Economic analysis of fish productions that use aerators in tanks: a case study in the Center-West region of Brazil

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Rosiane Araujo Rodrigues Nass
Doctor candidate in Animal Science, Federal University of Mato Grosso do Sul
Institution: Federal University of Mato Grosso do Sul
Address: Felinto Muller, 2443, Ipiranga, Campo-Grande, Mato Grosso do Sul, Brasil.
E-mail: **rosiaraujo_19@hotmail.com**

Jayme Aparecido Povh
Professor (Ph.D. in Zootecnia, State University of Maringá)
Institution: Federal University of Mato Grosso do Sul
Address: Felinto Muller, 2443, Ipiranga, Campo-Grande, Mato Grosso do Sul, Brasil.
E-mail: **jayme.povh@ufms.br**

Darci Carlos Fornari
Ph.D. in Animal Production, Federal University of Rio Grande do Sul
Institution: Criação de Peixes Genéticos e Assessoria em Piscicultura Ltda
Address: Rod BR 163, Km 713, s / n, Primavera do Norte, Sorriso, Mato Grosso, Brasil
E-mail: **darci.peixegen@gmail.com**

Ricardo Pereira Ribeiro
Professor (Doctor in Ecology of Continental Aquatic Environments, State University of Maringá)
Institution: State University of Maringá
Address: Av. Colombo, 5790 - Zona 7, CEP 87020-900 - Maringá, PR, Brasil.
E-mail: **ricardo.peixegen@gmail.com**

Ricardo Carneiro Brumatti
Professor (Doctor in Zootecnia, University of São Paulo)
Institution: Federal University of Mato Grosso do Sul
Address: Felinto Muller, 2443, Ipiranga, Campo-Grande, Mato Grosso do Sul, Brasil.
E-mail: **rbrumatti@gmail.com**

Abstract

The objective was to evaluate the economic and financial viability of using aerators in hybrid sorubim production in two fish farms, one extensive (without equipment) and another semi-intensive (with aerators), determining the items that impact the cost of production and the effects on the sale price variation. Methodologically the research is carried out through a case study. Production data (costs, revenue and profit) were collected from January/2014 to June/2015 and organized in spreadsheets. The results were compared using the Income Statement. Through ABC analysis, the cost items were classified by their representativeness in the total cost. Subsequently, the Financial Assessment was carried out in order to determine the viability of using aerators. Results for fish farms with and without aerators were, respectively: Revenue, US$ 590,020 and US$ 297,164; Cost, US$ 381,382 and US$ 193,112;

Net profit, US$ 198,588 and US$ 102,489; and Net margin, 33.7% and 34.5%. In ABC analysis, items with higher impact on cost were feed and fingerlings (89.1% with aerators and 89.2% without aerators). Electrical energy accounted for 6.5% of cost for the fish farm with aerators, but profit was 93.8% higher. Sensitivity analysis showed that the use of aerators was profitable with any fluctuation in the selling price of fish. Financial risk indicators (with aerators) were satisfactory: IRR 78.0%, NPV US$ 292,370, and discounted payback in the second year of production. It is concluded, therefore, that the use of aerators provides better economic results and is associated with environmental sustainability, because it increases production, while using fewer natural resources.

Keywords: ABC analysis. Cost of aquaculture production. Hybrid sorubim.

1. Introduction

The increase in world demand for quality food produced in a sustainable way has been one of the biggest challenges in Brazil. In the fish sector this challenge is no different. The Food and Agriculture Organization of the United Nations (FAO) believes that Brazil should be one of the largest fish producers in the world by 2030 (FAO, 2018).

The sustainable growth of fish production has been possible due to the various technological innovations, the genetic improvement of species, innovations in management practices and diets and in the improvement of property management.

Fish farming is the sector that most represents continental aquaculture in the country, with activity of cultivation of freshwater fish, with several cultivated species, native and exotic In recent years, aquaculture fish production has been increasing, and this trend will continue because extractivism is unlikely to meet the increased demand for fish. It is known that the activity is profitable and the most diverse properties are indicated, from the extensive to the most intensive, the latter being the one that should meet the growing demand (FAO, 2016).

In 2016, 171 million tons of fish were produced, of which 80 million tons are for farmed fish (fish, shrimps, molluscs, etc.) and 91 million tons for catch. Of this total, 151 million tons were used for human consumption (FAO, 2018).

Intensive systems provide increased production with high stocking rates and use fewer natural resources and materials, making the activity profitable and attractive (SEGINER, 2009). Aquaculture systems that allow profitable production, and are linked with sustainable interactions with the ecosystem (VALENTI *et al*., 2011), form the triad of sustainability: economic, environmental, and social development (FRANKIC; HERSHNER, 2003).

With intensification of systems, the need for a higher concentration of dissolved oxygen increases. Therefore, technologies are required to maintain concentrations suitable for production (LIMA *et al*., 2016). Electric aerators exemplify a technology that enables increased production of aquatic species. Aerators are essential in semi-intensive and intensive systems, ensuring necessary conditions for production (KUMAR *et al*., 2013).

Aerators have successfully been used in the production of many species, such as *Piaractus mesopotamicus* (INOUE *et al*., 2003), *Oreochromis niloticus* (LIMA *et al*., 2016), *Epinephelus fuscoguttatus* (CHING *et al*., 2016), and *Litopenaeus vannamei* (BETT; VINATEA, 2009), demonstrating the importance aerator use presents for increased production and improved water quality. However, there are no studies evaluating the cost and economic viability the use of aerators for species of economic importance to South America, such as hybrid sorubim (cross between female *Pseudoplatystoma reticulatum* and male *Leiarius marmoratus*) (FARIA *et al*., 2011). These fish, are known for their high growth rate and good carcass yield, presenting delicate meat and absence of blemishes.

Despite the benefits of aerators for production of aquatic organisms, there is a lack of economic evaluations, and when planning a fish farm, economic aspects are fundamental because they provide investment options that consider time of return and profitability (BARROS *et al*., 2016).

Aerators generate cost (e.g. electrical energy); however, it is believed that the increase in production, and consequent increase in profitability, justifies their use. Aerator use in Brazilian fish farms has increased to guarantee rates of productivity, but it is necessary to evaluate the economic viability of this equipment to ensure a return on investment is feasible (SIPAÚBA-TAVARES *et al*., 1999).

Economic criteria are important in production planning, in the control of revenues and expenses, and in decision-making within fish farms, where costs have two main functions, being managerial and business (AYROZA *et al*., 2011).

Cost accounting has the capacity to generate useful information for the decision-making process, but not all companies use this management tool, negatively affecting the result of the property, because without the control of expenses, it is not possible to form a price. sales appropriate to its products and services or seek cost reductions by optimizing processes (ASSIS NETO, ROBLES JUNIOR, 2019).

Along with the economic factors is the adequate management of the technologies available in fish production, as these technologies make it possible to intensify production, reduce average costs and consequently increase the profitability of the property (SCORVO FILHO, 1999).

Economic data regarding fish farms are scarce and some non-existent, resulting in production planning carried out using sector information in a partial and inconsistent way (BOECHAT *et al*., 2015). In view of the above, the objective of this study was to describe the costs and economic viability of inserting the aerator use compared to the conventional system production of hybrid sorubim, and this study is justified by the relevance that the activity presents in the country, being able to subsequently carry out the recommendation of the use of aerators for producers.

2. Literature Review

2.1. Economic analysis and ABC analysis

The producers face the lack of knowledge regarding the economic viability and efficiency of productive processes within fish farms. This is due to lack of cost control resulting in unsuccessful activity (BATALHA *et al*., 2010; BOECHAT *et al*., 2015).

One of the items of the economic evaluation is the calculation of the cost of production. The cost of production is obtained through total cost and operating cost. The total cost takes into account the fixed and variable costs. In the operational cost are considered the expenses incurred by the aquaculture, together with the depreciation of durable goods that were used in the production process and the cost of family labor (MARTINS; BORBA, 2004).

Among the cost items classified as variables are the inputs (feed, fertilizer, medicine, water quality kit, fingerlings etc.), temporary labor and technical assistance. Fixed costs are composed of the linear depreciation of facilities, equipment and machines and the remuneration of capital (land, fixed capital and equipment) (ANDRADE *et al*., 2005).

After obtaining the data, the following calculations are performed Effective Operational Cost= Σ inputs; Total Operating Cost= Σ effective operating cost + depreciation; Gross Revenue= kg produced/cycle x selling price (US$/kg); Net Revenue= (gross revenue - effective operating cost); Gross Profit (gross revenue - total operating cost), according to methodology quoted by Scorvo Filho *et al*. (2004).

The economic analysis is a very important tool in assessing the feasibility of productive activities, and its use is recommended by aquaculture producers in order to contribute to the development of the activity (KODAMA *et al*., 2011).

Another tool available for surveying and classifying costs emerged to meet the need to provide service to the management of properties and organizations since the Industrial Revolution, and over the years, has been improved. This tool, known as ABC Cost Analysis, measures the participation of productive costs and its main objectives are to obtain information on the costs of the products produced and to identify the relative costs of the activities (KHOURY; ANCELEVICZ, 2000).

The ABC analysis is a method that classifies costs into three categories, A, B and C: "A" category contains the items with the highest share of production costs (70% to 80% of costs and represent 10 to 20% of items); category "C" consists of the items with the lowest cost share (10% to 15% of the costs and represent 50% of the items); while "B" consists of items ranging from "A" to "C" (15% to 25% of costs and represent 15% to 25% of items). This analysis helps the producer to focus on the items with the highest participation (A and B) when seeking to reduce production costs, rather than on minor items (category C items) (MAHAGAONKAR; KELKAR, 2017).

2.2. Cost management in fish farms

Cost management in an efficient and correct manner is a recurring need because it allows for assertive decisions to reduce the risks related to these decisions (LIZOT *et al*., 2016). Cost management is a technique used to identify and measure the costs of all inputs that make up the production process, enabling accounting control (SCHIER, 2006). Through this control it is possible to analyze data, historical facts and updated values of inputs and sales prices (MARQUES, 2013).

Managing production costs, it is possible to identify several points: those that are contributing to a decrease in profits, those that should receive more attention on the part of the producer, those that lose importance over time and those that tend to increase their participation in the sum of costs (SOUZA FILHO et. al., 2003). With cost management, you can get information that will help you plan and make strategic short- and long-term decisions (MARTINS, 2010).

The producer needs to keep in mind how he will efficiently combine the use of his production factors, avoiding the increase in costs that will make his activity less competitive when compared to other producers in other regions of the country (BRUNETTA, 2004). A triad is necessary for the producer who wishes to remain in the market: availability of investment, skilled labor and knowledge in managing the costs of his activity (SABBAG *et al*., 2018). Producers who can better manage these resources can become technically efficient, and consequently be economically efficient (FERREIRA; GOMES, 2004).

2.3. Performance indicators

The economic performance of agricultural properties can be measured through the use of economic indicators that use production costs. These costs can offer a variable possibility of analysis. With data from Revenue and the different stages of production cost previously reported, performance measures can be obtained. All performance measures can obtain positive values, which means that the property made a profit, or negative, meaning the loss in the period, that is, it aims to help summarize the visualization of the economic result of the period of the activity carried out (FITZ; SILVÉRIO, 2011).

These values will subsidize the assessments of the real economic situation of an agricultural company, being able to determine if the company operates in profit or loss. Performance measures can also be segmented into economic indicators. Each indicator is an important item, when the objective is to compare agricultural companies that carry out the same productive activity (VIANA; SILVEIRA, 2008).

The indicators are the product of an information system of the analyzed property. The indicators are used to monitor whether the production processes are correct and being carried out by employees and whether the needs of the others involved in the production chain are met. For the calculation of these indicators there is a need to collect data. The number of indicators varies from one rural property to another and what really matters is its effectiveness. In some cases, you can have only a single indicator, as long as it is useful. On the other hand, it happens that many properties have hundreds of indicators, however, these are not used (MACHADO *et al*., 2009). As performance indicators in fish farm we would have, for example, Revenue and Profit per hectare or per kilo of fish produced, Average cost, Unit cost, Return on capital and Product profitability (OLIVEIRA, 2012).

According to Hoffmann *et al*. (1987), the average cost is obtained by dividing the total cost by the number of units produced. It is known that when the production is small, this average total cost is high due to the fact that the fixed costs greatly burden the first units produced, that is, they are distributed among a small number of them. However, as units increase, fixed costs will spread over an increasing number of units, gradually decreasing the average total cost. Once fixed costs have been distributed over many production units, their influence is reduced, and variable costs are therefore relatively important.

The unit cost indicates how much the producer spends to produce a kilo of the product. To obtain this value in a fish farm, the total cost of the activity is divided by the physical volume of fish production (MOURA, 2009).

Profitability of capital according to Antunes and Ries (2001) evaluates the profit obtained in a productive activity in relation to the capital invested in the activity. The business is now considered profitable if it generates return to the investor (producer) everything that has been invested. Profitability of products is represented as a percentage. Profitability is obtained in a specific activity or in the rural company through the sale of products developed and / or produced, that is, it is how much each product returns to the producer, after deducting the cost of its production, described as follows: L = profitability, RB = gross revenue and CT = total cost.

Although many are unaware, fish farming is a modern production system for obtaining profits, composed of different suitable and modern methodologies that can be applied, based on scientific, ecological, technological and economic principles, and that requires knowledge and analysis of the costs of operation of its fish farming projects, among others (SABBAG *et al*., 2007).

2.4. Financial economic viability study

The fish farm has become an important economic activity, especially for small and medium producers, since it does not require large areas or large investments to produce. The Brazilian fish sector is among the agricultural activities of major economic importance. However, there is little economic information that allows planning and consequent growth of activity (VILELA *et al*., 2013).

To determine economic viability, a number of techniques can be used, from the simplest to the most sophisticated. All the techniques have the same objective that is the aid in the decision making of investing or not in the project. One of the methods is based on cash flow, having the Net Present Value (NPV), Internal Rate of Return (IRR) and Discounted Payback (FREZATTI, 2008).

Net Present Value (NPV) is one of the most commonly used investment project evaluation criteria. With it the producer can measure the profit before the implementation of the project (FERREIRA, 2009). The Net Present Value indicates the difference between future cash flows transformed into present value through the opportunity cost of capital and the initial investment. If the NPV is positive it indicates that the capital invested will be recovered, remunerated at the minimum required rate and will generate an extra gain, at date zero. The minimum required rate is the lowest interest rate that the investor requires to accept the investment (LAPPONI, 2000).

The Internal Rate of Return (IRR), because it is easy to understand economically and financially by the producers, is one of the most known and used methods (FERREIRA, 2009). It is understood as the interest rate that equals the total investment or cost to the returns or total benefits obtained during the life of the project (BRABO *et al*., 2013).

The IRR can be defined as the interest rate received for a given investment over a period of time, where, at regular intervals, payments are made to cover all costs of rearing (inputs for production) and proceeds from the sale of the product (sale of fish for example) (KODAMA *et al*., 2011).

Payback (PB) is an index that represents the time needed for the investor / producer to recover the invested capital (DAMODARAN, 2002). This can be presented in two ways: Simple Payback or Discounted Payback, with Simple Payback being the time needed to recover the invested capital without considering the cost of capital and the Discounted Payback is the time needed to recover the invested capital considering the cost of capital, applying the Minimum Attractiveness Rate (LAPPONI, 2000) indicating the project with less time of recovery of the capital initially invested (FERREIRA, 2009).

2.5. Cultivation systems

The extensive system is characterized by a subsistence activity that presents low implantation cost and almost no maintenance (PESTANA *et al*., 2007). This system is found in small properties that perform simple management, make use of agricultural byproducts to feed the fish and use family labor (SANTOS; RIBEIRO, 2010).

The semi-intensive system is characterized initially by a production in excavated tanks, density calculated by area, use of feed to feed the fish and careful with water quality. This system is the most used in Brazil (MINUCCI *et al*., 2005). In the semi-intensive system technology is an essential variable to improve the level of efficiency. In the fish farms we can mention some technologies available in the semi-intensive culture: biometrics, water analysis, use of vaccines and use of equipment such as aerators (BAYER *et al*., 2011).

The fish farm with intensive production system is characterized by the use of recirculation of the water used, high productivity, less space demand and low water consumption. However, this system requires a strict control of water temperature, dissolved oxygen level and metabolites, especially nitrogenous ones, from feed, urine and feces, which can lead to intoxication and death of the fish (JORDAN *et al*., 2011).

2.6. Previous similar studies

In a study by Takahashi *et al*. (2004), the objective was to evaluate the economic feasibility of the production of piauçu, because, according to the authors, due to the greater fish supply, the value of sales has been decreasing over time. The authors found that in the fattening of piauçu, input costs accounted for 47.1% of the total cost of production. When analyzing financial viability, the project would be paid after 8.3 years, presenting net present value of US$ 291.07 and internal rate of return of 9%. The authors also mention that with these indicators the project does not present a good attractiveness and that it would be better if it improves the productive efficiency and the monitoring of the costs and revenues throughout the productive cycle.

When performing the economic analysis of the production of juvenile Nile tilapia in net tanks using different storage densities, Ayroza *et al*. (2011) concluded that the average total operating cost to produce one kilo of fish was US$ 0.61 kg, and in the highest density costs were higher (US$ 0.66 kg). The item with the highest participation in production costs was the feed (86.08% in the density of 100 m^3 fish and 94.23% in the density of 400 m^3 fish).

In the work done by Debus *et al*. (2016), it was sought to determine scientific studies related to financial management in fish farms between the period 2003-2015, and it was possible to conclude that there is a lack in this line of research and that the few that exist address the costs of the fish producing units being then greater volume of research involving control of revenues and expenditures and the economic viability of fish production for these producers could be maintained in rural areas.

3. Materials and Methods

In view of the objective of evaluating the economic and financial viability of the sorubim hybrids creation system in excavated tank, this case study used the gathering of information from producers two commercial fish farms, one that does not use aerators and one that does, located in Mato Grosso State, in the Center-West region of Brazil, from January 2014 to June 2015, comprising fish stages of fingerling, juvenile, and termination.

The fish farm with aerators is located in the city of Sorriso – MT, (12°14'35.80"S, 55°50'24.05"O has an area of 10.50 hectares where allocated 94,218 fish in Phase 1, with a density of 0.90 fish m². At the end of the production cycle, 84,105 fish were removed. The fish farm with aerators used 26 triangular paddle aerators, with 2 horse-power (HP). Aerators were on daily from 8:30 p.m. to 6:00 a.m., providing supplementary aeration.

The fish farm without aerators is located in the city of Sorriso – MT, (9°33'6.18"S, 54°51'19.70"O), has an area of 9.90 hectares where allocated 65 thousand fish in Phase 1 (0.10 kg to 0.40 kg), with a density of 0.70 fish m². Because the conventional system had low stocking densities, it did not require mechanical aeration. At the end of the production cycle, 55,572 fish were removed.

For both fish farms, hybrid fingerlings originated from the same source female *Pseudoplatystoma reticulatum* (cachara) and male *Leiarius marmoratus* (jundiá). Fish were fed extruded commercial feed, supplied in two daily treatments, 8:00 a.m. and 4:00 p.m., maintaining the same amount of feed between treatments. Both farms used the same feed.

Fish in Phase 1 were fed 4–6 mm pellets (3.0–5.0% of biomass day) containing 40.0% crude protein (3,900 kcal kg), 7.2% gross fiber, and 8.1% mineral matter. Fish in Phase 2 (0.401 kg to 1.00 kg) were fed 6–8 mm pellets (2.0% of biomass day) containing 32.0% crude protein (3,200 kcal kg), 10.2% gross fiber, and 7.1% mineral matter. Fish in Phase 3 (above 1.00 kg) were fed 8–12 mm pellets (1.0–2.0% of biomass day) containing 28.0% crude protein (2,800 kcal kg), 7.2% gross fiber, and 8.1% mineral matter.

Monthly biometrics were performed with 10% of the fish in each fish farm, in order to obtain average weight values and thus evaluate their development and guide their nutritional management.

The labor force active in the research period was a permanent employee in both fish farms, to assist the owners in the routine services of the property, with an average monthly salary of US$ 781.25. Social charges, such as contributions to the National Social Security

Institute (INSS) and vacations, among other expenses, were calculated to be 40% of the amount referring to labor costs.

Water characteristics measured included temperature, dissolved oxygen (YSI PRO 20 oxymeter), pH, alkalinity of carbonates, and hardness (by titration with the Acqua Supreme Kit) (Table 1). Measurements were taken in the morning (8:00 a.m.) and afternoon (4:00 p.m.).

Table 1: Parameters of water quality for the two fish farms during the production cycle of hybrid sorubim.

Water Parameters	With aerator	Without aerator
Temperature (°C)	26.5 ± 6.4	27.5 ± 4.9
Dissolved oxygen (mg O_2 L)	4.7 ± 2.7	5.5 ± 4.3
pH	7.1 ± 1.3	7.6 ± 0.6
Alkalinity (mg $CaCo_3$ L)	18.0 ± 12.7	26.5 ± 7.8
Hardness (mg $CaCo_3$ L)	16.5 ± 14.8	24.0 ± 4,2

Data on sale values, purchase of inputs and other expenses were obtained through the construction of the monthly cash flow and computed the inputs (revenues) and outputs (expenses) in electronic spreadsheets (MS-Excel®), of the two fish farms, this information being provided by fish farmers. The amounts used for the calculations were those practiced during the production period and converted to dollars referring to the average exchange rate for the period January 2014 to June 2015 (US$ 1.00 = R$ 2.56) disclosed by Banco Central do Brasil. Fish were sold at an average price of US$ 2.51 kg and R$ 2.29 kg per fish for farms with and without aerators, respectively.

The following information was collected to assess costs: acquisition of fingerlings, control of water quality (limestone and fertilization), employees (fixed and occasional), feed, sanitation (antibiotics), maintenance in machinery and equipment, fuel, depreciation and electrical energy. For machines, equipment, and vehicles, the linear depreciation method was used for considering useful life and the prices of the asset.

Based on data collected, we calculated revenues, costs, gross profit, and gross margin, composing the Income Statements. To obtain values, we used the following mathematical-financial calculations described and adapted of Costa *et al*. (2018):

• *Revenue (R$) = Total volume of production (kg) × Selling price (R$ kg)*

The values used in the calculation of Revenue were obtained from the properties evaluated.

- *Costs or Effective Operational Cost (EOC) (R$) = Σ (fingerlings + feed + employees + sanitation + maintenance + fuels and lubricants + electrical energy + freight)*
- *Profit (R$) = Σ Revenue - Σ Costs*
- *Net profit (R$) = Profit - Depreciation*
- *Net margin (%) = (Net Profit ÷ Revenue) × 100*

The total cost/ha (US$), was calculated through the sum of all costs divided by the total area (ha) used for fish production. The total cost/kg produced (US$) was calculated using the ratio between the total cost and the quantity of kilograms produced during the months of biological testing. The revenue/ha (US$) was calculated using the ratio of the revenue obtained from the sale of the fish and the total area where they were produced. Total production/ha followed the same ratio, taking into account the total quantity produced (kg) and the area used in production. Finally, the kg produced/m² was calculated, this being the result of the quantity produced (kg) divided by the production area presented in m².

After initial analyses, cost items were classified according to the ABC analysis. According to Ravinder and Misra (2014), after identifying the importance of cost items in decreasing order based on value, costs are divided into three classes:

- A: Few items that have high value and are important, deserving special attention (high demand);
- B: Intermediate quantity of items and value with average importance; and
- C: Many items that have low value and little importance (low demand) (KESKIN; OZKAN, 2012).

There is no percentage pattern for classification or analyses. Class A items represented, on average, 90.0% of the costs, Class B items represented around 8.0% of costs, and Class C items represented, on average, 2.0% of costs.

Since items categorized as class A are those with the greatest financial impact for the producer, the objective of this analysis was to clarify which items have the highest and lowest costs in production to optimize the control of the producer, facilitating their decision making to reduce costs.

For the financial evaluation, the following formulas according to methodology quoted by Gitman (2010); Gaspar *et al*. (2018):

- Net Present Value (NPV): Sum of the present values of the estimated flows of an application (inputs and outputs), calculated from a given rate and its duration period, subtracting the amount invested.

NPV = Σ Current Value of Cash Receipts - Net Investment

If NPV ≥ 0, the investment is accepted.

• Internal Rate of Return (IRR): Hypothetical discount rate, which causes the NPV of an investment alternative to be nil, that is, to equalize the current value of the cash inflows with the net investment.

For this, compare the IRR obtained with the opportunity cost of capital in an alternative use, given by the attractiveness rate, in this case the rate of 25.0% per year.

If IRR ≥ Capital Cost, the investment is accepted.

• Profitability Index (PI): Ratio of the sum of the current input values and the value of the initial investment, thus, measuring the return for each invested Real.

PI = Σ Current Value of Cash ÷ Net Investment

If PI ≥ 1, the investment is accepted.

• Benefit-cost ratio (BCR): Quotient between the current value of projected revenues (R) and the current value of projected costs (C), including investments (I), required to develop the project.

$BCR = \Sigma R \div (\Sigma C + \Sigma I)$

If BCR ≥ 1, the investment is accepted.

• Payback period: Time necessary for the return on a given investment.

Payback period = Net investment ÷ Average annual cash inflows

The financial evaluation was conducted only for the fish farm that used aerators because it took into consideration investments for purchasing aerators, establishment of the electrical network, and working capital necessary to maintain production. All calculations were performed using Microsoft Excel 2016 software.

The main objective of the sensitivity analysis was to allow for informed decisions using different zootechnical indicators or input prices that reflect economic indicators (BARROS *et al.*, 2016). Different scenarios were considered, with variations made in the economic scenario of sales prices of the total volume of production carried out in the two fish farms.

For the analysis, both fish farm selling prices were set to the highest value (US$ 2.51), which was paid to the fish farm that used an aerator. Therefore, the same opportunity of sale was used in an optimistic simulation. A pessimistic simulation was performed by matching both sales to the lowest amount paid for fish (US$ 2.29).

Subsequent to these analyses, three other selling price simulations were performed: 1) an average sale value (US$ 2.40), 2) an intermediate sale value between the average value and the maximum value (US$ 2.45), and 3) an intermediate sale value between the average value and the minimum value (US$ 2.34).

4. Results

In the fish farm with aerators, the production was 234,907 kg of fish (22.4 tons ha), with an average final weight of 2,817 kg (2.2 kg m^2) and a production cost of US$ 36,322 ha (cost = US$ 381,382). The total production for the fish farm without aerators was 130,041 kg of fish (13.1 tons ha), with an average final weight of 2,340 kg (1.3 kg m^2) and a production cost of US$ 19,506 ha (cost = US$ 193,112) (Table 2).

Table 2: Income Statements of fish farms without and with aerators producing hybrid sorubim.

Items	Without aerator		With aerator	
	US$	%	US$	%
Revenue	297,164.00		590,020.00	
Costs				
Fingerlings	35,861.00	12.1	72,503.00	12.3
Feed	136,362.00	45.9	267,386.00	45.3
Sanitation	4,023.00	1.4	4,893.00	0.8
Electrical energy	-	-	24,650.00	4.2
Employees	11,681.00	3.9	10,131.00	1.7
Fuels and lubricants	1,528.00	0.5	776.00	0.1
Freight	3,656.00	1.2	1,040.00	0.2
Subtotal	193,112.00	65.0	381,382.00	64.6
Profit	104,051.00		208,637.00	
Depreciation	1,562.00		10,049.00	
Net profit	102,489.00		198,588.00	
Net margin (%)		34.5		33.7

Average exchange rate (January 2014 to June 2015): US$ 1.00 = R$ 2.56 (Brazilian central bank).

The cost of fish production was US$ 1.92 kg and US$ 1.48 kg for fish farms with and without aerators, respectively. Revenues for fish farms with and without aerators were, US$ 590,020 (US$ 56,192 ha) and US$ 297,164 (US$ 30,016 ha), respectively, a difference of US$ 292,856 (Table 2).

The cost of buying fish was higher in the fish farm without aerators, accounting for 45.9% of the total revenue. Expenses for the purchase of fingerlings were similar for both fish farms with and without aerators, accounting for 12.3% and 12.1%, respectively, of the total revenue (Table 2).

The ABC curve indicated that in the composition of production costs for the two fish farms, the most relevant cost component was feed (70.1% with aerators and 70.6% without aerators) (Figures 1 and 2). The second most relevant item for costs was the purchase of fingerlings (19.0% with aerators and 18.6% without aerators). Together, these items represented almost 90.0% of the total cost of production (89.1% with aerators and 89.2% without aerators).

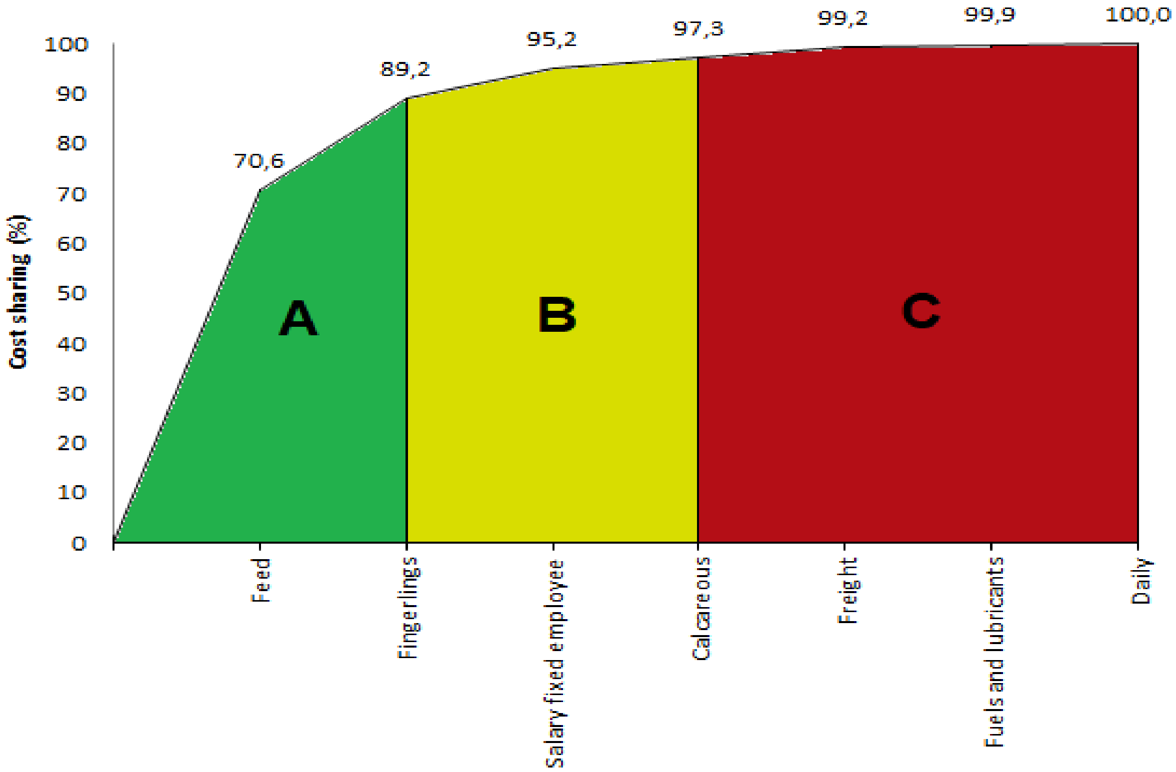

Figure 1: ABC analysis of the costs for a hybrid sorubim fish farm without aerators.

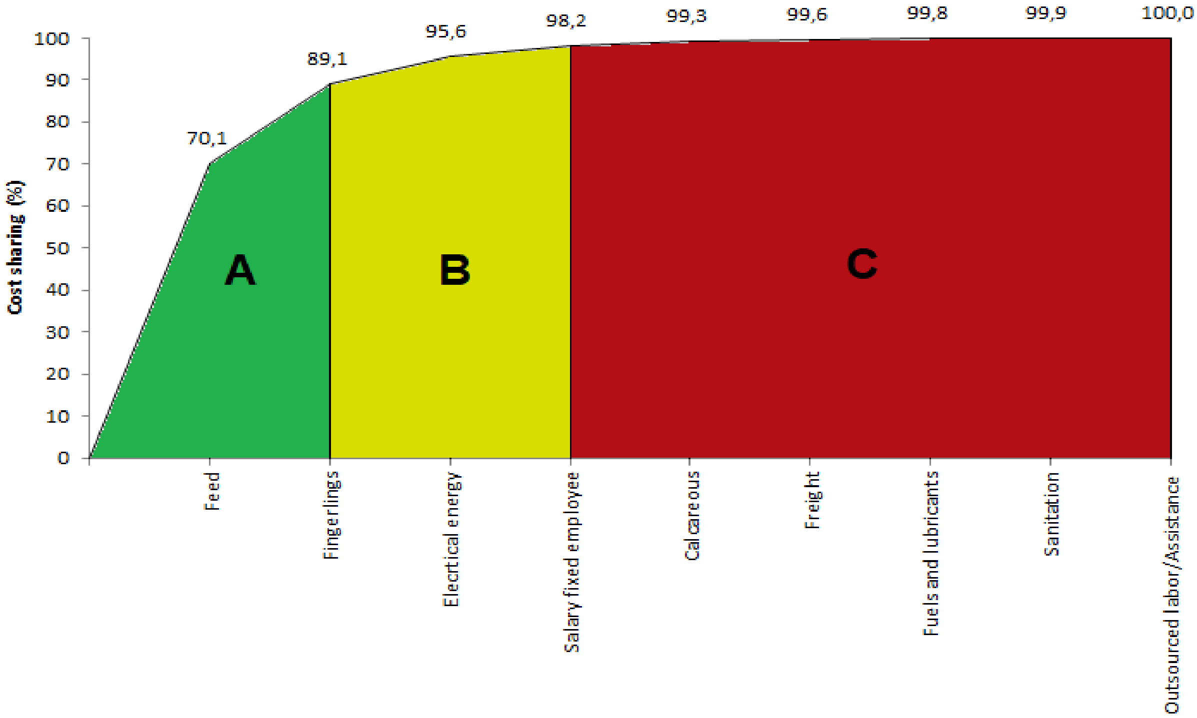

Figure 2: ABC analysis of the costs for a hybrid sorubim fish farm with aerators.

Economic indicators identified positive results for Profitability Index (2.21), Benefit-cost ratio (1.23), and Net Present Value (US$ 292,370) in Payback and Discounted payback periods (2 years) (Table 3). In addition, there was a high internal rate of return (78.0%). All indicators suggest investing in the production of hybrid sorubim, with fast returns and high profitability.

Table 3: Economic indicators of the feasibility of investment in the production of hybrid sorubim with aerators.

Indicators	Result
Profitability Index - PI (US$)	2.21
Benefit-cost ratio – BCR (US$)	1.23
Payback period (years)	2
Discounted payback period (years)	2
Net present value – NPV (US$)	292,370.00
Internal rate of return – IRR (%)	78.0

Note: Discount rate: 25.0% per year.

In the pessimistic scenario, the selling price in fish farm with aerators was reduced by 9.0%. As a result, revenue decreased 29.9%. In the optimistic scenario, the selling price of the fish farm without aerators increased by 9.0%, increasing revenue by 28.9%. Even with fluctuations, the aerated fish farm had lower financial risk in all scenarios.

Regardless of sale value, the use of aerators resulted in higher gross revenue (US$ 263,394, optimistic scenario and US$ 239,635 pessimistic scenario), higher effective operational cost (US$ 188,270 in both scenarios), and higher Profit (US$ 75,124, optimistic scenario and US$ 51,366, pessimistic scenario). Higher efficiency of Profit in production with aerators was 156.3% in the optimistic scenario and 149.4% in the pessimistic scenario (Table 4).

Table 4: Sensitivity analysis of fish farms with and without aerators for hybrid sorubim production, with different sales prices.

		Changes in selling price (US$)				
		(2.51 kg)	(2.45 kg)	(2.40 Kg)	(2.34 kg)	(2.29 kg)
Gross revenue (US$)	A	590,020.00	576,256.00	563,409.00	549,645.00	536,799.00
	B	326,626.00	319,007.00	311,895.00	304,275.00	297,164.00
EOC (US$)	A	381,382.00	381,382.00	381,382.00	381,382.00	381,382.00
	B	193,113.00	193,113.00	193,113.00	193,113.00	193,113.00
Profit (US$)	A	208,638.00	194,874.00	182,027.00	168,263.00	155,417.00
	B	133,514.00	125,894.00	118,782.00	111,163.00	104,051.00
Gross margin (%)	A	35.4	33.8	32.3	30.6	29.0
	B	40.9	39.5	38.1	36.5	35.0
Efficiency (%)	Profit (A/B)	156.3	154.8	153.2	151.4	149.4

Note: A, with aerators; B, without aerators; EOC, Effective Operational Cost (Σ Costs);

The Internal Rate of Return and Net Present Value for the farm with aerators were higher in the optimistic scenario (commercialization of fish for US$ 2.51; 78.0% and US$ 292,370 respectively) than the pessimistic scenario (commercialization of fish for US$ 2.29; 53.0% and US$ 149,243, respectively), (Table 5).

Table 5: Financial sensibility analysis of a fish farm with aerators for hybrid sorubim production, with different selling prices.

Sale price (US$ kg^{-1})	**Without aerator**	
	Internal Rate of Return – IRR (% a.a.)	Net Present Value – NPV (US$)
2.51	78.0	292,370.00
2.45	71.0	255,354.00
2.40	65.0	220,806.00
2.34	59.0	183,791.00
2.29	53.0	149,243.00

5. Discussion

Fish farms using technologies, such as aerators, enable sustainable production and environmental advantages because it allows increased production within the same area (high cultivation densities) (CNA, 2015). This avoids deforestation of new areas, and being a system with low water renewal, water consumption is only for replacement of evaporation/infiltration.

Nocturnal (supplemental) aeration improves growth and survival of animals in high densities (DAS *et al*., 2012; PAWAR *et al*., 2009, 2014). The use of aerators is required to provide increased biomass and allow adequate production conditions, with respect to dissolved oxygen rates, and thus, to obtain higher productivity of commercial species. According to Vinatea (2004) the dissolved oxygen level in the water of the production tanks is the main limiting factor for the good zootechnical performance of the organisms cultivated.

Oxygen level was maintained at satisfactory values for farms with aerators (4.7 ± 2.7 mg O_2 L) and without aerators (5.5 ± 4.3 mg O_2 L). However, based on the standard deviation, dissolved oxygen varied less with aerators, providing better conditions for fish. This may have reduced mortality in the aerator production (11.0%), compared with fish farming without aerators (15.0%). Inoue *et al*. (2003) observed that dissolved oxygen levels were satisfactory at densities of 20 and 40 fish m^2 when aerators were used (4.3 ± 0.7 mg O_2 L). At higher densities, oxygen level was at the limit (3.4 ± 0.7 mg O_2 L), indicating the importance of oxygen supplementation at higher densities.

As the system intensifies, is possible to increase production as long as the ideal production conditions are provided. The concentration of dissolved oxygen in the water of the production tanks is the main limitation for the good performance of the cultivated organisms. Aerators are devices that mechanically incorporate atmospheric oxygen into the water in cultivation tanks (KEPENYES; VARADI, 1984). Thus, to increase the intensification, the need for this equipment was recommended by FAO. In the present research, the system using aerators provided an increase of 104.866 kg of fish (9.3 tons ha) in relation to the property that did not use aerators. With this increase in production, the increase in revenue was 49.6%.

The use aerators provided an average weight gain difference of 0.477 kg/fish and a density of 0.9 kg m^2 higher than fish farming without aerator. This high performance is due to the fact that the aerator ensures better water quality, consequently improving the productive performance of the animals, which can be confirmed by the increase in weight gain and enables an increase in the productivity of the aquatic enterprise, as it allows the support of a larger biomass of fish in a given area (KUBITZA, 2008). In research carried out by YI and LIN (2001) they found that the use aerators for a period of five hours during the night improved the growth of tilapia grown in net tanks installed in nurseries and increased the carrying capacity of the environment.

When used in the production of shrimp (*Macrobrachium amazonicum*), Preto (2012), observed an increase in final average weight and productivity (kg/ha) with the use of supplementary artificial aeration at night. Likewise, Boyd (1998), described an increase of 24.01% in the final biomass in the production of channel catfish in comparison with that of cultivation using emergency aeration strategy.

The net margins of the two fish farms were similar, but the net profit for the farm with aerators was 93.8% higher than the farm without aerators. This was possible through the inclusion of aerators, allowing increased biomass in the dam, that is, it was possible to produce more in the same area. Although costs increased with aerators, the resulting increase in production led to higher revenue and profit.

The high freight cost for the fish farm without aerators was due to the greater distance from centers for sale and purchasing inputs (e.g. fridge). This shows the importance of fish farm location, and the need for organized purchase of inputs to obtain better prices.

Initially, the electrical energy cost (Table 2) for aerators was only 4.2% of gross revenue. This indicates that, with a low financial expenditure, it is possible to increase production and profitability within the same area. Although more was spent on aerators, the proportion of expenditures for both properties, relative to revenues, was similar. Castro *et al*., (2002) reported a 9.54% electricity cost in the cultivation of tambaqui with supplementary artificial aeration. According to Boyd and Hanson (2010), in preliminary economic studies it was found that the additional costs with electricity and the costs of purchasing the aerators are offset by the additional weight of the fish and the revenue produced.

Besides, feed cost for the two fish farms (45.3% and 45.9% with and without aerators, respectively) was higher than that reported by Coelho and Cyrino (2006), where feed was the second most expensive item (20.2% of the total cost), behind fish acquisition (48.7% of the total cost). However, the higher cost was due to sorubim species and age used (US$ 1.75 unit). According to Scorvo Filho *et al*. (2010), feed is relatively more expensive compared to other costs, representing 40.0 – 60.0% of the total cost of production, and this is why it deserves special attention. In Melo *et al.* (2001), feed represented 64.20% and Marinho-Pereira *et al.* (2009), 62.02%.

Melo *et al*. (2010) surveyed 17 fish farm operators in Dourados, Mato Grosso do Sul (Brazil), and concluded that feed costs could be reduced by utilizing byproducts from their properties. However, most producers were not sufficiently aware of their costs to perform an assessment, with only 11.0% using feed produced from soybean and corn byproducts from their properties, reducing the cost of feed by up to 50.0%. Despite the possibility of reducing feed production costs, animal performance is most important; therefore, it is necessary to maintain feed quality.

With the ABC curve, it was possible to highlight that, for the fish farm with aerators, the cost of electrical energy was 6.5% of the total operational cost (Figure 2), far below the first two items (feed and fingerlings). Despite being a technology that generates cost, the gross profit was more than the fish farm without aerators. Scorvo Filho *et al*. (1998) found similar costs of aerators, evaluating the production costs of round fish, common carp, and tilapia in nurseries (two 2 HP aerators per hectare). The cost of electricity for these species (8.2, 8.6 and 7.0% of production cost, respectively) was similar to this study. Kumar *et al*. (2013) found that the cost of aeration represented 15.0% of the total cost of production, below the costs of fingerlings and feed, reinforcing that electrical energy costs are low compared to other costs, in addition to generating higher revenues and increased production.

With all fluctuations of sale price for fish farms with aerators, investments presented satisfactory IRR and NPV (Table 5), showing that even in the pessimistic scenario, aerator use is profitable and presents low-risk investment. Viability of production using aerators was reinforced by Payback period (Table 3), where even with investment in aerators, an electrical network, and a working capital to maintain the activity during the production period, the farm with aerators recovered the investment value in the second year of production. A discounted payback period of two years allows the producer to recover the investment in a short period of time, which is acceptable with the risks presented, such as changes in market price or loss of animals due to environmental and health risks.

In the fish farm with aerators, the IRR was raised far beyond what is observed in other types of production or in other systems. Previous studies have shown that the more intensified a fish production system becomes, the more profitable it is and has higher internal rates of return. Examples include, IRR of 56.2% in African catfish production (MARTIN *et al*., 1995), IRR of 46.6% for round fish production (SCORVO FILHO *et al*. 1998), and IRR of 37.3% with exclusively pintado production (BARROS *et al*., 2016).

In an investment analysis, according to the theory, for a project to be accepted, it must necessarily meet the following criteria: the NPV must be positive and the IRR must be greater than the cash flow discount rate. Based on the results found, it can be said that production with aerators is a viable investment model for those who want to start fish farm with more intensive production.

The sensitivity analysis for the two production systems indicated that for the fish farm with aerators, even when the sale of the fish was US$ 2.29 kg and its gross margin dropped to 29.0%, Profit efficiency was 149.4% higher than the fish farm without aerators. However, the fish farm without aerators, when selling its fish at US$ 2.51 kg, obtained a gross margin of 40.9%, which was higher than the margin for the fish farm with aerators (35.4%). It is noticed that the production system with aerators supports price fluctuations that reach a 9% reduction in revenue (US$ 53,221). Therefore, this activity has high economic viability, associated with high stability to market price fluctuations.

Due to the importance of Brazilian aquaculture in agribusiness, it is important that scientific publications in this area indicate, not only the productive performance of animals, but also carry out the correct economic evaluation, which is often neglected in publications. Most importantly, this information should reach the producers knowledge so that they can be able to choose to use the technologies available on their properties, having knowledge of the investments and costs necessary for the installation and maintenance of the chosen production system and the returns that will be achieved at short, medium and long term.

6. Conclusions

The use of aerators in production tanks of hybrid sorubim is economically advantageous, presenting a low impact on the total cost of production and low financial risk of investment. This study suggests that the aerators use has potentiality to improve farming of hybrid sorubim in the Center-West region of Brazil.

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