AN ASSESSMENT OF CURRENT STATE AND FUTURE POTENTIAL OF BIOFLOC TECHNOLOGY IN PANCHAGARH DISTRICT

A Thesis

By

MD. HABIBUR RAHMAN

Examination Roll No. 1506109

Session: 2022

Semester: July-December 2024

MASTER OF SCIENCE (MS)

IN

AQUACULTURE

DEPARTMENT OF AQUACULTURE

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

DECEMBER 2024

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Submitted to the Department of Aquaculture
Hajee Mohammad Danesh Science and Technology University, Dinajpur
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DECEMBER 2024

Dedicated

To My

Beloved Parents

and

Wife

DECLARATION

I declare that this MS thesis entitled 'An Assessment of Current State and Future Potential of Biofloc Technology in Panchagarh District' which I submit to Department of Aquaculture, was conducted by me for the degree of Masters in Aquaculture under the guidance and supervision of Dr. A.S.M. Kibria, Professor, Department of Aquaculture, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

Furthermore, I took reasonable care to ensure that the work is original and has not been taken from other sources except where such work has been cited and acknowledged within the text.

The author

ABSTRACT

The present study was conducted to know the current state and future potential of biofloc technology in the Panchagarh district that cover five upazilas such as Panchagarh sadar, Tentulia, Debiganj, Boda and Atwari starting from July to December 2022. The study was done by analyzing socio-demographic characteristics, farming practices, and challenges faced by local farmers. Data were collected from 55 biofloc farmers through surveys and interviews. The findings revealed that 62.5% of respondents were young farmers aged between 21-30 years, with 40.5% having graduated from formal education systems. The majority (80.58%) hailed from nuclear families, while 74.54% did not hold any organizational membership. Fish culture (30.58%) and biofloc farming (20.32%) were identified as major occupations. Biofloc culture was predominantly practiced by farmers with 7 to 12 months of experience (51.58%), although 70.35% lacked formal training before initiating farming. Most farms (56.36%) operated on areas less than one decimal, with 55.58% having one or two tanks constructed primarily from cement (83.63%). Groundwater was the main water source (92.48%), and partial water exchange practices were widely adopted. Farmers used synthetic probiotics such as Pond Care (40.8%), Protox Aqua (22.81%), Aqua photo (17.32%), Dellomax (10.94%) and Ecopond (6.13%). The preferred tank shapes were rectangular (50.85%) and circular (35.6%), with a depth ranging between 4 to 6 feet. Despite challenges such as technical (50%) and financial (22.75%) difficulties, biofloc farmers reported fish production rates of 301-400 kg per cycle in 38.12% of cases. Diseases, particularly fungal (45.9%) and bacterial (34.5%), posed significant threats. Total harvesting was preferred by 61.82% of farmers, and most sales (52.72%) were made to wholesalers. The findings highlight the promising but challenging adoption of biofloc technology in the district. Investments in farmer training, disease management, and financial support can foster sustainable aquaculture practices and enhance productivity in Panchagarh.

Key Words: Biofloc, Aquaculture, Probiotics, Disease, Farming

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CHAPTER I

INTRODUCTION

Aquaculture, the farming of aquatic organisms, has seen rapid growth and now contributes significantly to the global food supply. This expansion is driven by the increasing global demand for protein and the overexploitation of wild fish stocks. Moreover, this industry plays a crucial role in enhancing health, fostering employment, and utilizing natural resources (Fatema *et al.* 2018). However, the rapid growth of the human population and expansion of human settlements have detrimental effects on this sector, diminishing the available land and water resources utilized for fish production (Islam *et al.* 2019). Therefore, the increasing demand for protein due to population growth should be met by expanding advanced aquaculture systems that maximize fish production while minimizing the use of limited land and water resources (Rashid and Ashab, 2022).

In recent years, a variety of enhanced aquaculture systems such as biofloc technology (BFT), recirculating aquaculture systems (RAS), raceway culture, aquaponics, and indoor tank culture have been introduced. These systems aim to accelerate economic growth, increase production, and offer abundant employment opportunities while optimizing resource utilization (Diatin *et al.* 2021). Biofloc technology (BFT) is an innovative culture practice that has captured the interest of scientists and fish producers due to its biosecurity and environmental benefits, making it a promising option for sustainable aquaculture compared to traditional semi-intensive and extensive systems (Lee *et al.* 2023).

Biofloc technology (BFT) involves using aggregates of bacteria, algae, or protozoa, combined with particulate organic matter, to enhance water quality, manage waste, and prevent disease in intensive aquaculture systems. Additionally, biofloc operates as a symbiotic process involving heterotrophic bacteria, various microbial species in the waterbody and aquatic animals. This approach focuses on recycling waste nutrients, especially nitrogen, into microbial biomass. This biomass can be directly utilized by cultured animals or harvested and processed into feed ingredients (Sharma *et al.* 2018). The fundamental idea of this technique is the practice of nutrient regeneration. Controlling the carbon-nitrogen (C/N) ratio promotes the growth of heterotrophic bacteria and generates microbial biomass (Azim *et al.* 2008). In a biofloc culture system, microbial biomass transforms wasted feed and ammonia into nitrate and nitrite, regulates water pollution by removing waste, and so helps to prevent disease with little water exchange. This merely implies that BFT can be a perfect substitute aquaculture system for aquaculture that is both environmentally friendly and sustainable (Crab *et al.* 2012).

BFT is used in the commercial production of animals such as tilapia and penaeid shrimp. BFT was viewed as the next "blue revolution" and remains so in light of the recent challenges in the aquaculture sector (Mugwanya *et al.* 2021). Due to its ability to interchange zero water, biofloc technology is being embraced globally, enabling the effective use of scarce water resources and preventing the release of wastewater into the environment. By using more affordable, highly nutritious protein sources, this method lowers the requirement for artificial feed and saves feed and production expenses by thirty percent (Ogello *et al.* 2021). The microbial biomass that naturally forms in the water not only filters it but also enhances aquatic species' development, immunity and performance. Moreover, BFT is thought to be an economical, ecologically benign technique that supports sustainable development objectives and has a lot of promise for raising aquaculture productivity (Khanjani and Sharifinia, 2020).

Maintaining a healthy, balanced and productive aquaculture system heavily depends on water quality parameters, which are crucial for the well-being of aquatic creatures. The quality of water in the culture system directly impacts fish growth. In other words, optimal environmental conditions, such as pH levels, dissolved oxygen concentration, water temperature, and the amount of total dissolved solids and waste, typically lead to better growth of cultured organisms. Regular monitoring of water quality is essential, especially when it deviates from the ideal range. If water quality parameters are not within the optimal range, fish may experience significant stress, which can alter their metabolic rate, hinder growth, increase disease susceptibility, and reduce survival rates (Popoola *et al.* 2021).

In traditional aquaculture systems, regular water exchange is necessary to remove contaminated water and feed waste. As fish are fed artificial or supplementary nutrition for growth, their waste accumulates, leading to harmful ammonia contamination in the water. The nitrogen and protein from the feed impact water quality and can cause various diseases. However, BFT eliminates the need for water exchange by using heterotrophic bacteria to consume nitrogen, thereby reducing harmful ammonia levels and decreasing water pollution. Moreover, the BFT system minimizes the need for water exchange or water usage in intensive aquaculture systems. It produces cost-effective microbial aggregates (floc) that are high in protein-rich organic matter, which can serve as feed for aquatic organisms (Crab *et al.* 2012). Additionally, BFT offers a cost-effective alternative, reducing water treatment expenses by approximately 30%, and enhances protein utilization, making it twice as efficient as other intensive aquaculture systems. These unique characteristics make BFT an economical and sustainable option for the future development of aquaculture. In intensive commercial aquaculture, supplemental or artificial feed is essential for the growth of cultured species but comes at a high cost. The biofloc system can replace conventional supplemental feed, providing a rich source of beneficial heterotrophic bacteria that boost the immunity of cultivated fish species. Numerous studies have demonstrated that the biofloc method improves the non-specific immunity of farmed fish. Several studies have been conducted to demonstrate the effectiveness of the biofloc culture system. Rashid and Ashab (2022) found that a majority (73.9%) of farmers opted to culture monosex tilapia (*Oreochromis niloticus*) in their biofloc units, considering it highly suitable for this method of fish farming. Catfish species, especially Pangasius, have shown successful cultivation in biofloc systems, exhibiting enhanced growth rates and increased disease resistance (Rahman *et al.* 2008). Similarly, common carp flourishes in biofloc environments, achieving better feed conversion efficiency (Azim *et al.* 2008). Mohammadi *et al.* (2021) examined how various carbon sources in the biofloc system affect the growth performance, body biochemical compositions, and digestive and hepatic enzymes of Nile tilapia (*Oreochromis niloticus*). Mugwanya *et al.* (2021) discussed factors associated with BFT for the successful production of aquatic species. Zafar *et al.* (2021) conducted experiments to assess the effects of the biofloc system on the growth, digestive activity, proximate composition, and hematology of Asian stinging catfish. Tongsiri *et al.* (2020) performed an economic analysis, estimating the costs and benefits of Nile tilapia culture in the biofloc system.

Panchagarh is a district in northern Bangladesh where biofloc fish farming has gained popularity recently. Although most farmers in this district were unaware of this technology prior to 2018, they have been using it for the past two or three years to culture fish. Because of the district's elevation above sea level and geographic position, farmers in Panchagarh district struggle with water scarcity all year round (Zafar *et al.* 2020). Thus, for both small- and large-scale fish farmers, biofloc fish farming in indoor or outdoor tanks may show to be the ideal option. GOs and NGOs carried out several extension initiatives in the Panchagarh district to introduce and implement this enhanced technology.

Objectives of the study:

- To know the present situation of the biofloc fish farmers and farming technology being practiced in Panchagarh district.
- To figure out the issues and constraints arises amidst performing biofloc.
- To understand the future prospective of biofloc farming through a construction of a cost benefit analysis

CHAPTER-II

REVIEW OF LITERATURE

Abubkr and Hanafiah (2022) studied the impact of dried bioflocs, made using oven- and freeze-drying methods, on the proximate composition, growth performance, and water quality of red hybrid tilapia. They conducted a 57-day feeding trial with five experimental groups: a control (no bioflocs), 4% freeze-dried bioflocs, 16% freeze-dried bioflocs, 4% oven-dried bioflocs, and 16% oven-dried bioflocs. The 16% biofloc treatments showed the lowest growth performance and water quality, while the 4% treatments, whether freeze-dried or oven-dried, resulted in higher growth rates and better water quality, similar to the control. Additionally, tilapia fed 4% bioflocs had better body composition with higher protein and energy content compared to those fed 16% bioflocs. Moisture content increased significantly with 16% bioflocs.

Shamsuddin *et al.* (2022) studied the effects of stocking density, floc volume, growth performance, and profitability of *Heteropneustes fossilis* using Biofloc Technology (BFT) in Bangladesh. They discovered that a lower stocking density (700 fish/m^3 tank) with BFT led to better growth performance in stinging catfish, indicated by a lower feed conversion ratio (FCR) and improved water quality, compared to higher stocking densities. The study involved stocking fingerlings in 5000-L tanks with three densities: 3500 fish/tank (Treatment-I), 4000 fish/tank (Treatment-II), and 4500 fish/tank (Treatment-III). Among these, Treatment-I achieved the highest final biomass of 29.51±0.04 kg/m^3. Additionally, BFT improved dissolved oxygen levels and reduced concentrations of ammonia, nitrite, nitrate, total dissolved solids (TDS), and floc volume, particularly at lower stocking densities.

Mugwanya *et al.* (2021) presented a scenario on biofloc technology (BFT) as a sustainable method for producing economically significant aquatic species. They emphasized that implementing BFT could help meet the global food demand by enhancing the production of crucial fish species, thereby addressing issues like hunger, malnutrition, and poverty over time. BFT facilitates integrated multi-trophic aquaculture systems, where the waste produced by one species serves as feed for another, without harming the co-cultured organisms. This review highlights the core principles of BFT, factors essential for its successful application in aquaculture, the significance of this method for the sustainable production of economically valuable aquatic species, and its benefits, drawbacks, and limitations.

Ahmadi *et al.* (2021) offer the first detailed account of the biofloc system-based fish marketing of climbing perch in South and Central Kalimantan, Indonesia. Fish were sold daily through two distinct marketing channels. The prices per kilogram at various stages were IDR 60,000 for fish farmers, IDR 70,000 for wholesaler, and IDR 77,667 for retailers. In the first marketing channel, fish farmers earned the highest net profit at 45%, with wholesalers and retailers earning 33% and 22%, respectively. In the second channel, restaurants secured a significant 74% profit, nearly three times the profit of fish farmers, who earned 26%. The marketing margins were 14% for wholesalers, 23% for retailers, and 50% for restaurants.

El-Sayed *et al.* (2021) conducted an in-depth review of biofloc technology (BFT) in shrimp farming over the last decade. They found that, since the early 1990s, extensive research has focused on developing and applying BFT in aquaculture, particularly for shrimp. Over 40% of BFT-related aquaculture studies pertain to shrimp farming. Thus, a thorough evaluation of BFT's use in shrimp farming over the past ten years (2010-2020) is both timely and valuable. This review compiles recent data on BFT applications in marine shrimp and freshwater prawn aquaculture. It covers factors influencing shrimp production in BFT systems, the integration of biofloc-based shrimp farming with other species, the nutritional value of bioflocs as natural feed, the role of BFT in different rearing stages, biofloc's probiotic effects on shrimp health, the economic aspects of BFT-based shrimp farming, and the main challenges faced.

Ogello *et al.* (2021) outlined the step-by-step procedures for establishing biofloc technology (BFT) and highlighted its potential to achieve three key objectives: increasing fish production, enhancing the resilience of fish farming systems, and optimizing the use of resources such as energy, water, and land while reducing greenhouse gas emissions. BFT relies on nutrient cycling through complex biological pathways to generate natural fish food. Bacterial flocs act as the system's engines, transforming pond waste into nutrients that fish can consume, thereby cutting feed costs by approximately 30% and boosting profitability. BFT is also beneficial for large-scale production of live food, essential for hatchery larviculture, and enhances gonad and ovary development in brood stock, improving fish reproduction.

Das *et al.* (2021) conducted research on intensive farming of Asian stinging catfish (*H. fossilis*) in a biofloc system aimed at conserving this freshwater species. The study focused on a 90-day culture of *H. fossilis* in 1000-liter biofloc (T1 and T2) and non-biofloc (C) systems, minimizing water exchange. They monitored microbial populations and observed that each tank had a stocking density of 500 fish per 1000 liters of water. Fish in T1 ranged from 4.3 to 22.5 grams, in T2 were around 24.0 grams, and in C were about 18.5 grams. Survival rates were notably high in T1 (88-95%) and T2 (88-95%), and slightly lower in C (80-90%), with feed conversion ratios (FCRs) of 1.5 in C and 0.6 and 0.8 in T1 and T2 tanks, respectively.

Zafar *et al.* (2021) conducted a 120-day study in Singair, Manikganj, using a biofloc system to evaluate its effects on Asian stinging catfish. Fingerlings (n=2,700, average weight 4.40±0.10 g) were fed a commercial diet (35% crude protein) at 5%-2% biomass in the control and 2%-1% in the biofloc group with sugarcane molasses to achieve a C/N ratio of 10:1. Housed in six outdoor circular tanks (3,000 L) with aeration, significant differences ($P<0.05$) were observed in ammonia, nitrate, nitrite, and suspended solids levels. Biofloc substantially improved weight gain, biomass, growth rate, and feed efficiency ($P<0.05$), and enhanced hepatic lipase, intestinal protease, and amylase activities ($P<0.05$), along with higher crude protein and fat content compared to the control, highlighting biofloc as optimal for sustainable Asian stinging catfish aquaculture.

Deb *et al.* (2020) investigated the effectiveness of the biofloc system in farming Indian major carps such as Rohu, Catla, and Mrigal at different stocking densities (4.28, 8.57, and 12.85 fish m^{-3}). They found that the biofloc system effectively removed inorganic nitrogen from the water and significantly enhanced the growth parameters of the fish compared to a control system without biofloc. Optimal water quality and floc formation were observed at a stocking density of 4.28 fish per meter, resulting in specific growth rates of 1.1% day^{-1} for Catla and 0.98% day^{-1} for Rohu. Overall, the biofloc system proves efficient for polyculture of Indian major carps and is suitable for large-scale aquaculture setups.

Aftabuddin *et al.* (2020) conducted a pioneering study on *Penaeus monodon* culture in Bangladesh using biofloc technology. Over 127 days at the Harbour Aquaculture Research and Training Centre in Cox's Bazar, they utilized twelve 5000-liter enclosed cement tanks. Post larvae of *P. monodon*, weighing 0.18±0.02 g and in optimal health were sourced from a nearby hatchery. Significant differences ($P<0.05$) were observed among treatments and the control group in specific growth rate, food conversion ratio, and protein efficiency ratio of shrimp. BFTI achieved significantly higher final biomass (5.88±0.12 kg/m^3) compared to the control (3.40±0.09 kg/m^3) and other BFT groups. The study highlighted BFT's effectiveness in enhancing total heterotrophic bacteria and reducing ammonia nitrogen, nitrite-N, and nitrate-N levels in water with lower stocking densities.

Chen *et al.* (2020) studied the impact of biofloc concentrations and methods of adding carbohydrates on water quality, bacterial community composition, and growth performance of African catfish (*Clarias gariepinus*) in biofloc systems over 140 days. They operated biofloc systems with and without polycaprolactone as an external carbohydrate source. The study found no significant differences in the relative abundance of the top five bacterial phyla between treatments ($p > 0.05$). However, at the genus level, bacterial populations were significantly influenced ($p < 0.05$) by the methods and amounts of carbohydrates introduced and the concentrations of biofloc. Survival rates for African catfish ranged from 89% to 97%, with food conversion rates ranging from 1.17 to 1.43.

Fagun *et al.* (2020) conducted a survey in Habiganj Sadar Upazila, Bangladesh, to assess the socioeconomic conditions of fish farmers and identify challenges in aquaculture. Most surveyed ponds (37.61%) ranged from 0.02 to 0.06 hectares, with 63.33% owned by single individuals. Farmers primarily stocked Rohu, Catla, Mrigal, and other species, averaging 16,236 fry per hectare. All farmers provided feed, and 73.33% took measures against diseases. Annual production ranged from 0.54 to 6.19 metric tons per hectare, with incomes varying from 74,534 to 500,000 Tk per hectare. High feed costs were a major concern for 34.38% of farmers. Training, economic support, and disease management advice could significantly enhance profitability and improve livelihoods in fish farming.

Zafar *et al.* (2020) studied aquaculture practices among fish farmers in Birganj Upazila, Dinajpur district. Most farmers (52.24%) owned ponds ranging from 5 to 10 decimals with an average depth of 4.44 feet. About 79% of ponds held water year-round, while 21% retained water for 6 to 8 months. Indian major Carp and Small Indigenous Species were the main species cultured. Around 76% of farmers used feed, but none actively managed water quality. Tilapia was the most produced species at 22%. Challenges included expensive fish seeds and feeds, low feed protein content, and inadequate technical knowledge. Training, institutional support, and accessible credit are crucial for sustainable fish farming and livelihood improvement.

Halim *et al.* (2019) emphasized the potential of Biofloc Technology (BFT) in aquaculture, likening it to a transformative "blue revolution." BFT centers on converting waste nutrients, particularly nitrogen, into microbial biomass. These microorganisms can be used directly as feed or to enhance water quality by absorbing nitrogen compounds and producing microbial protein. The technology aims to improve nutrition by reducing Feed Conversion Ratio (FCR) and costs while also competing against pathogens. They stressed the need for further research to optimize BFT operations, including nutrient recycling, metabolite synthesis, and immunological benefits. Educating farmers about these advancements is crucial for effective implementation of BFT in aquaculture.

Farooqi and Qureshi (2018) explored the potential of biofloc technology (BFT) as a comprehensive solution in aquaculture. They highlighted the manipulation of the C/N ratio to convert nitrogenous wastes into beneficial microbial protein, thereby enhancing water quality in systems with zero-water exchange. BFT not only provides essential nutrition for aquatic organisms but also incorporates bioactive compounds that boost growth, survival, and immune defenses. This technology presents a sustainable approach to address environmental, social, and economic challenges in aquaculture, aiming for increased productivity with minimal environmental impact. They underscored the need for ongoing research and development by current and future generations of researchers, farmers, and consumers to fully integrate BFT into sustainable aquaculture practices.

Prabu *et al*. (2018) investigated the impact of dietary supplementation with biofloc meal on the growth and survival of juvenile GIFT tilapia. They conducted a 60-day experiment to assess how different levels of biofloc meal (0%, 20%, 30%, and 40%) in isonitrogenous and isoenergetic diets (32% crude protein) affected the tilapia. The results indicated that incorporating 20% biofloc meal in the diet (T_2) yielded the highest average body weight gain of 25.28±0.81 g compared to other biofloc meal inclusion levels and the commercial diet (T). This suggests that 20% biofloc meal could effectively enhance growth performance in GIFT tilapia.

Fauji *et al.* (2018) investigated the growth performance and resilience of African catfish *Clarias gariepinus* (Burchell) in a biofloc-based nursery setup using different stocking densities. The study divided African catfish, averaging 0.96 g in weight and 4.20 cm in length, into 12 circular plastic-lined tanks (1,020 L). Three biofloc treatments—BFT4 (4 fish/L), BFT6 (6 fish/L), and BFT8 (8 fish/L)—alongside a control group without added carbon source were used in triplicates. Tapioca flour was used as the organic carbon source in biofloc systems at a C/N ratio of approximately 10. Fish in biofloc systems exhibited enhanced growth, improved feed utilization, resilience to salinity stress and A. hydrophila infection, and increased nursery profitability. However, higher fish densities (6 and 8 fish/L) led to increased mortality and poorer feed conversion ratios.

Fatema *et al.* (2018) studied the socio-economic status and aquaculture practices of fish farmers in Parbatipur, Dinajpur district from May to October 2016. Most farmers were aged 31 to 40 (44.3%) and primarily Muslim (68.6%), with 40% having secondary education. Nuclear families were prevalent (64.3%). Fish farming was a primary occupation for 24% and secondary for 53%. Over 80% had electricity, and 41% used village doctors for health services. Only 9% received formal fish farming training. With an average pond size of 0.18 ha and 84% perennial ponds, training, institutional support, credit, and extension services are crucial for improving production.

Sharma *et al.* (2018) investigated biofloc culture as feed for *Labeo rohita* in a limited water exchange system. Set 2, with 50% biofloc, yielded the best results. Molasses served as the carbon source, and pond silt was used to introduce heterotrophic bacteria. Maintaining a C/N ratio above 10 facilitated biofloc development, which was fed to the fingerlings. Over a 90-day trial, three diets were tested: 100% artificial feed, 50% biofloc and 50% artificial feed, and 100% bioflocs, to monitor fingerling growth.

Avnimelech (2007) studied the consumption of microbial flocs by Mozambique tilapia in low-discharge BFT ponds. Fish averaging 107 grams were placed in 1 m^3 tanks with water from a limited exchange intensive tilapia pond. Tagged ammonium nitrogen and starch were added to trace 15N incorporation into bio-flocs. Over two weeks, with one week of no additional feed, only microbial flocs were available. Monitoring floc volume, TSS, carbon, and nitrogen showed a feed uptake of 10.3 ± 1.0 g/kg fish/day. This initial study, however, did not account for floc production and degradation, focusing on fish consumption as the main factor affecting biofloc mass.

Kathia *et al.* (2017) reviewed fish and crustacean culture results using probiotics and biofloc systems. They applied *Bacillus amyloliquefaciens* to enhance the immune system of white shrimp (*Litopenaeus vannamei*) in biofloc. In a study with *Clarias gariepinus* juveniles, Bacillus sp., molasses, and fish pellets in a biofloc system led to 30% better growth compared to no biofloc. Another study with commercial probiotics in biofloc with *Vibrio parahaemolyticus*-infected *L. vannamei* showed controlled vibriosis but no significant growth differences. Probiotics increased survival to 83% compared to 52% in the control, though another study found no significant growth impact with Bacillus and Lactobacillus probiotics in shrimp biofloc systems.

Rajagopalasamy *et al.* (2016) assessed the impact of biofloc on the growth and survival of blue morph cichlids. They used circular cement tanks with a 14,000 L capacity to house thousands of fish in both standard and biofloc environments. Growth metrics, biofloc characteristics, and water quality were periodically measured and analyzed using ANOVA. Water quality parameters were superior in the biofloc tank, which also had a higher floc volume (44) and microorganism count than the control. The survival rate of blue morph juveniles was 93% with biofloc, compared to 90.2% in the control. All growth indices, except mean length, weight gain, and length, showed significant differences ($P<0.01$) between treatments and over time.

Sarker *et al.* (2016) explored fish farming in Sreemangal, Moulvibazar, from January to December 2015. They found 40% of ponds were seasonal and 60% perennial, with 85% single-owned and 15% multi-owned. The average pond size was 0.13 ha and 2.6 m deep. All 17 farmers practiced polyculture with Indian and exotic carps, stocking 15,500 fingerlings/ha from March to June. Fish production was profitable, but challenges included insufficient credit support and technical assistance, highlighting the need for institutional and government support for sustainability.

Hastuti *et al.* (2014) studied the production of African catfish (*Clarias gariepinus*) using biofloc technology. Fish were reared at a density of 1,000 per square meter in cement tanks and fed a diet with 30% protein, 5% fat, 6% fiber, 13% mineral mix, and 13% water. Results showed that biofloc technology reduced feed conversion rates, increased fish production, and improved feed efficiency. Additionally, it enhanced water quality and survival rates, demonstrating that catfish could thrive at high densities using this method.

Ogello *et al.* (2014) reviewed the viability of tilapia production using BFT in ponds. They detailed BFT's potential to enhance productivity, safety, and financial sustainability of farmed tilapia. Well-managed biofloc ponds showed tilapia growth rates up to 0.3 g/day and yields of 300 mt/ha, with a 20% reduction in feed, lowering production costs. The study emphasized the role of biological, chemical, and physical interactions in bioflocs, though exact mechanisms remain unclear. The authors advocate for integrating easily digestible, energy-rich bacteria to maximize BFT's benefits in aquaculture.

Choudhury *et al.* (2014) reviewed common fungal diseases in fish, noting that aquatic fungi can affect eggs, fry, fingerlings, and adults. Most aquatic fungi are saprophytic, feeding on decomposing organic matter, and typically act as secondary invaders attacking hosts weakened by injury or infection. Common fungal diseases include Saprolegniasis, Achlya, EUS, Branchiomycosis, and Ichthyophoniasis, affecting various aquatic environments.

Crab *et al.* (2012) examined the benefits and challenges of BFT in aquaculture. They emphasized BFT as a method to enhance water quality in aquaculture by balancing nitrogen and carbon levels. Recently, it has gained attention for its sustainable approach to water management and its capability to produce protein-rich feed onsite. Challenges identified include optimizing aerator placement and selection, integrating BFT with existing systems like polyculture and raceways, identifying beneficial microorganisms for biofloc production, and developing monitoring techniques for biofloc composition and characteristics.

Azim and Little (2008) studied Nile tilapia in light-limited tank culture using BFT. They conducted experiments in 250-liter indoor tanks with two biofloc treatments and one clean water control. The BFT tanks were fed diets with different protein levels (24% and 35% CP), aerated using dome diffusers. Tilapia found biofloc nutritionally suitable, achieving 100% survival. Biofloc utilization was evident in higher net fish production (45% greater) compared to controls. Evaluation of welfare measures showed no significant stress differences between BFT and control tanks, suggesting biofloc did not adversely affect fish.

CHAPTER-III

MATERIALS AND METHODS

Several methods and techniques of data collection were adopted depending upon the aim, objectives and nature of the research. The patterned system was followed for data collection depending on primary and secondary data, in support of the present study.

3.1 Selection of the Research Area

The study was conducted in five upazilas such as Panchagarh sadar, Tentulia, Debiganj, Boda and Atwari of Panchagarh district. Panchagarh is considered as an important freshwater aquaculture portion of the northern part of Bangladesh. Several national and international projects, GOs and NGOs are working to introduce improved fish culture system and accelerate the fish production in the selected area. The study area is shown in Plate 3.1.

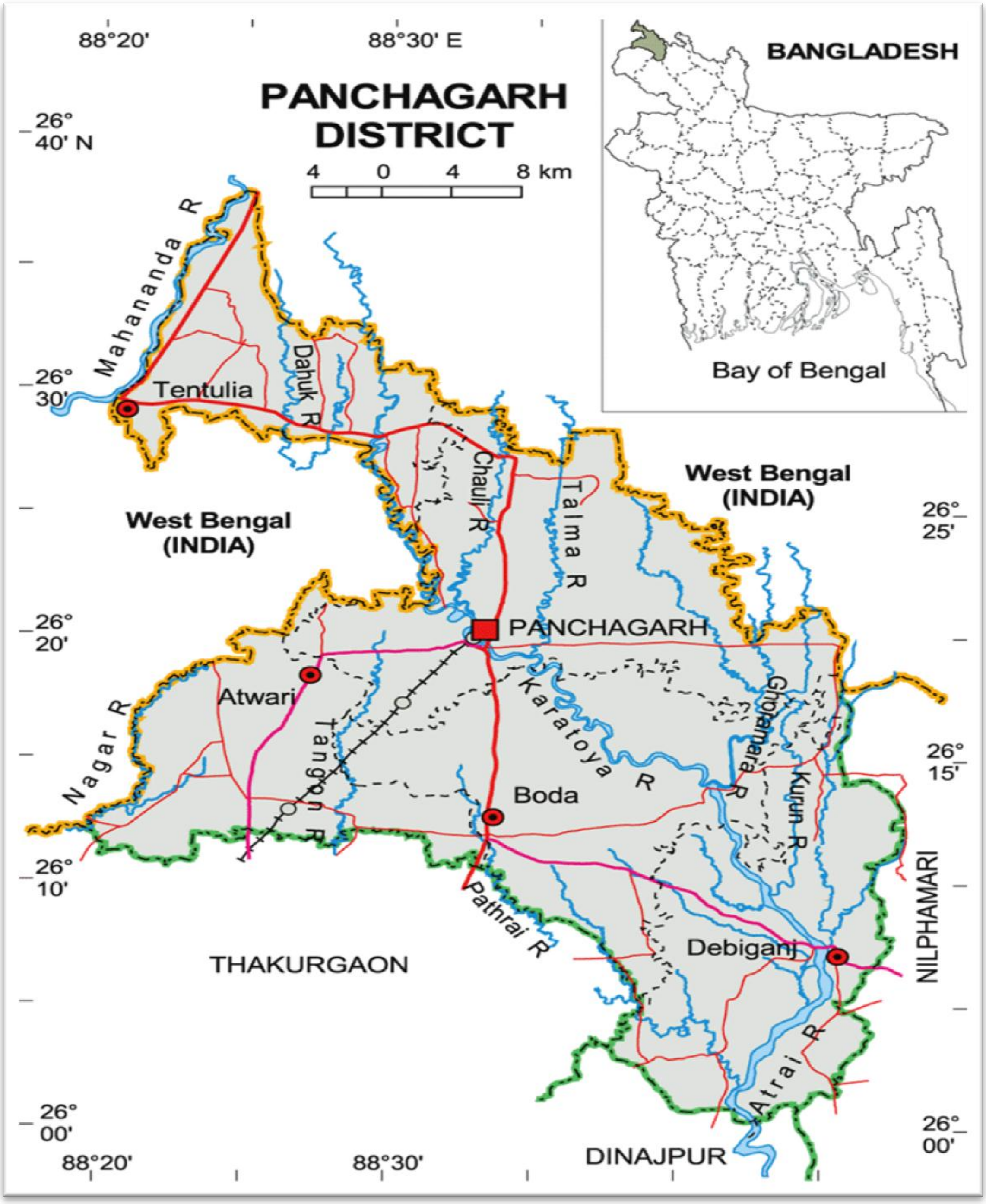

Figure 3.1: Map of Panchagarh district

3.2 Study Period

The survey was undertaken from July to December 2022. Data were collected randomly from 55 biofloc fish farmers of the selected upazilas of Panchagarh district through frequent field visit.

3.3 Collection of Data

Preparation of the survey schedule and questionnaire are course of a carrying absolute necessity for collecting data. With the aim of getting a complete picture of the present situation of biofloc fish farming in selected areas and to achieve the objective of the study, a questionnaire was prepared. The questionnaire was developed in a logical sequence of that the target group could answer chronologically and related to the biofloc farmers, their biofloc farming status, water quality, species cultured, feeds used, feeding frequencies, marketing related information etc. were included in the questionnaire.

Plate 3.1: Data collection from fish farmers

3.4 Questionnaire survey

For the present study, data were collected both from primary and secondary sources through the questionnaire interview and participatory rural appraisal (PRA) respectively. A total of 55 farmers having different farm size were interviewed. For the questionnaire interview, a set of preliminary questionnaires was prepared. This was field-tested with a few fish farmers of each representative location and necessary modifications were made based on their feedback. For the interview, a simple random sampling method was followed. Before the field survey, circumstantial information on the number, location, and distribution of fish farms and aquaculture activities were collected. The question was asked stepwise. The first step question on farmer's personal information, the second step question about culture preparation and farm related information, the third step was culture related (stocking and management) information, the fourth step was feed and disease related information and the final step end up with marketing and cordially thanking him/her for the information. During the survey, questions were asked systematically and explanations were made wherever it was felt necessary. The information supplied by the sample farmers was recorded directly on the interview schedules. The information was checked carefully before leaving the study area and any confusion was rationalized and corrected by comparing those with local standards to keep the consistency of data. To minimize errors, data were collected in local units. These were subsequently converted into appropriate units.

3.5 Participatory rural appraisal (PRA)

Focus group discussion (FGD) was conducted as PRA tools with rural fish farmers to get an overview map about biofloc culture system and their opinion on it. It is a discussion with a selected group of people following a set of detailed guidelines designed to generate discussion on a particular set of the topic. Several FGD sessions in different study areas were performed. FGD session was held in areas where there was local gathering. The PRA discussion was recorded for further reference and learning.

3.6 Key informant interview

The information was collected from key informant if there were any items incongruous. In those cases, cross-check interviews were conducted with key informants such as upazilla Fisheries Officer, NGO Workers working with aquaculture, local leader, fishermen leader, village old man, school headmaster and village headman was interviewed by a semi-structured questionnaire where information was contradictory. It was mandatory to check the information for justification of the collected data, after completing the collection of the data through questionnaire interviews and FGDs.

3.7 Summarizing and Tabulating of Data

Most of the survey research was presented in the tabular form because of their simple presentation technique, widely used and easy to recognized. Thats why mainly tabular analysis technique was used in this study. After collection of data from the field, the data were recorded in an Excel sheet. On the basis of aims and objectives of the study a number of tables were prepared.

3.8 Analysis of Data

The tabulated data were coded and entered into a computer for analysis. Some of the data were collected in local units due to familiarity with the respondent. These were converted into international units before transfer to the computer. Data were processed using Microsoft Excel. Preliminary data sheets were compared with the original sheets to ensure the accuracy of the data. Entered data were analyzed tabular and descriptive statistical techniques. The summary tables were prepared following the objective of the study. The technique of analysis followed by the classification of tables into meaningful results by the arithmetic mean, percentage and ratios.

CHAPTER-IV

RESULTS

This chapter provides a comprehensive analysis of the collected data, addressing the research objectives and presenting the findings in an organized manner. The results are divided into two main sections: personal information of biofloc farmers and farm-related information. The personal information section covers demographic details and the farm-related information section delves into specifics about biofloc farming practices.

4.1 Personal Information of Biofloc Farmers

The biofloc farmer's personal information is represented in this area, including age, sex, marital status, educational attainment, family size and composition, yearly income, access to hygienic facilities, health care, and membership in organizations, among other details.

4.1.1 Age group

Out of 55 respondents, the majority (62.50%) were young farmers aged 21-30 years, while a small fraction (6.56%) were in the 51-60 years age group. Farmers aged 31-40 years made up 18.68% and 14.26% were between 41-50 years old (Figure 4.1).

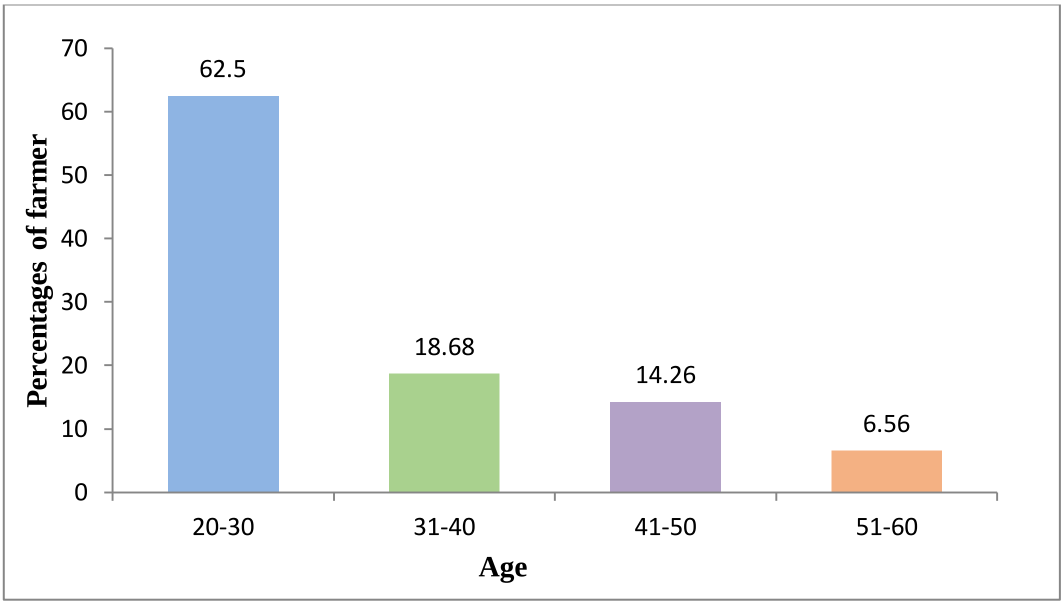

Figure 4.1: Age distribution of farmer

4.1.2 Educational status

It was revealed that the majority of biofloc farmers got formal education, with the highest percentage (40.50%) of respondents graduating. While 5.75%, 10.84%, 22.56%, and 20.35% attended primary, secondary school certificate, higher secondary certificate, and master's degrees, respectively (Figure 4.2).

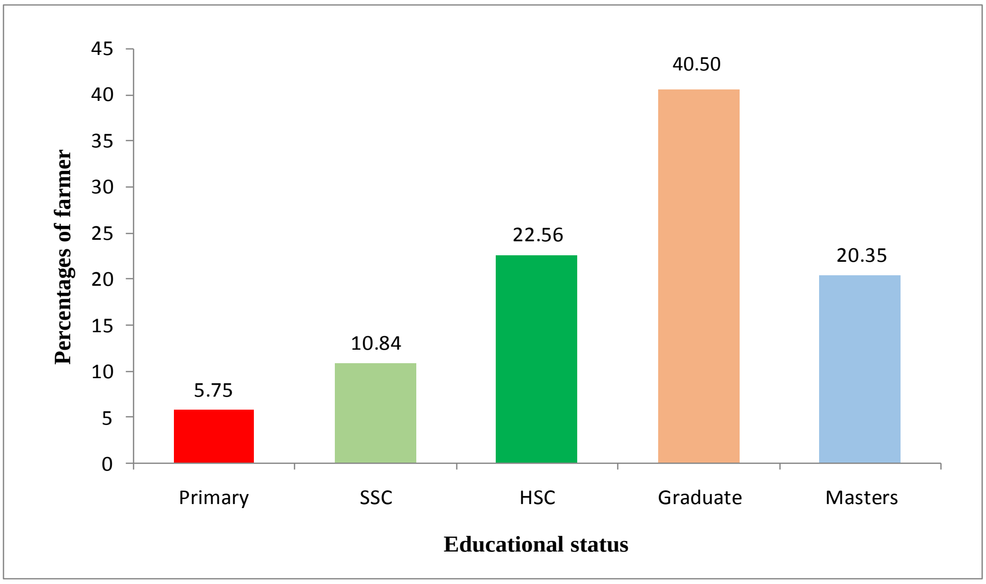

Figure 4.2: Educational status of the biofloc farmers

4.1.3 Family types

In accordance with nuclear and joint family classes, 80.58% were from nuclear families and 19.42% from joint family structures (Figure 4.3).

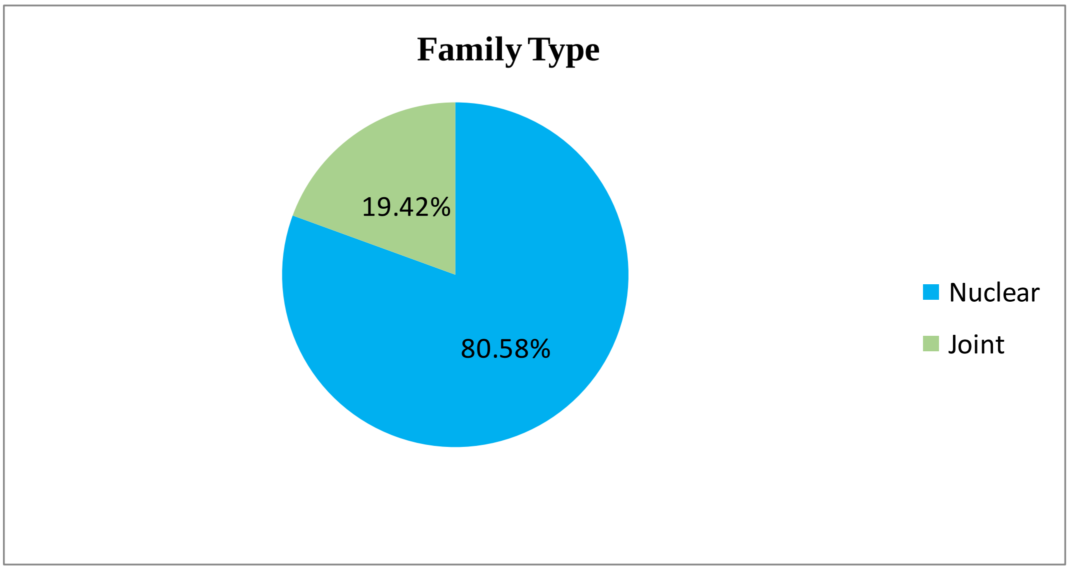

Figure 4.3: Family types of the biofloc farmers

4.1.4 Organizational membership

In the study area it was found that majority of the biofloc farmer (74.54%) did not have the membership of any organization and 25.45% were members of several organizations.

Table 4.1: Organizational membership of the biofloc farmers

Membership	No of respondents	Respondents (%)
YES	14	25.45
NO	41	74.54

4.1.5 Major occupation of biofloc farmers

It was reported that a large number of farmer (30.58%) adopted fish culture as their major profession whereas few respondents adopted biofloc culture (20.32%) as their major profession. Other respondents rely on professions such as 26.82% with crops, 16.64% with business, while 5.64% farmers were engaged in other occupations (Figure 4.4).

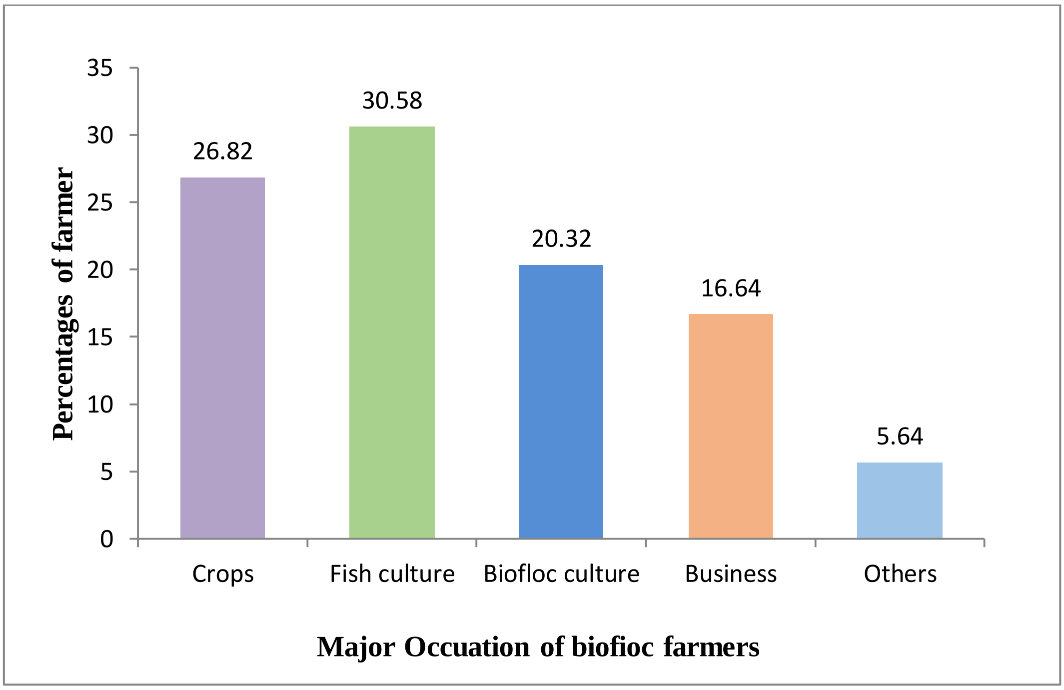

Figure 4.4: Major occupation of the biofloc farmers

4.1.6 Monthly income

The selected biofloc producers were divided into four groups based on their monthly income. The biggest percentage of biofloc farmers (35.75%) belong to the monthly income range of BDT. 21,000 to 30,000, while the lowest percentage (15.77%) was identified in the range of over BDT. 40,000 (Figure 4.5).

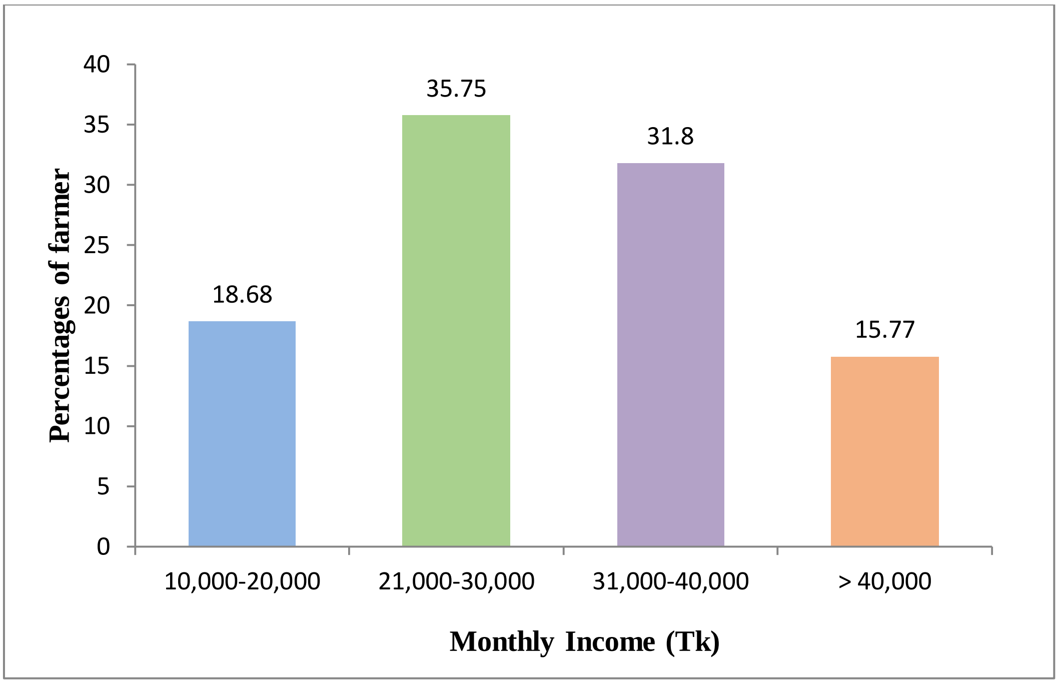

Figure 4.5: Monthly income of the biofloc farmers

4.1.7 Sanitary facilities

The majority of respondents (50.68%) had improved sanitary facilities, followed by 42.25% who had good sanitary facilities and 7.07% who did not.

Table 4.2: Sanitary facilities of biofloc owners

Sanitary Facilities	Percentage of farmer (%)
Better	50.68
Good	42.25
Not good	7.07

4.2 Farm Related Information

4.2.1 Duration of biofloc initiation

The majority of farmers (51.58%) had been engaged in biofloc farming for 7 to 12 months, while 44.86% had been farming for 1 to 6 months. Only a small fraction (3.56%) had continued biofloc farming for over 12 months (Figure 4.6).

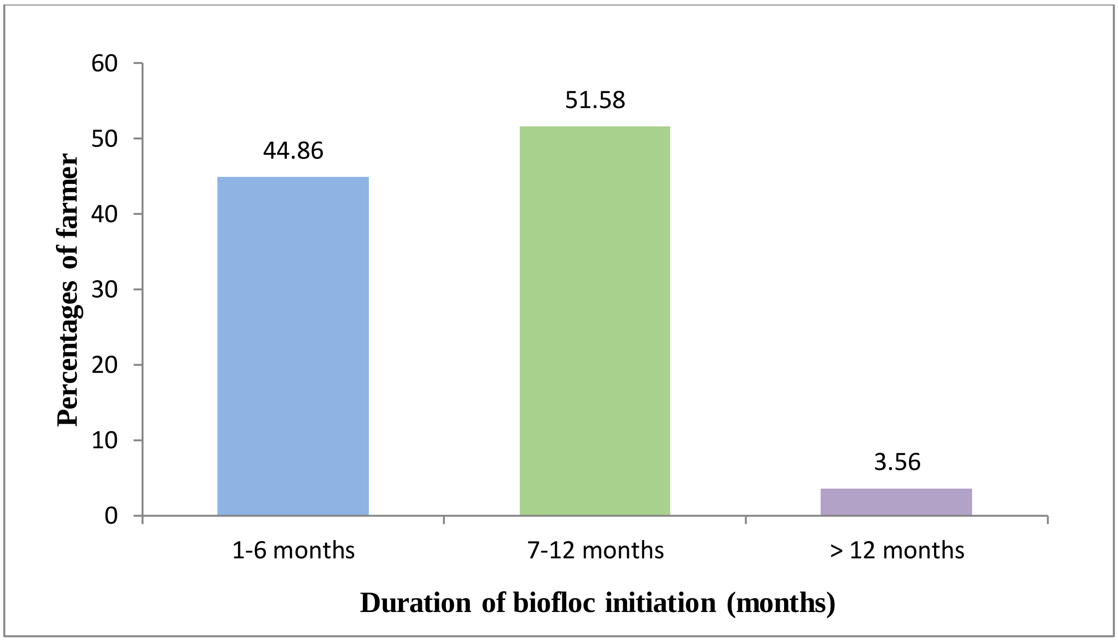

Figure 4.6: Duration of biofloc initiation

4.2.2 Training on biofloc before culture

Regarding training, only a minority of the respondents (29.65%) received training before starting biofloc culture, whereas the majority (70.35%) began biofloc farming without any prior training (Table 4.3).

Table 4.3: Training on biofloc before culture

Training on biofloc	Percentage of farmer (%)
YES	29.65
NO	70.35

4.2.3 Biofloc farm size

A significant portion of the respondents (56.36%) practiced biofloc farming in areas smaller than 1 decimal. Meanwhile, 30.90% conducted biofloc farming in areas ranging from 1.1 to 1.5 decimals, and 12.72% farmed in areas larger than 1.5 decimals (Table 4.4).

Table 4.4: Size of biofloc farms

Range (decimal)	No of respondents	% of respondents
<1	31	56.36
1.1-1.5	17	30.90
>1.5	7	12.72

4.2.4 Number of the tank

In the study area, it was observed that the majority of biofloc farmers (55.58%) had only one or two tanks for biofloc culture, while 30.50% used three to four tanks, and only 13.92% had five to six tanks for biofloc farming (Figure 4.7).

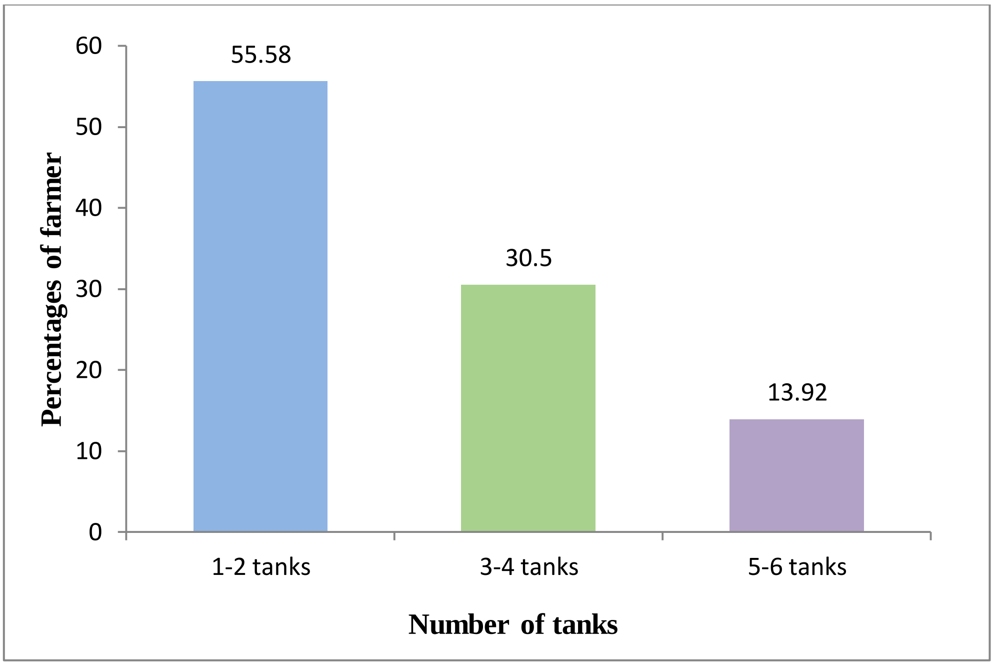

Figure 4.7: Diagram of number of tanks in each farm

4.2.5 Shape of the tank

In the study area, it was discovered that the majority of the biofloc culture was conducted in rectangular tanks (50.85%). Conversely, circular tanks accounted for 35.60% and square tanks made up 13.55% (Figure 4.8).

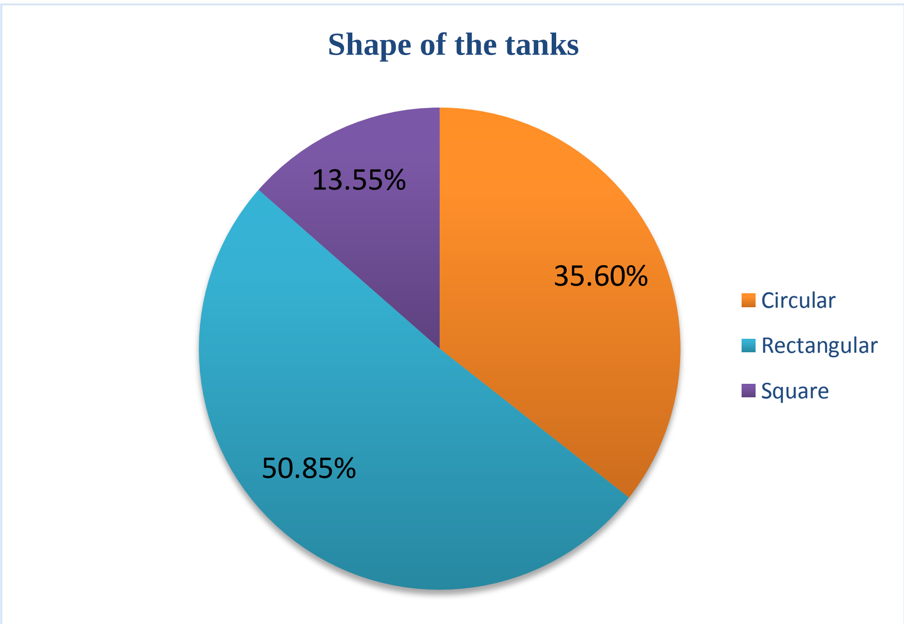

Figure 4.8: Diagram of the shape of the tank

4.2.6 Tank materials

The majority of biofloc tanks (83.63%) were constructed from cement, while the remaining tanks (16.37%) were made from tarpaulin (Table 4.5).

Table 4.5: Tank materials of biofloc farm

Materials used	No of respondents	% of respondents
Cement	46	83.63
Tarpaulin	9	16.37

4.2.7 Water holding capacity (Liters) and depth of tanks (Feet)

A significant portion of biofloc farmers (56.98%) utilized tanks with a capacity of 10,000-20,000 liters. Tanks with a capacity of 21,000-30,000 liters were used by 30.52% of the farmers, and 12.50% had tanks holding 41,000-60,000 liters (Table 4.6). The majority of tanks had a depth ranging from 4 to 6 feet.

Table 4.6: Water holding capacity and depth of tanks

Amount of water	Percentage (%)	Depth (feet)
10,000 L-20,000 L	56.98	4-6
21,000 L-40,000 L	30.52	≤4
41,0000 L-60,000 L	12.50	≥6

4.2.8 Water Exchange

It was noted that nearly all biofloc farmers practiced partial water exchange during the culture period. The frequency of water exchange varied based on their specific culture systems and management practices. Most respondents (49.32%) exchanged water as needed, while 24.32% did so every two weeks. Additionally, 18.50% of the farmers exchanged water weekly, and 9.86% did so monthly (Figure 4.9).

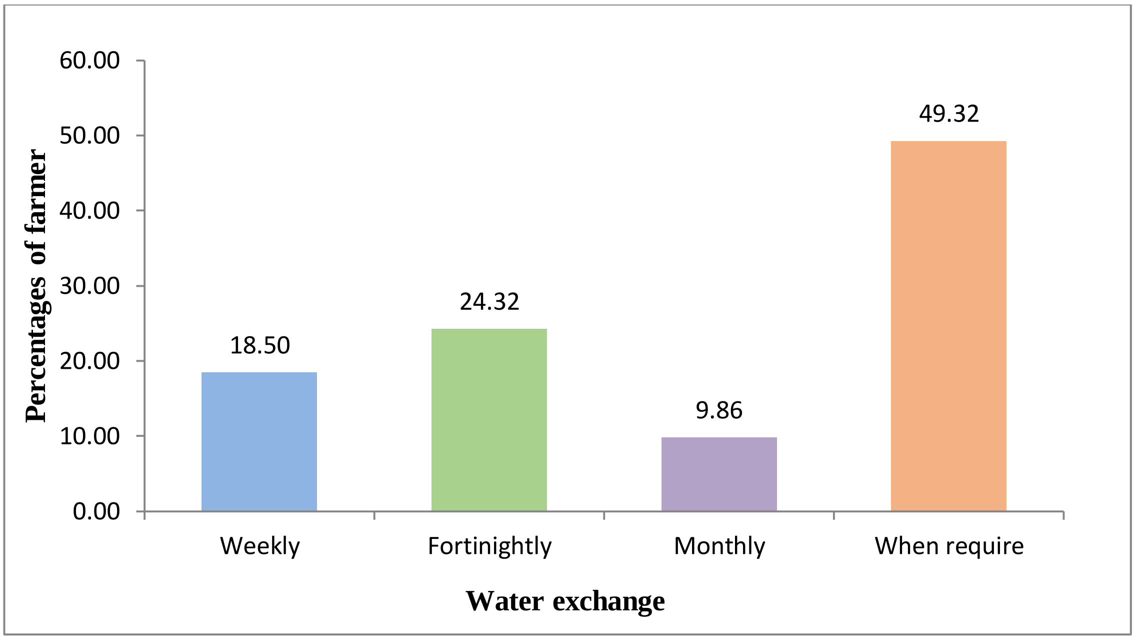

Figure 4.9: Duration of water exchange in biofloc farm

4.3 Culture Related Information

4.3.1 Source of water

A large portion of the water used by the biofloc farmers (92.48%) came from groundwater, with a little percentage (7.52%) coming from surface water (Figure 4.10).

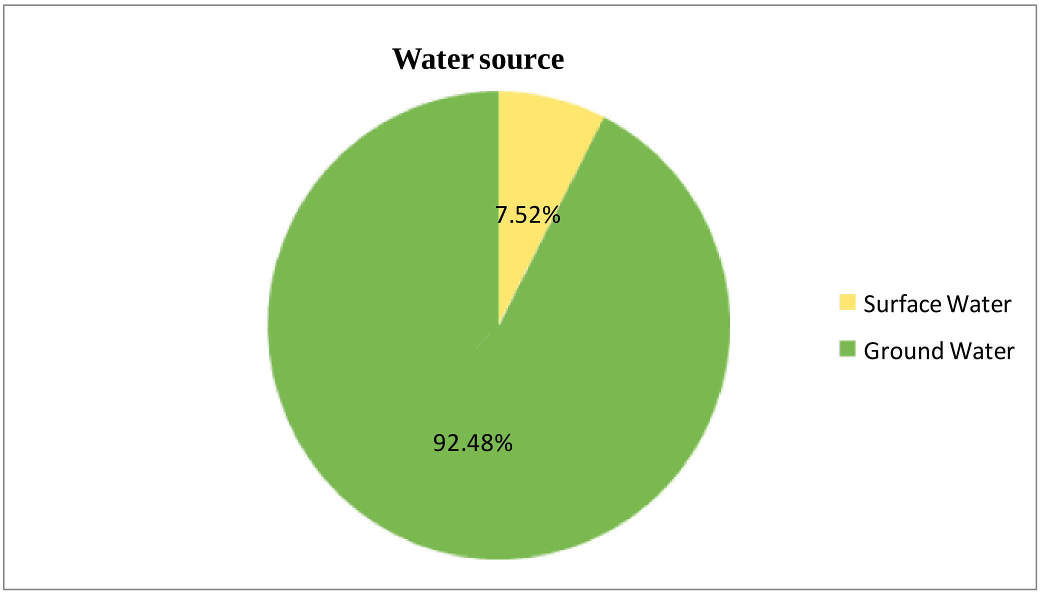

Figure 4.10: A graphical presentation of water source of farmers

4.3.2 Probiotic used

It was stated that the majority of farmers employed commercial or synthetic probiotics in their farms that were available on the market. Pond care (40.80%) was the most prevalent probiotic in the study area. In addition to protox aqua (22.81%), farmers employed aqua photo (17.32%), dellomax (10.94%), and ecopond (6.13%) as beneficial probiotics in biofloc farming (Figure 4.11).

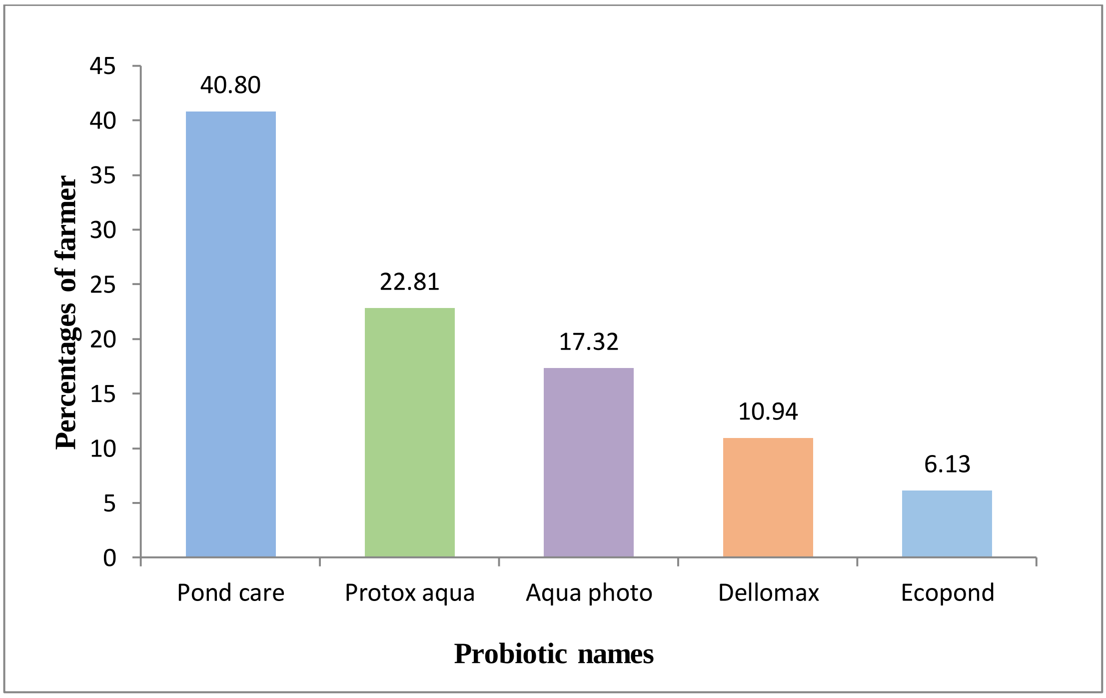

Figure 4.11: Probiotics used in biofloc farm

4.3.3 Water color during culture

The water color in 55.98% of tanks was brownish, 30.56% was greenish, and 13.46% was grayish (Figure 4.12).

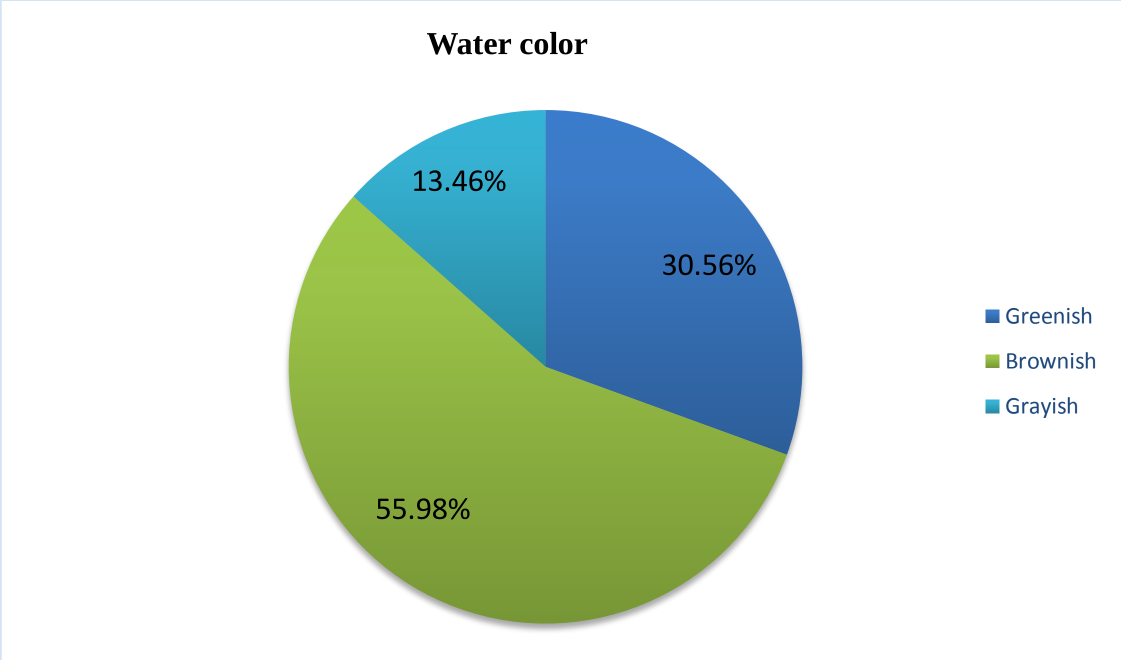

Figure 4.12: Watercolor during culture period

4.3.4 Materials used to check water quality parameters

Not all respondents had access to all the necessary tools for checking water quality parameters. Among the biofloc farmers, 28.25% used pH meter, 24.16% used TDS meter, 16.32% used thermometer, 10.56% used DO meter, 13.74% used ammonia test kit, and 6.97% used alkalinity test kit (Table 4.7).

Table 4.7: Tools used to check water quality parameters

Name of the materials	% of respondents
pH meter	28.25
TDS meter	24.16
DO meter	10.56
Thermometer	16.32
Ammonia test kit	13.74
Alkalinity test kit	6.97

4.3.5 Checking water quality parameters

A majority of biofloc farmers (60.25%) monitor water quality parameters every three days interval. Additionally, 28.59% check daily, while 11.16% conduct checks on a weekly basis (Table 4.8).

Table 4.8: Checking water quality parameters

Duration	% of respondents
Daily	28.59
After 3 days	60.25
Weekly	11.16

4.3.6 Electricity backup

Regular aeration is required in biofloc culture. Farmers in the study area used solar (24.56%), IPS (38.92%), generators (12.56%), and no electricity backup (23.96%) (Table 4.9).

Table 4.9: Electricity backup for aeration in biofloc farm

Backup system	% of respondents
Solar	24.56
IPS	38.92
Generator	12.56
No backup	23.96

4.3.7 Method of culture

Most of the farmers (56.36%) preferred monoculture system for biofloc farming in single tank where 43.63% practice polyculture system with different tanks (Table 4.10).

Table 4.10: Culture methods used in biofloc farm

Type of culture	No of respondents	% of respondents
Monoculture	31	56.36
Polyculture	24	43.63

4.3.8 Cultured species

Different species such as koi (26.15%), tilapia (23.58%), magur (25.52%), shing (14.96%), Gulsha tengra (7.45%) and Golda chingri (2.34%) were cultured in the study area (Figure 4.13)

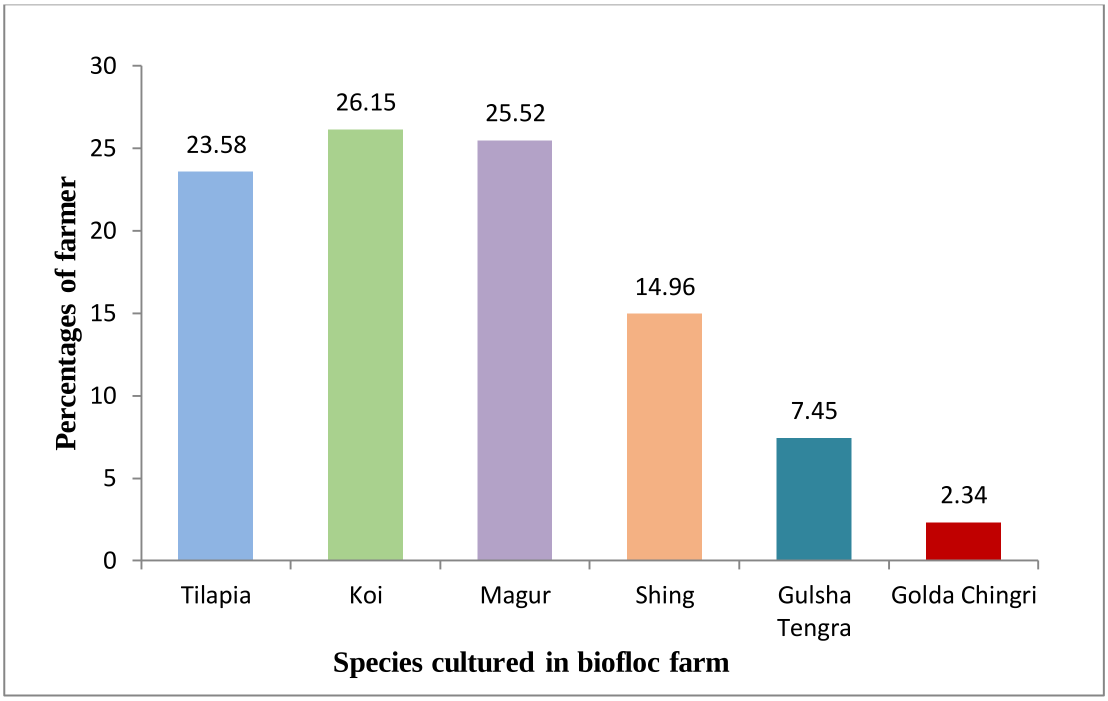

Figure 4.13: Species being cultured in biofloc fish farm

4.3.9 Culture duration

A significant majority of biofloc farmers (58.62%) practiced a culture period ranging from 4 to 6 months. A smaller percentage, 28.34%, had a culture period of less than 4 months, while 13.04% reported a culture period of more than 6 months (Table 4.11).

Table 4.11: Culture duration in biofloc farming

Time period (months)	% of respondents
<4 months	28.34
4-6 months	58.62
>6 months	13.04

4.3.10 Feed used in biofloc fish farming

All respondents in biofloc culture employ commercial, floating, and ball-shaped feeds, which are manually administered. A significant majority of biofloc farmers primarily use commercial feed from ACI Godrej (30.50%). Other feed suppliers include Tongwei (25.97%), Nourish (24.58%), Quality (8.25%), Mega (6.54%) and CP (4.16%) (Figure 4.14).

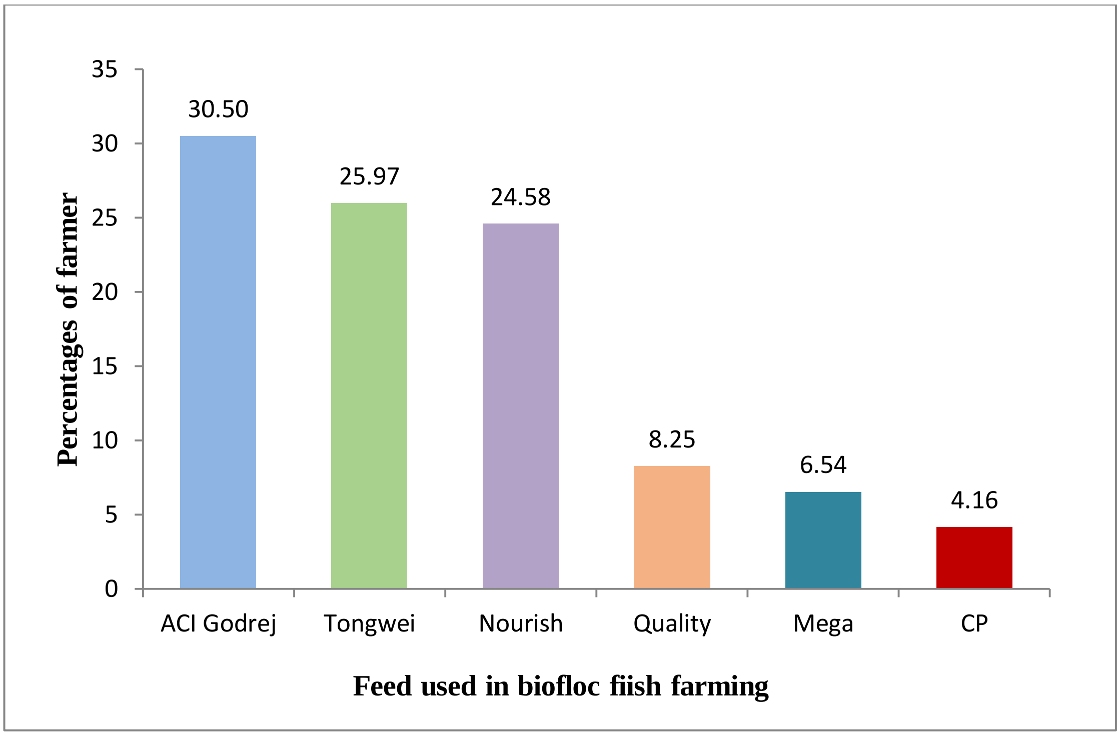

Figure 4.14: Commercial fish feed used in biofloc culture in Panchagarh

4.3.11 Occurrence of disease

Different types of diseases were found in the study area where most common (45.90%) were fungal and bacterial (34.50%). Viral diseases (10.32%) and other diseases (9.28%) were also found in the study area which is very harmful for fish species (Figure 4.15).

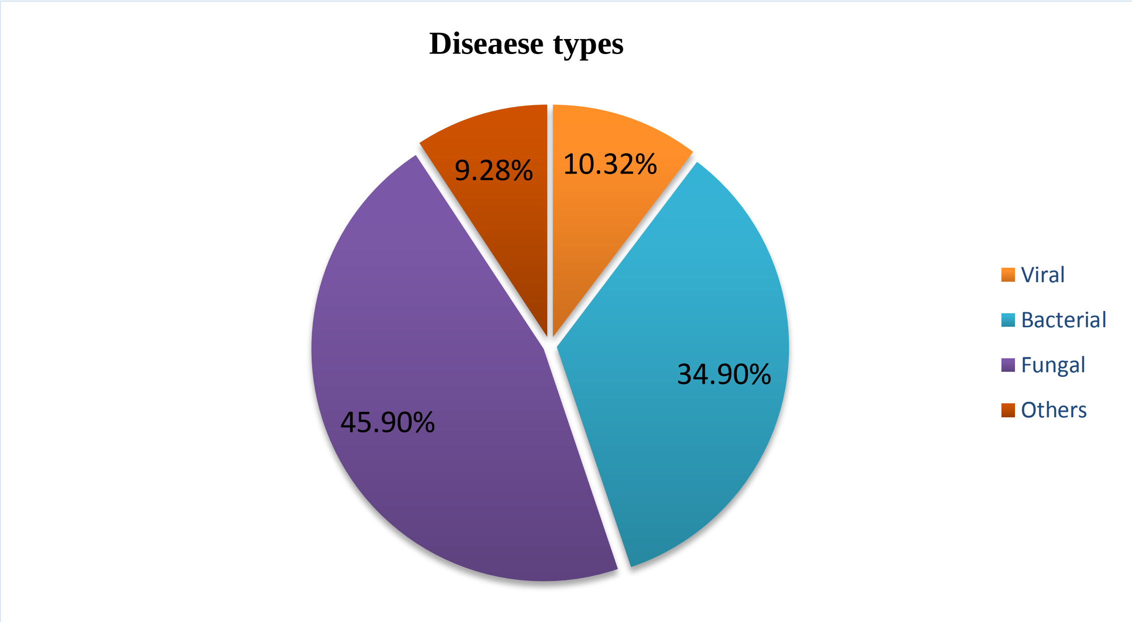

Figure 4.15: Occurrence of disease in biofloc culture

4.3.12 Harvesting of biofloc product

In the study region, farmers preferred total harvesting rather than partial harvesting. Here, 61.82% of farmers followed total harvesting technique and 38.18% farmers followed partial harvesting technique in that region (Table 4.12).

Table 4.12: Harvesting of biofloc product

Harvesting method	No of respondents	% of respondents
Partial harvesting	21	38.18
Total harvesting	34	61.82

4.3.13 Selling of harvested product

Among the surveyed biofloc farmers, 52.72% sold their fish to wholesalers, while 32.74% sold to both wholesalers and consumers. Another 14.54% directly sold their fish to consumers (Table 4.13).

Table 4.13: Selling of harvested product

Selling of product	No of respondents	% of respondents
Consumer	8	14.54
Wholesaler	29	52.72
Both	18	32.74

4.3.14 Fish production (kg/10,000 Liters/cycle)

In the study region, most of the biofloc farmers such as 38.12% and 35.65% respondent produced 301-400 kg and 200-300 kg fish, respectively. On the other hand lowest percentage (3.5%) of farmer was produced greater than 500 kg whereas 12.58% farmer productions were less than 200 kg fish in that region.

Table 4.14: Production of fish in biofloc culture

Fish production (kg)	% of respondents
<200 kg	12.58
200-300 kg	35.65
301-400 kg	38.12
401-500 kg	10.15
>500 kg	3.5

4.3.15 Problems in biofloc culture

It was found that due to the sensitive issues in biofloc farming majority of biofloc owner faced technical problems (50%) in their culture system. Others problems such as financial (22.75%), physical (14.32%), and social (10.50%) were also found in that study region. Only 2.43% of farmers were reported with no problems faced in biofloc farming (Figure 4.16).

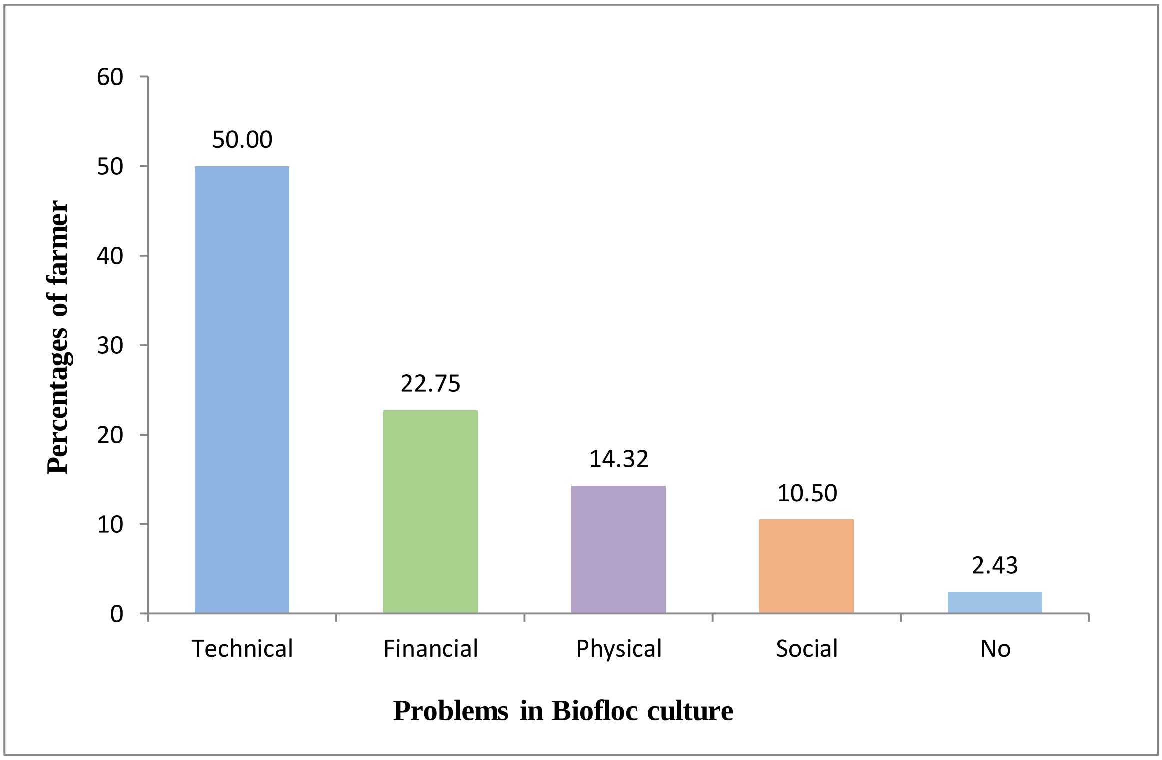

Figure 4.16: Problem of biofloc culture system

CHAPTER V

DISCUSSION

This chapter aims to interpret and contextualize the findings presented in the previous chapter, comparing them with existing literature and theoretical frameworks. It delves into the implications of the results for biofloc farming practices, considering both the personal characteristics of the farmers and the specifics of their farming operations. The discussion will highlight key trends, draw conclusions, and offer recommendations for future investigation and practical applications in the field of biofloc aquaculture.

The study showed that the majority (62.50%) were young farmers aged 21-30 years, while a small fraction (6.56%) were in the 51-60 years age group. Farmers aged 31-40 years made up 18.68% and 14.26% were between 41-50 years old. Rahman (2021) found that 57% of biofloc farmers were aged between 20 and 30 years, which closely align with the current study's findings. Conversely, Zafar *et al.* (2020) reported that a greater proportion of traditional fish farmers were between 41 and 60 years old.

It was revealed that the majority of biofloc farmers got formal education, with the highest percentage (40.50%) of respondents graduating. While 5.75%, 10.84%, 22.56%, and 20.35% attended primary, secondary, higher secondary, and master's degrees, respectively. Rahman (2021) noted that 93% of biofloc respondents had achieved secondary school education, a result that closely mirrors the findings of the current study. Ogello *et al.* (2021) suggested that biofloc is a modern, advanced, and technical farming system, attracting educated and younger farmers who are keen to embrace the challenges associated with this innovative technology.

In the study area it was found that majority of the biofloc farmer (74.54%) did not have the membership of any organization and 25.45% were members of several organizations. Crab *et al.* (2012) found that, in case of member of any organisation, 54% of the biofloc farmers were members of different non-government organizations (NGOs). It was reported that a large number of farmer (30.58%) adopted fish culture as their major profession whereas few respondents adopted biofloc culture (20.32%) as their major profession. Rahman (2021) indicated that around 17% of the farmers had adopted biofloc fish farming as their primary occupation. In this study, the biggest percentage of biofloc farmers (43.40%) belong to the monthly income range of BDT. 21,000 to 30,000, while the lowest percentage (15.77%) was identified in the range of over BDT. 40,000. Halim (2019) found that 40.50% of biofloc owners earned a monthly income between 21,000 and 30,000 Tk, placing them in the lower-middle-income class. This suggests that individuals who are relatively economically stable are more inclined to adopt biofloc technology, while those with lower incomes are hesitant to risk engaging in this newly introduced farming system. The majority of respondents (50.68%) had improved sanitary facilities.

The result revealed that, the majority of farmers (51.58%) had been engaged in biofloc farming for 7 to 12 months, where only a small fraction (3.56%) had continued biofloc farming for over 12 months. Crab et al. (2012) discovered that over 40% of biofloc farmers maintained their farming activities for a period ranging from 6 to 12 months. Regarding training, the majority (70.35%) began biofloc farming without any prior training. Likewise, Rahman (2021) noted that 72% of respondents began biofloc fish farming without any prior experience in aquaculture, and 83% had not received any biofloc training before starting their operations. A significant portion of the respondents (56.36%) practiced biofloc farming in areas smaller than 1 decimal. Meanwhile, 30.90%

conducted biofloc farming in areas ranging from 1.1 to 1.5 decimals. Halim (2019) found that 48.58% of respondents had farm sizes smaller than 1 decimal, highlighting the minimal use of land and water. In the study area, it was observed that the majority of biofloc farmers (55.58%) had only one or two tanks for biofloc culture. Rahman (2021) found that above 62% of respondents used 1-2 tank in their farm. In the study area, it was discovered that the majority of the biofloc culture was conducted in rectangular tanks (50.85%). Conversely, circular tanks accounted for 35.60% and square tanks made up 13.55%. But experts recommend that biofloc tanks should ideally be circular to ensure efficient water circulation. A significant portion of biofloc farmers (56.98%) utilized tanks with a capacity of 10,000-20,000 liters and the majority of tanks had a depth ranging from 4 to 6 feet. Jamal *et al.* (2020) found that nearly 50.95% of tanks were capable of holding 10,000-20,000L of water for biofloc culture, suggesting that many practitioners viewed it as an initial or experimental phase.

The frequency of water exchange varied based on their specific culture systems and management practices. Most respondents (47.32%) exchanged water when needed. Farooqi and Qureshi (2018) narrated that biofloc technology is useful in maintaining optimum water quality parameters under a zero-water exchange system. Minabi *et al.* (2020) explained that biofloc is an excellent technology used to develop the aquaculture system under limited or zero water exchange with high fish stocking density. It was stated that the majority of farmers employed commercial or synthetic probiotics in their farms that were available on the market. Pond care (40.80%) was the most prevalent probiotic in the study area. In addition to Protox aqua (22.81%), farmers employed Aqua photo (17.32%), Dellomax (10.94%), and Ecopond (6.13%) as beneficial probiotics in biofloc farming. Akter *et al.* (2016) also used different types of beneficial probiotics in aquaculture system which were protox aqua, aqua photo, MI plus etc.

The water color in 55.98% of tanks was brownish, 30.56% was greenish, and 13.46% was grayish. Avnimelech (2013) described that a green-water biofloc system relies on the interplay between algae and bacteria in outdoor tank settings, while a brown-water biofloc system is more associated with indoor tank environments, where bacteria predominantly manage water quality. In this study, 28.30% of the tank water exhibited a green hue, while 60% displayed a brownish color. Due to sensitivity of this culture system, a majority of biofloc farmers (60.25%) monitor water quality parameters every three days intervals which was similarly found by Minabi (2020). Regular aeration is required in biofloc culture. 76.04% farmers in the study areas had electricity supply for break-free aeration. Most of the farmers (56.36%) preferred monoculture system rather than polyculture system for biofloc farming. Mohammadi (2021) also found that monoculture farming of tilapia species is more favorable than polyculture system. Different species such as Koi (26.15%), Tilapia (23.58%), Magur (25.52%), Shing (14.96%), Gulsha tengra (7.45%) and Golda Chingri (2.34%) were cultured in the study area. Rashid and Ashab (2022) found that a majority (73.9%) of farmers opted to culture monosex tilapia (*Oreochromis niloticus*) in their biofloc units, considering it highly suitable for this method of fish farming. Catfish species, especially Pangasius, have shown successful cultivation in biofloc systems, exhibiting enhanced growth rates and increased disease resistance (Rahman, 2008). Similarly, common carp flourishes in biofloc environments, achieving better feed conversion efficiency (Azim, 2008). Pacific White Shrimp (*Litopenaeus vannamei*) also benefits from biofloc systems, which enhance water quality and offer additional nutritional support (Kuhn, 2010).

A significant majority of biofloc farmers (58.62%) practiced a culture period ranging from 4 to 6 months. Rashid and Ashab (2022) revealed that the installation of the Biofloc unit was for a long-term basis and the unit is considered to last for at least 5 years. All respondents in biofloc culture employ commercial, floating, and ball-shaped feeds, which are manually administered. According to Rahman et al. (2018) all farmers supplied feeds to the cultured fish species. Different types of diseases were found in the study area where most common (45.90%) were fungal and bacterial (34.50%). According to Lee (2023), different types of fungal, bacterial and viral fish diseases were found which is caused by *Aphanomyces invadans*, *Vibrio harveyi*, *Aeromonas hydrophila*, *Edwardsiella tarda*, and *Streptococcus iniae*, all of which cause great damage in fish farms. It is speculated that factors such as fish rubbing against the rough surfaces of cement tanks, overcrowding, overfeeding, and an imbalance in the carbon-nitrogen ratio leading to water pollution could be responsible for fungal infections. These conditions may subsequently allow other microbes to thrive, resulting in severe infectious diseases (Choudhury *et al.* 2014). In the study region, farmers preferred total harvesting (61.82%) rather than partial harvesting. In the study region, most fish production reported by 38.12% and 35.65% respondent which were 301-400 kg and 200-300 kg respectively. Rahman (2021) demonstrated that in biofloc systems, the average fish yield ranged from 300 to 400 kg. It was found that due to the sensitive issues in biofloc farming majority of biofloc owner faced technical problems (50%) in their culture system. Others problems such as financial (22.75%), physical (14.32%), and social (10.50%) were also found in that study region. Only 2.43% of farmers were reported with no problems faced in biofloc farming.

CHAPTER VI

SUMMARY AND CONCLUSION

6.1 Summary

This study presents a comprehensive assessment of the current state and potential of biofloc technology in the Panchagarh district, focusing on both the personal and farm-related information of biofloc farmers. The research reveals key demographic details, such as the majority of biofloc farmers being young, with 62.50% aged between 21 and 30 years. Education levels are relatively high among these farmers, with 40.50% having graduated and a significant portion holding higher degrees. Most of these farmers belong to nuclear families, and a large majority (74.54%) are not members of any professional organization. Occupation-wise, many farmers have diversified their income sources, with 30.58% adopting fish culture as their primary profession, while 20.32% focus on biofloc farming specifically. The monthly income of these farmers varies, with most earning between BDT 21,000 and 30,000. Sanitary facilities are generally adequate, with 50.68% having improved facilities.

Regarding farm-related practices, biofloc farming is relatively new in the region, with 51.58% of farmers having initiated their operations within the past 7-12 months. Interestingly, a majority (70.35%) started biofloc farming without prior training, indicating a gap in formal educational resources. Farm sizes are generally small, with 56.36% operating in areas less than one decimal, and most farmers (55.58%) maintain one or two tanks. Rectangular tanks made of cement are predominant, with capacities ranging from 10,000 to 20,000 liters and depths of 4-6 feet being common. Water exchange practices are varied, though many farmers (47.32%) exchange water as needed, primarily sourced from groundwater (92.48%). Probiotics like Pond Care are widely used to maintain water quality, which is monitored frequently, with 60.25% of farmers checking parameters every three days. Electricity backup systems are crucial, with IPS being the most common solution (38.92%). Farmers primarily engage in monoculture, focusing on species such as Koi and Tilapia, with culture durations typically between 4-6 months. All farmers use commercial floating feeds to sustain their fish. Disease management remains a challenge, with fungal and bacterial infections being the most common issues. Harvesting practices vary, though total harvesting is preferred by 61.82% of farmers, who primarily sell their produce to wholesalers. Fish production levels are moderate to high, with 38.12% reporting yields of 301-400 kg per 10,000 liters per cycle.

The biofloc farming in Panchagarh district shows significant promise despite several challenges. The young and educated demographic of farmers, coupled with their willingness to adopt new technologies, positions the region well for future growth in aquaculture. However, the lack of formal training, limited organizational support, and issues with disease management highlight areas needing improvement. Enhancing training programs, promoting organizational memberships, and addressing technical and financial challenges are crucial steps to ensure the sustainable development of biofloc farming in the region. This study underscores the importance of continued research and support to fully realize the potential of biofloc technology in boosting aquaculture productivity and farmer livelihoods in Panchagarh.

6.2 Conclusion

In conclusion, biofloc farming in Panchagarh district is a burgeoning sector with considerable potential for growth, driven by a predominantly young and educated farmer base. The study highlights the critical role of education, as a significant portion of farmers holds higher degrees, which may contribute to their ability to manage the complexities of biofloc systems. The prevalence of nuclear families and the diversification of occupations among farmers indicate a dynamic and resilient community capable of embracing new agricultural technologies. The lack of professional organization membership suggests a need for greater community and institutional support. Additionally, while farmers have adopted various management practices to maintain water quality and fish health, the frequent occurrence of diseases indicates a gap in effective disease management strategies. This underscores the necessity for enhanced training programs and better access to technical resources. Farm infrastructure, characterized by small-scale operations with limited tank capacities, also points to potential scalability issues. The reliance on groundwater and the prevalent use of commercial floating feeds highlight both opportunities and vulnerabilities in resource management. Despite these challenges, the reported fish production levels are promising, with many farmers achieving moderate to high yields. This indicates that with the right support and improvements in farm management practices, biofloc farming can significantly contribute to the local economy. By addressing the current challenges and building on the existing strengths of the farming community, biofloc farming can become a sustainable and profitable venture, contributing to the overall development of the district.

6.3 Recommendations

- Promotion of laws and policies should be needed that will assist the expansion of the biofloc farming business and create an atmosphere that is favorable to its growth.
- Provision of subsidies, low-interest loans, and other financial incentives to help farmers invest in necessary infrastructure and technology upgrades should be needed.
- Invest in research to develop more resilient biofloc systems adapted to the local environment and challenges faced by farmers in Panchagarh.
- Financial and technical support should be provided to help farmers scale up their operations, including increasing tank capacities and improving farm layouts.

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APPENDIX

Department of Aquaculture

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An interview schedule on

An Assessment of Current State and Future Potential of Biofloc Technology in Panchagarh District

Serial no:………

(Please answer the following questions)

Section-A: Personal Information:

Name of the respondent……………………………………...… Village………………………….

Union……………………………………………Post office…………..

Upazila……………………………………… Farmer's Mobile No:.………..…………………

1. Age: ……………………..years

2. Sex:

○ Male	○ Female

3. Educational status:

○ Primary (up to class five)	○ S.S.C	○ H.S.C
○ Graduate	○ Masters	

4. Family type:

○ Nuclear	○ Joint

5. Organizational membership:

○ Yes	○ No

6. Major occupation of biofloc farmers:

Please mention your monthly family income from the followings:

Sources	Tk
1. Crops	
2. Fish culture	
3. Biofloc culture	
4. Business	
5. Others	
Total (tk)=	

Section-B: Farm Information

7. Duration of biofloc initiation:

- 1-6 months
- 7-12 months
- >12 months

8. Training on biofloc before culture:

○ Yes	○ No

9. Size of biofloc farms:

- <1 decimal
- 1.1-1.5 decimal
- >1.5 decimal

10. Number of the tank:

○ 1-2 tanks	○ 3-4 tanks	○ 5-6 tanks

11. Shape of the tank:

○ Circular	○ Rectangular	○ Square

12. Tank materials:

○ Cement	○ Tarpaulin

13. Sanitary facilities:

○ Better	○ Good	○ **N**ot good

14. Water holding capacity (Liters) and depth of tanks (Feet):

Amounts (liter)	Depth (ft)
10,000-20,000	
21,000-40,000	
41,000-60,000	

15. Duration of water exchange:

- ○ Weekly
- ○ Fortnightly
- ○ Monthly
- ○ When require

Section-C: Culture Related Information

16. Source of water:

○ Surface	○ Ground

17. Probiotics used in biofloc farm:

Name of the probiotics
1.
2.
3.
4.
5.
6.
7.

18. Watercolor during culture period:

○ Greenish	○ Brownish	○ Greyish

19. Materials used to check water quality parameters:

- ○ pH meter
- ○ TDS meter
- ○ DO meter
- ○ Thermo meter
- ○ Ammonia test kit
- ○ Alkalinity test ki

20. Checking water quality parameters:

○ Daily	○ After 3 days	○ Weekly

21. Electricity backup for aeration in biofloc farm:

- ○ Solar
- ○ IPS
- ○ Generator
- ○ No backup

22. Method of culture:

○ Monoculture	○ Polyculture

23. Cultured species:

Name of the species
1.
2.
3.
4.
5.
6.
7.

24. Culture duration in biofloc farming:

- <4 months
- 4-6 months
- >6 months

25. What are the types of ready / commercial feeds you use in your fish farm?

○ Floating	○ Sinking	○ Both

26. What is the feeding frequency?

○ One time	○ Two times	○ Three times

27. Commercial fish feed used in biofloc culture:

Name of the feed company
1.
2.
3.
4.
5.
6.
7.

28. Occurrence of disease in biofloc culture:

○ Viral	○ Bacterial	○ Fungal	○ Others

29. Harvesting of biofloc product:

○ Partial harvesting	○ Total harvesting

30. Selling of harvested product:

○ Consumer	○ Wholesaler	○ Both

31. Fish production (kg/10,000Liters/cycle):

- <200 kg
- 200-300 kg
- 301-400 kg
- 401-500 kg
- >500 kg

32. Problems in biofloc culture:

- Technical
- Financial
- Social
- Physical
- No problem

Thank you for your kind information and cooperation.

…………………………….. ……..…………………

(Signature of the interviewer) (Signature of the farmer)

Date:………………………