be applied to determine the input-output relationship in fish cage farming [18].

Given a cage fish production model with  $n$  inputs, and output  $Y_i$ , as in equation (9).

$$Y_i = \beta_0 + \beta_1 x_1 + \dots + \beta_n x_n + e_i \tag{9}$$

where  $Y_i$  is the dependent variable (revenue);  $x_1$  to  $x_n$  are the independent variables (costs);  $\beta_0$  is the intercept;  $\beta_1$  to  $\beta_n$  are the coefficients of the respective explanatory variables;  $e_i$  is the stochastic error term.

### Sensitivity analysis

According to a specific set of assumptions, sensitivity analysis evaluates how various values of an independent variable impact a specific dependent variable [13,30]. In other words, sensitivity analysis, also referred to as what-if analysis, examines how different sources of uncertainty in an economic model impact the overall uncertainty of the model, thereby raising the level of confidence in the predictions [22].

Given a cage fish production model with  $n$  inputs, and output  $Y$ , using the function  $f$ , as in equation (10).

$$Y = f(X) \tag{10}$$

$$X = (x_1, \dots, x_n)$$

A sensitivity analysis considers how variations in the output  $Y$  can be related with the variations in inputs  $X = (x_1, \dots, x_n)$ .

In fish cage farming, sensitivity analysis can be used to determine how revenue is affected based on changes in input costs [13]. It is a way to predict the outcome of farm management decisions given the costs and revenue [30]. By considering a given set of cost items, for instance, cost of feeds, cost of fingerlings or labour costs, a farmer can determine how changes in each of the cost items affect the farm’s revenue.

## Marketing

Marketing marks the culmination of the farm production process. When a farmer markets their produce, they receive a return known as revenue. Fish marketing includes all of the processes involved in moving fish or fish products from the farmer to the consumer [52,53]. It consists of a number of procedures needed to get fish or fish products from the producer to the consumer. Aquaculture marketing is frequently overlooked, and the majority of fish farmers focus more on production than on the market [54,55]. However, in the fish farming businesses, marketing is just as crucial as production, finance, cash flow, and other elements that affect profit [41]. Due to the escalating level of competition within the industry, a market-driven approach should be more crucial for aquaculture producers. In order to keep their competitiveness and profitability, fish farmers must create and retain competitive advantages over other producers.

### Marketing plan

Similar marketing plans can be used for both small-scale and large-scale fish farming [23]. A marketing plan should be devised before starting production or choosing a specific marketing option, taking into account some broad market strategies [56]. Producers who have a solid marketing plan and prioritize marketing over production will unquestionably be at a financial advantage over those who do not [23,57].

The business's collection of marketing elements and the arrangements for their application are combined in a marketing plan, which also outlines the firm's marketing objectives and describes how they will be met, ideally within a predetermined timeline [58,59]. The plan chooses the target market groups, market positioning, and allocates resources along each marketing element [60]. It works best when it is implemented as a crucial element of the entire business strategy, outlining how the business will effectively interact with clients, prospects, and competitors in the marketplace [61]. Marketing plans are created to indicate the strategic course the marketing function will follow over the given period. The plan needs specific goals that align with the overall objectives of the business [62].

### Developing a marketing plan

Development of a marketing plan involves assessing the current condition, deciding on the ultimate marketing goals, and creating a logical plan to move from the current position to the ultimate goal [23,63]. The most effort and time are frequently expended on assessing the current condition [63]. It is necessary to comprehend and evaluate a certain market, take into account the significance of supply and demand, and have up-to-date knowledge of the state of the market and its trends. Deciding on the ultimate marketing goals is done based on evaluations done when assessing the current condition [23]. If realistic marketing goals are not set, the producer could ramble through sales prospects. The farmer should link objectives to expenses incurred and establish targets that will at least cover expenditures and be aware of the costs associated with various levels of operation [23,59]. Goals and other personal and professional objectives will determine the extent to which objectives exceed operating costs. The farmer must next create a logical plan to move from the current position to the ultimate goal after taking into account all viable options [62]. Analyze each option's operating, labour and budgetary needs, as well as additional benefits and drawbacks. The decision to choose one or more marketing options should be based on the market evaluations, the magnitude of the operation, and individual financial situations [23].

## Conclusion

This paper concludes that fish cage farming business in Lake Victoria should adhere to the economic principles in order to ensure its success and improved investments in the industry towards improving food security and alleviating poverty in the region. All the key economic elements of a business including capital costs and operating costs, revenue, marketing and profitability indicators need to be taken into consideration when making management decisions in fish cage farming.

## Conflict of interest

The authors declare that there are no conflicts of interest

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