Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 28(4): 1591 – 1622 (2024)
www.ejabf.journals.ekb.eg

Socio-Ecological Impacts and Business Analysis of the Climbing Perch (*Anabas testudineus* bloch) in the Biofloc System

Agussyarif Hanafie*, Akhmad Murjani, Muhammad Adriani, Junius Akbar
Aquaculture Departement, Fisheries and Marine Science Faculty,
Lambung Mangkurat University Banjarmasin, Indonesia
***Corresponding Author**: agus.shanafie@ulm.ac.id

ARTICLE INFO
Article History:
Received: July 23, 2024
Accepted: Aug. 9, 2024
Online: Aug. 16, 2024

Keywords:
Climbing perch,
Biofloc,
Social impact,
Ecological impact,
Business income

ABSTRACT

The objectives of this study were to analyze the socio-ecological impact and to conduct simple business analysis of tuna (*Anabas testudineus* Bloch) in a biofloc system. The average public perception was 4.3820, which when compared with the range of Likert score values, is considered high. A high score indicates that the public's perception of biofloc system aquaculture is very supportive. The implication for the climbing perch waste is that the biofloc system can be disposed into the environment and can be used to raise fish and vegetable crops. The total production and equipment costs in this study were Rp8,652,718, with total sales of Rp15.400.000. The income obtained during one period (7 months) was Rp6,747,282, with an average monthly income of Rp963,897.43. When linked to the 2024 South Kalimantan UMR standard, to achieve an income of Rp3,282,812.11, a minimum of four maintenance ponds with a diameter of 2 meters are required under normal conditions, without disease attacks, and using the high-quality female climbing perch seeds. Therefore, the climbing perch aquaculture using a biofloc system is worth pursuing. The combined findings from all research suggest that rearing 75-100% female climbing perch fish with a seed size of approximately 7cm in a biofloc system, at a density of 1 fish per 1-2 liters, is technically feasible, economically viable, and environmentally friendly.

INTRODUCTION

The blue transformation vision that was released by FAO in 2021 aimed to maximize opportunities for a sustainable aquatic food system to enhance food security, increase nutrition, reduce poverty, and contribute to the achievement of sustainable development agenda 2030 **(FAO, 2022)**. Among the three global goals to be achieved through the transformation of aquatic food systems in 2030 and beyond, which align priority policies and actions are (1) sustainable expansion and intensification of aquaculture that meet the growing worldwide demand for equitable aquatic food sources while ensuring equitable distribution of benefits; (2) management of effective fisheries that ensures healthy fish stocks and equitable livelihoods, and (3) improved fisheries value chains that ensure environmental, economic and social sustainability of equitable food systems **(FAO, 2024)**.

Rising global food demand, driven by the world's growing population, which is projected to reach 8 billion by 2022, has led to an intensified production of farmed aquatic animals **(McCusker *et al.*, 2023)**. However, the sustainable development of the aquaculture industry is hampered by the limited availability of natural resources and their negative impact on the surrounding environment **(Mugwanya *et al.*, 2021)**. Aquaculture, through the production of aquatic animals and plants, offers a potential solution to reduce, rehabilitate, and even prevent the extinction of various aquatic fish species. Due to limited fish resources globally, the demand for fish as food is increasing. This is the reason why today, of the total amount of globally consumed fish, 50% originates in aquaculture. In addition to the main role of aquaculture, it is also an important way to renew populations of rare fish and other aquatic organisms in their natural habitat **(Araujo *et al*., 2022; Marković & Poleksić, 2023)**. Increasing aquaculture production needs to be sustainable in several aspects of activity, including the use of aquaculture systems that reduce water requirements, reducing dependence on space for increased production and the availability of natural complementary feed **(Oliveira *et al.*, 2024)**. There is a need for water technology innovation that can stimulate increased livelihood resilience of small farmers **(Ogelloa *et al.*, 2021)**. Aquaculture is considered a rising sector in terms of growth across the world. There is an urgent need to ensure that this growth is sustainable to protect the environment and preserve the world's natural resources **(Mahanand & Pandey, 2021)**.

The biofloc technology (BFT) was identified as an impressive and environmentally sustainable farming method, especially beneficial to tropical warm-water species. This technology is largely utilized in intensified aquaculture of a number of different aquatic types for its ability to reduce the water exchange rate significantly, thereby improving both the yield system and the environmental benefits. The potency of BFT in aquaculture operation is clearly linked to the proper organization of the quality parameters of the water within the optimum limits of the host species since they have a direct influence on the outcome of the unit production. Basically, BFTs act as a water balance and control system, transforming the dangerous nitrogen effluents such as ammonia and nitrite into less harmful forms like nitrates by microbial movement, thus protecting the safety of all living aquatic species **(Mahanand & Pandey, 2021; Mugwanya, *et al.*, 2021; Chirwa *et al.*, 2023; McCusker *et al.*, 2023; Basumatary *et al.*, 2024; Bilal *et al.*, 2024; Kumar *et al.*, 2024)**. The main environmental parameters like temperature, pH, dissolved oxygen (DO), alkalinity, salinity, TAN (total ammonia nitrogen), nitrate-nitrite, suspended (SS) solids, and TSS can affect the development of the aquatic life species and microbial function **(Khanjani *et al.*, 2024)**. Additionally, strategic farming equipment is essential for improving conversion of feed, ensuring bio-security, and recycling wastewater **(Nisar *et al.*, 2021)**.

The rapid intensification of aquaculture systems has caused several environmental impacts including decreased water quality, pollution, and disease outbreaks. Therefore, environmentally friendly techniques are inevitable to guarantee better production with less impact on the environment by minimizing waste discharge from aquaculture practices **(Zafar *et al.*, 2022)**. As an emergency disposal alternative for wastewater, Biofloc Technology (BFT) utilizing microbes offers an additional and sustainable food source for livestock, thereby reducing the demand for artificial feed and decreasing feed conversion ratios **(McCusker *et al.*, 2023)**. Important areas of the emphasis is on the necessity for a greater insight into the sophisticated community of microbes in biofloc rearing systems, in addition to the elaboration of strategies designed to navigate and maximize their organic structural integrity, development, regulation, and activity **(Bilal *et al.*, 2024)**. Moreover, there is a need for practical research to increasing energy and resource efficiency as well as utilizing renewable resources from technology used in aquaculture **(Laktuka *et al.*, 2023)**.

The use of biofloc in aquaculture has recently increased, especially in research related to the survival and growth rate of fish as well as their economic viability. The physiological activity and disease resistance of fish fed biofloc diets is being studied extensively. Standards for an effective application of biofloc in aquaculture are also recommended **(Yu *et al.*, 2023)**. Analyzing the financial aspects linked to the successful automation of aeration system into a biofloc culture system were critical to promoting the sustainability in the aquaculture industry. The efficacy of the aeration system in optimizing oxygen transfer and creating a conducive environment for biofloc breeding confirms this **(Laktuka *et al.*, 2023)**. The development and further implementation of bio-eco-economic fuelled modelling would focus the efforts of the research by providing primary measurement indicators for the use of water, energy, and many other valuable resources. This will improve the efficacy and continuity of the system, taking into account both the financial aspects and environmental concerns. Promotion of biofloc production in the future is favorable since it provides great environmental sustainability opportunities and find innovative ideas to minimize the cost of production, improve efficiency, consistency and increase profits **(Bilal *et al.*, 2024)**. Limited land use causes an unfavorable benefit-expense rate in maintaining social/economic stability. In addition to continuity, fish farmed in BFT also showed enhanced fitness outcomes when challenged with a variety of emerging pathogens **(Kumar *et al.*, 2024)**. In addition, the importance of bioflocs in enhancing water balance, health preventive qualities of fish, shellfish, and their effect on gut flora were also investigated. To further assess the financial viability of implementing BFT and addressing its current and prospective use of implementing the system, as well as the potential to generate an additional income through the biofloc business as a value-added product **(Kumar *et al.*, 2024)**. Produced progress in the survival rate and growth of aquatic species in person affects financing results, meaning higher crop results and improvements in accountability during the long term. Moreover, the prudent utilization of nutrition in the biofloc system, mediated by an advanced aeration facility, is not only promoting the production of cost-effective products, it is in line with environmental friendly practices, tackling both the environmental and economic aspects of farming. The scalability of BFT for widely uptake within bioflocs is likely to be limited by inherent costs, the gaps in technical knowledge, and the many potential users. Since available data show optimal operational costs and good performance of biofloc, this could increase its widespread adoption. On the other hand, sustainable commercial scalability will depend on further research into the optimization of FBT in biofloc. Overall, BFT is on the way to commercial success to promote environmentally friendly biofloc aquaculture **(Laktuka *et al.*, 2023)**.

Biofloc aquaculture research is predominantly focused on various aspects of the system, including its efficiency, sustainability, and impact on fish health and growth. This technology primarily uses shrimp and tilapia, but it can be applied to a wider range of species, particularly those that can tolerate bioflocs. The tilapia (*Oreochromis niloticus*) and the white shrimp (*Penaeus merguiensis*) have been extensively used in research due to their adaptability and lower carnivorous nature **(Hargreaves, 2013; Khanjani *et al.*, 2023; McCusker *et al.*, 2023)**. Research on the climbing perch (*Anabas testudineus* Bloch) in biofloc systems has also begun, focusing on stocking density **(Debnath *et al.*, 2022; Arnuparp *et al*., 2020)**. Recent studies **(Hanafie, 2020; Hanafie *et al.*, 2023a, b)** have shown promising results in this area. However, there has been a lack of research on the social-ecological impacts and business analysis of this system. This study aimed to address this gap by analyzing the social and ecological impacts of the climbing perch aquaculture in a biofloc system, as well as conducting a business feasibility analysis, including community perception, ecological assessment, and economic viability.

MATERIALS AND METHODS

Research design

To map the distribution of biofloc system aquaculture businesses and explore their social and ecological impacts, we employed a delineation approach. This method involved:

Data collection: Direct observation techniques were utilized to gather data in the field. This included visiting various biofloc system aquaculture sites to assess their distribution and operational practices.

Analysis: The collected data were analyzed to understand the relationships between the use of biofloc technology and its social and ecological effects. This analysis provided insights into the implementation and impact of biofloc systems within the aquaculture sector.

Data types and sources

The collection of social data for the preparation of marketing network map analysis and the dynamics of biofloc system aquaculture utilization were obtained through interviews and direct observation of selected biofloc system aquaculture users. The respondents interviewed were 15. Secondary data were collected from sources relevant to this research. Secondary data sources were selected structurally starting from the village/sub-district, sub-district, district/city, provincial to central levels, with various institutions related to the research objectives, such as the South Kalimantan provincial Maritime and Fisheries Service, and the KKP, as well as literature studies. Ecological data were obtained from studies one and two. Simple business analysis data were obtained from business calculations carried out by the community and comparable to the results of studies-1 and 2.

Sampling and data collection techniques

Collecting primary data for BFT users was achieved by conducting in-depth interviews to explore perceptions and record data on fixed costs, variable costs, sales results of respondents periodically, and the results were then averaged. Data collection was carried out by appointing 15 respondents. Information about respondents was obtained from local extension officers (PPL) and related agencies. Moreover, research on social impacts on the climbing perch aquaculture biofloc system was obtained from data collection by distributing questionnaires to users, local communities, fisheries PPL and other stakeholders to detect perceptions compared to score values.

Analysis method

Public perception analysis method

Data on public perception of the climbing perch aquaculture biofloc system was compiled tabulatedly, compared with existing criteria or standards, including perceptions of fisheries aquaculture, waste and water management, and increasing income. Analysis of community perception and participation was conducted using a Likert scale. To measure someone's agreement and disagreement with an object, the levels consisted of:

1. Strongly agree
2. Agree
3. Neutral between agree and not (undecided)
4. Don't agree
5. Strongly disagree

Data analysis continued with a quantitative descriptive approach with the following formulation:

1. Average score

$$\text{Average score} = \frac{\Sigma\ (\text{question score} \times \text{score frequency})}{N}$$

2. **Scale range (SR)**

$$SR = \frac{(m-1)}{m}$$

information :
N = number of samples
M = number of alternative answers for each item

$$RS = \frac{(5-1)}{4} = 0.80$$

Table 1. Scoring range and description

Score	Description		
1.00 – 1.79	Strongly disagree	Very damaged	Very annoying
1.80 – 2.59	Don't agree	Damaged	Often annoying
2.60 – 3.39	Undecided	50% damaged	Bother
3.40 – 4.19	Agree	Good	Sometimes
4.20 – 5.00	Strongly agree	Very good	Do not disturb

Hypothesis test

Ho = accepted if the community does not support biofloc system aquaculture

H1 = accepted if the community does not support the biofloc aquaculture system

Ecological analysis methods

Ecological data were analyzed by comparison of water condition variable values with aquaculture values and environmental quality standards. Water quality criteria were assessed based on their grade relative to quality standards and permissible limits for wastewater discharge into the environment.

Simple business analysis

The business analysis calculations in this research refer to the ongoing implementation of the biofloc aquaculture system and simulation of research results, which produce the best data from a series of research that has been carried out. Analysis of a simple climbing perch aquaculture business with a biofloc system includes the following components:

A. Equipment purchase costs

1. Round pool tarpaulin
2. Iron wire size
3. Intake and exhaust pipes
4. AeratorComplete Unit
5. Scales
6. Fishing tools
7. Drugs

B. Production costs

1. Estimated price of the climbing perch fish deed
2. Media ingredients (probiotics, dolomite lime, salt, chlorine, molasses, etc.)
3. Feed

C. Proceeds from sales of rock climbing harvests

Fish harvest size × Current price (estimated)

D. Calculation of profit and loss

1. Profit: Sales - (Equipment costs + Production costs)
2. Total profit based on the number of pools
3. Revenue for one maintenance cycle

Descriptive analysis was employed in this research, focusing on quantitative data. The research data are presented using tabulations, histogram graphics, and qualitative explanations of processed images and graphs. This approach was selected to meet the analytical needs and achieve the research objectives effectively.

RESULTS

Analysis of public perceptions of the biofloc system

In general, the respondents' profiles are well-suited for biofloc system aquaculture businesses, except for income level and experience in the field. It is assumed that respondents are motivated to increase their income and gain experience through this business. The biofloc system's climate is consistent, with no seasonal variations and no need for water changes.

A significant 78% of respondents agreed or strongly agreed on the importance of water quality, a fundamental principle in fisheries aquaculture. All respondents (100%) agreed or strongly agreed that water quality parameters are crucial in aquaculture, and recognize the importance of soil texture in supporting the weight of maintenance media (water and fish) in biofloc ponds. Furthermore, 91% of respondents strongly agreed that paved roads provide an essential infrastructure for biofloc aquaculture.

The quality and availability of seeds are considered very supportive factors by 100% of the respondents, and marketing is viewed as essential for achieving optimal results. Similarly, 100% of respondents strongly agreed that fish marketing must carefully consider profitability and production costs. Based on public perception, 94% of the respondents find biofloc system aquaculture easy to implement, while a minority find it challenging.

The quality and availability of seeds are considered very supportive factors by 100% of the respondents, and marketing is viewed as essential for achieving optimal results. Additionally, all the respondents (100%) strongly agreed that fish marketing must carefully consider profitability and production costs. Public perception indicates that 94% of the respondents find the biofloc system aquaculture easy to implement, with only a minority finding it challenging.

Furthermore, 94% of the respondents believe that the market opportunity for the climbing perch fish is quite promising and substantial. Of those surveyed, 42% of them are aware of biofloc system aquaculture, with 33% possessing a high level of knowledge about it. Additionally, 83% of the respondents reported that the biofloc system does not cause disturbances to local residents in terms of odors or waste discharge. The average score of public perception regarding the physical and non-physical factors of the climbing perch biofloc system aquaculture is detailed in Table (2).

Table 2. Average score of community perception of physical and non-physical factors of the climbing perch aquaculture biofloc system

NO	Perception	Score value
1	Physical condition factors that encourage the success of the climbing perch biofloc system aquaculture.	3.9583
2	Non-physical condition factors that encourage the success of the climbing perch biofloc system aquaculture.	4.9167
3	Biofloc system aquaculture	4.2709
	Total	13.1459
	Average	4.3820
	Highest score range	4.20 – 5.00

Ecological analysis

Ecological data were analyzed by comparing water quality variable values with aquaculture and environmental quality standard values.

Water quality

The range of water temperature (ºC), acidity (pH), DO (mg/L), and dissolved ammonia (mg/L) for research-1 and research-2 can be seen in Table (3). The results of water quality analysis from research-1 and research-2 were then compared with quality standards and wastewater quality standards that are permitted to be discharged into the environment based on Decrees of the Minister of Environment and Forestry the Republic of Indonesia No. P.68/Menlhk/Setjen/Kum.1/8/2016 concerning the standard quality of domestic wastewater.

Table 3. Water temperature range (ºC), acidity (pH), dissolved oxygen (mg/L) and dissolved ammonia (mg/L) in study-1 and study-2

Treatment	Water temperature (°C)	pH	Dissolved oxygen (mg/L)	Dissolved ammonia (mg/L)
		Study-1		
BFT3	26.60 - 30.10	6.92 - 7.52	6.25 - 7.53	0.23 - 0.62
BFT5	26.60 - 30.10	6.88 - 7.45	5.30 - 8.87	0.27 - 0.53
BFT7	26.60 - 30.10	6.80 - 7.42	6.29 - 6.40	0.33 - 0.65
K3	26.70 - 29.40	6.27 - 6.84	5.49 - 6.24	0.25 - 0.77
K5	26.77 - 29.70	6.19 - 6.75	5.35 -6.30	0.26 - 0.72
K7	26.77 - 29.73	5.77 - 6.79	6.30 - 5.17	0.32 - 0.57

Treatment	Water temperature (°C)	pH	Dissolved oxygen (mg/L)	Dissolved ammonia (mg/L)
Treatment	Water Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Dissolved Ammonia (mg/L)
		Study-2		
B100J0	26.74-27.50	6.57 -7.32	2.98 - 6.30	0.21 - 0.67
B75J25	26.84-28.10	6.64 -7.35	3.64 - 6.28	0.20 - 0.65
B50J50	26.46-27.20	6.70 -7.40	3.58 - 6.10	0.23 - 0.68
B25J75	26.30-27.42	6.63 -7.60	3.46 - 5.98	0.20 - 0.69
B0J100	26.62-27.92	6.31 -7.60	3.16 - 6.34	0.23 - 0.73

Information:

BFT3 = BFT seed size ± 3 cm
BFT5 = BFT seed size ± 5 cm
BFT7 = BFT seed size ± 7 cm
K3 = Conventional seed size is ± 3 cm
K5 = Conventional seed size is ± 5 cm
K7 = Conventional seed size is ± 7 cm
B100J0 = BFT of female fish 100% and male fish 0%
B75J25 = BFT of female fish 75% and male fish 25%
B50J50 = BFT of female fish 50% and male fish 50%
B25J75 = BFT of female fish 25% and male fish 75%
B0J100 = BFT of female fish 0% and male fish 100%

The first trial of biofloc wastewater quality had water temperature values of 25.2 – 26.7°C, acidity between 5.67-6.46, DO between 4.33-3.34mg/ L, dissolved ammonia in the range of 0.55–0.88mg/ L, and biological oxygen requirements (BOD5) in the range of 60.36-101.80mg/ L. The results of the second trial of the biofloc wastewater temperature were recorded at 26.6°C, acidity at 7.22, DO between 1.9-3.06mg/ L and dissolved ammonia between 0.03–1.88mg/ L. The research water quality range values were: for Quality Range 1, water temperature between 26.0 and 30.10°C, pH from 5.77 to 7.52, dissolved oxygen (DO) between 5.30 and 8.87mg/ L, and dissolved ammonia from 0.23 to 0.77mg/ L; and for Quality Range 2, water temperature between 26.30 and 28.10°C, pH from 6.31 to 7.60, DO between 3.16 and 6.34mg/ L, and dissolved ammonia from 0.20 to 0.73mg/ L.

Trial of utilization of the climbing perch biofloc waste

To reduce the waste discharged from the biofloc system maintenance container into the environment, a trial has been carried out: utilization of biofloc waste for aquaculture and vegetable crops. In connection with the climbing perch aquaculture activities using a biofloc system, observations and trials have been carried out on the use of biofloc waste. Some of the impacts of these observations were that many silk worms (*Tubifex* sp.) were found to breed in drains, where silk worms are an important natural food in fish hatchery activities. Other observations showed that plants watered with biofloc waste water showed good growth and development; this shows that biofloc waste water acts as a liquid fertilizer. Some observations of the impacts caused by biofocal wastewater, which is generally disposed of around 5-10L/ day, were as follows:

Test results for the utilization of biofloc aquaculture waste from the climbing perch (*Anabas testudineus* Bloch) for the rearing of the pearl catfish (*Clarias gariepinus*) and the land water spinach (*Ipomoea reptans*). The Budikdamber system did not have a real influence on the relative length growth and relative weight of the pearl catfish, but it did have a real influence on the mortality and FCR of fish reared in the climbing perch biofloc waste waters. From the results, the best relative length growth was in treatment B (100% biofloc waste) at 190.98%, relative weight growth was in treatment D (50% biofloc waste + 50% irrigation water) at 1031.53%, mortality in treatment C (75% biofloc waste + 25% irrigation water) was 97.33%, and FCR in treatment C (50% biofloc waste + 50% irrigation water) was 1.49%. Meanwhile, the effect of maintaining the kale plants on the height of the kale plants and the number of kale leaves was also found in treatment C (50% biofloc waste + 50% irrigation water), namely 26cm and 189.33 (number of leaves). Judging from each parameter of the test fish and water spinach, the best and optimal maintenance dose using biofloc waste was obtained in treatment C, with a dose of 75% biofloc waste + 25% irrigation water. Water quality analysis showed a temperature of 26.06°C, pH of 6.18, dissolved oxygen (DO) of 3.79mg/ L, ammonia level of 0.69mg/ L, and BOD results, all of which support the growth and survival of catfish and water spinach plants.

Simple business analysis

The simple business analysis calculations in this research refer to applications that have been carried out by @akuakultur entrepreneurs in collaboration with the Mina Satu Hati pokdakan in Iwak Village, Mentaos Subdistrict, Banjarbaru City and business analysis simulations by combining current business, ongoing business, and current business walk. The results can be seen in Tables (4, 5).

Table 4. Simple business analysis of the climbing perch fish biofloc system for round ponds measuring 2 meters in diameter

Simple analysis of aquaculture pond diameter climbing perch biofloc system 2 service life 7 years about 11 maintenance cycles			
Equipment Purchase Costs			
Equipment and Materials	Lots	Unit price (Rp)	Total price (Rp)
Complete 2 diameter pool	1	1.500.000	1.500.000
1 Complete aerator unit	1	425.000	425.000.
1 Temperature meter	1	25.000	25.000
1 pH meter	1	65.000	65.000
Ammonia Meter	1	325.000	325.000
Scales	1	200.000	200.000
Fishing equipment	2	50.000	100.000
Total equipment cost			2.640.000
Production Costs (Materials)			
Fry climbing perch size 5-6	2500	320	800.000
Feed PF 500 40% (10 kg)	1	240.000	240.000
Feed PF 1000 39-41% (10 kg)	2	240.000	480.000
Fish Feed LP 1 Protein 32% 30kg	5	400.000	2.000.000
LP2 fish feed 32% protein 30 kg	5	400.000	2.000.000
Probiotics (litre)	1	50.000	50.000.00
Molasses (litre)	2	15.000	30.000.
Dolomite Lime (gram)	1	7.000	7.000.
Chlorine (grams)	0.5	50.000	25.000
Pineapple (fruit	1	8.000	8.000
Salt (kilogram)	4	10.000	40.000
Medicines (sachets)	2	45.000	90.000
Electricity Cost (16.8 kwh)	168	1.444.75	242.718
Cost of depreciation	1	285.714	285.714
Total Production Costs			6.012.718
			Harvest Sales Proceeds
Main Harvest Size < 10/kg	90	90.000	8.100.000
Harvest size 11-13 /kg	85	70.000	5.950.000
Harvest size > 14 /kg	45	30.000	1.350.000
Number of Sales	**220**		**15.400.000**
Profit and Loss Calculation			
Profit: Sales - (Equipment costs + Production costs)			
Sale			

Equipment Costs			2.640.000
Production cost			6.012.718
Total production and equipment			
Costs			8.652.718
Number of sales			15.400.000
Profit (profit) 1 period			6.747.282
1 period = 7 months			
for 11 maintenance cycles	**11**	**5.047.282**	**55.520.102**
for 12 units 1 cycle	**12**	**5.047.282**	**60.567.384**
Under normal conditions good quality seeds			

Table 5. Comparison of average expenditure costs and sales results from 4 businesses carried out per kilogram (Rp)

Information	Biofloc (2024)	Biofloc climbing perch (2018)	Sakti climbing perch irrigation pond (2021)	Bangladesh Pond (Sarker *et al.*, 2014)
Production Cost/kg	46.657.96	38.602.38	43.282.91	21441.4
Profit/kg	70.000.00	53.271.03	65.546.22	24704.2
Difference	23.342.04	14.668.65	22.263.31	3.262.8
Maintenance Container	Diameter of 2 biofloc ponds, one piece	Diameter of 3 biofloc ponds, 24 ponds	pool area 10x10 m	Pool area 1 hectare

DISCUSSION

The average value of public perception is 4.3820, when compared with the range of Likert score values; this perception is classified as high. **Sugiyono (2022)** believed that the Likert scale is used to measure the attitudes, opinions and perceptions of a person or group of people toward social phenomena. Using a Likert scale, each statement item has a graduation from very positive to very negative. According **to Oktopura *et al.* (2020)**, there are seven policy options and strategies that can be recommended to improve the performance of aquaculture fisheries development in all ecosystem typologies in the future, namely (1) increasing managerial capacity and knowledge of fish farmers through technology outreach, training and technical assistance; (2) providing quality production inputs at affordable prices; (3) expansion of product quality and added value markets; (4)

improving the supply chain system for fisheries aquaculture businesses; (5) increasing business scale through technological intensification; (6) research and engineering for the development of technological innovation; and (7) strengthening regulations and simplifying permits related to aquaculture fisheries businesses. The role and involvement of multi-stakeholders, including the central government, regional government, researchers, academics, extension workers, business associations in the fisheries aquaculture sector, fish farmers, traders or exporters, and financial institutions are very necessary in implementing this strategy to achieve optimal results.

The obstacle faced in implementing organic farming/fishing systems is the difficulty of maintaining organic aquaculture, while the obstacles faced in implementing inorganic farming/fishing systems are the high costs required and low selling prices **(Juliantika *et al.*, 2020)**. **Firdiansyah *et al.* (2020)** reported that the people of Enggano Island have a good level of perception (79.00%) and a level of active participation (89.20%) in the management of Marine Protected Areas (KKL); strategies that can be implemented in continuing Marine Protected Areas (KKP). **Ulfa (2018)** stated that the impact of climate change causes people to experience socio-economic problems. In terms of economic problems, the impact of climate change makes people unable to meet their daily needs and vulnerable to poverty, while in social problems, especially fishermen, they are unable to determine the season due to unpredictable weather, long distances to fish and reduced fisheries resources. **Tohari *et al.* (2020)** reported that the economic aspect cumulatively has the highest value (0.73), while the institutional and environmental aspects have the lowest value, namely 0.64 and 0.67, respectively. These results indicate that the main focus of this business is still on economic aspects, while environmental and institutional aspects are still not a priority. **Mappasomba and Haidir (2024)** reported that the level of public understanding and knowledge is still low. Community participation is in the medium category even though it is known that the community's perception of the benefits of the mangrove ecosystem for them is quite good. **Arianti *et al.* (2022)** reported that most farmers felt the negative impact of climate change on freshwater fisheries. Freshwater farmers have the perception that climate change has a negative impact on fisheries. **Marie *et al.* (2024)** reported that BFT, a method that is developing in it, has attracted attention for its continuing adoption in the tilapia aquaculture. By manipulating communities of microbes to produce high density suspensible solids referred to as bioflocs, they serve a dual purpose: supplying a source of nutrients for aqueous organisms and increasing the quality of water by dissolving excessive nutrients. Growing interest in the culture of the tilapia has fuelled the increased use in biofloc systems due to its potential to improve grow-out, lower feed costs, and minimize the impact on the environment. The present review seeks to synthesis comprehensively the latest study, compiled from reputable key databases, with a particular focus on biofloc pond aquaculture in the advanced tilapia aquaculture.

The result of the current study can be summarized as follows: suitable BFT can be developed for the climbing perch in an efficient manner and requires little innovation. Standardization of the climbing perch breeding procedures, based on induced breeding, can be considered a breakthrough in the propagation of this species in aquaculture farms. It is hoped that the achievements in this research would encourage fish and aquaculture farmers from all categories to adopt and diversify these potential fish species in aquaculture systems.

The Decree of the Minister of State for the Environment Number 112 of 2003, dated July 10, 2003, specifies domestic wastewater quality standards with parameters including pH (6– 9), BOD (100mg/ L), TSS (100mg/ L), and Oil and Fat (10mg/ L). This aligns with **Tatangindatu *et al.* (2003). Kordi and Tancung (2007)** and **Aisyah and Subehi (2012)**, who stated that the optimal temperature range for aquaculture is between 27 and 32°C. According to Government Regulation of the Republic of Indonesia Number 82 of 2001 concerning water quality management and water pollution Control, water temperature quality standards for Class III water are set between 26 and 33°C, with deviation 3 indicating a normal temperature range of 29-30°C **(Hanisa, 2017)**. Thus, the water temperature in studies-1 and 2 can still support the life and growth of the climbing perch fish. Temperature greatly influences the growth and life of aquatic biota. In general, growth rate increases as temperature increases. An extreme (drastic) increase in temperature can suppress the life of aquaculture animals, and even cause death.

When compared with the water quality standards in Government Decree of the Republic of Indonesia Number 82 of 2001 regarding the management and quality control of class III water pollution, the pH in research-1 and research-2 is suitable for aquaculture activities with values ranging from 6.01 to 7.2. The death point for fish is at an acidic pH of 4 and at an alkaline pH of 11 **(Lesmana, 2002)**. In general, freshwater fish can live well at a slightly acidic pH ranging from 6.5 to 8, while the acidity level of water for good aquaculture ranges from 6.4 to 7.0 according to the type of fish while the optimal pH range for fish is around between 6.5 and 8.5. From the measurement results, the DO range in studies-1 and 2 was 1.2 – 4.3mg/ l.

The number of the kale leaves in the aquaculture system in buckets was counted at the end of the study. Kale leaves are counted as whole in 1 bucket or per treatment. The results of the 42- day study showed that the application of biofloc waste to the kale aquaculture media gave good results on the number of kale leaves. Research by **Hasan *et al.* (2017)** stated that an increase in the number of kale leaves maintained using an aquaponics system in catfish has an average number of leaves above the average number of kale leaves when maintained in compost and soil media.

Khodijah *et al.* (2022) reported an experiment using a Split Plot Design with two treatment factors. Firstly, the main factor was the stocking density of catfish (P), which consisted of three treatment stages, namely: 10 heads/50L; 15 heads/50L; and 20 heads/50L of water. The secondary factor is the type of fertilizers (J), which consists of three treatment stages: No fertilizers (control); fertilizer type 1 (N 20%, P 15%, K 15%, and Mg 1%); and fertilizer type 2 (N 32%, P 10%, K 10%, and Mg 0.1%). Variables of growth and yield of water spinach observed were crop heights, leaf number as well as plant mass, yield weight, peak wet mass, root wet mass, peak dry mass, root dry mass, roots in terms of volume, leaves in terms of area, leave colors, and diameter of stems. No significant interaction among foliar fertilizer effects of the catfish densities on the aquaponics growth of kale in Budikdamber system. The independent effect of treatment of foliar fertilizer with relatively higher N concentration (N: 32%, P: 10%, K:10% and Mg: 0.1%) was significantly better in promoting crown growth compared to foliar fertilizer, with lower N and P composition, higher K and Mg (N: 20%, P: 15%, K: 15% and Mg: 1%) but did not lead to improved roots growing. The stocking density treatment of the catfish (10, 15 and 20 fish per 50 liters of water) showed no obvious variation in all parameters of the growth and production of water spinach.

In this trial, the highest average number of the kale leaves was in treatment C (189.33) with a dose of 75% biofloc waste + 25% irrigation water, followed by treatment B (118.67) and D (114.67). Meanwhile, in treatment A (irrigation water control), the number of kale plant leaves was less than in other treatments, namely 98.33. The high number of leaves growing is thought to be caused by rearing water spinach and the catfish in the aquaponics system by providing biofloc waste which has good nutrients for plants to absorb, while the low number of leaves growing in the aquaponics system. Water spinach plants, namely treatment A, are caused by controlled waters/irrigation; water not having enough nutrients to be absorbed by kale plants. This finding agrees with the results of **Hasan *et al.* (2017)** who determined that, upon growing water spinach in an aquaponic system, the nutrients in the form of nitrate and phosphate that can be absorbed by water spinach plants are higher compared to plants grown in compost and soil media, hence high levels of water, nitrogen, and phosphorus are absorbed by plants in an aquaponic system. This is proven by the condition of the roots of the kale plants being greater than those without aquaponics. **Setijaningsih and Suryaningsih (2015)** and **Setijaningsih and Umar (2015)** emphasized that the nitrogen sources contained in compost and soilgiven a fertilizer at the beginning of planting are increasingly insufficient to meet the needs of plants, while in the aquaponic system, the nutrients are increasingly reduced enough all the time.

Utilizing biofloc wastewater to raise the catfish provides better productivity than the case using no biofloc at all. However, at doses greater than 50%, the use of biofloc waste as an inoculum can result in high mortality rates in fish fry. Apart from that, although fish productivity when given a dose of 50% is considered good, its effectiveness is still below that of a rearing system that uses media with the addition of new biofloc **(Syam *et al.*, 2019)**. The addition of biofloc had no effect on the growth and survival of the tilapia. The growth rate range for the tilapia is 0.21-0.24g/ day and the survival rate for the tilapia is 57-88% **(Septiani *et al.*, 2014)**. **Arthanawa *et al.* (2021)** reported that the catfish aquaculture using biofloc system generates sewage in the form of pond residue which may be favorable for aquaponic using aquaculture system. Combining fermented catfish waste with chicken manure at 1400ppm in an aquaponics system resulted in the highest yields for spinach, the most leaves for pak choy, and the greatest fresh and dry weight for pak choy, with an average fresh weight of 142.39 grams. The best high yields are found in spinach plants. The best number of leaves is found on pak choy plants. In the aquaponics system, pak choy plants showed the best fresh and dry weight results, with the optimal growth achieved at a concentration of 1400 ppm of fermented catfish waste combined with chicken manure; this concentration also yielded the highest average fresh weight of 142.39 grams, while kale, pak choy, and spinach thrived using this nutrient mix, though lettuce exhibited the lowest fresh weight.

Management strategies and reducing environmental impacts from BFT are recommended in aquaculture activities as means toward a sustainable aquaculture and at the same time leading to solving environmental, social and economic problems along with its growth **(Crab *et al.*, 2012)**. Based on environmental impact analysis using LCA and sensitivity analysis, there are several points that need to be improved in the management of the climbing perch aquaculture using BFT. The first is related to feed management, which is the biggest source of costs in the aquaculture process. The provision of high protein with a content of 36% should be reduced and replaced by feed with lower protein, or mixed in line with increasing biofloc growth, consideringseveral proximate results of research conducted on the protein value of biofloc reaching 43.0% **(McIntosh *et al.*, 2000)**.

In BFT, the carbon sources used are mostly by-products originating from animal and plant-based food industry are available localized. Prior to post larval propagation and while the growth period, inexpensive carbohydrate substances such as the plant-based food molasses and meal are used in order to supply food in the early growing stages and keep up the C:N conversion ratio **(Nisar *et al.*, 2022)**. The harvest yield of shrimp could be raised, and feeding conversion rate could be reduced by using corn to promote biofloc formation in mixed aquaculture of shrimp, manure, and kale. The process can subsequently decrease the amount of both gross phosphorus and gross nitrogen in the aquaculture waters **(Liu *et al.*, 2017)**. The biofloc-based poly-culture of the tilapia, shrimp, seaweed and shellfish resulted in increased growth levels and decreased nutrient effluent and the microbial mass. Biofloc systems decrease the cost in organic and inorganic manures and offset the cost in terms of the source of carbon **(Ekasari, 2014)**. BFT is likewise accountable for decreasing water treating costs by up to 30%, and twice the utilization efficiency of protein as opposed to traditional water processing techniques **(Schryver *et al.*, 2008; Avnimelech & Kocba, 2009)**. Additionally, biofloc systems can be integrated with other food production methods to create a more productive and efficient system, maximizing output from the same land area with fewer inputs. It's crucial that the study findings are communicated to farmers for practical implementation, as biofloc technology requires skill enhancement **(Bossier & Ekasari, 2017)**.

Osama *et al.* (2018) found that biofloc systems with specific carbon sources, such as oat bran and cellulosic materials, outperformed controlled systems across all parameters. While the treatment of biofloc showed no significant difference in the tilapia performance; the initial delay in water quality improvement was noted due to the slower breakdown of carbon sources, leading to fewer fluctuations in NO3 and NH4+ levels. The research highlights that cellulose-based carbon sources are particularly effective in enhancing bacterial numbers, microorganism diversity, and biofloc composition quality. Economically, using inexpensive, cellulose-rich agricultural products as a carbon source is beneficial for both environmental sustainability and system performance. Furthermore, biofloc provides an additional food for aquatic organisms and contributes to cleaner water and higher biosecurity by reducing wastewater pollution and mitigating disease risks **(Arias-Moscoso *et al.*, 2018; Reddy, 2019)**.

The strengths of biofloc technology (BFT) in aquaculture are well-established, including its potential for water conservation, reduction of water changes, and stabilization of temperature and heat fluctuations. BFT effectively supports nitrogen removal, even under high organic matter and biochemical oxygen demand conditions **(Avnimelech & Zohar, 1986; Crab *et al.*, 2009)**. This leads to decreased pond water pollution and improved water quality by lowering concentrations of hydrogen sulfide, toxic ammonia, and nitrites. Additionally, BFT facilitates the reuse of waste nutrients through microbe proteins, which can meet nearly 50% of fish or shrimp protein needs, thus reducing feed consumption **(Krummenauer *et al.*, 2014)**. This approach promotes healthier growth, enhances survival rates, and minimizes pathogen and disease risks without relying on antibiotics, thereby improving meat quality. Furthermore, BFT serves as a natural probiotic and an immunostimulant **(Emerenciano *et al.*, 2013)**.

No technique has no challenges, and biofloc technology (BFT) is no exception. A significant barrier to adoption is convincing farmers to embrace BFT, as it contradicts the traditional belief that pond water should be clear **(Avnimelech, 2009)**. However, several factors drive the adoption of BFT, including water scarcity; water resources are becoming increasingly scarce or costly, which limits the growth of aquaculture, environmental regulations; many countries have restrictions on the disposal of contaminated waste, making BFT a more attractive option for waste management, and disease control; severe communicable disease outbreaks necessitate stricter biosecurity measures such as reducing water exchange rates **(Avnimelech & Kocba, 2009)**. The most obvious disadvantage is that continuous aeration maintains high levels of DO > 5mg/ L, thus requiring high energy costs. Advanced know-how and better-equipped laboratories are required to efficiently supervise and operate the biofloc system. This system is practicable in both extensive systems and intensive systems. The pond should be covered with HDPE sheets, or a concreted pond, which is necessary for an efficient organization of this system **(Suneetha *et al.*, 2017)**.

BFT is increasingly popular because the aquaculture sector faces considerable economic disadvantages resulting from water pollution that causes a variety of pathogens to be present. Due to the increasing healthy fish demand, null water exchanges are heavily utilized in the production of fish and shellfish. This minimizes the discharge of aquaculture effluent water into the water ecosystem, which includes the nutrients, the organic matter, and the pathogens. The system utilized minimum land, thus providing an unbiased benefit-cost balance to preserve social and economic continuity. In addition to being sustainability, fish farmed in BFT also showed a better health status after being challenged by various potential pathogens **(Kumar *et al.*, 2024)**.

Aquaculture techniques have become a source of cooling in recent years. For example, many of the world's largest shrimp farms are built in areas that previously had mangrove forests, such as in Indonesia, the Philippines, and Malaysia. These forests have proven to not only provide important protection from floods and storms but also provide important ecosystems for certain species, such as finfish and shellfish **(Naylor *et al.*, 2000)**. It has been well documented that traditional fish and shrimp farming systems using flowing water, ponds and cages produce excessive amounts of waste in the form of phosphates and nitrates. This is associated with harmful algal blooms, which can damage and drastically reduce oxygen solubility, making the environment anoxic and resulting in shrimp and fish mortality **(Paez-Osuna *et al.*, 2003; Khan & Mohammad, 2013)**.

Compared to traditional fish farming, BFT has several advantages and offers solutions to problems. BFT during the production cycle uses less water volume and, through the help of organisms, is able to recycle nutrients **(Crab *et al.*, 2012)**. Total *in situ* nutrient recycling into biomass by microbes not only contributes to biosecurity but also serves to improve FCR values, thereby reducing overall feed production costs. As is commonly known, water costs are around 30% and feed contributes 40- 75% of the total cost, therefore BFT is very useful in reducing these costs **(Crab *et al.*, 2012; Ansari *et al.*, 2021)**. Carbon dioxide as a by-product of respiration and heterotrophic activity is one of the major problems in BFT systems. Heterotrophic reduction of ammonia-nitrogen levels produces approximately 65% more carbon dioxide per gram of total ammonia nitrogen (TAN) than production from nitrifying bacteria **(Browdy *et al.*, 2012)**. The study analyzed the CO2 content in 52 BFT shrimp ponds and found that 27 of the 52 ponds were able to absorb carbon, and these ponds were mostly ponds with shorter shrimp cultivation maintenance periods and were found to have more phytoplankton and algae, which are naturally able to absorb CO_2 **(Manan *et al.*, 2019)**.

As the biomass of the climbing perch fish increases, the environment's carrying capacity decreases, leading to uneven growth and significant size variations. Fish that are slower to grow at the beginning of rearing due to competition will continue to lag, resulting in size differences by the end of the rearing period. Implementing partial harvesting in stages, once the climbing perch have reached a marketable size (typically after 7 months), is recommended by several researchers and industry experts. This approach offers numerous economic and environmental benefits. Partial harvesting reduces fish density, which decreases competition for space and food, minimizes the risk of disease outbreaks caused by high density, and promotes better growth for the remaining fish. It also lowers feed costs, reduces the accumulation of total ammonia nitrogen (TAN) and other organic materials, and lessens the need for organic carbon and lime for pH balancing, thereby cutting overall production costs. Additionally, waste from the climbing perch in a biofloc system can be repurposed for raising additional fish and vegetable crops.

The price of the climbing perch fish varies at different levels: Rp60,000 per kg at the aquaculture level, Rp70,000 per kg at the collector level, and Rp77,667 per kg at the retailer level. The highest net profit was observed at the aquaculture level (45%), followed by collectors (33%) and retailers (22%). Conversely, restaurants achieve a profit margin of 74%, which is nearly three times higher than that of aquaculture (26%). Marketing margins are 14% for collectors, 23% for retailers, and 50% for restaurants. The highest net profit per kg was obtained by aquaculture, followed by collectors and retailers **(Ahmadi *et al.*, 2022)**.

According to **Ratnasari (2022)**, the current aquaculture production of the climbing perch is 500,000 fish, or approximately 1 ton per month. The production prices are Rp80,000 per kg for grade A (8-12 fish per kg), Rp40,000 per kg for grade B (13-15 fish per kg), and Rp25,000 per kg for grade C (≥15 fish per kg).

The effectiveness of the biofloc technology (BFT) system in improving water quality and fish growth compared to traditional aquaculture systems is noteworthy. Future research should focus on optimizing biofloc composition and management. BFT is recognized as a promising and sustainable alternative due to its economic feasibility, resource efficiency, positive impacts on water quality, and superior growth performance **(Marie *et al.*, 2024)**. For aquaculture businesses to remain profitable, it is crucial to reduce production costs and prioritize environmental protection **(Avnimelech & Kochba, 2009)**. The biofloc system enhances fish growth and reduces feed conversion rates, thus increasing profitability and lowering aquaculture costs **(Khanjani, 2015)**. **Megahed (2010)** reported that the BFT system reduced production costs by 33% for the tiger prawns (Penaeus semisulcatus) and by 10% for the tilapia. **Schryver and Verstraete**

(2009) emphasized that species-specific feed and carbohydrate prices are critical factors to consider when using the BFT system.

Sontakke and Haridas (2018) argued that biofloc technology (BFT) is more effective in increasing growth rates and shortening maintenance periods compared to conventional aquaculture methods. For new technologies like BFT to be successfully adopted and optimized, they need to be embraced by the user community **(Sanches *et al.*, 2014)**. **Rego *et al.* (2017)** found that the financial feasibility of *Litopenaeus vannamei* BFT aquaculture is high, with operational costs per hectare potentially being ten times greater than those of conventional systems. Feed costs contribute significantly to total variable costs in both systems: 54% for BFT and 79% for conventional systems. In intensive shrimp farming in Asia, feed is a major expense, accounting for 23-46% of total costs **(Shang *et al.*, 1998)**. **Rego *et al.* (2017)** reported that the total production cost per cycle and per year were US$33,294.87 and US$124,369, respectively, for a BFT system with a stocking density of 113 shrimp per m^2. The annual operating profit was US$51,871.54 per productive hectare, which is 141% higher than that of conventional systems. **Hanson (2013)** reported an initial cost of approximately US$992,000 and a total annual production cost of US$983,950.00 for a BFT system with a density of 500 shrimp per m^3 and 10 rearing tanks covering 500m^3 in Texas, USA. The higher overall production costs of the BFT system compared to conventional systems are due to high feed expenditures as well as significant labor and energy costs.

Sontakke and Haridas (2018) also analyzed the production cycle of the milkfish (*Chanos chanos*) in India using three systems: clear water (control), biofloc, and open pond. Their analysis showed a total net profit of US$6,533 for the BFT system, compared to US$4,468 for the open pond system and US$3,779 for the clear water system.

In a recent study, the total production and equipment costs were Rp8,652,718 with total sales of Rp15,400,000. The income for one period (7 months) was Rp6,747,282, with monthly receipts amounting to Rp963,897.43. Based on the South Kalimantan UMR standard in 2024, an income of Rp3,282,812.11 requires a maintenance pool with a diameter of 4 meters, under normal conditions without disease and with high-quality female climbing perch seeds. Thus, the climbing perch aquaculture using a biofloc system is promising. The research indicates that rearing 75-100% of the female climbing perch fish with a biofloc system can positively impact aquaculture production technically, economically, and ecologically. However, further research is needed to understand the factors affecting the stability and function of biofloc systems, as well as the potential for reducing environmental impacts or utilizing waste for other aquaculture activities and as liquid fertilizer for vegetable crops.

CONCLUSION

The average public perception score is 4.3820, which falls within the high range on the Likert scale. This high score indicates strong support for biofloc system aquaculture. For climbing perch waste, this implies that the biofloc system allows for environmentally friendly disposal and repurposing for raising additional fish and vegetable crops. The study reported total production and equipment costs of Rp8,652,718, with total sales amounting to Rp15,400,000. The income obtained over a 7-month period was Rp6,747,282, with monthly receipts averaging Rp963,897.43. According to the 2024 South Kalimantan UMR standard, achieving an income of Rp3,282,812.11 requires a minimum of 4 maintenance ponds, each with a diameter of 2 meters, under normal conditions without disease and with the high-quality female climbing perch seeds. Therefore, the climbing perch aquaculture using a biofloc system is considered a viable pursuit. Research findings suggest that rearing 75-100% of the female climbing perch fish with a seed size of ±7 cm in a biofloc system, at a density of 1 fish per 1-2 liters, is technically feasible, economically viable, and environmentally friendly.

Conflict of interest

The author team has no conflict of interest to declare in this research and worked with full dedication and responsibility.

Acknowledgements

We would like to thank all respondents and students who helped collect data for this research.

REFERENCES

Ahmadi. ; Lilimantik, E. and Mahreda, E.S. (2022). Marketing Efficiency of the Climbing Perch (*Anabas testudineus*) Cultured with Bioflock System. Egyptian Journal of Aquatic Biology & Fisheries Zoology Department, Faculty of Science, Ain Shams University, Cairo, Egypt. ISSN 1110 – 6131 25(2): 561 – 572 (2021) www.ejabf.journals.ekb.eg . https://dx.doi.org/10.21608/ejabf.2021.165912

Aisyah S. and Subehi L. (2012). Pengukuran dan evaluasi dalam rangka mendukung Pengelolaan Perikanan di Danau Limboto. Prosiding Seminar Nasional Limnologi VI Tahun 2012. Bogor. http://ejournal-balitbang.kkp.go.id/index.php/bawal/ article/view/6922

Ansari, F.A.; Guldhe, A. ; Gupta, S.K. ; Rawat, I. and Bux, F. (2021). Improving the feasibility of aquaculture feed by using microalgae. Environmental Science and Pollution Research, 28, 43234–43257.

Araujo, G.S. ; José.W.A.S.; João. C and Pereira, L. (2022) Fish Farming Techniques: Current Situation and Trends J. Mar. Sci. Eng. 2022, 10(11), 1598; https://doi.org/10.3390/jmse10111598

Arianti.N.N.; Rizky.M.B. and Gita.M. (2022). Persepsi dan Adaptasi Petani Perikanan Air Tawar Terhadap Perubahan Iklim di Kecamatan Padang Jaya Kabupaten Bengkulu Utara. Vol 14, No 2 (2022) http://ejournal-balitbang.kkp.go.id/index.php/jkpi/article/view/10395/8009

Arias.M.J.L.; Gabriel. E.B.; Anselmo.M.B.; Marta. E.R.V. and Mario. N.S. (2018). Effect of commercial probiotics addition in a biofloc shrimp farm during the nursery phase in zero water exchange,Aquaculture Reports, Volume 11,2018, Pages 47-52, ISSN 2352-5134, https://doi.org/10.1016/j.aqrep.2018.06.001 (https://www.sciencedirect.com/science/article/pii/S2352513418300279

Arthanawa, I.G.N.; Gusti.N.; Astiko, I.N.;Yana, D.P.S.; Darmawan, I.K.; Yohanes. P.S and Sudita, I.D.N. (2021). Utilization of Biofloc System Catfish Pond Waste Nutrients in the Cultivation of Kale, Spinach, Pakcoy, and Lettuce Using the Aquaponic System SEAS (Sustainable Environment Agricultural Science) Volume 05, Number 01, April 2021, Pages: 66-71 Sustainable Environment Agricultural Science (SEAS) Page 66 E-ISSN 2614-0934.http://dx. doi.org/10.22225/seas. 5.1.3304.66-71

Avnimelech. Y and Kocba, M. (2009). Evaluation of nitrogen uptake and excretion by tilapia in bio floc tanks, using 15N tracing. Aquaculture, Volume 287, Issues 1–2, 2009, Pages 163-168, ISSN 0044-8486, https://doi.org/10.1016/j.aquaculture. 2008.10.009. (https://www.sciencedirect.com/science/article/pii/S0044848608007539)

Avnimelech. Y. and Zohar, G. (1986). The effect of local anaerobic conditions on growth retardation in aquaculture systems,Aquaculture,Volume 58, Issues 3–4, 1986, Pages 167-174, ISSN 0044-8486, https://doi.org/10.1016/0044-8486(86)90082-7 (https://www.sciencedirect.com/science/article/pii/0044848686900827)

Basumatary, B.; Verma, A.K. and Kushwaha, S. (2024). Global research trends and performance measurement on biofloc technology (BFT): a systematic review based on computational techniques. Aquacult Int 32, 215–240 (2024). https://doi.org/10.1007/s10499-023-01162-z

Bilal, R.; Zhongming, Z. and Wen, Y. (2024). A Review on Biofloc System Technology, History, Types, and Future Economical Perceptions in Aquaculture. Animals 2024, 14(10), 1489; https://doi.org/10.3390/ani14101489

Bossier, P. and Ekasari, J. (2017)Biofloc technology application in aquaculture to support sustainable development goals. Microb Biotechnol. 2017. Sep;10(5):1012–1016. 10.1111/1751-7915.12836

Browdy, C.L.; Ray, A.J.; Leffler, J.W. and Avnimelech, Y. (2012). Biofloc-based aquaculture systems. In: J.H. Tidwell (Ed.) Aquaculture production systems. Hoboken, New Jersey: John Wiley & Sons, Ltd., pp. 278–307. https://doi.org/10.1002/9781118250105.ch12

Carlos, I.P.R.; Jorge, A.; Fuentes, P. and Martha, P.H.V. (2013). Pond-reared Malaysian prawn *Macrobrachium rosenbergii* with the biofloc system. Aquaculture 400–401, 105–110. http://dx.doi.org/10.5772/57501

Chirwa,W. (2023). Application of Fine Bubbles in Biofloc Aquaculture: Towards Environmental Sustainability. |Indian Journal of Environment Engineering (IJEE) ISSN: 2582-9289 (Online), Volume-3 Issue-2, November 2023 PP: 16-25 | Volume-3 Issue-2, November 2023 | Retrieval Number: 100.1/ijee.A184804010524 | http://doi.org/10.54105/ijee.A1848.03021123

Crab, R.; Defoirdt, T.; Bossier, P. and Verstraete, W. (2012). Biofloc technology in aquaculture: beneficial effects and future challenges. Aquaculture, 356–357, 351–356. https://doi.org/10.1016/j.aquaculture.2012.04.046

Crab, R.; Defoirdt. T.; Bossier. P. and Verstraete, W. (2012). Biofloc technology in aquaculture: Beneficial effects and future challenges. Aquaculture, Volumes 356–357, 2012, Pages 351-356, ISSN 0044-8486, https://doi.org/10.1016/j.aquaculture.2012.04.046. (https://www.sciencedirect.com/science/article/pii/S0044848612002852)

Crab, R.; Kochva. M.; Verstraete, W. and Avnimelech, Y. (2009). Bio-flocs technology application in over-wintering of tilapia, Aquacultural Engineering, Volume 40, Issue 3, 2009, Pages 105-112, ISSN 0144-8609, https://doi.org/10.1016/j.aquaeng.2008.12.004. (https://www.sciencedirect.com/science/article/pii/S0144860908001088)

De Schryver, P.; Crab, R.; Defoirdt, T.; Boon, N. and Verstraete, W. (2008). The basics of bio-flocs technology: the added value for aquaculture. Aquaculture, 277(3–4), 125–137. https://doi.org/10.1016/j.aquaculture.2008.02.019

Ekasari, J. (2014). Biofloc Technology as an Integral Approach to Enhance Production and Ecological Performance of Aquaculture, (Dissertation) Ghent University; (2014). p. 207. http://hdl.handle.net/1854/LU-5721724

Emerenciano, M.G.C, Gaxiola G. and Cuzon G.L. (2013). Biofloc technology (BFT): a review for aquaculture application and animal food industry. In: Matovic MD, editor. Biomass now-cultivation and utilization. London (UK): IntechOpen; 2013. p. 301–328. 10.5772/53902 . http://dx.doi.org/10.5772/53902

FAO. (2022). Blue Transformation – Roadmap 2022–2030: A vision for FAO's work on aquatic food systems. Rome. https://doi.org/10.4060/cc0459en

FAO. (2024). The State of World Fisheries and Aquaculture 2024 - Blue Transformation in action. Rome. https://doi.org/10.4060/cd0683en

Firdiansyah, A.; Yar, J. dan Zamdial, T. (2020). Persepsi dan Partisipasi Masyarakat dalam Pengelolaan Kawasan Konservasi Perairan Pulau Enggano Provinsi Bengkulu. Jurnal Penelitian Pengelolaan Sumber Daya Alam dan Lingkungan. ISSN: 2302-6715 and e-ISSN: 2654-7732. Vol. 9 No. 1 (2020) https://ejournal.unib.ac.id/naturalis/article/view/12235 https://doi.org/10.31186/naturalis.9.1.12235

Garlock, T.M.; Frank, A.; James L.A.; Håkan, E.; Thomas M. A.; Bin, C.; Carlos A.C.; Jingjie, C.; Nnaemeka, C.; Madan, M.D.; Kevin, F.; Jimely, F.,; Jordi G.; Ganesh, K.; Lijun, L.; Ignacio L.L.; Ly. N.; Rasmus, N.; Ruth B. M. P.; Pratheesh O.S.; Byela, T. and Ragnar, T. (2024). Garlock, T.M., Asche, F., Anderson, J.L. *et al.* Environmental, economic, and social sustainability in aquaculture: the aquaculture performance indicators. Nat Commun 15, 5274 (2024). https://doi.org/10.1038/s41467-024-49556-8

Hanafie, A. (2020). Laju Pertumbuhan Ikan Papuyu (*Anabas testudineus* Bloch) Sistem Bioflok dengan Sumber Probiotik yang Berbeda. Prosiding Seminar Nasional Lingkungan Lahan Basah. Volume 5 Nomor 2 Halaman 104-112 April 2020 p-ISSN 2623-1611 e-ISSN 2623-1980. https://www.researchgate.net/publication/343587875

Hanafie, A.; Biyatmoko, D.; Fatmawati and Fauzana, N.A. (2023a). Growth Performance and Survival of Climbing Perch (*Anabas testudineus* Bloch) Raised in Conventional and Bioflocs System. Published: 2023-01-25. Page: 14-37 Issue: 2023 - Volume 21 [Issue 2] DOI: 10.9734/ajfar/2023/v21i2530

Hanafie, A.; Biyatmoko, D.; Fatmawati and Fauzana, N.A. (2023b). Study Of Growth And Survival Of Climbing Perch (*Anabas testudineus* Bloch) With Different Sex Ratio In Biofloc System. RJOAS: Russian Journal of Agricultural and Socio-Economic Sciences ISSN 2226-1184 (Online) | Issue 2(134), February 2023 185 UDC 639; DOI 10.18551/rjoas.2023-02.22

Hanisa, E.; Nugraha, W.D. dan Sarminingsih, A. (2017). Penentuan Status Mutu Air Sungai Berdasarkan Metode Indeks Kualitas Air-National Sanitation Foundation (IKA-NSF) Sebagai Pengendalian Kualitas Lingkungan. Jurnal Teknik Lingkungan, Vol. 6, Nomor 1. https://www.neliti.com/publications/190934/penentuan-status-mutu-air-sungai-berdasarkan-metode-indekskualitas-airnational-s

Hasan, Z.; Adriani, Y.; Dhahiyat, Y.; Sahidin, A. dan Rubiansyah, M. (2017). Pertumbuhan tiga jenis ikan dan kangkung darat (Ipomoea reptans Poir) yang dipelihara dengan sistem akuaponik. Jurnal Ikhtiologi Indonesia. 17 (2): 175-184. http://dx.doi.org/10.32491/jii.v17i2.357

James, H.T. and Geoff, L.A. (2001). Fish as food: aquaculture's contribution: Ecological and economic impacts and contributions of fish farming and capture fisheries. EMBO reports (2001) 2: 958 - 963 1 November 2001. FREE ACCESS https://doi.org/10.1093/embo-reports/kve236

Juliantika, T.H. dan Begem, V. (2020). Persepsi Petani Terhadap Sistem Pertanian Organik dan Anorganik dalam Budidaya Padi Sawah. Jurnal Ilmu Agribisnis: Journal of Agribusiness Science Vol 8, No 1 (2020). http://dx.doi.org/10.23960/jiia.v8i1.4332

Keputusan Menteri Negara Lingkungan Hidup, Nomor : 112 Tahun 2003 Tanggal : 10 Juli 2003 Baku Mutu Air Limbah Domestik. Kualitas Air Dan Pengendalian Pencemaran Air. https://www.regulasip.id/book/10014/read

Khadem, H.S. and Manjulatha, C. (2024). Isolation, Identification, and Biofloc Production: Potential of Floc-Forming Bacteria Using a Novel Monoculture Approach and Medium. Published by Central Fisheries Research Institute (SUMAE) Trabzon, Turkey. Aquaculture Studies, 24(4), AQUAST1878 http://doi.org/10.4194/AQUAST1878

Khan, M.N. and Mohammad, F. (2013). Eutrophication: challenges and solutions. In: A. Ansari & S. Gill (Eds.) Eutrophication: causes, consequences and control. Oxford: Elsevier, pp. 1–15. https://doi.org/10.1007/978-94-007-7814-6_1

Khanjani, M. (2015). The Effect of Different Feeding Levels in Biofloc System on Water Quality, Growth Performance and Carcass Composition of Pacific White Shrimp (Litopenaeus vannamei Boone, 1931). (Ph.D. Thesis). Hormozgan University, Hormozgan, Iran. (2015). 165 p. http://isfj.ir/index.php?sid=1&slc_lang=fa

Khanjani, M.H.; Mohammadi, A. and Emerenciano, M.G.C. (2024). Water quality in biofloc technology (BFT): an applied review for an evolving aquaculture. Aquacult Int (2024). https://doi.org/10.1007/s10499-024-01618-w

Khodijah N.S.; Arisandi, R.; Saputra, H.M. dan Santi, R. (2022). Pertumbuhan dan hasil kangkung akuaponik dengan perlakuan berbagai jenis pupuk foliar dan padat tebar lele pada sistim budikdamber lele-kangkung Jurnal Kultivasi Vol. 21 (1) April 2022 105 ISSN: 1412-4718, eISSN: 2581-1380078. http://dx.doi.org/10.24198/kultivasi.v21i1.37436

Kordi, M.G. dan Tancung, A.B. (2007). Pengelolaan Kualitas Air Dalam Budidaya Perairan. Penerbit Rineka Cipta. Jakarta. 208 Halaman. https://opac.perpusnas.go.id/DetailOpac.aspx?id=8503

Krummenauer, D.; Luis, P.; Luiz A.R.; Gabriele R.L.; Pedro , E and Wilson, W. Jr. (2014). The Effect of Probiotics in a Litopenaeus vannamei Biofloc Culture System Infected with Vibrio parahaemolyticus, Journal of Applied Aquaculture, 26:4, 370-379, https://doi.org/10.1080/10454438.2014.965575

Krummenauer, D.; Peixoto, S.; Cavalli, R.O.; Poersch, L.H. and Wasielesky, W. (2011). Superintensive culture of white shrimp, Litopenaeus vannamei, in a biofloc technology system in southern Brazil at different stocking densities. J World

Aquacult Soc. 2011; 42(5):726-733. https://doi.org/10.1111/j.1749-7345.2011.00507.x

Kumar, S.;, Praveen, K.S.; Vineet, K. and Chandra, S.S. (2024). Biofloc technology: A sustainable approach towards wastewater utilization and fish production. Volume29, Issue1. January/December 2024. e12449. First published: 21 February 2024 https://doi.org/10.1111/lre.12449

Laktuka, K.; Antra, K.; Liga, S.; Kalvis, L. and Dace, L. (2023). Towards the Sustainable Intensification of Aquaculture: Exploring Possible Ways Forward. Sustainability 2023, 15(24), 16952; https://doi.org/10.3390/su152416952

Lesmana, D.S. (2002). Kualitas air untuk ikan hias air tawar . Penerbitan Jakarta : Penebar Swadaya, 88 halaman. ISBN 979-489-601-2. https://opac.perpusnas.go.id/DetailOpac.aspx?id=613137

Liu, G.; Zhu, S.; Liu, D.; Guo, X and Ye, Z. (2017). Effects of stocking density of the white shrimp Litopenaeus vannamei (Boone) on immunities, antioxidant status, and resistance against Vibrio harveyi in a biofloc system. Fish Shellfish Immunol. (2017) 67:19–26. https://doi.org/10.1016/j.fsi.2017.05.038

Mahanand, S.S. and Pandey, P.K. (2021). Prospect and Challenges of Biofloc Technology for Sustainable Aquaculture Development. In: Pandey, P.K., Parhi, J. (eds) Advances inFisheries Biotechnology. Springer, Singapore. https://doi.org/10.1007/978-981-16-3215-0_22

Manan, H.; Zhong, J.M.H.; Kasan, N.A.; Suratman, S. and Ikhwanuddin, M. (2019). Carbon dioxide flux from intensive aquaculture shrimp farming applying biofloc system of Setiu Terengganu, Malaysia. Aquaculture, 509, 52–58. https://doi.org/10.1016/j.aquaculture.2019.05

Manlosa, A.O.; Hornidge, A.K. and Schlüter, A. (2021). Aquaculture-capture fisheries nexus under Covid-19: impacts, diversity, and social-ecological resilience. Marit Stud. 2021;20(1):75-85. doi: 10.1007/s40152-021-00213-6. Epub 2021 Jan 16. PMID: 35300182; PMCID: PMC7811386. https://doi.org/10.1007%2Fs40152-021-00213-6

Mappasomba, Z. and Haidir, M. (2024). Analisis Persepsi Masyarakat Terhadap Pengelolaan Ekosistem Mangrov di Kawasan Mangrov Biringkassi Kabupaten Pangkep. Jurnal Teknologi Lingkungan Lahan Basah. 12. 143. http://dx.doi.org/10.26418/jtllb.v12i1.74187

Marie, J.; Bangeles, C.; Ellen, M.I.T. and Arboleda, E.R. (2024). Biofloc Pond Farming: A Systematic Review of the Literature on Advanced Tilapia Aquaculture Practices. 7. 167-177. http://dx.doi.org/10.5281/zenodo.10529625

Marimuthu, S.; Puvaneswari, S. and Lakshmanan, R. (2024). Effect of Biofloc Technology Enriches the Growth of Litopenaeus vannamei (Boone, 1931). Appl Biochem Biotechnol 196, 3860–3890 (2024). https://doi.org/10.1007/s12010-023-04729-x

Marković, Z.Z. and Poleksić, V.D. (2023). The Role and Importance of Aquaculture for the Ecological Sustainability of Fish Resources in the Inland Water of Serbia. In: Simić, V., Simić, S., Pešić, V. (eds) Ecological Sustainability of Fish Resources of Inland Waters of the Western Balkans. Fish & Fisheries Series, vol 43. Springer, Cham. https://doi.org/10.1007/978-3-031-36926-1_15

McCusker, S.; Majbritt, B.W.; Simon J. D.; Cecilia, S.V.; Mark P. J.; Ronan, C and Cooney, Alex, H.L.W. (2023). Biofloc technology as part of a sustainable aquaculture system: A review on the status and innovations for its expansion. Aquaculture, Fish and Fisheries REVIEW ARTICLE. First published: 12 June 2023 https://doi.org/10.1002/aff2.108

McIntosh, D.; Samocha T.M.; Jones E.R.; Lawrence A.L.; McKee D.A.; Horowitz, S. and Horowitz, A. (2000) The effect of a bacterial supplement on the high-density culturing of Litopenaeus vannamei with low-protein diet in outdoor tank system and no waterexchange. Aquac Eng 21:215–227. https://doi.org/10.1016/S0144-8609(99)00030-8

Megahed, M.E. (2010). The effect of microbial biofloc on water quality, survival and growth of the green tiger shrimp (Penaeus semisulcatus) fed with different crude protein levels. J Arabian Aquac Soc. (2010) 5:119–42. https://www.arabaqs.org/journal/vol_5/2/Text%2010%20-%2010.pdf

Mugwanya, M.; Mahmoud A. O. D.; Fahad, K. and Hani, S. (2021). Biofloc Systems for Sustainable Production of Economically Important Aquatic Species: A Review Sustainability 2021, 13(13), 7255; https://doi.org/10.3390/su13137255

Naylor, R.L.; Goldburg, R.J.; Primavera, J.H.; Kautsky, N.; Beveridge, M.C.M., and Clay, J. (2000). Effect of aquaculture on world fish supplies. Nature, 405(6790), 1017–1024. https://doi.org/10.1038/35016500

Naylor, R.L.; Ronald W. H.; Alejandro H. B.; Simon R. B.;, Ling.C , Dane H.K.; David C.L.; Jane , L.; Sandra E.S. and Max, T. (2021) A 20-year retrospective review of global aquaculture. Nature 591, 551–563 (2021). https://doi.org/10.1038/s41586-021-03308-6

Nazarpour, S. and Hamid, M. (2024). Optimizing Stocking Density in Biofloc Culture of Juvenile Common Carp (Cyprinus carpio) Using Growth and Immune-biochemical Indices as Indicators. Published by Central Fisheries Research Institute (SUMAE) Trabzon, Turkey. Aquaculture Studies, 23(6), AQUAST1223 http://doi.org/10.4194/AQUAST1223

Nina, N.; Rudi, I. and Raehanul, B. (2020). Persepsi Masyarakat Akan Pentingnya Social Distancing Dalam Penanganan Wabah Covid-19 Di Indonesia. Jurnal Kependudukan Indonesia (JKI) ISSN : 1907-2902 (Print) ISSN : 2502-8537 (Online) https://ejurnal.kependudukan.lipi.go.id/index.php/jki/article/view/573

Nisar, U.; Daomin, P.; Yongtong, M. and Yu, S. (2022). A Solution for Sustainable Utilization of Aquaculture Waste: A Comprehensive Review of Biofloc

Technology and Aquamimicry. Front Nutr. 2021; 8: 791738. Published online 2022 Jan 12. https://doi.org/10.3389/fnut.2021.791738

Ogelloa, E.O.; Nicholas, O.O.; Kevin, O.O.; Domitila, N.K. and Jonathan, M.M. (2021). The prospects of biofloc technology (BFT) for sustainable. aquaculture development. 2468-2276/© 2021 The Author(s). Published by Elsevier B.V. on behalf of African Institute of Mathematical Sciences / Next Einstein Initiative. This is an2468-2276/© 2021 The Author(s). Published bScientific African 14 (2021) e01053 open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/) https://doi.org/10.1016/j.sciaf.2021.e01053

Oktopura, A.A.D.; Akhmad, F.; Ketut S. And Heti, M. (2020). Pembangunan Perikanan Budi Daya Nasional: Kinerja Dan Perspektif Peningkatan Efisiensi Dan Produktivitas Berbasis Ekosistem. Buletin Ilmiah Marina Sosial Ekonomi Kelautan dan PerikananVol 6, No 1 (2020). http://ejournal-balitbang.kkp.go.id/index.php/mra/article/view/8870

Oliveira, L.K.; Wilson, W. and Marcelo, B.T. (2024). Fish culture in biofloc technology (BFT): Insights on stocking density carbon sources, C/N ratio, fish nutrition and health, Aquaculture and Fisheries, Volume 9, Issue 4, 2024, Pages 522-533, ISSN 2468-550X, https://doi.org/10.1016/j.aaf.2022.08.010 (https://www.sciencedirect.com/science/article/pii/S2468550X22001459)

Omoniyi, M.P. and Oyelade. A.M. (2021). Performance of Different Biomaterials as Carbon Sources on the Immunological Response and Oxidative Status of African Catfish *Clarias gariepinus* in Biofloc Systems. Published by Central Fisheries Research Institute (SUMAE) Trabzon, Turkey. Aquaculture Studies, 22(2), AQUAST800 http://doi.org/10.4194/AQUAST800

Osama M.E.; Ashraf, M.A.; Goda, S.; Rania, S.M. and Soaudy, M. (2018). Complexity of carbon sources and the impact on biofloc integrity and quality in tilapia (Oreochromis niloticus) tanks AACL Bioflux, 2018, Volume 11, Issue 3.. http://www.bioflux.com.ro/docs/2018.846-855.pdf

Páez-Osuna, F.; Guerrero-Galván, S.R.; Ruiz-Fernández, A.C. and Espinoza-Angulo, R. (1997). Fluxes and mass balances of nutrients in a semi-intensive shrimp farm in north-western Mexico. Marine Pollution Bulletin, 34(5), 290–297. https://doi.org/10.1016/s0025-326x(96)00133-6

Peraturan Menteri Lingkungan Hidup Dan Kehutanan Republik Indonesia Nomor: P.68/Menlhk/Setjen/Kum.1/8/2016 Tentang Baku Mutu Air Limbah Domestik**.** https://ppkl.menlhk.go.id/website/filebox/5/170314114854P.68%20BAKU%20MUTU%20LIMBAH%20DOMESTIK.pdf

Peraturan Pemerintah Republik Indonesia Nomor 82 Tahun 2001 tentang Pengelolaan Kualitas Air dan Pengendalian Pecemaran air tentang baku mutu . https://peraturan.bpk.go.id/Details/53103/pp-no-82-tahun-2001

Ratnasari, D , (2022) Strategi Pengembangan Kampung Papuyu Kecamatan Karang Intan Kabupaten Banjar Provinsi Kalimantan Selatan .Digital Library Penerbit : Universitas Lambung Mangkurat Tanggal : 2022-11-21.Abstrak. http://digilib.ulm.ac.id/archive/digital/detailed.php?code=23646

Rego, M.A.S.; Sabbag, O.J.; Soares, R. and Peixoto, S. (2016) Financial viability of inserting the biofloc technology in a marine shrimp Litopenaeus vannamei farm: a case study in the state of Pernambuco, Brazil. Aquaculture International, 25(1), 473–483. https://doi.org/10.1007/s10499-016-0044-7

Schryver De. P, Crab, R.; Defoirdt, T.; Boon N. and Verstraete W. (2008). The basics of bio-flocs technology: The added value for aquaculture, Aquaculture, Volume 277, Issues 3–4, 2008, Pages 125-137, ISSN 0044-8486, https://doi.org/10.1016/j.aquaculture.2008.02.019 (https://www.sciencedirect.com/science/article/pii/S0044848608000896)

Schryver, De. P. and Verstraete, W. (2009). Nitrogen removal from aquaculture pond water by heterotrophic nitrogen assimilation in lab-scale sequencing batch reactors. Bioresource Technology,Volume 100, Issue 3,2009,Pages 1162-1167,ISSN 0960-8524,https://doi.org/10.1016/j.biortech.2008.08.043 (https://www.sciencedirect.com/science/article/pii/S0960852408007608)

Septiani Nani, Henni Wijayanti Maharani dan Supono. (2014). Pemanfaatan Bioflok Dari Limbah Budidaya Lele Dumbo (*Clarias gariepinus*) Sebagai Pakan Nila (*Oreochromis niloticus*).e-Jurnal Rekayasa dan Teknologi Budidaya Perairan Volume II No 2 Februari 2014 ISSN: 2302-3600 © e-JRTBP . https://jurnal.fp.unila.ac.id/index.php/bdpi/article/view/398

Setijaningsih, L. and Suryaningrum L.H. (2015). Utilization of Catfish (Clarias Batrachus) Waste by Tilapia (*Oreochromis Niloticus*) in Recirculation System]." Berita Biologi, vol. 14, no. 3, 2015. https://biologyjournal.brin.go.id/index.php/berita_biologi/article/view/1836/1721

Setijaningsih, L. and Umar C. (2015). Pengaruh retensi air terhadap pertumbuhan ikan nila (*Oreochromis niloticus*) pada budidaya sistem akuaponik dengan tanaman kangkung. Jurnal Ilmu-ilmu Hayati, 14(3): 267-275. http://dx.doi.org/10.14203/beritabiologi.v14i3.2085

Sontakke, R.; Tiwari, V.K.; Kurcheti, P.; Asanaru, M.B.R., Ande, M.P. and Haridas, H. (2021) Yam-based biofloc system improves the growth, digestive enzyme activity, bacterial community structure and nutritional content in milkfish (*Chanos chanos*). Aquaculture Research, 52(7), 3460–3474. https://doi.org/10.1111/are.15190

Sugiyono (2022). Metode penelitian kuantitatif / Prof. Dr. Sugiyono. ISBN 978-602-289-373-8 Bandung :: Alfabeta,. Cetakan ke 3, Maret tahun 2022. xviii, 546 halaman :

ilustrasi ; 24 cm. https://www.scribd.com/document/359411371/SUGIYONO-METODE-PENELITIAN-DAN-PENGEMBANGAN-pdf

Suneetha, K.; Kavitha, K and Darwin CH. (2017). Biofloc Technology an Innovative Aquaculture System for Sustainable Growth. International Journal of Multidisciplinary Educational Research. 2017; 8(2):189-199. http://dx.doi.org/10.13140/RG.2.2.18973.15840

Syam, A.T.; Cut,M. and Teuku, M.F. (2019). Efektifitas Penggunaan Limbah Bioflok Budidaya Ikan Lele Sebagai Inokulum Untuk Memulai Siklus Produksi Baru. Jurnal Ilmiah Samudra Akuatika, 3(2), 7 - 13. Retrieved from https://ejurnalunsam.id/index.php/jisa/article/view/1991

Tatangindatu, F.; Kalesaran, O. and Rompas, R. (2013). Studi Parameter Fisika Kimia Air pada Areal Budidaya Ikan di Danau Tondano, Desa Paleloan, Kabupaten Minahasa. https://doi.org/10.35800/bdp.1.2.2013.1911

Tohari, P.A.I.; Suadi and Subejo. (2020). Shrimp Farmers Perception in Development of Sustainable Fishpond Business in South Beach Special Regions Yogyakarta and Central Java. Jurnal Perikanan Universitas Gadjah Mada (Journal of Fisheries Sciences . Vol 22, No 1 (2020) https://doi.org/10.22146/jfs.36520

Troell, M. ; Barry, C.P.; Selina, S.; Richard, S.C.; Cecile, B. ;Anna, K.F.; David, C. L.; Åsa, S.; Roger, P.; Doris, S.; Malcolm, B ; Khalid, S.; Jorge, D .; Patricia, M.V. ;Julia, B.; Philip, J.; Rodrigue,Y.; Edward, A.; Christopher, D and Uwe.B. (2023). Perspectives on aquaculture's contribution to the Sustainable Development Goals for improved human and planetary health REVIEW ARTICLE First published: 10 May 2023 https://doi.org/10.1111/jwas.12946

Ulfa. M. (2018). Persepsi Masyarakat Nelayan dalam Menghadapi Perubahan Iklim (Ditinjau dalam Aspek Sosial Ekonomi). Jurnal Pendidikan Geografi: Kajian, Teori, dan Praktik dalam Bidang Pendidikan dan Ilmu GeografiVol 23, No 1 (2018) http://dx.doi.org/10.17977/um017v23i12018p041

Yousef, A.A.; Airin, S. ; Shaikh, T.A.; Rahman, A. M. ; Sheikh. M.R. ; Roshmon, T.M.; Nagarajan,G.; Afrin, S.; Alngada, R.S.; Whed, R.A.; Aljaafari, N. A and Md. Moshiur Rahman, M.M. (2023). The Impact of Biofloc Technology on Water Quality in Aquaculture: A Systematic Meta-Analysis, Aquaculture Nutrition, 2023, 9915874, 20 pages, 2023. https://doi.org/10.1155/2023/9915874

Yu, Y.B. ; Ju.H.L.; Jae.H.C.; Young.J.C. ; Jo.A. ; Cheol.Y.C.; Ju.C.K. and Jun, H.K. (2023). The application and future of biofloc technology (BFT) in aquaculture industry: A review. Journal of environmental management. 342.

Yu, Y.B.; Choi, J.H.; Lee, J.H.; Jo, A.H.; Lee, K.M. and Kim, J.H. (2023). Biofloc Technology in Fish Aquaculture: A Review. Antioxidants. 12. 398. https://doi.org/10.3390/antiox12020398

Zafar, M.A. and Rana, M.M. (2022). Biofloc technology: an eco-friendly “green approach” to boost up aquaculture production. Aquacult Int 30, 51–72 (2022). https://doi.org/10.1007/s10499-021-00781-8

Zhang, R.; Tao, C.; Yang, W. and Michael, S. (2023) .Systems approaches for sustainable fisheries: A comprehensive review and future perspectives,Sustainable Production and Consumption,Volume 41,2023,Pages 242-252,ISSN 2352-5509, https://doi.org/10.1016/j.spc.2023.08.013