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DEVELOPMENT OF BIOFLOC FISH FARMING BUSINESS IN PALU CITY, CENTRAL SULAWESI PROVINCE

Pengembangan Usaha Budidaya Ikan Sistem Bioflok di Kota Palu Provinsi Sulawesi Tengah

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ABSTRACT

The fisheries sector plays a crucial role in food security and the economy, particularly through aquaculture. One rapidly growing method is the biofloc system, which enhances production efficiency by utilizing microorganisms to process organic waste into biomass that can be consumed by fish. This technology not only improves feed efficiency but also reduces environmental impact. Palu City holds great potential for developing biofloc-based aquaculture due to its abundant water resources and supporting infrastructure. This study aims to identify the factors influencing biofloc aquaculture businesses in Palu City, analyze their technical and economic feasibility, and formulate sustainable development strategies. The research employs a descriptive qualitative and quantitative approach using purposive sampling techniques. The applied analysis includes descriptive analysis, business feasibility analysis (BCR, BEP, and PP), marketing margins, and SWOT analysis. The findings of this study are expected to provide strategic recommendations for fish farmers and stakeholders to develop biofloc systems more effectively and sustainably in Palu City.

Keywords: biofloc, fish farming, production efficiency, development strategy, Palu City.

ABSTRAK

Sektor perikanan memiliki peran penting dalam ketahanan pangan dan ekonomi, terutama melalui budidaya ikan. Salah satu metode yang berkembang pesat adalah sistem bioflok, yang meningkatkan efisiensi produksi dengan memanfaatkan mikroorganisme untuk mengolah limbah organik menjadi biomassa yang dapat dikonsumsi oleh ikan. Teknologi ini tidak hanya meningkatkan efisiensi pakan tetapi juga mengurangi dampak lingkungan. Kota Palu memiliki potensi besar dalam pengembangan usaha budidaya ikan dengan sistem bioflok karena sumber daya perairan yang melimpah dan dukungan infrastruktur. Penelitian ini bertujuan untuk mengidentifikasi faktor-faktor yang mempengaruhi usaha budidaya ikan dengan sistem bioflok di Kota Palu, menganalisis kelayakan teknis dan ekonomi, serta merumuskan strategi pengembangan yang berkelanjutan. Metode yang digunakan meliputi pendekatan deskriptif kualitatif dan kuantitatif dengan teknik purposive sampling. Analisis yang diterapkan mencakup analisis deskriptif, kelayakan usaha (BCR, BEP, dan PP), margin pemasaran, serta SWOT. Hasil penelitian ini diharapkan dapat memberikan rekomendasi strategis bagi pembudidaya dan pemangku kepentingan dalam mengembangkan sistem bioflok secara lebih efektif dan berkelanjutan di Kota Palu.

Kata kunci: bioflok, budidaya ikan, efisiensi produksi, strategi pengembangan, Kota Palu.

INTRODUCTION

The fisheries sector, which significantly contributes to food security in terms of increased production, animal protein consumption, employment, income generation, and regional development, is the aquaculture sector. The scope of fish farming activities includes growth control and breeding. Fish rearing efforts are also part of growth control. Fish farming aims to achieve higher or more abundant yields (Zain and Febrianty, 2018). Fish farming is a fisheries sector with significant potential to meet animal protein needs and support the local and national economy (Damayanti, 2012). As an archipelagic nation with a long coastline and abundant aquatic resources, Indonesia has a comparative advantage in the fisheries sector. Particularly in Palu City, the fisheries sector is a leading sector that can support community welfare and increase regional income.

One increasingly popular and proven efficient fish farming method is the biofloc system. The biofloc system is a cultivation technology that relies on the principle of water treatment by utilizing microorganisms to process organic waste into biomass that can be consumed by fish. This technology not only increases feed efficiency but also reduces negative impacts on the environment (Pangaribuan and Sembiring, 2022). Biofloc is a collection of microorganisms such as bacteria, algae, protozoa, and yeast that combine to form floc particles. This system allows the utilization of nutrients from fish waste to be converted into supplementary feed, thereby increasing production efficiency (Sefianingsih *et.al*, 2023). Fish commodities that are widely cultivated using the biofloc system are tilapia (*Oreocromis niloticus*) and catfish (*Clarias sp.*). The aquaculture business for these two commodities is growing rapidly in Indonesia due to their relatively fast growth, ease of development, and efficiency in supplemental feed provision, which has led to many aquaculture practitioners cultivating them (Az, 2022).

Biofloc offers a solution that not only increases fisheries productivity but also reduces the negative environmental impacts often encountered in conventional aquaculture (Marlida, 2020). By utilizing the principle of microbial filtration in a controlled environment, biofloc enables more efficient water use and reduces the risk of environmental pollution while reducing reliance on antibiotics (Indariyanti et al., 2024). The choice of Palu City as the appropriate location for the biofloc system was driven by a combination of significant fisheries potential, environmental challenges that need to be addressed, and the existence of educational and research infrastructure that supports the development and sustainable application of this technology. Therefore, investment in aquaculture technologies such as biofloc in Palu City will not only increase fisheries production but also support environmental conservation and the local economy more holistically. However, to optimize the implementation of the biofloc system, a thorough understanding of the characteristics of fish farming businesses using this system is required. Based on the above description, research will be conducted on the development of fish farming businesses using the biofloc system in Palu City, Central Sulawesi Province.

The purpose of this study is to identify factors influencing biofloc fish farming in Palu City. Furthermore, the study will analyze technical and economic aspects to assess the feasibility of biofloc fish farming. Based on the identification and analysis, this study is expected to formulate appropriate development strategies to improve the effectiveness and sustainability of biofloc fish farming in Palu City.

RESEARCH METHODS

Time and Place

This research took place over three months, from August to October 2024, in Palu City, Central Sulawesi. The location was chosen purposively because Palu City has many fish farmers who implement the biofloc system. Tools and Materials: The tools used in this research include a circular tarpaulin pond, an aerator, a water pump, water quality measuring instruments (thermometer, pH meter, DO meter), a digital scale, and documentation equipment (camera, stationery). The materials used include tilapia and catfish seeds, fish feed, molasses, probiotics, and clean water.

Types of research

This research is both qualitative and quantitative descriptive. According to Rusandi and Rusli (2015), qualitative descriptive research aims to describe phenomena in depth within a specific context. According to Sugiyono (2017), quantitative descriptive research aims to describe the variables studied in the form of numbers, graphs, or tables that are processed statistically. This study examines the use of biofloc technology by fish farmers in Palu City through interviews, observations, and document analysis to understand the practices, benefits, and challenges in its implementation.

Data Types and Data Collection Methods

- Data Type: Qualitative data was obtained through in-depth interviews with fish farmers and direct observation of biofloc practices. Secondary data was obtained from scientific literature, industry reports, and fisheries sector statistics to enrich the analysis.
- Data Collection Method: Data were collected through in-depth interviews regarding experiences, challenges, and benefits of biofloc technology, as well as direct observation of cultivation infrastructure and management.

Sampling Method

A purposive sampling method was used to select farmers who had been implementing the biofloc system for at least two years, had production data, and were willing to be interviewed and observed. According to Aisyiah *et al*. (2024), farmers with 2 to 5 years of experience contribute to cultivation effectiveness and efficiency, increasing production and product continuity in the market. The sample was determined until data saturation was reached, which is when information begins to repeat itself.

Data Analysis Techniques

- Descriptive Analysis: Describes the characteristics of biofloc cultivation efforts, including aspects of production, feed management, and water quality.
- Business Feasibility Analysis: Using Benefit-Cost Ratio (BCR), Break-Even Point (BEP), and Payback Period (PP) to assess economic feasibility. According to Supriyono (2011), BEP is calculated using the formula: BEP=FCP−VBEP = \frac{FC}{P - V}BEP=P−VFC Where FCFCFC is the fixed cost, PPP the selling price per unit, and VVV the variable cost per unit.

- Payback Period (PP) is calculated based on Yanti's formula (2023): PP=K0 APP = \frac{K0}{Ab}PP=AbK0 Where K0K0K0 is the initial investment and AbAbAb is the net benefit per year.
- Marketing Margin Analysis: According to Uliya and Gusniyati (2018), marketing margin is calculated using the formula: MP=Pr−PfMP = Pr - PfMP=Pr−Pf Where PrPrPr is the consumer price and PfPfPf is the producer price.
- SWOT Analysis: Used to develop business development strategies based on strengths, weaknesses, opportunities and threats in biofloc cultivation in Palu City.

RESULTS

Overview of Research Location Business

Based on 2024 data from the Palu City Statistics Agency (BPS), the aquaculture sector in Palu City reached 216 people, with a production of 127.73 tons per year and a production value of IDR 3,934,250,000. The majority of farmers are not pure cultivators, but only do it as a side job using their home yards. Initial capital sources come from government assistance, their own capital, or a combination of both. Types of fish cultivated include tilapia, catfish, gourami, carp, and ornamental fish, but only tilapia and catfish are cultivated using the biofloc system. Although many use round tarpaulin ponds, the implementation of the biofloc system is still not optimal due to limited costs and knowledge. The market in Palu City is still wide open, with high demand from restaurants and household consumers. However, the supply of fish in this city is still dominated by those from outside the region, such as Sigi Regency, Parigi, West Sulawesi, Gorontalo, and Manado. In terms of social background, farmers have diverse educational backgrounds, ranging from junior high school to bachelor's degree (S1). The existence of fish farmer groups provides a space for them to share experiences and increase productivity. Economically, fish farming is not just a hobby but a serious source of income, although challenges remain in financing and fully implementing biofloc technology.

Respondent Characteristics

a. Respondent Age

The age distribution of respondents in biofloc system cultivation in Palu City is as follows:

Table 1 Age Level of Respondents

Age Level	Number of people	Percentage (%)
33-40	6	37,5
42-43	6	37,5
44-51	4	25,0
Total	**16**	**100,0**

Source: Primary data after processing 2024

b. Respondents' Education Level

Table 2. Respondents' Education Level

Level of education	Number of people	Percentage (%)
SMP	1	6,25
SMA	6	37,5
S1	9	56,25
Total	**16**	**100,0**

Source: Primary data after processing 2024

c. Number of Family Dependents

Table 3. Family Dependencies

Family Dependencies	Number of people	Percentage (%)
1-3	9	56,25
3-4	7	43,75
Total	**16**	**100,0**

Source: Primary data after processing 2024

d. Cultivation Experience

Table 4. Cultivation Experience

Cultivation Experience (Years)	Number of people	Percentage (%)
2	16	100,0
Total	**16**	**100,0**

Source: Primary data after processing 2024

Aspects that influence fish cultivation using the biofloc system
a. Technical Aspects

- Biofloc technology relies on heterotrophic bacteria to convert nitrogenous waste into feed with a C/N ratio >10.
- Aeration is necessary to increase dissolved oxygen levels.
- Technical factors include site selection, cultivation SOPs, water quality management, and appropriate fish species.
- Influential water quality parameters: temperature (27-30ºC), pH (6.5-8), dissolved oxygen (5-7 ppm), and floc density.
- Cultivation stages: pond preparation, seed distribution, feeding, water management, and harvesting.

b. **Managerial Aspects**

- Thorough planning and oversight contribute to business efficiency.
- Good operational cost management will increase profitability.
- Identifying issues such as water quality and disease is a crucial factor in business success.

c.. **Social Aspects**

- Community acceptance of biofloc technology can increase participation and employment opportunities.

- Partnerships with government agencies and farmer groups help with access to training and financial assistance.

d. **Market and Marketing Aspects**

- Understanding market dynamics, demand, and pricing is key to marketing success.
- Distribution efficiency and partnerships with merchants and restaurants help expand the market.

Financial Feasibility

a. Operating costs

Table 5. Total Operational Costs of Respondents in Biofloc Cultivation Businesses in Palu City, Central Sulawesi

Respondents	Commodity	Fish Seed (Rp)	Feed Value (Rp)	Labor Value (Rp)	Electricity	Total
1	Parrot fish	10,000,000	48,960,000	8,000,000	9,600,000	76,560,000
2	Parrot fish	9,100,000	44,460,000	8,000,000	2,800,000	64,360,000
3	Parrot fish	3,150,000	11,863,385	2,250,000	1,125,000	18,388,385
4	Parrot fish	2,100,000	7,560,000	1,575,000	900,000	12,135,000
5	Parrot fish	2,380,000	7,996,800	1,500,000	750,000	12,626,800
6	Parrot fish	630,000	2,457,000	800,000	140,000	4,027,000
7	Parrot fish	490,000	1,666,000	800,000	120,000	3,076,000
8	Parrot fish	7,700,000	34,034,000	12.000,000	3,200,000	44,934,000
9	Parrot fish	4,900,000	27,072,500	6,000,000	3,000,000	40,972,500
10	Parrot fish	1,750,000	7,560,000	1,200,000	800,000	11,310,000
11	Parrot fish	1,680,000	6,854,400	2,000,000	600,000	11,134,400
12	Parrot fish	3,375,000	13,311,000	2,000,000	1,200,000	19,886,000
13	Parrot fish	2,250,000	9,082,800	3,000,000	1,200,000	15,532,800
14	Catfish	9,000,000	27,417,600	1,250,000	500,000	38,167,600
15	Parrot fish	1,500,000	7,830,000	1,350,000	675,000	11,355,000
16	Parrot fish	1,312,500	6,851,250	1,350,000	675,000	10,188,750
Jumlah		**61,317,500.00**	**264,976,735**	**41,075,000**	**27,285,000**	**394,654,235**

Source: Primary data after processing 2024

b. Initial capital

This initial capital calculation serves as the basis for a business feasibility analysis and helps entrepreneurs determine production targets that balance their investment. In the following discussion, we present a table of 6 initial capital requirements for biofloc cultivation:

Table 6 Initial Capital/Investment for Biofloc System Cultivation in Palu City, Central Sulawesi

Respondents	Investment Cost (Rp)
1	120,200,000
2	127,900,000
3	42,650,000
4	31,450,000
5	23,800,000
6	10,850,000
7	8,400,000
8	163,400,000
9	54,500,000
10	27,100,000
11	30,850,000
12	48,850,000
13	39,800,000
14	38,700,000
15	27,150,000
16	39.300,,000

Source: Primary data after processing 2024

c. Cultivation Business Income

Factors influencing income are crucial in assessing the success of a biofloc cultivation business. Furthermore, the income from biofloc cultivation businesses in Palu City can be seen in Table 7 below:

Table 7 Income from biofloc cultivation systems in Palu City, Central Sulawesi

Respondents	Income Rp/Year
1	331,500,000
2	298,350,000
3	71,400,000
4	51,000,000
5	41,616,000
6	13,770,000
7	12,138,000
8	238,425,000
9	126,437,500
10	57,375,000
11	52,020,000
12	97,537,500
13	66,555,000
14	195,840,000
15	51,000,000
16	44,625,000

Source: Primary data after processing 2024

Benefit Cost Rasio

The Benefit Cost Ratio (BCR) measures the ratio of economic benefits gained to costs incurred. A BCR value greater than 1 indicates that the venture is financially feasible and profitable. The BCR values from respondents are shown in Table 8.

Table 8 Benefit Cost Ratio

Respondents	BCR value
1	1,36
2	1,43
3	1,33
4	1,44
5	1,26
6	1,29
7	1,44
8	1,26
9	1,45
10	1,53
11	1,47
12	1,55
13	1,29
14	1,05
15	1,60
16	1,46

Break Even Point

BEP analysis also helps identify opportunities to improve efficiency and profitability, for example by reducing costs or finding markets with higher selling prices. The following discussion will review the BEP analysis results from biofloc farming respondents to provide insight into business sustainability, as shown in Table 9 below:

Table 9. Break even point of biofloc system cultivation in Palu City, Central

Respondents	(Rp)	Kg
1	46,587	8,550
2	47,926	7,916
3	57,269	2,264
4	55,733	1,574
5	57,937	1,335
6	66,540	507
7	58,891	396
8	62,730	8,280
9	47,649	3,335
10	47,921	1,522
11	54,090	1,558
12	48,759	2,633
13	58,367	2,151
14	28,802	9,025
15	49,231	1,390
16	66,613	1,646

Source: Primary data after processing 2024

Payback Period

The following discussion will explain the payback period calculations obtained from several respondents in biofloc fish farming businesses. This is shown in Table 10 below:

Table 10 Payback period of biofloc system cultivation business in Palu City, Central Sulawesi

Respondents	PP Value	Day
1	1,360960145	497
2	1,424149296	520
3	2,391055911	873
4	2,019780361	737
5	2,740773497	1000
6	3,544361688	1294
7	2,258793159	824
8	3,273827431	1195
9	1,390927072	508
10	1,369932262	500
11	1,851318427	676
12	1,41649631	517
13	2,661744446	972
14	4,340745128	1584
15	1,423478215	520
16	2,810957728	1026

Source: Primary data after processing 2024

Marketing Channels

The biofloc fish marketing channel in Palu City involves three main parties: farmers, collectors, and restaurants. The marketing process is as follows:

1. Farmers sell the fish to collectors at a set price.
2. Pedagang Collectors then sell the fish to restaurants or eateries at a higher price after covering marketing costs such as transportation and packaging.

Table 11. Marketing Costs, Profits, and Marketing Margins for Tilapia

No	Marketing Agency	Marketing Cost (Rp)	Fish Price/Kg (Rp)
1	**Cultivators**	-	Rp 42.500
2	**Collector Trader**		
	Purchase price		Rp 40.000
	Selling price		Rp 50.000
	Profit		Rp 10.000
	Total Marketing Cost	Rp 2.500	
	Marketing Margin		**Rp 7.500**

Source: Primary data after processing 2024

Table 12. Marketing Costs, Profits, and Marketing Margins for Catfish

No	Marketing Agency	Marketing Cost (Rp)	Fish Price/Kg (Rp)
1	**Cultivators**	-	Rp 25.000
2	**Collector Trader**		
	Purchase price		Rp 22.500
	Selling price		Rp 30.000
	Profit		Rp 7.500
	Total Marketing Cost	Rp 2.500	
	Marketing Margin		**Rp 5.000**

Source: 2024 Research Data Analysis Results

SWOT Analysis

1. Strategy Formulation

The results of the quantitative analysis between internal and external factors in the biofloc fish farming system will be accumulated in a SWOT diagram to determine the quadrant location. This point can then be used as a reference in determining alternative strategies, which are in accordance with the quadrant where the point is located. Based on the internal and external factors data, the weighted scores are obtained as follows: strength factor = 1.68061, weakness factor = 1.21187, opportunity factor = 1.34260 and threat factor = 1.08409.

The weighted scores above are then plotted on a SWOT diagram analysis image consisting of four quadrants, namely from the intersection of the four lines of strengths, weaknesses, opportunities, and threats. The quadrant position of the biofloc fish farming business development system in Palu City, Central Sulawesi, formulated in the SWOT diagram is shown in Figure 2 below:

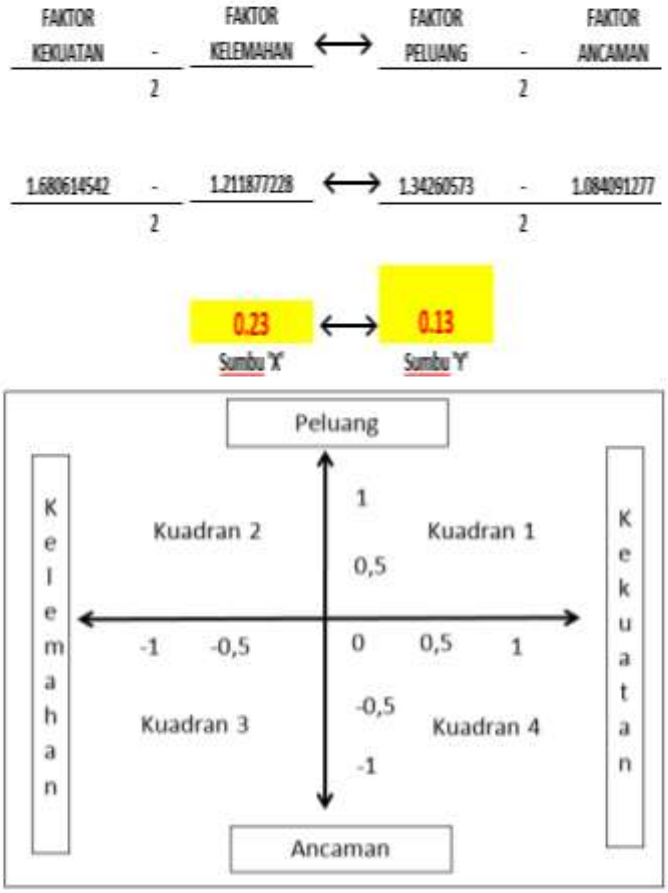

Figure 1. SWOT diagram

2. Strategy Determination

Based on the stages in the SWOT analysis, after the IFAS and EFAS analysis and the SWOT diagram, the next stage is to create a SWOT matrix diagram. The purpose of the SWOT matrix diagram is to determine the S-O strategy (use strengths to take advantage of opportunities in making decisions), W-O (use opportunities to overcome weaknesses), S-T (use strengths to avoid threats) and W-T strategy (minimize weaknesses and avoid threats).

Table 13. Strategic Planning

IFAS / EFAS	**Strengths** S1. Increasing production efficiency through the biofloc system. S2. Reduced feed costs with the addition of biofloc microorganism feed. S3. Stable water quality and longer shelf life. S4. Increased fish productivity. S5. Reduced environmental pollution due to reduced organic waste.	**Weakness** W1. High initial investment W2. Biofloc technology requires a high level of technical knowledge W3. Difficulty obtaining quality seeds W4. High risk of failure if the system is not managed properly W5. Limited mastery of the technology by local farmers
Opportunities O1. High selling price for live fish O2. Government support through technology and aid. O3. Marketing potential for biofloc-cultured fish O4. Increasing innovation in biofloc technology O5. Opportunities for collaboration with the private sector and research institutions	1. Utilize government support and cooperation with the private sector to increase production efficiency through the biofloc system. 2. Optimizing the use of biofloc technology to increase fish productivity and target markets with high selling prices. 3. Increase marketing of quality fish by taking advantage of high selling price opportunities for live fish products. 4. Producing feed independently to reduce costs and increase the efficiency of the biofloc system.	**Strategi (W-O)** 1. Utilize government assistance for high initial investment and technical training for farmers. 2. Leverage potential collaborations with research institutions to address limitations in technical knowledge and seed quality. 3. Utilize emerging biofloc technology innovations to increase production and reduce the risk of failure in system management. 4. Develop breeding techniques to produce high-quality seeds with government support, research, and innovation..
Threats T1 Competition with traditional farming methods T2. High prices for feed and seeds T3. Changing environmental conditions affecting biofloc systems T4. Difficulty in accessing capital for farmers to develop biofloc systems T5. Development of more efficient and affordable competing technologies	**Strategy (S-T)** 1. Reduce feed costs using biofloc microorganism feed to address high feed prices. 2. Utilize the stable water quality of a closed-environment biofloc system to cope with changing environmental conditions. 3. Leverage the advantages of biofloc fish to compete with traditional farming methods.	**Strategy (W-T)** 1. Improve technical training and knowledge for farmers to reduce the risk of failure. 2. Expand access to capital by supporting government and private companies to overcome the high initial investment barrier. 3. Use technological innovation to reduce dependence on high-quality seeds, which are difficult to obtain.

DISCUSSION

Overview of Research Location Business

Research results show that fish farming in Palu City is still dominated by small-scale businesses using conventional farming systems. Although some farmers have tried implementing biofloc systems, limited funding and a lack of knowledge are major obstacles to their implementation.

The high demand from the local market, which still relies on fish supplies from outside the region, indicates a significant opportunity for local farmers to increase their production capacity. Furthermore, the presence of active farmer groups also has the potential to support increased production through knowledge transfer and technological innovation.

Respondent Characteristics

a. **Respondent Age**

The majority of respondents were aged between 33 and 43, a productive age group with a high adaptability to innovation. This group is more open to new technologies like biofloc than older farmers. However, the 44-51 age group continues to contribute significantly to aquaculture businesses, given their greater experience.

b. **Respondents' Education Level**

The majority of respondents had a high school or bachelor's degree, indicating that most farmers have sufficient capacity to understand and implement innovations in fish farming. Higher education contributes to increased business efficiency, particularly in the implementation of biofloc systems, which require a more in-depth technical understanding.

c. **Number of Family Dependents**

Most respondents had family members ranging from 1-3 people, allowing them to focus more on running their farming businesses. Having fewer family members also provided flexibility in allocating resources to business development.

d. **Cultivation Experience**

All respondents had two years of aquaculture experience, indicating they had passed the initial adaptation stage to the biofloc system. This experience is crucial for business sustainability, as the longer someone has been involved in aquaculture, the greater their skills and understanding of the system.

Aspects that influence fish cultivation using the biofloc system

a. **Aspek Technical Aspects**

Biofloc technology reduces nitrogen waste and increases feed efficiency, but requires optimal aeration to maintain water quality. Selecting a suitable location with access to electricity and roads simplifies operations. Strict standard operating procedures (SOPs) for water maintenance and feeding will improve fish survival.

b. **Managerial Aspects**

Good planning encompasses production targets, maintenance schedules, and cost efficiency. Decisions regarding quality feed and modern technology will support business sustainability.

c. **Social Aspects**

Public acceptance of biofloc technology and partnerships with institutions are crucial for expanding business networks. Public awareness of the benefits of biofloc can increase community involvement in the industry.

d. **Market and Marketing Aspects**

Effective marketing requires an understanding of market trends and consumer preferences. Collaborating with distributors and restaurants, as well as optimizing distribution, can help increase profits and competitiveness.

Financial Feasibility

a. Operating costs

The details of expenses in biofloc fish farming in Palu City varied among respondents. Feed was the largest cost component, reaching Rp. 264,976,735 or 67.1% of the total operational costs, emphasizing the importance of efficiency in its use. Other costs included fish seeds at Rp. 61,317,500 (15.5%), labor at Rp. 41,075,000 (10.4%), and electricity at Rp. 27,285,000 (6.9%), indicating the high energy requirements for aeration and water circulation. Differences in business scale affected total operational costs, with the highest expenditure reaching Rp. 76,560,000 and the lowest at Rp. 3,076,000. Most respondents cultivated tilapia, while one respondent cultivated catfish with an operational cost of Rp. 38,167,600. The type of fish and the management strategy implemented influenced total expenses. To increase efficiency and profitability, cost optimization strategies are needed, especially in feed management and energy use. Regulating the amount and frequency of feeding and selecting energy-efficient aerators can help reduce costs. With the right strategy, biofloc fish farming in Palu City has the potential to grow and become sustainably profitable.

b. Initial capital

The table of initial capital for biofloc cultivation systems in Palu City shows significant investment variation among respondents. The highest investment reached IDR 163,400,000, while the lowest was only IDR 8,400,000, reflecting differences in business scale and production capacity. Large investments generally include the construction of biofloc ponds, aeration systems, water pumps, and supporting equipment to increase efficiency and productivity. Most respondents had investments in the range of IDR 20,000,000 to IDR 50,000,000, indicating a small to medium-sized business scale. Meanwhile, those with investments above IDR 100,000,000 tended to operate larger-scale businesses with higher production capacities. Although biofloc technology offers good profit potential, a large initial capital is a determining factor in business sustainability. An effective investment strategy is needed to optimize yields with better cost efficiency. Optimizing pond construction, selecting efficient raw materials, and implementing energy-efficient technologies can help reduce costs without compromising productivity. Furthermore, access to financing or assistance from the government and related institutions can be a solution for farmers with limited capital. Biofloc cultivation offers flexibility in scale, allowing it to be adapted by businesses with varying capital capacities. Respondents with low investment can be provided with training or access to simple technology to remain competitive, while those with large investments need to focus on optimizing management to maximize returns on their large capital.

Cultivation Business Income

The table of annual income from biofloc farming systems in Palu City shows significant variation among respondents, with the highest income reaching IDR 331,500,000 per year and the lowest IDR 12,138,000 per year. This difference reflects business scale, production management efficiency, and technical factors such as fish species, stocking density, feed management, and water quality in the biofloc system. Higher income is also associated with an optimal number of harvest cycles. Most respondents had annual incomes in the range of IDR 40,000,000 to IDR 100,000,000, indicating a medium-scale business. Several respondents with incomes above IDR 200,000,000 reflect the high profit potential of biofloc farming systems if properly managed. The efficiency of this system can accelerate fish growth and reduce operational costs, resulting in optimal profits. However, low incomes among some respondents indicate challenges in production efficiency, fish selling prices, and market access. This income variation demonstrates the flexibility of biofloc farming systems to be implemented at various business scales. To increase revenue, low-income businesses need access to better technology and effective marketing strategies. Meanwhile, high-income businesses can focus on product diversification and business expansion to optimize market share. These efforts are crucial for increasing the competitiveness and economic contribution of biofloc cultivation in Palu City.

Benefit Cost Rasio

A Benefit Cost Ratio (BCR) analysis of biofloc fish farming businesses in Palu City showed values ranging from 1.05 to 1.60, indicating that all businesses studied were profitable. Respondents with the highest BCR (1.60) demonstrated high efficiency in feed use, water management, and marketing strategies, while those with the lowest BCR (1.05) were still profitable but with smaller margins. The majority of farmers had a BCR above 1.30, reflecting good economic potential (Dewi & Anisa, 2019; Fattah *et al*., 2023). Increasing profits requires operational efficiency, appropriate technology, policy support, and market access.

Break Event Point

Break-even point (BEP) analysis of biofloc farming businesses in Palu City showed variations in BEP values among respondents, ranging from IDR 28,802 to IDR 66,613. Respondents with the lowest BEP (IDR 28,802) had better operational efficiency, while those with the highest BEP (IDR 66,613) faced the challenge of greater investment costs (Wahyuni et al., 2020). The majority of respondents had BEPs in the range of IDR 46,587–IDR 66,540, reflecting differences in financial management strategies and business success rates (Manuho et al., 2021). Furthermore, production BEPs ranged from 396 kg to 9,025 kg, indicating that larger production scales tend to yield better profits, although this still depends on cost efficiency and marketing strategies. Overall, biofloc cultivation businesses have good prospects, especially for those who are able to optimize the use of feed and technology to reduce production costs and increase business sustainability (Marisda & Anisa, 2019).

Payback Period

An analysis of the payback period for biofloc farming businesses in Palu City shows variations in investment return time between respondents, ranging from 152 days (approximately 5 months) to 1460 days (approximately 4 years). Respondents with shorter payback periods, such as Respondent 12 (152 days), demonstrated high operational efficiency, while those with longer periods, such as Respondent 7 (1460 days), faced challenges in profitability and financial management (Fahmi *et al*., 2023). This difference is due to factors such as business scale, production costs, and marketing strategies implemented. Respondents with payback periods of less than one year had more viable businesses and achieved financial stability more quickly. Conversely, those requiring more than two years needed to optimize costs and improve production efficiency to increase business viability (F. P. Putri, 2020). With better managerial strategies, biofloc farming businesses can reach break-even more quickly and increase their competitiveness in the market (Pasien & Studi, 2024).

Marketing Channels

Marketing margin analysis shows that the difference between the price received by farmers and the price paid by end consumers varies across commodities. For tilapia, the marketing margin reaches IDR 7,500/kg, while for catfish it is only IDR 5,000/kg. This difference reflects the higher profit margin for tilapia compared to catfish, thus giving tilapia a higher market value (Yunita *et al*., 2021). In terms of marketing channel efficiency, farmers incur no additional marketing costs, while collectors bear marketing costs of IDR 2,500/kg, which include transportation and labor. The higher selling price of tilapia compared to catfish indicates that tilapia is in a more premium market segment. This factor is one reason why the marketing margin for tilapia is higher than that for catfish. The implication of this analysis for business actors is that tilapia farmers receive a higher selling price than catfish farmers, indicating a more promising market opportunity for tilapia. Furthermore, collectors earn similar profits between the two commodities, namely IDR 10,000/kg for tilapia and IDR 7,500/kg for catfish, even though marketing costs remain low. Distribution efficiency that does not require special packaging and minimal transportation costs are key factors in maintaining optimal profits (R. K. Putri & Nurmalina, 2018). To improve marketing efficiency, farmers can consider marketing strategies that are more direct to restaurants or end consumers to reduce the role of collectors in the distribution chain, thereby significantly increasing profit margins.

SWOT Analysis

1. SWOT Analysis and Formulation of Strategy for Developing Biofloc Fish Farming Business

The SWOT analysis shows that the development of biofloc fish farming in Palu City has key strengths in production efficiency, reduced feed costs, stable water quality, increased fish productivity, and a contribution to reducing environmental pollution. However, challenges include high initial investment, the need for in-depth technical knowledge, the difficulty of obtaining quality seeds, and the risk of failure in system management. In terms of opportunities, the high selling price of live fish, government support, the development of technological innovations, and the potential for collaboration with the private sector are driving factors for business sustainability. On the other hand, threats such as competition with traditional cultivation methods, fluctuations in feed and seed prices, and changes in environmental conditions can hinder the development of this system. The SWOT analysis places biofloc farming in Quadrant 1 (Strength-Opportunity/SO), which emphasizes offensive strategies by leveraging internal strengths to capture market opportunities. Key strategies that can be implemented include increasing production capacity, optimizing biofloc technology, and strengthening collaboration with the government and private sector to support business development. Furthermore, innovations in biofloc system management, including independent feed production and waste management, can improve business efficiency and competitiveness sustainably. With the right strategy, biofloc fish farming has the potential to become a leading sector that not only increases economic productivity but also contributes to environmental sustainability and food security in Palu City.

CONCLUSION

The results of the study indicate that fish farming in Palu City is still dominated by small-scale, conventional systems, despite the potential for developing biofloc systems. The main obstacles to implementing biofloc systems are limited funding and a lack of technical knowledge. Respondent characteristics indicate that the majority are of productive age and have a relatively high level of education, thus potentially adopting technological innovations. From a technical perspective, the biofloc system offers efficiency in managing nitrogen waste and feed, but requires optimal management. Financially, this business has good prospects with a positive profit ratio, although there are variations in initial capital, income, and payback period. A SWOT analysis identified that the main strengths of the biofloc system are production efficiency and environmental stability, while the main challenges are investment costs and the need for specialized skills. With the right strategies, including cost optimization, increased access to financing, and more efficient marketing strategies, fish farming using the biofloc system in Palu City has the potential to grow sustainably and provide greater profits for local farmers.

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REFERENCES

Aisyiah, N., Kurniati, D., & Maswadi. (2024). Pengaruh penggunaan sistem bioflok pada produktivitas & kelayakan usaha pembesaran ikan lele konsumsi di Kota Pontianak. *Jurnal Pemikiran Masyarakat Ilmiah Berwawasan Agribisnis*, 10(2), 2102–2109.

Az, R. S. (2022). *Analisis usaha pembesaran ikan nila (Oreochromis niloticus) menggunakan sistem bioflok dengan pakan tambahan azolla (Azolla microphylla) (Studi kasus M Idris Aqua Fams di Desa Pulau Punggung Kecamatan Semende Barat Laut Kabupaten Muara Enim)* (Skripsi, Fakultas Pertanian, Universitas Sriwijaya).

Damayanti, Y. (2012). Kontribusi perikanan tangkap terhadap penyediaan pangan ikan dalam mendukung ketahanan pangan di Provinsi Jambi. *Buletin PSP*, 20(1), 81–87.

Dewi, M. H., & Anisa. (2019). Penerapan teknologi bioflok budidaya ikan nila untuk pemanfaatan pekarangan rumah nonproduktif. *Jurnal Pengabdian Kepada Masyarakat SEWAGATI*, 3(3), 79–84.

Fahmi, R. M., Sundari, R. I., & Hidayati, R. (2023). Analisis usaha budidaya pembesaran ikan nila secara intensif dengan sistem bioflok. *Jurnal Teknologi Pangan dan Ilmu Pertanian*, 1(3), 112–123.

Fattah, M., Tjahjono, A., Ghuffron, M. S., Sofiati, D., Aisyah, D., & Anandya, A. (2023). Revenue cost analysis dalam mengukur profit usaha budidaya ikan lele mutiara (*Clarias gariepinus*) sistem bioflok PT Abai Kota Malang. *Jurnal Ilmu Perikanan & Kelautan*, 5(2), 201–212.

Indariyanti, N., Febriani, D., Verdian, H. A., & Prastiti, A. L. (2024). Penerapan teknologi bioflok pada pembesaran lele di Pokdakan Mina Karya Desa Way Dadi Sukarame Kota Madya Bandar Lampung. *Jurnal Pengabdian Nasional*, 5(1), 42–48.

Manuho, P., Makalare, Z., Mamangkey, T., & Budiarso, N. S. (2021). Analisis break even point (BEP). *Jurnal Ipteks Akuntansi Bagi Masyarakat*, 5(1), 21.

Marisda, D. H., & Anisa. (2019). Penerapan teknologi bioflok budidaya ikan nila untuk pemanfaatan pekarangan rumah nonproduktif. *Jurnal Pengabdian Kepada Masyarakat*, 3(3), 79–84.

Marlida, R. (2020). Bioflok sebagai solusi mengatasi permasalahan lingkungan untuk akuakultur masa depan berkelanjutan. *Jurnal Sains STIPER Amuntai*, 10(1), 38–45.

Pangaribuan, D. R., & Sembiring, J. (2022). Pembuatan teknologi bioflok untuk pemeliharaan ikan gabus di Kampung Tambat. *Jurnal Dinamika Pengabdian*, 7(2), 213–225.

Putri, F. P. (2020). Peningkatan efektivitas dan efisiensi manajemen rantai pasok agroindustri buah: Tinjauan literatur dan riset selanjutnya. *Jurnal Teknologi Industri Pertanian*, 30(3), 338–354.

Putri, R. K., & Nurmalina, R. (2018). Analisis efisiensi dan faktor yang memengaruhi pilihan saluran pemasaran. *MIX: Jurnal Ilmiah Manajemen*, 8(1), 109–135.

Rusandi, & Rusli, M. (2015). *Merancang penelitian kualitatif dasar/deskriptif & studi kasus*. Literasi Media Publishing.

Sefianingsih, D., Purbomartono, C., Rijal, A. M., Rochmayati, J., & Tumisem. (2023). Penerapan teknologi bioflok dalam pembenihan ikan nila (*Oreochromis niloticus*) di Madrasah Aliyah (MA) Miftahussalam Banyumas. *UMP Proceedings Series on Physical & Formal Science*, 5, 129–134.

Supriyono. (2011). *Akuntansi manajemen*. Rajawali Pers.

Uliya, & Gusniyati, R. (2018). Analisis margin pemasaran ikan dalam keramba di Kecamatan Pemayung Kabupaten Batang Hari. *Prosiding Seminar Nasional Fakultas Pertanian*, Universitas Jambi.

Wahyuni, Y., Yulinda, E., & Bathara, L. (2020). Analisis break even point & risiko usaha pembesaran ikan nila (*Oreochromis niloticus*) dalam keramba jaring apung (KJA) di Desa Pulau Terap Kecamatan Kuok Kabupaten Kampar Provinsi Riau. *Jurnal Sosial Ekonomi Pesisir*, 1(1), 22–33.

Yanti, R. (2023). *Analisis kelayakan finansial usaha pembesaran ikan nila dengan sistem bioflok* (Skripsi, Fakultas Pertanian, Universitas Lampung).

Yunita, R., Syahril, S., & Noviar, H. (2021). Analisis perkembangan farmer's share dan marketing margin padi di Indonesia tahun 2010–2020. *Ekombis: Jurnal Fakultas Ekonomi*, 7(2), 90.

Zain, A. M., & Febrianty, I. (2018). Strategi pengembangan usaha budidaya ikan di kawasan minapolitan Kabupaten Banjar dalam menghadapi persaingan masyarakat ekonomi ASEAN. *Prosiding Seminar Nasional Lingkungan Lahan Basah*, 3(2), 535–539.