DRAFT FOR COMMENTS

Biofloc Fish Farming – A Resource Book

Prof. Yoram Avnimelech, the Guru of Bioloc

https://www.aquaculturealliance.org

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Partners in Prosperity

Preface

Welcome to Partners in Prosperity. Teaching is an important part of the mission of our organisation, and you are now an important part of that teaching mission. Your role as a practitioner is to do your best to help yourself and others who have begun their journey as biofloc fish farmer. This manual, in conjunction with hundreds of fish farmers, is intended to assist you in your enterprise. It is mostly a collection of standard operating procedures gathered from field visits, available literature, and advice of experts.

Biofloc is rapidly spreading in many parts of the country. There is lack of definitive source of information, and technical hand holding. This manual is a humble effort to put together available knowledge and practices in one place.

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You can help us in continuously improving the manual with your insights, improvement upon current practices, and new knowledge. Please direct comments to me at info@pnpindia.org.in. Enjoy reading!

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Abbreviations

AH	Ampere Hour
CMFRI	Central Marine Fisheries Research Institute (India)
EBA	Ecosystem Based Approach
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross Domestic Product
GOI	Government of India
HP	Horse Power
ICAR	Indian Council of Agricultural Research
K	Thousand units
KwH	Kilowatt Hours
MT	Metric Tonne(s)
Mn	Million
NFDB	National Fisheries Development Board

Glossary

Algae

Algae (one alga, but several algae) are a type of plant-like living things that derive solar energy and carbon dioxide from the atmosphere to form their biomass. Too much algae growth blocks sunlight from reaching fish and depletes oxygen.

Autotroph

An autotroph is an organism that feeds itself, without the assistance of any other organisms, by manufacturing own food from inorganic substances, such as carbon dioxide and ammonia. Au*totrophs*, such as green plants, certain algae, and photosynthetic bacteria, use energy from light or inorganic chemical reactions. Autotrophs provide the food that all phytoplankton need to exist.

Bacteria

Bacteria are microscopic, simplest cells that live in their millions, in diverse environments. These single cells exist alone, but also found in pairs, chains or clusters. These organisms can live in water, soil, and inside body of living animals. bacteria serve a purpose, and are used in agriculture and pisciculture. Among bacteria, spherical (cocci), rod (bacilli), and spiral (spirilla) are most common shape of bacteria, followed by comma (vibrios) or corkscrew (spirochaetes).

Biomass

the organic material that comes from fish stock. Biomass is a renewable resource; it contains stored energy from sun.

Eutrophication

is when a water body becomes overly enriched with compounds containing nitrogen or phosphorus which induce growth of algae. This process may result in drop of oxygen level in the water body.

Heterotroph

All animals, protozoans, fungi, and most bacteria are heterotrophs. A heterotroph cannot manufacture its own food, instead it obtains nutrition from other sources of organic carbon, usually plant or animal matter.

Phytoplankton

micro, free-floating, photosynthetic organisms in aquatic systems. They include bacteria, and algae.

Protozoa

Protozoan infections are responsible for diseases that affect many fishes. The severity of infection depending on the immunity of the host and strain of the parasite. Protozoa are single-celled eukaryotes (organisms whose cells have nuclei); they commonly show characteristics of mobility and heterotrophy (using organic carbon as a source of energy).

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Chapter 1: An Introduction to Biofloc Fish Farming in India

1.1.Overview

Indian fisheries and aquaculture are making significant contribution to the country's nutritional security. Providing livelihood and gainful employment to more than 14 million people and earning foreign exchange through exports. India's diverse ecosystem, landscapes, deep seas, rivers, lakes, water bodies in the mountains harbour 10% of the global biodiversity in terms of fish and shellfish species. According to "Indian Fish Market: Industry Trends, Share, Size, Growth, Opportunity and Forecast 2019-2024" report- the Indian fish market was worth INR 1,110 Billion in 2018, projected to reach INR 1,998 Billion by 2024, at a CAGR of 10.2% during 2019-2024. The National Fisheries Development Board estimated the total fish production during 2018-19 is estimated to be 13.7 million tonnes up from12.60 million metric tonnes in 2017-18. Nearly 65% of the production is from inland sector and about 50% of the fish production is from culture fisheries. Accounting for nearly 6.5% of the global fish production, India is the second largest producer of fish after China.

India's domestic consumption as well as export of fishes has witnessed a strong spurt over the last few years. The market drivers for rising fish consumption include lifestyle changes, increasing cost of meat and the perception of fish as a healthy protein source with high levels of digestible protein, polyunsaturated fatty acids (PUFAs) and cholesterol lowering capability.

India's aquaculture production is classified into freshwater and brackish water production. Indian major carps and shrimp are among the dominant species farmed. Aquaculture is rapidly growing in India with an annual growth rate of over 7% (Jayasankar, 2018). Freshwater aquaculture contributes over 34% of the total annual aquaculture production of 7.0 million tonnes (Table 1). Technologies of induced carp breeding and polyculture of the three Indian major carps (*Catla, Labeo rohita and Cirrhinus mrigala*) as well as 'composite carp culture' with the addition of three exotic carps (*Hypophthalmichthys molitrix, Ctenopharyngodon idella* and *Cyprinus carpio*) in freshwater has dramatically increased freshwater aquaculture production. Further diversification in the sector is visible with the inclusion of medium and minor carps, catfishes and mudfish (snakehead murrels).

West Bengal, Andhra Pradesh, Gujarat and Kerala are the top four leading producers of freshwater fish through aquaculture. Haryana and Punjab have also made significant progress in aquaculture. System diversification has resulted in productivity rising to 3-6 t/ha. The private sector involvement in hatcheries, fish processing, and concentrated feed is increasing. Input-related, social, and environmental constraints of aquaculture in India need to be tackled through horizontal and vertical expansion, investment and adaptation of R&D to climate change mitigation and adaptation for more sustainable ways of aquaculture management.

Table 1: Fish Production Facts

Present fish Production (Capture)	7.0 mt
Inland	3.2 mt
Marine	3.8 mt
Potential fish production	8.4 mt
Fish seed production	40,000 million fries
Hatcheries	1,604 units
FFDA	429
BFDA	39

Source: National Fisheries Development Board http://nfdb.gov.in/about-indian-fisheries.htm

All matters related to fisheries schemes are administered by the Ministry of Fisheries, Animal Husbandry and Dairying. The Ministry was formed in May 2019 by Modi government from the department of same name under Ministry of Agriculture and Farmers Welfare. The Department of Fisheries in the Ministry is in control of planning, monitoring and the financing of centrally sponsored developmental schemes related to fisheries and aquaculture in all the Indian States. Most of the states possess a separate Department of Fisheries or else it remains within the Department of Animal Husbandry. Most states have well-organized fisheries departments with HQ at respective state capital, with qualified fisheries officers at district level and extension officers at block level. Besides, there are 429 Fish Farmers Development Agencies (FFDA) and 39 Brackish water Fish Farmers Development Agencies (BFDAs) for promoting freshwater and coastal aquaculture.

The key fisheries institutions under the control and management of the central Government are National Fisheries Development Board (NFDB), Fishery Survey of India (FSI), National Institute of Fisheries Post Harvest Technology and Training (NIFPHATT), Central Institute Of Coastal Engineering For Fishery (CICEF), Central Institute of Fisheries Nautical and Engineering Training (CIFNET), National Federation of Fishers Cooperatives Ltd. (FISHCOPFED), ICAR Fisheries Institutions and Universities supported through Central grant. The Indian Council of Agricultural Research located within the Ministry of Agriculture and Farmers Welfare is a key stakeholder in fish production, R&D and extension services. There are about 716 Krishi Vigyan Kendras (Farm Science Centres) in the Country, operated through State Agricultural Universities, ICAR Research Institutes and NGOs.

The Marine Products Export Development Authority *(*MPEDA*)* functioning under the Ministry of Commerce regulates the export of aquatic products and promotes coastal aquaculture within India. There are large number of organizations and agencies also support or conduct R&D in the subject and include the departments of Science and Technology, departments of Biotechnology, University Commission, NGOs, and private industry.

In 2017, Government of India has restructured the scheme by merging all the ongoing schemes under an umbrella of Blue Revolution – Integrated Development and Management of Fisheries (IDMF). The restructured scheme provides focused development and management of fisheries, covering inland fisheries, aquaculture, marine fisheries including deep sea fishing, mariculture and all activities undertaken by the National Fisheries Development Board (NFDB). Promotion of biofloc as one of the innovative technologies to double farmers income is part of drive for intensive backyard inland fisheries. In May 2020, a new scheme called Pradhan Mantri Matsya Sampada Yojana (PMMSY**)** was announced to encourage artisanal fisheries. Both IDMF and PMMSY recognizes the potential of BFT in ushering blue revolution in the country.

1.2.Biofloc Technology

BFT is an advanced fish and shrimp farming technique researched by Professor Yoram Avnimelech, an Israeli scientist, who pioneered techniques of optimum aquatic production by maintaining the required Carbon Nitrogen Ratio (CN Ratio). Professor Yoram is considered the Father of BFT. As a vital part pf BFT, he developed new aeration systems, which is energy efficient and as such helps sludge control.

To feed growing human population, aquaculture industry will need to enhance output as well. To preserve global and local ecology, this expansion in output will need to take place in a sustainable way, and largely through increase in productivity. BFT promises to enhance water quality through balancing carbon and nitrogen in the system while increasing productivity 5 times compared to traditional pond culture. Compared to traditional aquaculture, BFT is more efficient in removing Geosmin and 2-methylisoborneol (MIB), the two common odorous compounds that have significant bearing on the quality of fish. Ma et al (2016) found that BFT has higher removal efficiency of geosmin and MIB under in situ and in vitro conditions over a recirculating aquaculture system (RAS).In traditional intensive pond farming, about 70-80% of it remains in the pond, in the water or the sediment (see Figure 1). This high load of nutrients in the pond causes build-up of toxic residues (Sulphides, Ammonia etc). In turn fish growth is affected. The benefits of intensification are lost due to morbidity of fish stock, and wastage of money on feed. BFT converts the unused food residues and excreta into bacteria, thus increasing feed uptake and reducing the feed cost. The key in BFT is to maintain a low level of nitrogen presence at the sediment. The challenge is how to take the sediments out without killing the biofloc.

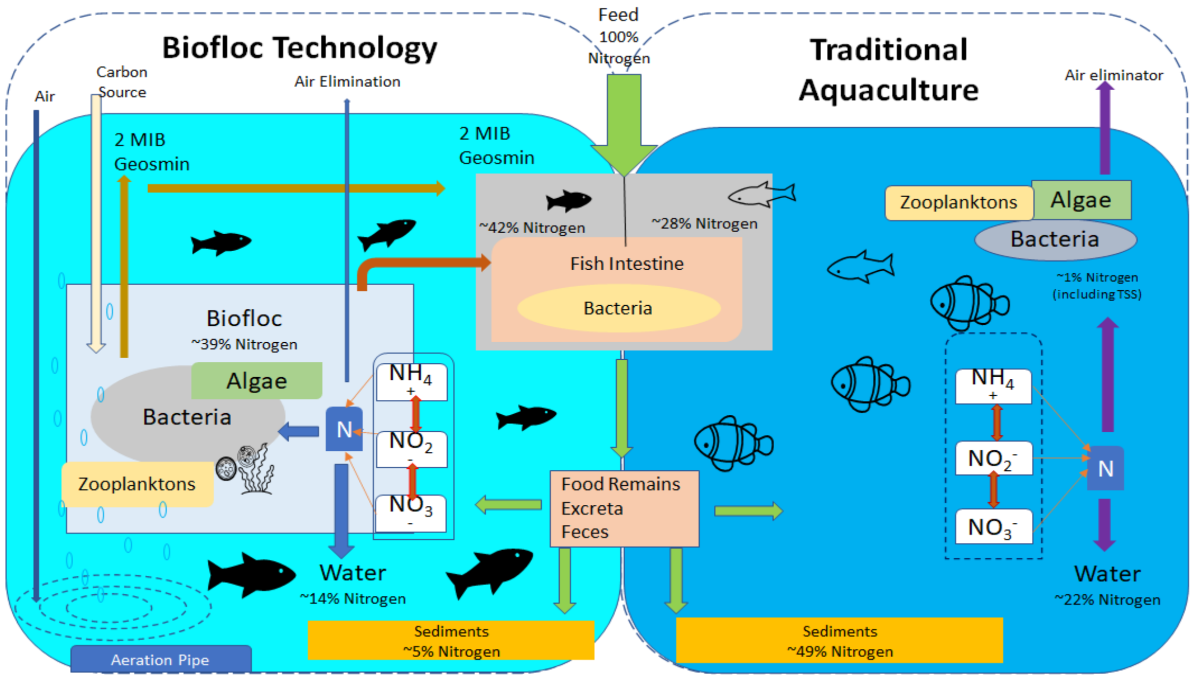


Figure 1: Comparison of Biofloc Technology and Traditional Aquaculture Pond

Source: Liu et al. (2019).

BFT aims to achieve well balanced carbon and nitrogen solution, so that ammonium and organic nitrogenous waste is converted into bacterial biomass. The nitrification is a biological process of breaking down ammonia into nitrate. When nitrogenous sources are added into the tank in the form of feed, urine or fish excreta, it decomposes and produces ammonia (NH_3), nitrate ($NO\text{-}_3$), and nitrite ($NO\text{-}_2$) affecting the water quality. *Ammonia* is composed of nitrogen and hydrogen atoms. It is a colourless gas with strong pungent smell, which disperses in water to produce a strongly alkaline solution. In fish health, *ammonia* and the ammonium ion are vital components of metabolic processes. Nitrification is the biological oxidation of ammonium ions to nitrite followed by the oxidation of the nitrite (NO_2) to nitrate (NO_3). Between nitrite (NO^2) and nitrate (NO3), the NO^2 is more toxic and harmful as it enters the fish's immune system and blood circulatory system, and the fish get killed. The bacteria that carry out this process are called as nitrifying bacteria. These are chemoautotrophic bacteria useful for bioremediation of water. *Nitrosomonas, Nitrosococcus, and Nitrosospira* convert ammonia into nitrites[1]. Nitrobacter then oxidise nitrite into nitrate. These are chemoautotrophic bacteria useful in bioremediation of water. The *Nitrosomonas* bacteria only removes ammonia from water but does not convert undigested feed into micro-bacteria protein as Heterotrophic Bacteria do. *Nitrobacter, Nitrospina, Nitrococcus* convert nitrites into nitrates. These bacteria obtain the necessary carbon for metabolic processes,

[1]Nitrobacter cells double in 13 hours (Grundmann, Neyra and Nomand, 2000) at temperatures of 21°C while most heterotrophic bacteria in the same environment have a typical doubling time of 20-30 minutes.

from the carbon dioxide in their environment, and release nitrogen oxide and nitrogen gases into the tank water completing the nitrification cycle. The types include ammonia-oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB).

Biofloc is a macroaggregate that controls the system. Biofloc are the heterotrophic particles consisting of multiple smaller micro aggregates joined by microbes, algae, fungi, plants, animals, and detritus and the chemicals that they produce. Each floc is loosely held together in a pool of mucus that is released by bacteria and held by filamentous microorganisms or electrostatic attraction. These micro-bacterial proteins are known as flocs and it is again consumed by fishes. In biofloc system, it is heterotrophic bacteria that eats plants, uneaten food, dead organisms and colonize the faeces, and moults to produce bacterial biomass, which is consumed by detritivores. Viewed from another way, heterotrophic bacteria area type of bacteria that take the sugars they need to survive and reproduce from their environment, rather than making the sugars themselves from carbon and hydrogen. Autotrophic bacteria produce their own sugars from carbon and hydrogen. Large flocs can be seen with the naked eye, but most of them are microscopic. Floc sizes range from 50 – 200 microns. It is a natural feed formed because of conversion of undigested feed, feces, and urine into micro-bacterial proteins in a culture system on exposure to sunlight. Biofloc has good nutrition value; the dry weight protein ranges from 25 – 50 percent, and fat ranges 0.5 – 15 percent. It also contains many vitamins and minerals, particularly phosphorous.

BFT system is controlled by the colony of bacteria -mostly Heterotrophic Bacteria from bacillus group of bacteria. In the BFT system, bacteria are grown and fed to control the system and provide optimum conditions to grow fishes. The feeding of bacteria is also known as C:N Ratio, how much carbon feed is required to kill nitrogen from the water. By adding carbohydrates to the tanks, heterotrophic bacterial growth is stimulated and nitrogen uptake through the production of microbial proteins takes place. Biofloc technology is a technique of enhancing water quality through an external carbon source or elevated carbon content of the feed (Fig. 2).

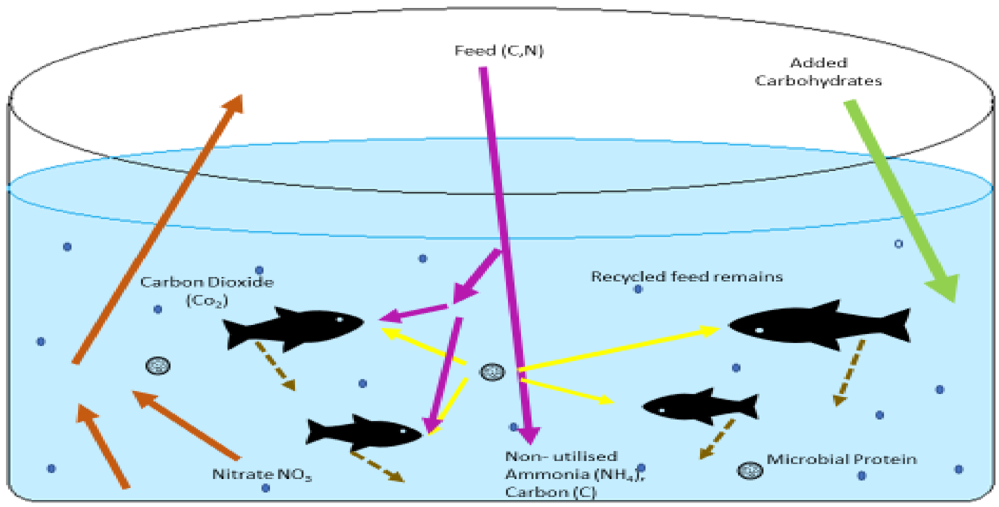


Figure 2: Biofloc Culture

An attractive feature of biofloc is the reduction of feed cost and ability to put limited water/land available to productive use. Feed cost account for 60% total production cost in intensive aquaculture systems. In the biofloc feed cost is 20-30% only. The use of continuous aeration, and careful management of water properties, permit stocking density 4-5 times higher than traditional pond culture.

Considerable effort of BFT practitioners goes into maintaining the right C: N by adding carbon source in such a way the water quality is improved by stimulating heterotrophic microbial growth, which assimilates the nitrogenous waste exploited by the cultured species as a feed. The BFT is not only effective in treating the waste but also grants nutrition to the aquatic animal. The dense microorganisms develop and function both as bioreactor controlling water quality and protein food source. The biofloc growth rate and microbial production per unit substrate of heterotrophs are ten-times greater than that of the autotrophic nitrifying bacteria. The result is immobilization of toxic nitrogen species. BFT technology is based on the principle of flocculation within the system.

Box item 1: C: N Ratio Explained

A carbon to nitrogen ratio is a ratio of the weight of organic carbon to the weight of total nitrogen in a water. The C:N ratio is important because due to the fact that it has a direct impact on residue decomposition and also nitrogen cycling in our soils. For estimating C:N ratio, three factors are kept in mind

a) Protein content in feed – in the range of 25-32%
b) Nitrogen waste generated out of protein fed – generally in the range of 15.5-16%
c) Carbon material generated – generally around 50%

Example for 1 kg of feed with 32% protein, protein content is 320-gram x 15.5% approximately 50 grams, nitrogen generated is 150 grams, and carbon material 500 grams[2]. The C:N ratio is thus 500/50 or 10:1. At the initial stage of water preparation, the desired C:N ratio is 20:1, but later the ratio is reduced to 10:1.

The chart below suggests C:N ratio required for different levels of feeding. For 6% body weight of 30% protein content, the C:N ratio is 19.87. Similarly, at 2% daily feed of 30% protein content, the C:N ratio required is 6.62. In early stages of fish life, more feed is given, hence the need for maintaining a high C:N ratio. Since the feed as % of body weight is reduced with time, the desired C:N ratio also declines.

Daily Required Carbon Content (in grams) for 1 Kg of Fish in Tank

	Protein Content in Feed				
Daily feed as % of fish body weight	**20%**	**25%**	**30%**	**35%**	**40%**
2	1.87	4.26	6.62	9.07	11.42
3	2.81	6.39	9.94	13.61	17.14
4	3.74	8.52	13.25	18.14	22.85
5	4.68	10.65	16.56	22.68	28.56
6	5.62	12.78	19.87	27.22	34.27
7	6.55	14.91	23.18	31.75	39.98
8	7.49	17.04	26.50	36.29	45.70

Source: Pramod Dash https://www.youtube.com/watch?v=1bX1HlpE14I

A kg of sugar contains 421 grams of carbon. For 100 kg of fish fed at 2% of body weight with 30% protein content, the amount of sugar needed is carbon content in protein feed divided by carbon content in sugar multiplied by the wight of fish in the tank. In other words, 6.62/421 x 100 = 1572 gram of sugar should be added to the tank. To achieve carbon of 6.62 Fish does not grow when the protein content is below 15%. If ammonia is not present in water, then it is likely that feed does not contain enough protein.

BFT has many advantages over the traditional way of fish growing because it is able to control external environment. Compared to RAS, biofloc technology provides a more economical alternative (decrease of water treatment expenses in the order of 30%), and additionally, a potential gain on feed expenses (the efficiency of protein utilization is twice as high in biofloc technology systems when compared to conventional ponds), making it a low-cost sustainable constituent to future aquaculture development. The strength of the BFT lies in its ‘cradle to cradle’- concept, in which nothing is wasted. The conversion of uneaten feed, excreta and urine from the fish into proteinaceous feed is a

[2]From sugarcane, jaggery, sugar and molasses are extracted. Jaggery, sugar and molasses and sugar contain 83.5-95% (Sahu and Saxena, 1994), 41% (https://chem.libretexts.org/ University of California Davis), and 24% (Samocha et al, 2006) of carbohydrates.

wonderful example of recycle and reuse. Here we witness the phenomenon of ‘upcycling’ wastes back into the nutrient loop.

Another advantage is the need for limited water exchange. Conventional technologies use mechanical and chemical filtration to manage and remove nitrogen compounds through a combination of solids removal and nitrification reactors. These conventional techniques require frequent maintenance and in most instances the units can achieve only limited water purification at considerable cost. BFT, on the other hand, relies on removal nitrogenous substances through floc creation. Where biological means fail, water exchange and physical sludge removal is an option. However, the cost of filtration in biofloc is low.

BFT delivers bioremediation of water at an economical cost. This happens through self-filtering and minimal water exchange. The water exchange can be decreased without deterioration of water quality and, consequently, the total amount of nutrients discharged into land may be reduced. BFT is also used for maintaining appropriate water temperature, good water quality and high fish survival in low/no water exchange during winter months. An experiment in Karnal, Haryana show that survival levels in overwintering Vietnam koi cultured in greenhouse ponds with biofloc technology were excellent, being 97 ± 6% for 100 g fish and 80± 4 for 50 g fish. In Karnal, the temperature in January varies from high of 30^0C to low of 15^0C.

Another benefit of BFT are high density fish farming is the ability to select species with high Feed Conversation Ratio (FCR) that quickly grow to marketable size in 3-4 months. To the farmers, possibility of earning good returns within a few months using BFT is a huge attraction. In 20 square meters of area, it is possible to culture 2000-3000 fishes; 5 times more land area would be required in a traditional pond. A distinct benefit of BFT is assured quick growth of species. Research conducted to assess the larval growth and reproductive performance of shrimps and Nile tilapia have shown good results. A superior breeding performance was observed in shrimp reared in the biofloc system when compared to that of pond culture practices. Similarly improved larval growth performance was also observed.

BFT is not free of shortcomings. The time required to prepare tank water conducive to microbial community is approximately 2-4 weeks, depending on nutrients, water flow rate and temperature. This is huge gestation period for fish growing cycle of 16 weeks. Moreover, BFT requires sophisticated understanding of how feed, carbon sources, bacteria and living organisms’ function in a closed environment. There is a demand to continuously check on all water quality parameters and fish health which requires considerable time and effort. Further, biofloc maintenance depends on 24/7 aeration, which in turn requires electric power, a relatively unreliable service in rural India. Though the promise of biofloc is zero or limited water exchange, the reality is farmers resort to water exchange as a convenient way to reduce the influence of chemical compounds that reduce dissolved oxygen or raise the alkalinity level in water tanks. The mortality rate of fish can be very high if corrective response is not taken on time. Finally, much to the disappointment of practitioners, the body weight gain of fish in tanks is not uniform. Even if the size and age of fingerlings are the same, they grow at different rates. The farmer must separate the marketable stock from others. Some practitioners report that only 60% of the stock reach marketable size in expected time, while others take longer period.

One hopes that future research will focus on improving construction designs to maximize aeration and minimize solids build up. Fine tuning of the design of these water tanks in terms of water mixing and sludge control will ease the burden on the farmer. Likewise, efforts to shorten the water preparation time will accelerate turnaround time from seeding to harvest. It might be interesting to investigate the effect of adding nucleation sites, such as clay to the water at start-up, which will stimulate floc formation. Also, the inoculation with water from existing good-performing biofloc ponds or with specific inocula might shorten start up time (see Table 2).

Table 2: Advantages and Disadvantages of Biofloc Culture System

Advantages	**Disadvantage**
• Enhanced biosecurity • Superior land and water efficiency compared to conventional system. • High density animal culture • The potential for production under controlled conditions leading to higher fish productivity due to efficient feed conversion, growth performance and survival rate • Zero water exchange, thus reducing environmental impact. • Lowers water pollution and controls the spread of pathogens • Lessens utilization of protein rich feed and cost of standard feed (25-30% lower). • Full cost recovery within 1 year due to high ROI (>30%) • Suitable for women because the work does not involve heavy lifting.	• High operational expenses due to continuous power back up, and external feed • Increased energy requirement for high oxygenation, floc respiration, and periodic water exchange • Potential contaminant accumulation with water reuse • Two weeks of start-up period required for water preparation and floc generation • Availability of quality fingerlings are a challenge • Intensive captive fishing is prone to catastrophic losses due to disease outbreaks • Inconsistent and seasonal performance for sunlight-exposed systems • Not suitable for extremely hot (40^0C plus), or cold conditions (below 8^0 C).

1.3.Suitability of Biofloc Technology for India

BFT has gained popularity in Haryana, Odisha, Bihar, and West Bengal. The investment cost is low (approximately Rs. 30000/- only for the installation of 4M dia tank), production of 600 kgs of biomass within 5 months, and recouping of all costs within one year due to

ROI >30%. Tilapia, magur (*Clarias batrachus*), pangasius (*Pangasius sutchi*), koi (*Cyprinus rubrofuscus*) have done well in Indian tropical conditions.

According to the World Resources Institute, India is placed thirteenth among the world's 17 'extremely water-stressed' countries. A growing concern is the rapid depletion of all water sources and the overall long-term availability of replenishable water resources. Water used by agriculture, industry and drinking water has for a long time matched its replenishment by rain, snow fed rivers, canals, and reuse. However, in many parts of the country exploitation of ground water has far exceeded that of replenishment causing serious falls at water table. Agriculture remains the main consumer of water. Any effort to extend cultivation area or intensification of agriculture with higher use of water per crop will cause further stress on available water resources. 70 percent of India's surface water and growing percentage of its groundwater reserves are polluted. By far untreated sewage is the largest source water pollution. Other sources of pollution include solid wastes, agricultural run-off, plastic and discharge of biological, toxic, organic, and inorganic pollutants by small scale industries and households. India's water dilemma is such that it must tap into water sources for food and human sustenance, knowing fully well that the country's overall water availability is running dry. Scarcity and pollution of freshwater will have serious bearing on country's economic sustainability, and social cohesion.

Whatever the means, India needs solutions now. The key to mitigate threats of climate change on aquaculture and maximizing opportunities will be through understanding and promoting a wide array of out of the box new technologies, such as the biofloc technology combined with greenhouse ponds. BFT has zero water exchange, hence it is environmentally beneficial. With as little of 10,000 liters of water, a farm can have 3 harvests generating a net return of Rs. 35,000 per tank. Biofloc offers an opportunity for raising farm income rapidly and addressing malnourishment without adding further stress on natural resources. The promise of biofloc is that every family can raise their children with dignity without withdrawing water from other more immediate, human needs such as drinking water. In Bihar and West Bengal, small farmers are adopting biofloc because of its superior return compared to many other economic activities. In Haryana, biofloc has made huge inroads because there is less dependence on external labor for various operations in fish farming.

1.4.Challenges to Biofloc Fish Farming

The supply and availability of quality fish seed is essential for rapid expansion and growth of aquaculture. However, uncertainty in timely seed supply is one of the major constraints. There is acute shortage of quality seed. There is over dependence on Kolkata market for seed supply. New centres of seed production will assist in further expansion of biofloc.

The focus of India's fisheries has largely been on exploitation of marine resources and coastal areas. Consequently, inland fisheries have not received much attention. Biofloc fish farming is not mainstreamed in India. However, with more emphasis being placed on inland fisheries in Blue Revolution, there is hope that biofloc would receive its due attention. Currently, biofloc ventures are largely set up by rural entrepreneurs with their own money under individual proprietorship. The farmer turned entrepreneurs remain unorganised and have little influence over fisheries policy making.

Training and capacity building of entrepreneurs is a neglected area. The Central Government coastal areas. Consequently, inland fisheries have not received much attention. The Central Institute of Brackishwater Aquaculture (CIBA) under the Ministry of Agriculture, Government of India has organised few training programmes in biofloc fish farming. Videos on social media platforms remain the principle source of information, supplemented by large number of self-styled training institutions. There is a paucity of individuals and experts with strong background in aquaculture who can guide, support and mentor biofloc entrepreneurs.

1.5.Conclusion

This chapter introduced the basic science behind BFT. It highlighted various technical aspects in managing the technology and its suitability under Indian conditions. Biofloc is a promising approach which can be easily adopted by small and marginal farmers for income generation, and meeting subsistence needs.

Chapter 2: Tank Construction

2.1.Introduction

In this chapter technical aspects of site selection, and tank installation will be discussed. To keep our discussion simple, it is assumed that the tank is of 10,000 litres, 4 m dia and 1.3 metre in height. The tank is made of iron mesh and tarpaulin to hold water.

2.2.Site Selection

Site selection is a critical factor affecting biofloc tank construction in Indian condition. The geographical location of the tank contributes a lot to the success of any business venture. The process of selecting the best location for present use should include consideration of how much land is required now and in future, access and proximity to all weather road, power supply, security of the property, and availability of good quality water.
While selecting site the following specific factors should be kept in mind:

Area: Each biofloc tank of 4 metre dia, 1.3 metre high containing 10,000 liters of water requires 12.56 meters of land, plus gap of half a metre between two tanks. It is suggested that tanks are placed in two column each having 4-5 tanks. For 10 tanks, the area required is a square piece of land with 70 meters in length and 70 meters in breadth.

Topography: The area should be relatively level. Lands with uniform sloping fields with slopes up to 3 percent are recommended. Steep and uneven topography pose stiff challenges especially where runoffs occur. Sites which are prone to subsidence or risk flash floods are not suitable.

Type of soil: Sand, sandy loam, and loam soil are good locations because these have high infiltration rate >15 mm/h. The infiltration rate is the velocity or speed at which water enters the soil. It is most often measured by the depth (in mm) of the water layer that can infiltrate the soil in meters per day. An infiltration rate of 10 mm/hour denotes that a water layer of 10 mm on the soil surface, will take one hour to infiltrate. Firm soil surface slows down the rate at which infiltration occurs. Additional precaution may be taken by raising brick lining around the tank circumference to stop rainwater infiltration. Good internal drainage will avoid problems of water logging, and damage.

Water and pressure availability: The source of water can be a spring, borewell, rain water, or another tank. A booster pump of suitable capacity can deliver the flow at the desired pressure.

Water quality: The biological, chemical, physical and radiological characteristics of water should fit the requirement for fish. The quality aspects (temperature, pH, oxygen concentration, salinity, hardness, etc.) within which fish each specie survive, thrive and reproduce differ widely. As far as possible, water be neither acidic nor alkaline, free from suspended solids, excess salinity, sodium deposit and toxicity problems caused by bicarbonates, nitrates, or boron. Poor water quality over prolonged periods of time reduce the chances of fish survival. The composition of tank water changes continuously, depending on climatic and seasonal changes.

In intensive fish product systems, suspended fish wastes are a major cause of poor water quality: For every kg of fish an equal amount of waste is produced adding up to 70% of the nitrogen load in the system, build-up of ammonia and nitrite, and reduction of reduction of dissolved oxygen. It is for this reason, daily check on water quality parameters is essential to yield the best conditions for the fish. The regular measurement of pH, alkalinity, dissolved oxygen, nitrogen, ammonia and salinity are essential for proper maintenance of good water quality.

Box item 2: Handling Iron

Iron in water is a secondary containment, which does not have a direct impact on fish health. It will not affect fish health, but it will cause costly damage and other issues. Iron in water causes the water to taste harshly, metallically offensive, and the absorbs the taste of the water in fish gills and flesh. Aside from bad taste, iron taken shine of fish scales by adding an unpleasant, inky blackness on the body.

Iron is mainly present in water in three forms: the soluble ferrous iron, the insoluble ferric iron, and the bacterial iron. Water containing ferrous iron is clear and colourless because the iron is completely dissolved. The bacterial iron is commonly seen in eastern parts of India, it makes the watercolour reddish and slimy. Overall, 0.1-0.3ppt iron content in water is acceptable for fish farming, but even at 15 mg/L, the level is still not enough to cause physical harm.

At the time of water preparation, it's very crucial to understand what species you wish to stock and how much iron content in the water they can tolerate. Based on which the required water parameter to be maintained.

The most affordable and effective solution to remove iron from water is using the potassium permanganate ($KMNO_4$) Solution. 20 grams of potassium permanganate is mixed and stirred well in a 25-liter water bucket. Pour the water uniformly in the tank. Run aeration for the next 18-24 hours for the oxidation process before switching off the air pumps. Leave the treated water for at least 4-5 days so that ferric iron residues can completely settle down at the bottom of the tank. Transfer the water in another tank and scrape away the residues from the base. The iron removal process kills bacteria in the biofloc tank. Add FCO and probiotic to create new batch of bacteria to grow in the iron-free water tank.

<u>Electricity requirements:</u> Without 24/7 aeration, fishes will not survive. The site will require uninterrupted power. The site should have adequate power from grid, backed up by inverter. Diesel generator are must to drive the booster pump, and solar panels for air pumps. At the minimum, a 5 HP generator is required to support 10 biofloc tanks.

<u>Temperature:</u> Maintaining right temperature and ambient conditions is of major importance for microbial metabolism. The influence of sunlight and temperature on biofloc characteristics is complex. The temperature in open systems is normally modulated d by the ambient environment. The ideal temperature for Indian

major carps lies between 8^{0}C and 35^{0}C. In deserts, temperatures rise dramatically during day time that will only support open-air biofloc operations in terms of faecal coliform growth or even their thermotolerant varieties. Measures to reduce temperature in water tank by creating shades or other insulations may be helpful to curtail the rise in temperature. Small chillers can be successfully employed for maintaining smooth air flow and cut down on inside temperature.

2.3.Ground Preparation

A 10,000 liters tank of 4 diameter will sit heavy on soil. Hence, we need prepare solid ground. To begin with, the periphery of the tank is marked. A simple way is to dig a small pole in the center, tie a rope with a pointed stick at the end. Use the stick to etch the circle. In the middle of the circle, carefully dig a hole for laying the drainage outlet pipe. Connect outlet from each tank to the drainage chamber.Make 6-inch slope from the outlet to the drainage chamber.After levelling the ground, construct the brick structure (3-inch height) around the circle to support the iron frame or mesh for the tarpaulin tank. The inside of the circumference should be such that no rainwater can sink in. Excess water can sink the tank. In case of any doubt, use concrete to strengthen the base of the tank.

2.4.Tank Installation

After ground is well prepared, physical construction of tank can begin. A detailed step by step method for tank installation, developed by Mr. Kallol Parida of Bhubaneswar is given in Annexure 2.1.

While erecting the tanks, attention is paid to:

- **Drainage work:** Removal of sedimentation and sludge is central to avoiding building up of ammonia nitrate and nitrite. A good drainage is essential to trap and push out sludge but retain biofloc and water. All tanks are connected to a central chamber as show in the illustration. The slope between the central chamber and biofloc tank central drainage point should be 15.24 cm or 6 inches.The slope within the tank should be at least 15 cm (5.9 inches), but preferably 30 cms (11.81 inches). This is to ensure that sludge is collected around the central drainpipe. The current practice is to connect a two-inch PVC pipe at the center secured with an end cap placed over a valve connected with elbow to the outlet drain. These endcaps are situated 2 inches above the ground. A more recent novel practice is to fix a kitchen sink filter 1 inch below the tank floor level to trap all sludge, and let it flow into the central chamber. The trick is to seal the sink filter with washer over a large polythene sheet. The sludge will pass through a 3 inches elbow/bend right into the central chamber. In some instances, sludgeis airlifted using air blowers into a nylon saree where sludge is trapped, while water flows back into the tank. The efficacy of this system is not well known.

- **Weaving the wire mesh:** It is advisable to buy iron mesh from local market. They come in standard sizes, the most popular being 13mtr long, 1.25-metre-high, 4mm in thickness with opening of opening 4” x 4”. The wire mesh must be welded to form a circumference of 12.56 meters.

- **Welding MS mesh with iron rod to give strength:** To give additional strength to the grid, round iron rods may be welded at the top and bottom to strengthen the tension of the build. These iron rounds of 10mm, 11.872 meter (39 feet) in length are commonly used in house construction. Since the circumference of tank is 12.56 meter, an additional 0.678 meter (2.21 feet) of iron rod must be welded to complete the mesh reinforcement. Application of red oxide primer and paint coat on the iron mesh and rod will add to its aesthetic appeal and prevent rusting[3].

- **Placing inner line protective sheet:** Before installing tarpaulin biofloc tank, High-Density Polyethylene (HDPE) or EPE Foam sheet is used for increasing the life of fish tank. The protective sheets are used

    - To protect the main biofloc tarpaulin fish from damage during operation
    - To control temperature
    - To increase the life span of the fish tank
    - To protect the tanks from UV radiations and chemicals etc., and Cost-effective as compared aluminum or to any other material in use

  These HDPE come in 0.5 - 0.75-micron dimensions, are UV treated to resist radiation, inert to most chemicals and acids, and lightweight and easy to handle. The protective sheets are placed between the mesh and tarpaulin to serve as extra layer of insulation. While placing the protective sheet, care should be taken to avoid wrinkles that may affect the tarpaulin.

Picture 1: HDPE Protective Liner

Picture 2: EPE Foam Sheet

[3]Instead of wire mesh, tin sheets can be used to stop rats chewing into the tarpaulin. The tin sheets are bolted into supporting iron bars. These designs eliminate the need for welding, and eases transportation of odd sized frames in smaller vehicles.

- **Placing tarpaulin:** Tarpaulins arelarge sheet of sturdy, supple, water-**proof** vinyl-coated polyester often coated with flame-retardant polyvinyl chloride (PVC). PVC polymer of **non-migratory nature** is good for biofloc fish tank. The migration of PVC chemicals into water body, has a very detrimental effect on growth and survival of fish. Cheap tarpaulins have sub-standard film coating which migrate into water. Tarpaulin sheet of a minimum 550 GSM thickness, but those with even higher GSM are longer lasting. Transparent PVC film are reinforced at all the joints to tolerate water pressure and provide durability. Avoid any wrinkle in the tank. Presence of wrinkles increase the chances of accidental tear, accumulation of toxicity causing ammonia concentration, and damaging biofloc formation. Good quality, branded tarpaulin come with a written warranty of five years with an expected life span of 7 years**.** Light colored tanks (such as sky blue Colour)is better for visibility of fish and for spotting accumulated sludge. Biofloc tanks are hemmed and strengthened with 10mm PP Rope for extra strength on the periphery of the tank. In case, the iron mesh is welded to iron rod, there is no need for hemming with PP rope.

- **Roofing:** A roofed structure is necessary[4]
  - To prevent direct sunlight reaching the tank
  - To check algal growth that can deprive fish of oxygen
  - To protect fishes from birds and other predators
  - To cut down on excess heat or cold and protect the tanks from windstorms, rain, and hailstorm, and
  - To avoid falling of leaves or other debris from the surroundings etc.

A variety of material and roofing structures are seen on the field.

- <u>Garden net</u>: For shading simple green nylon nets are used. There are also shade net 50% UV stabilized, green, 30 Sq. M (10 x 32 Ft) that are available. UV stabilizersprotects PVC and tarpaulin tanks from ultraviolet radiation from catalytic degradation, polymer ageing, weathering, and photo-oxidation.

  Cost: The prices of garden net generally vary in the range of Rs 33/square meter to Rs 40/square meter.

- <u>Thatched roof:</u> Thatching is the traditional art of fabricating a roof with dry vegetation such as hay, twigs, reeds, grass, palm, and coconut leaves, layering the vegetation to keep water away from the inner roof. Dry, densely packed vegetation are bad conductors of heat, by trapping air it also functions as insulation. With a thatched roof the water is also constantly forming drops, by dripping from one piece of thatch to the next; this effectively keeps the water in small amounts, as it flows over the roof. If both thatch and roof structures are at the correct angle water will not penetrate more than an inch (25mm) or so. For additional protection, water

[4]In addition to roofing for tanks, there is need to have a roofed store house to securely keep generator, inverter, toolboxes and store material. This area should be protected from rain, water, and pilferages.

resistant plastic sheets placed below thatch. Dwellings with thatched roof are 8-10^0 cooler than ambient temperature. The drawback is frequent repair (every two years), fire hazard due to inflammability, and lack of specialized labor for the thatch work. While thatching material is available, in the market high quality water reed for thatch treated with preservative to increase fire retardation and biodegradation.

Cost: The prices of thatch roofing is highly location specific but are available in the range of Rs 50/square meter to Rs 70/square meter.

- **Plastic roofing sheets:**This material type is the least favoured choice for roofing applications because they are not durable. However, they are cheap and useful for covering temporary structures. The better the quality of the plastic (with higher GSM) are more expensive but offer longer term functional utility.

  Cost: The prices of plastic roofing sheets can carry depending on the brand and material quality. The price range in between Rs 500/square meter to Rs 1000/square meter

- **Metal roofing sheets:**The roofing sheets made of metal usually comprise Zinc, Aluminum, Copper and Tin. They can be customized to create rooftops varying based on their price, durability, style, energy efficiency, and aesthetic value. They come in variety of styles, textures and colors. They have less twists than corrugated roofing sheets.

  Metal roofing sheets have high insulating capabilities useful for the construction of household cladding and biofloc tank roofs. Metal roofing panels can withstand high winds, snow, hail, torrential rains, and fire. Generally, they do not corrode, crack, split or break easily. Metal sheets are also resistant to attacks by insects and pests.

  Cost: In India, the price of metal roofing sheets range between 250/square meter and 350/square meter.

Picture 3: Types of Sheds

Box item 3: Growing Fish in Hot and Cold Temperature of Rajasthan

Alwar district experiences high fluctuations in temperature. In December, the day and night temperature vary between high of 11^0C and low of 6^0C. C. In June, the temperature fluctuates between high of 45^0C and low of 30^0C. To protect, fish from extreme temperature, it is advisable to build thatched roofs, or tarpaulin covered monsoon sheds that can provide shade, and regulate flow of air. The water tank temperature will be 10^0C cooler in summer and 8-10^0C warmer in winter. A paddy or wheat straw mat stitched together placed on the outerwalls of the tank will reduce temperature by another 4-5%. Mud walls around the tank enclosure will further reduce and stabilize the temperature.

2.5.Circular Shape or Rectangular Shape of Tanks

Most biofloc tanks are circular in shape. This is because:

- Round structures reduce the surface area through which heat can radiate, they keep the enclosed water at a more steady temperature than rectangular structures. Consequently, the water is less affected by ambient temperature fluxes and loses less heat in winter and gains less heat during the summer.
- Round tanks do not have sharp edges. As a result, they are much easier to keep clean than rectangular tanks with corners. Corners are hiding places for microbes.
- Other things being equal, a round shape construction is stronger geometrical structure and more robust than rectangular alternatives. Therefore, a round structure will withstand better hydrostatic pressure of the water stored within and the force of gushing wind and rain that impact upon the structure from outside.

Circular shape has most uniform stress distribution. The hydrostatic pressure generated by fluid in the tank distributes equally in all directions. In case of rectangular or square shapes, the stress concentration would be too high in corners. This is the prime reason that most of the large storage tanks are made in round shape.

Hydrostatic pressure is generated by water on the walls of the tank. Due to gravity, increases at lower depths as the fluid can exert more force from the liquid above that point. The tank material should be strong enough to with stand the pressure.

In order to determine the water pressure (expressed in per square inch (PSI)) at the bottom of a tank on its side, convert the radius stated in feet by multiplying the radius by 2 and then multiply the product by 0.4333. In case, the radius is stated in meters, multiply the radius by 2 and then multiply by 1.422 to get PSI. For a tank[5] with 1.78 radius, the PSI is 5.062.

[5] The radius of a 10,000 liters tank is calculated using the formula $\pi rrh=10m^3$. Given that $\pi=3.14$, h =1m, the radius works out to 1.78m.

2.6.Tank Type by Construction Material

There is considerable discussion among practitioners on what types of tank is best for biofloc aquaculture. Tanks made out of cement, plastic, fibre, and tarpaulin tanks are used for cultivating fish in tanks.

This section discusses on the advantages and disadvantages of each kind of tank available in the market which will help in making the correct decision on the make you decide which kind of biofloc tank is best suited for the buyer.

Cement tanks are exceptionally durable, last for 8-10 years and used on the primary level because of their strength of water carrying capacity. The main disadvantage of cement tanks are high upfront capital costs, frequent wear and tear maintenance, and bad conductivity of heat requiring temperature control. Cement tanks require chemical s to wash, clean and sanitise. The corners of rectangular tanks are breeding places for microbes. Cement tanks are not portable. Cemented areas, upon disuse, are no longer suitable for cultivation.

Several companies have introduced plastic tanks. These are highly portable, convenient to install and cost effective. The disadvantage of the plastic tanks is their high initial cost, limited local availability, and high cost of replacement. The drainage system in plastic tanks lies on the high end of the tank; sludge at the bottom must be manually lifted instead of simply washing them away. In the long run, however, plastic tanks may become the norm due to lower unit cost because of mass production and distribution.

Of all the type of tanks, tarpaulin is material of popular choice because of low cost, adaptability to various shapes, sizes, and look. Circular and rectangular are in vogue. Households and small entrepreneurs prefer building a series of 5,000, and 10,000 liter tanks. However, for commercial purposes tanks over 50,000 are more cost effective and convenient to manage. Tarpaulin tanks can withstand temperature variation between 10°C~+50°C. The benefits of tarpaulin tanks are low initial set up cost, and infrequent maintenance, and easy to mount a drainage system. The repair cost of tarpaulin (due to rat bites) is low as these can be fixed with industrial tapes.

There are various types of biofloc tarpaulin available in India. Both sides coated PVC tarpaulin lasts more than 7-9 year otherwise other types of tarpaulin has a life of 5-7 years. The material is Anti-UV, anti-leaking, Anti bacteria, Anti-Fouling, Anti- acid and alkali, and corrosion and shock resistant. The best quality 650 GSM blue colour, UV stabilized PVC fish tank in the market lasts between 5-7 years. Particular attention should be paid on the length of the tarpaulin so that the tank is adequately covered with few inches to spare.

Selection of the right tank size and material is important to save fixed costs on a longer run.

Box item 4: Hospital Tank

Hospital tanks are used for quarantining sick fish. A simple plastic tub, or water-proof tarpaulin tank (see photos below) can do the job. A low-cost option is to place a waterproof plastic sheet on a rectangular surface having 8 inches of raised wall. An outlet pipe is fixed to drain water. An alternate to drainpipes is a 14W submersible (cost Rs. 165) which can empty the tank when needed.

Picture 4: Hospital Tanks

2.7.Conclusion

This chapter underline the critical importance of proper site selection and choice of material for biofloc tank has strong influence on the economic success of fish farming. Assess your exact conditions, requirements, and budget before setting out to install a tank. Once these decisions are made, only then purchase what you need and when you need. To supplement your own market research, it is wise to seek the help of a reliable technical expert for further clarity. Speak to your local contractor, plumber, and technicians for insights.

Chapter 3: Biofloc Operations – First Five Steps

3.1.Introduction

This chapter explains the various activities required for scientifically conduct biofloc fisheries operation to maximise yield, and minimise risks posed by improper management, diseases and toxic build up. Eutrophication, or hyper-trophication is a well-known phenomenon in closed environments. When a tank is over enriched with minerals and nutrients, it induces excessive growth of algae, eventually leading to low levels of oxygen in the water body. An appreciation of underlying principles of biofloc operation will alert the farmer on how to avoid dangers and mitigate risks through sound operational processes.

Biofloc operations forconvenience purpose can be classified into ten steps. These steps are:
Step 1: Organise Biofloc Material, Accessories, and Tools
Step 2: Ensure 24/7 Aeration
Step 3: Water Preparation Process with beneficial microbes
Step 4: Species selection and stocking densities
Step 5: Balancing Carbon Source Addition
Step 6: Monitoring Biofloc Growth
Step 7: Water Parameters and Associated Farm Infrastructure
Step 8: Disease and Morbidity Control
Step 9: Monitoring of Fish Stock
Step 10: Harvest, clean-up, and discharge of water

The first five of these steps pertain to getting organised, securing aeration system, starting, preparing water, selecting the right species for culture, and adding carbon to accelerate biofloc formation. The first five steps are discussed in this chapter. Steps 6-10 are part of regularoperations which will be discussed in the next chapter.

3.2.Step 1: Organise Biofloc Material, Accessories, and Tools

A variety of testing kits, accessories, minerals, feed tools, instruments, and equipment, are needed to support fish farming operations. Fortunately, the wherewithal of the operations is are available on online and specialized stores in large towns in India. Here is a complete list of accessories that is needed before the start of operations:

- Probiotics contain useful bacteria for floc formation.
- Carbohydrates like sugar, or molasses help to maintain carbon nitrogen ratio.
- Calcium Carbonate ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$) moderates pH level in the water.
- Fish tanks made of tarpaulin, cement, fiber glass or any other non-toxic material.
- Aeration pumps are required to generate air flow and accessories like air stones, air tubes, and air controllers to distribute oxygen in an orderly manner.
- pH meter helps to measure the amount of free hydrogen and hydroxyl ions in water.
- DO meter measures the free, non-compound oxygen dissolved in the water.

- Salinity meter are solid state instrument to measure the salt level in the water.[6]
- TDS meter measures the TDS level in water
- Ammonia Test Kit presence of ammonia (NH_3), nitrite (NO_2), and nitrate (NO_3), in the water.
- Chlorine Test Kit shows presence of chlorine in the water.
- Iron Test Kit shows presence of Iron in the water
- Potassium Permanganate ($KMNO_4$) is used for removing iron from water, tank sanitization and kill harmful bacteria.
- Water Hardness Check Kit useful in checking hardness of water.
- Raw Sea Salt (also called sodium chloride or NaCl) is required to control parasites, and stress[7]
- Imhoff Cone are used to measure the volume of sludge in a specific volume (usually one liter) of water or wastewater
- Water temperature meter monitors water temperature in the range of -5 degrees Centigrade to +50 degrees Centigrade with an accuracy level of 0.1 degree.
- Power backup equipment such as diesel generator, inverter, solar panels offer continuouspower backup.

Source: Kallol Parida, Road to Biofloc

Picture 3: Biofloc Equipment and Material

Once these pieces of equipment in place, the next step is to prepare for aeration system.

[6] Salinity meters are calibrated before use. Once in calibration mode, the probe is placed in 35.00 ppt calibration standard. When the standard value is recognized and stability reached, the meter will automatically accept and store the value.

[7] Iodine free sea salt in fish tanks reduce pathogens, minimizes osmotic stress during transport, and prevents nitrite poisoning, and brown blood disease in catfish

3.3.Step 2: Ensure 24/7 Aeration

Oxygen is dissolved into water due to the action of pumping or circulating air into the system is called aeration. Oxygen is introduced into the system as a by-product of photosynthesis from aquatic plant, and from surrounding air. Not only DO is vital for respiration by the fishes growing in the tanks, but also crucial for aerobic breakdown of organics in the water column, change of ammonia to nitrite and then to nitrate by the biofloc (nitrification). Algae also need DO for night time respiration. The overall demand on DO is significantly high in biofloc system. Further to the requirement for aeration, mixing is also particularly important as the floc particles must remain in suspension in the water column. Continuous circulation of water maintains both high oxygen levels and keep solids from settling down. Pockets without churn will quickly lose oxygen and turn into anaerobic zones which release large amounts of ammonia and methane. Sustaining proper water flow velocity is essential for optimizing biofloc systems and keeping microorganisms suspended in the water column. Non-stop aeration and mixing remove gases from the water column, which has positive effect on overall water quality. The aerators should be installed strategically so that a current is created in the pond. The aerators should remain close to the bottom floor, and regularly moved to ensure solid particles would not settle in areas with little or no current.

Box item 5: Right Air Pump

An air pump is a hydraulic machine that increase the overall mechanical energy of a liquid such as water. While buying a pump, consideration are given to:

- Flow rate. This is measured by liters per minutes (LPM) rate, and denotes the effectiveness of the equipment.

- The size of the inlet: The bigger the size of an inlet valve, the more amount of water the pump will be able to pump out and the lesser is time taken to do the job.

-Maximum head and pressure. The maximum head of a water pump refers to the longest distance in terms of height that the pump will be able to carry water. Pressure is measured by Kilo Pascal (KPa). KPa is the pressure exerted by a 10-g mass resting on a 1-cm2 area.

The engine and motor type affects the quality of the pump. Diaphragm uses less power, generate more pressure and are durable due to fewer moving parts. Electromagnetic pumps are cheap, usually of Chinese make, effective but not long lasting. Root blowers and root pumps are best for heavy use due to higher compression.

Assuming multiple tanks each of 10,000-liter tank capacity, the technical parameters recommended for Diaphragm/Magnetic Pump are given below:

Tanks Nos.	1-2	2-4	5-6	7-8
LPM	60	100 LPM	200	280
KPa	32	40	45	50
HP	0.047	0.27	0.4	0.8

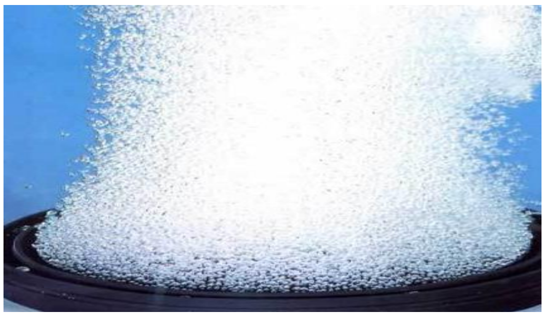
For more than, 8 tank installation, use either ring blower/root blower pumps.

Tanks Nos	9-12	12-15	15-18	18-20
LPM	2000	3000	4000	4000
KPa	35	35	35	35
HP	1	1.5	2	2

Ring blower are suitable for 10 more tanks, over that root blowers are preferred. Ring blowers use airoxy tubes for diffusion. For over 20 tanks, root blowers with 3 or more HP is suitable.

Diffuser systems work constantly churning and pushing deeper waters to the surface. Through mixing effect, oxygen is transferred into the water column visible to onlookers as air bubbles rising to the surface. Constant mixing of water through a diffused air system prevents emergencies arising from low dissolved-oxygen levels. Oxygen is lifeblood of biofloc system. Oxygen is pumped by the aeration pump, carried by tubes and disbursed by air stones. The tank ecosystem is built around flow of oxygen to fish and bacteria.

Tubes coming from aeration pumps are connected to diffusers made of silica stones, tubing, or porous hose. With the use of air controllers, care is taken that air flow is even to all the tanks. Air stones -round or cylindrical - are suspended in the water column by plastic tubing or hoses connected to a floating air pipe. A broad array of diffuser types based on bubble diameter is available in the market. Bubble size diameters in fine-pore diffusers are 0.5 to 2.0 mm, medium-pore diffusers are 1 to 3 mm, while bubbles from coarse diffusers are generally greater than 5 mm. 70-80% of large air bubbles produced by air stones get wasted. The distance travel from the tank button to the upper surface water is about 3ft and takes a few seconds to reach. Due to which large or big size oxygen bubble gets wasted. Air Stones with microbubbles or nanobubbles are more preferable because they disburse dissolved oxygen slowly and more effectively. Small bubbles create less vertical mixing of the water column but are more efficient in terms of transferring oxygen than large bubbles that require less pressure but are not very efficient in terms of oxygen transfer. Small pore diffusers require higher air pressure but clog more frequently than coarse-bubble diffusers.



Picture 4: Microbubbles

Picture 5: Nanobubbles

Both steel and plastic variants of air stones are equally good provided every month the pores are reopened with soap washing and a gentle touch of brush. High-efficiency rubber/polyethylene tubing (called ‘airoxy tubes’) is a popular diffuser material made from linear low-density polyethylene and rubber from recycled car tires. Rubber poly tubing with inner diameter of 12 mm deliver a high volume of fine bubbles (1 mm, flow rate 1 cum/hr). Soaker hoses with 60 PSI have fewer and larger pores that need much higher air pressure to operate. On balance, it is recommended that each tank of 10000[8] liters has a minimum of 8, but preferably 10 cylindrical type air stones placed at the bottom of the tank. Between the round and cylindrical air stones, the cylindrical air stones produce more air bubbles compared to rounded shaped ones. These commercial air stones are available with brick and mortar stores.

Figure 3: How Bubble diffuses

Source: http://www.lifenanobubbles.com/?page_id=99

[8]The volume of water (V) in a circular tank is calculated using the formula V= лr²h where is ‘r’ is radius and ‘h’ is height. Since r is 2-meter, height 1 meter, and ‘л’ is 3.14, the volume of water in a 10,000 liter tank is 6.28 meters.

As soon as the biofloc system has turned brown, aeration must be significantly stepped up to sustain the high respiration rate. Respiration rates at this stage can reach 6 mg per liter per hour, requiring up to six times more energy compared with the start of operations.

It is always vital for the aeration system to stay functional. At this time, stoppage of aeration triggered by power failure can result in total loss of fish. In response to low-oxygen environment, heterotrophic bacteria start producing.

Regular maintenance of the aerators themselves, plus the power system that provides the energy to run this system should form part of weekly review. Power supply is at best intermittent and unreliable in rural India. It is advisable for fish farmers invest in off-grid solutions such as diesel generator, inverters, and solar power system. Of these diesel generators are most reliable, but very expensive to operate. Inverters can be converted to grid power or solar power. An inverter and battery combination are effective but involves significant upfront capital cost. Solar electrification is an option popular with rural folks because of the subsidy support. For instance, Haryana offers 90% subsidy to farmers for the solar powered water pumps, home lighting solutions, and solar water heating. However, solar power is unreliable in parts of the country where sunshine is limited to less than 300 days due to rains and gathering of clouds.

Given frequent black outs, uncertain hours of power supply, and low voltage of supply, it is inevitable to have power back up 24/7 aeration and water pumping. Inverter and power back up are must to keep the fish production system going. Battery is the heart of the inverter. The performance of the inverter is contingent on the connected battery and vice-versa. The capacity of the inverter chosen should factor into on how much watt of appliances are powered at a time plus some extra watts for future expansion. There are three steps involved in choosing the right inverter size. The first step is to determine the power load, the second step is to size of the inverter, the third steps is to calculate the size of the battery. Box 2 shows the method for calculation of inverter size and battery power needed under certain assumptions.

Box item 6: Power Back Up

First calculate the size of the inverter needed by using the simplified formula given below:
Inverter Size VA = Power load in VA *Aging Factor/Battery Efficiency.

Air pump power load in VA is Watt of the pump/Power Factor. By convention Power Factor (PF) is taken as 0.8. By convention, the Additional load expansion is taken as 20% and Efficiency of inverter as 80%.

The size of inverter can now be calculated by imputing the values derived
Power load 250 VA (equal to 200 Watt) * 125%)/80% = 390.65 VA (250 Watt).

Next calculate the size of battery needed by using the formula:

Battery Size = Inverter VA rating X Usage time (in hours) / Input voltage

If you wish to have a backup for 8 hours with a 390.65 VA[9] inverter and battery input voltage of 12 V, the total battery size would be: 390.65 X 8/12 = 260 Ah

Dry and tubular batteries are more efficient than wet batteries. Getting the right size of inverter and battery backup saves money and troubles due to technical specification. There are different capacity of inverters ranging from 200VA to 1200VA.

Serious commercial operators will benefit from combining clean solar power and reliable diesel generator power. The solar panels can top up battery during day time. Then, use a back-up generator when the weather is bad or at night during power cuts. Combining the two options will reduce diesel expenses and generator's run time and ensure you still have reliable power 24/7.

3.4.Step 3: Water Preparation Process with beneficial microbes

- Before introducing fishes into the biofloc tank, ensure that the following criteria are fulfilled.
- The fish tank and air stones are well sanitized with $KMNO_4$ Solution.
- Water is suitable for fish culture free of harmful substances such as iron, heavy metals, and chlorine.
- Use $CaCO_3$ or Dolomite to regulate pH and alkalinity balance.
- Water contains all the required minerals in it.
- Air Pump provides required DO in the water. DO 4+ is satisfactory.
- Do not feed fishes for the next 24 hours because the fish feed, as our system is not ready to control the production of ammonia which fish excreta generates.

[9]To generate 250 Watts of power, one solar panel of 250 Watts is needed. A unit consuming 10000 KWh of power will require 40 high efficiency solar panels.

Immediately after the above conditions are satisfied, prepare the tank water. Detailed guidelines are provided in Annexure 3.1. The following day wise acts may be undertaken:

Day1 Sanitize and fill Water in the Tank: Before commencing operations, it is a good idea to check that tanks are clean, and free of anyunwanted material suchas tools, clothes, plastic tapes, glue, card boxes, nuts and bolts scattered during putting up the tanks. Prior to adding water, the fish tank and air stones should be properly sanitized using Potassium Permanganate ($KMNO_4$) solution to ensure that no nematodes or protozoa is present. Thereafter, fill the tank approximately half to its capacity i.e. 5000 litres. 8-12 air stones should be equally distributed across the tank.

Day 2 Check for right pH level: It will take 48 hours for pH to stabilize. Check the pH level of the water. If the pH is below 7.0, it needs to be fixed.

Day 3 Add $CaCO_3$, Molasses, Probiotics: If pH is below 7.0,add 0.05 gram per liter of Calcium Carbonate ($CaCO_3$) or Dolomite. Start with a small dose. Check the pH level and TDS level after 4-5 hours. Check pH level after 2 hours. If the pH level is lower than 7.4, further mix 100-gram $CaCO_3$ or Dolomite. This iterative process may continue till desired level is reached. Do not add excessive $CaCO_3$ into the water otherwise, it will raise the pH level.

Once the pH level has reached between 7.4 - 8.0, then after 4 hours, mix molasses/jaggery (0.1 gram per litre i.e. 100 grams in 10000 litre tank) along with Probiotics (0.02 gram per litre in the first instance[10], at least 10B cfu per gram) and put it into the fish tank. Take a bucket of water from the biofloc tank, mix molasses/jaggery and probiotics. Uniformly put this mix in the tank. All through ensure the biofloc tank remain well aerated. It will take upto 7 days to develop the floc in the tank.

[10]Thereafter, 0.4 gm per liter once in every two weeks depending on the stocking density.

Box item 7: Probiotics Protocol

Please carefully read manufacturer's instructions on how to use the material. Read in full. Check whether the probiotic is suitable for the species you have selected. Normally, probiotic is suitable for species grown under biofloc conditions.Here the protocol for a hypothetical product called Best Aqua Biofloc Pro is discussed for illustrative purposes.

Dosage and Application Protocol:200g Best Aqua Biofloc Pro for 10000 liters of tank.

If the C: N Ratio is maintained no need to dose the second time. If not,repeat the dose in every beginning of the month.

Propagation Protocol:

1. Take 250 liter drum add 3/4th of water to it.
2. Add 02 Kg Molasses / Jaggery+ 200g Best Aqua Biofloc Pro and 100g table salt stir it to dissolve properly.
3. Aeration required for 48 Hours.
4. Don't close the lid of the drum.
5. Incubation duration 38-42 Hrs.
6. After 48 Hours add 200 Litre propagated Inoculum to 10000 Litres of water uniformly.
7. Add 500g Molasses for 05 days continuously.
8. Maintain the aeration continuously.
9. Floc will be observed from 7-9th day after the introduction of propagated inoculum.

Check TDS level. The desired TDS level is species dependent ppm. Give aeration by aerator pump for whole day and continue (Minimum 2 days to if any issue in PH level of water, and stable the TDS of water[11]. For most fishes, normal TDS level is 1000 ppm, for tilapia it is 1500 ppt.

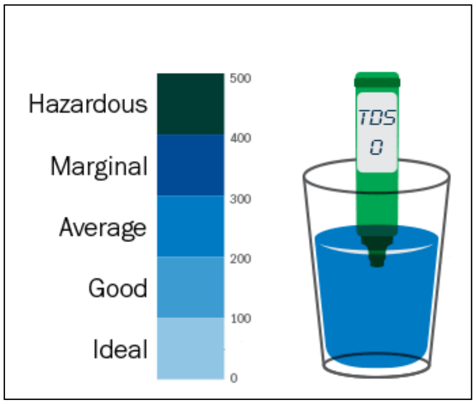


Figure 4: TDS Level

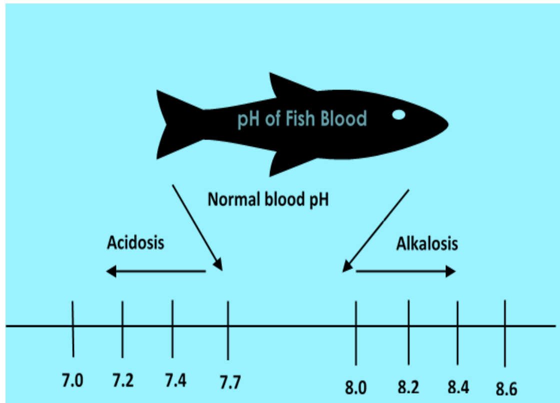
The ideal pH level for koi is 7.6 with TDS 800 which is slightly alkaline. Maintaining a pH of 7.5 is ideal for the species. Optimal salinity levels differ with fish varieties. A range of 10–20 ppt is optimal for growth. Optimal dietary protein content is 20–25% and feeding rates close to satiation levels lead to the highest growth.

Ensure the Aeration system is working all the time. DO level should be around 6 and maintain steady temperature for optimal bacteria growth.

[11]At the initial stage, no need to add raw sea salts (not iodized salt), it might hamper the initial bacterial growth. When salt is added at the initial stage, it slows down the floc development process and sometimes floc do not grow. Salt does not kill the bacteria, but it inhibits multiplication of bacteria. Salt will be added into the system when the floc is fully developed and depending upon the fish that is being cultivated.To ensure that sea salt is iodine free, it is a good idea to wash the salt beforehand. Some sea salt is iodine sprayed.

Box item 8: pH Level

pH is important in aquaculture as a measure of the acidity of the water or soil. Based on a pH scale of 0 to 14, water is characterized as being acidic, alkaline or neutral. A pH level measures how acid or alkaline. Acidity indicates a higher activity of hydrogen ions. Fish cannot survive in waters below pH 4 and above pH 11 for long periods. The optimum pH for fish in tanks is between 7.4 and 8.5. Fish will grow poorly, and reproduction will be affected at consistently higher or lower pH levels. The effects of pH on freshwater pond fish are:



pH Level	Effects
pH 4 or below	Acid death point
pH 4 to 6.5	No reproduction or slow growth
pH 6.5 to 7.0	Slow growth
pH 7.0 to 8.5	Desirable range for fish reproduction
pH 9 to 10	Slow growth
pH >11	Alkaline death point

Day 4-6: Check water quality parameters and take corrective actions. Add 0.25 grams of molasses, mix in water, and evenly pour in the tank.

Day 7: For the next 6 days, the water is left untouched. On day 7, check salinity and add salt as required. Floc will generate after 3 days, check for biofloc in Imhoff Cone. Microbial Community Color Index (MCCI) count over 1500 is ideal. Fingerlings can be introduced into tank prepared with microbials. Without movement of fish, biofloc would start settling down at the bottom of the tank and form sludge. Since the tank was only half filled at the start, 2500 liters of water on day 7. Any addition of water would inevitably lower TDS and pH level. It is important to check both the water parameters again. More water diluted sea salt mix is poured evenly in the tank till desired level of TDS is achieved. Likewise, molasses is mixed in water to improve TDS and Ph level.

Box item 9: How to make FCO

Fermented carbon organic (FCO) denotes any carbon containing molecule (carbohydrate, fatty acid, amino acid, carbon dioxide (CO_2)) consumed by an organism for the synthesis of its organic molecules. Carbon is the main element in all four classes of macromolecules such as carbohydrates, proteins, lipids, and nucleic acids. On a dry weight basis, 50% of all cells comprise of carbon. Carbon is required by all cells to nourish, live and function. Heterotrophic bacteria require one or more organic compounds as their carbon source while autotrophs require CO_2 as the carbon source (Gomez, 2011). Fermentation is the metabolic process of turning sugars and other carbohydrates into preservative amino acids and carbon dioxide using bacteria, yeasts, or other microorganisms. The use of fermented carbon source is intended to boost reproduction of biomass (viable cellular material in form of heterotrophic bacteria), production of intracellular components (enzymes and other proteins), control of extracellular metabolites (chemical compounds -toxic nitrogen), and act as substrate from which an organism lives, grows, or obtains its nourishment. The product of FCO are single cell protein, and algae which allow photosynthesis to occur. The organisms used in FCO are bacteria, yeasts, algae, molds (a type of fungi), plant and animal cells. Attention is also paid to the characteristics of the specific organisms used in the fermentation, such as nutrient levels, aeration rate and duration, and temperature.

Picture 6: Setup for FCO preparation

A low-cost way of producing FCO is to mix probiotic, molasses, rice bran, sugar in the ratio of 5 g: 400 g: 300 g: 200 g. Some add two ripe bananas (without skin) and 2 eggs (only white portion), though it is not must. All items are hand stirred and well mixed. The mix is poured into a bucket containing 20 liters of water, and stirred well. The mix is sealed with a lid containing two holes – one for letting out air, and the other is to pass aeration pipe fitted with an air stone placed at the bottom of the container. The container is left for 4 days with continuous aeration. When ready, FCO has some froth and carries strong odour. The FCO can be used for a maximum of 20 days before it gets spoilt. The FCO is given along fish feed in the ratio of 1:10 i.e. for every 1 unit of FCO, 10 units of feeds is used.

FCO with rice bran reduces pH level and improves digestibility of feed. FCO without rice bran aids only digestibility.

Day 13: Prepare More FCO: Take 50 liter of water with maintained pH and make FCO with full aeration with 100 grams of probiotics (in powder form only) and 1 kg of molasses. Heterotrophs use carbon source to make floc.

Day 14: Add Balance Water: The balance 2500 liter of water is added, water quality parameters are checked, and sea salt, and rock lime, mixtures are added to raise the TDS and Ph level. Further molasses is mixed with maintenance probiotic feed before releasing fish into the tank.

Box item 10: Sanitation of Fish

Fingerlings brought from outside should first be released in the nursery tank after proper sanitisation. For long term bath for 4 hours or more use of Potassium Permanganate ($KMNO_4$) for 0.001g/L for seed and 0.002g/L for fingerlings. For short time bath under 30 minutes, use solution of 0.002g/L. An alternative way is to use turmeric powder (20 g) and iodine salt (50 g) mixed in 20 liter water to sanitise fish.

Day 15: Add FCO at daytime. Keep adding in small quantity of FCO throughout the day. Addition of large quantity in one go will deplete DO level, causing stress in fish stock.

Day 25: Prepare More FCO: Follow the same procedure as indicated in Day 10.

Day 27: Add FCO at daytime. Follow the procedure outlined in Day 12.

Note that the C:N ratio till 25th day should be 1:15. From 25th day onwards, it can be changed to 1:2.5 for protein feed 28%-32%. If 24% protein feed is used, there is no need for adding external carbon source of 1:2.5 from 25th day onwards.

The addition of probiotic accelerates the development of biofloc system and stabilize tank faster. It takes 1-3 weeks to fully activate the bacteria to control the system. The addition of material rich in carbon is necessary to ensure a C to N ratio of 15:1 to 20:1 (Avnimelech, 2014). Probiotics have performed well in variety of fishes grown in India (Daniel and Nageswari, 2017). Commercially available multi strain starter packs (from Abis, Feed Wale etc, just check Alibaba, IndiaMart or Amazon India site for more reference) is added to water provide starter cultures for various probiotic microbes. It is recommended not to feed high protein feeds to the fishes, it will imbalance the system. 20% protein feed has worked well for Biofloc system. An alternate to commercial starter packs is home produced probiotic using molasses, milk, organic salt mixed in an air tight drum and left to ferment for 48 hours, after which the contents are mixed with tank water. However, given the availability of commercial probiotic formulations, there is little or no cost advantage of preparing probiotic at home.

FeedWale® Grow Fast... Grow Healthy

Shuaib - 9819496993

Bilal - 9967021414

ABIS *Floating Fish Feed*

Code	Size	Protein	Fat	Fiber	Rate / Kg	Bag Size	Rate / Bag
Abis FF Concentrate	Crumble / Powder	42	6	5	46.00	50kg	2300.00
Abis Aqua Star 32	1mm	32	6	4	61.00	20kg	1220.00
Abis Pre Starter	2mm	32	4	4	47.14	35kg	1650.00
Abis Maintenance	4mm	24	3	7	34.86	35kg	1220.00

Figure 5: Floating Fish Feed Dietary Composition

3.5.Step 4: Species selection and stocking densities

Though most freshwater species benefit from the improved water quality of biofloc systems, some species are better suited to use the extra proteins generated by feeding and digesting the biofloc themselves.

Some of the species that are suitable for BFT are:

- Air breathing fishes like Vietnam koi (*Anabas testudineus*), Magur (*Clarias batrachus*), Singhi (*Heteropneustes fossilis*), Pabda(*Ompok pabda*), Pangasius (*Pangasius bocourti*)
- Non air-breathing fishes like common carp (*Cyprinus carpio*), rohu (*Labeo rohita*), tilapia ((*Oreochromis niloticus*), milkfish (*Chanos chanos*)
- Shellfishes like Vannamei or whiteleg shrimp (*Litopenaeus vannamei*) and Asian tiger shrimp (*Penaeus monodon).*

Tilapia, Pangashius, and Magur and Koi exhibit good growth and marketability. Their physiological adaptations make them excellent candidates, as they eat up biofloc, thereby dramatically improving the feeding efficiency and FCR of farming operation. The species that are easy to sell and fetch good price in the market should have priority.

Different species have their own best time for seeding. Fish seed calendar is very important for fishermen to know the exact time of availability of fish seed. The calendar will be helpful to take decisions for fish farming. Fries are available approximately 15-20 days after spawning, and fingerlings after two months of spawning. Table 1 provides ideal timing for some selected species.

Table 3: Fish Seed Calendar

	Breeding Months										
Fish Species	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**
Vietnam koi											
Monosex Tilapia											
Gift Tilapia											
Pangasius											
Singhi											
Pabda											
Rupchanda											
Desi Magur											
Gulsha and Desi Tangra											
IMC and other carp											
Common Carp											
Amur											

Picture 7: Fingerlings

Picture 7a: Fingerlings of Desi Magur (Clarias batrachus)

There is strong tradeoff between higher stocking density and growth of stock. Stocking density refers to the ideal number of fish that a tank can hold to ensure optimum welfare and minimal stress. Getting the livestock density correct help in managing ammonia and nitrate levels effectively and ensure good water quality. The higher the number of individuals per cubic meter, the lower will be growth for the same amount of feed.

Box item 11: How Many Fish to Stock in a Tank?

For tank water volume of 10000 liters, the number of fish is given by the formula Volume of water (m^3) x Density factor/weight of fish at harvest. For a 10,000-liter tank with given density factor of 25kg/ m^3 and expected weight of fish at harvest of 180 grams, the amount of fish to stock is 10m^3 x 25kg/ m^3 divided by 0.180 grams i.e. 1389. If mortality rate of 10% is factored, the fish to stock is 1528 individuals. The expected harvest after accounting for mortality is 1389 fish @ 180 grams = 250.02 kgs. The changes of density factor, fish size at harvest and mortality rate has a bearing on the number of fish stocked.

Another way of calculating number of seeds required in the tank is to first pre-determine targeted harvest and marketable size of the fish. If the targeted harvest is 250.02 kg (i.e. 250, 020 grams) and marketable size is 180 grams, given mortality is 10%, then the number of seeds required are

Targeted harvest/Marketable Size x Expected Mortality Rate

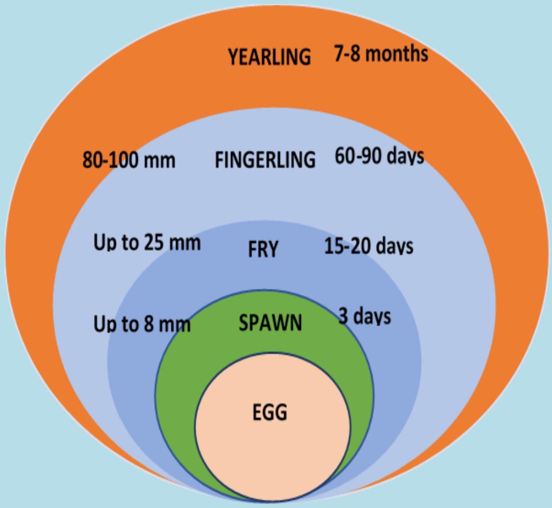
250,020 grams/180 gram) x 110% = 1528 individuals.

Either way the results are same.

Fingerlings of same species and age group are released first in a tank for fingerlings only. Fries are kept for in rearing tank till they reach desired size, before a smaller number is transferred to the main tanks for further growth.

Box item 12: Life Stages of Fish

Fish seed production includes egg to spawn production for 3 days, spawn to fry nursing for 15-20 days, fry to fingerling rearing for 60-90 days and fingerling to yearling rearing for 7-8 months. The seed size grows into spawn (6-8 mm), fry (20-25 mm), fingerlings (80-100 mm size) and yearlings (>100mm). Of the five stages, biofloc fishery is mainly concerned with only 3 stages namely fry, juvenile, and yearlings. This is because biofloc activities start with introduction of fries in tanks and ends with harvest of yearlings.Fertilized eggs develop into fish. Larval fish live off a yolk sac attached to their bodies. When the yolk sac is fully absorbed, the young fish are called fry. Juvenile period is the time fish spend developing from fry into reproductively mature adults varies among species. This forms the bulk of the time fish spends in tanks. When fish can reproduce, they are considered adults. Brood are those fishes kept for spawning. Spawning is referred to release of eggs into water by female fish. Biofloc fish varieties with shorter lifespans reach maturity faster. For example, tilapia reach sexual maturity in ponds is reached at an age of 5-6 months. However, reproduction is not of interest to biofloc farmers; their interest lies in selling fish which has maxed out weight and growth potential.



The strong aeration and self-filtering capacity of culture water allows high stocking densities of post larvae seeds – stocking of 4000-5000 Vietnam koi or Tilapia per 10,000 litre tank has been observed in Haryana. Monoculture is best suited for biofloc culture. Only individuals of same species and age should be raised in a single tank. Rearing multiple species in the same tank lead to uneven growth and lowering average weight gain.

However, different tanks may have different species to suit market demand and take advantage of varied rearing cycles of species. Some farmers attempt to load higher stocking densities, which inadvertently increases the risk of disease, mortality and economic losses.

3.6.Step 5: Balancing Carbon Source Addition

To jump-start the growth and development of biofloc in tanks carbohydrates are added at the start of rearing cycle. The organic carbon enables heterotrophic bacteria to multiply and synthesize ammonia, thus maintaining water quality.

Carbon source enhances not only microbial load but also the growth of fishes. Sugar, molasses etc. are some of the organic carbon sources.

Carbon sources and feed mixtures with a carbon-to-nitrogen (C/N) ratio above 10 are good candidates as this favours the growth of heterotrophic bacteria. Since most fish feeds have a C/N ratio of 9:1 or 10:1, additional inputs are needed to increase this ratio to between 12:1 and 15:1.

Any material that decomposes fast due to presence of sugar is used; in India FCO made of milk powder, rice bran, mustard oil cake, jaggery, wheat, molasses, soybean or maize is gaining popularity. Feed containing lower amounts of protein also serves the purpose. Every kilo of ordinary probiotics contains 300 grams (30%) of protein, 16% of these 300 grams are converted into ammonia Cal nitrogen. Addition of FCO, through accelerated floc formation impedes ammonia build up. A straighter forward management solution is to shift to external feed with lower protein content. To avoid ammonia peaks at later weeks of the production process, probiotics as % of percentage of body weight should be reduced to around 2-2.5%. Controlling ammonia is one of the hardest steps for successfully implementing biofloc principles.

3.7. Conclusion

The price of business success is eternal vigilance and scientific management. The first five steps outlined are essential for good results. It is important that the fish farmer do the basics right and seek advice from professionals for complicated problems.

Chapter 4:Biofloc Operations: Next Five Steps

4.1.Introduction

This chapter discusses various aspects of routine operations that are encountered week after week till the harvest is marketed. This chapter will discuss five steps which are common to all biofloc operators:

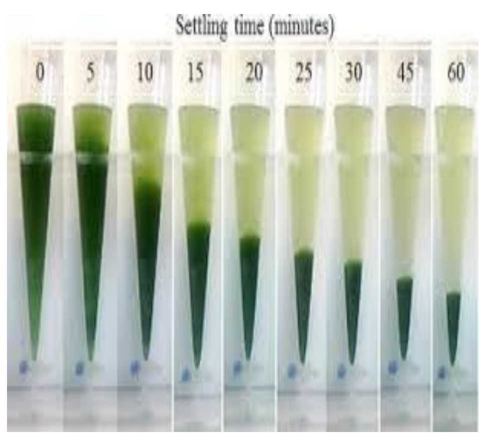
Step 6: Monitoring Biofloc Growth
Step 7: Monitoring and Control of Water Parameters and Associated Farm Infrastructure
Step 8: Disease and Morbidity Control
Step 9: Monitoring of Fish Stock
Step 10: Harvest, clean-up, and discharge of water

4.2.Step 6: Monitoring Biofloc Growth

For formation and maintenance of the microbial community (flocs), a fish biomass of 2.5 kg / m^3 (juveniles of ~70 g) is recommended for each macrocosm tank; this works out to be approximately 5000 adults and 12000 juveniles for each tank. These fishes are fed with commercial feed (32% Crude protein or CP) twice per day (8:00 a.m. and 6:00 p.m.) and a C: N ratio of 15: 1.

With plenty of aeration, diffused sun light and a readily available source of carbon, biofloc numbers should start to multiply rapidly. The number of flocs will increase from close to zero to about four to five units per millilitre within a few weeks, subject to host of factors including right water temperature, available organic carbon, and diffusion of sun light, plus the number of seeded flocs during the commencement of operation. In time, a mind-blowing density of up to 10 billion bacteria per cubic centimetre can be expected - all working hard to minimize the ammonia content in the water column and maintain good water quality.

Picture 8: Bioflocin an Imhoff Cone



Picture 9: Algae and Carbohydrate in Imhoff Cone

From this time on, water samples of every alternate tank must be regularly taken every week in the morning hours to monitor the water quality and verify the activity of the two biofloc types plus their respective densities. Tank water now has green algae (green in colour) and brown bacteria (brown in colour). The algae mainly utilize photosynthesisfor their growth, while the bacteria (floc) utilize uneaten feeds, and associated wastes. Monitoring the growth of these flocs can be done by using Imhoff Cone to collect multiple water samples from different tanks just below the top level at a depth of 15 cm to 25 cm. Within 20 minutes the solid particles would settle in the bottom of the Cone. The floc will stick to the sides of the Cone, making it easy to add them up.

With increase in biofloc multiplication and feeding activities, the water colour will begin to change. Initially, the tank water will look milky with the appearance of CN (depending on exposure to light). There will be a tipping point within 3 weeks when water will turn brown indicating that bacterial colonies have started to dominate. This colour shift is beautifully illustrated in the colour index[12] in the Figure below:

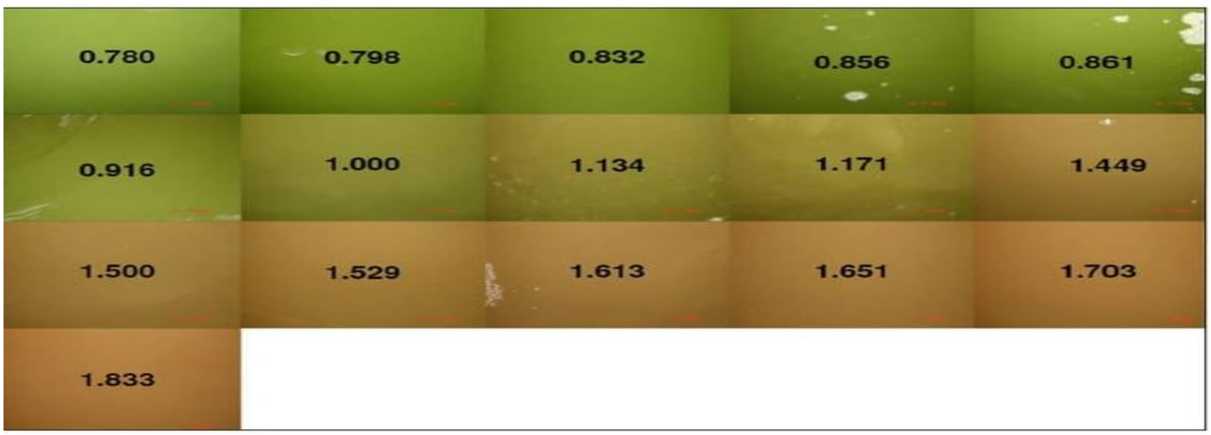
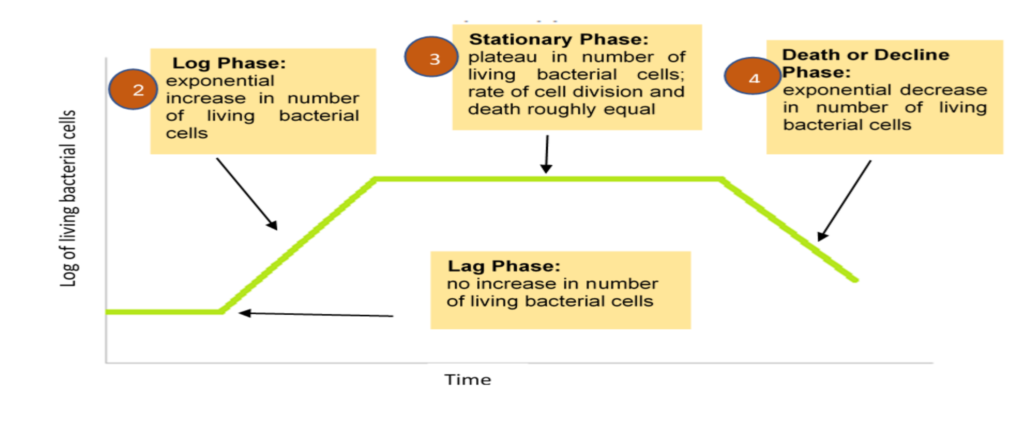


Figure 6: The Microbial Community Colour Index (MCCI)

[12]MCCI indicates the transition from an algal to a bacterial system as feed loading increases. The transition between algal and bacterial systems occurs at a feed loading of 300 to 500 kg/ha per day, indicated by an MCCI between 1 and 1.2 Source: Hargreaves. 2013.
https://aquaculture.ca.uky.edu/sites/aquaculture.ca.uky.edu/files/srac_4503_biofloc_production_systems_for_aquaculture.pdf

Box item 13: Growth Curve of Microbes

Microorganisms grown in Biofloc culture follow a reproducible growth pattern referred to as the growth curve[13]. The growth curve of a bacterial culture is exemplified by the logarithm of the number of live cells produced as a function of time. The graph is split into four phases according to the slope, each of which matches metamorphosis of the cell. The four phases are characterized as lag, log,stationary, and death (figure below).During the lag phase, the bacteria prepares amino acids and vitamins for DNA division. In the Log phase, the heterotrophic bacteria for the first 10 days follow an exponential growth splitting itself every 30 minutes, and for Nitrosomonas bacteria, the process takes 10-12 hours. Growth and death rates are equal in the stationary phase. Cell multiplication is inhibited by infections or unfavorable external conditions. In the Death phase, bacteria lose the power to reproduce.



4.3.Step 7: Water Parameters and Associated Farm Infrastructure

An intensive aquaculture system is characterized by the high stocking density which is followed by the needs of high quality and quantity of artificial feed. As application of high fish biomass and feed input brings about water quality deterioration, an active water quality management should therefore be regularly performed in an intensive aquaculture system. Widanarni and Kasarisiti (2012) noted that fish assimilate only 20-25% of protein in feed, and the remaining is excreted as ammonia and organic nitrogen in faeces and unconsumed feed. At the same time organic nitrogen in faecal matter and unconsumed feed is further mineralized by the decomposing bacteria resulting inorganic nitrogen in the form of ammonia.

Regular monitoring of water-quality parameters especially dissolved oxygen and ammonia levels are indicative of how well the system is working, or if aeration needs to be increased further. The key parameters to be monitored are dissolved oxygen (DO), ammonia (NH_4), pH balance, alkalinity balance, temperature, nitrate (NO_3^-), and nitrite (NO_2^-) level.

[13]Source: Bruslind, Linda. (2019). Allied Health Microbiology, Oregon State University, 2019. DOI: https://dx.doi.org/10.5399/osu/1118

The minimum water quality conditions necessary to main good fish health are presented in Table 1[14].

Table 4: Water Quality Parameters and Corrective Steps

Parameter	Ideal ranges	Corrective Steps
Color	Light green/ Greenish yellow	If dark brownish, or dark green, add water or exchange water, and remove plankton, use Algaecides or copper sulphate to reduce abundance of phytoplankton
Total Dissolved Solids (TDS)*	Species dependent; between 600-1500 ppm	Indicative of presence of Nitrate and Nitrite which is dangerous for fish.
Total Suspended Solids (TSS)*	Less than 600 ppm	High levels of TDS (measured in Imhoff cones) will contribute to the DO consumption by heterotrophic community and gill occlusion
Temperature*	26–34° (ideal for tropical species) Temperature below 20° C) could affect microbial development.	If>40, reduce stress factor, minimise feed, harvest fish
Dissolved oxygen (DO)#	4-6 ppm for correct fish, microbiota respiration, and growth	If DO<4, exchange or add water, reduce fish density
pH#	7.0–8.5 At pH level less than 7.0, biofloc is adversely affected by accentuated nitrification.	If pH<6.5, apply lime If pH>9. apply gypsum or water exchange
Salinity#	Varies according to the cultured species. Some fishes do well in saline or brackish water.	
Ammonia#	<0.5 ppm	If ammonia >0.5ppm, remove sludge.
Total Ammonia Nitrogen (TAN)#	Less than 1 mg/l (ideal). Toxicity values are Ph dependent.	Whenever the TAN concentration of any tank exceeds 1 mg/L, 25% of the water must be replaced.
Nitrite (NO_2) #	<0.3 ppm is the critical level.	Lowering of protein level in feed, and control of salinity, and alkalinity will help.
Nitrate (NO_3) #	<0.5 ppm	
Alkalinity#	120-150 ppm.	Rise in alkalinity will aid the nitrogen assimilation by heterotrophic bacteria and nitrification process by chemoautotrophic bacteria.
Floc density*	25-40 mg/l	

Source: Emerenciano et al. 2017, pp. NB: *Physical characteristics; #Chemical Characteristics

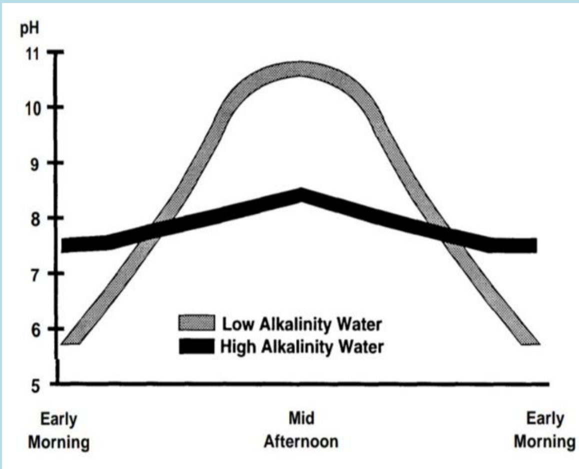
[14]For ready reference, the minimum water quality conditions necessary to maintain good fish health are: Dissolved oxygen — 5 mg/liter; Range of pH — 7.5-8.0; Ammonia — 0.02 -0.05 mg/liter or less; Nitrite-0.3 ppm, Nitrate-150 ppm. Alkalinity — at least 20 mg/1 liter, TDS 600 ppm, Floc density-25-40 mg/l, and Temperature 26-34 degrees.

A variety of handheld instruments and probes are commercially available to test water quality parameters. Fish growth performance is greatly affected if pH is below 6.5 or above 8.5. Likewise DO and temperature level should be measured every morning just after sunrise. DO and water temperature should be measured at the same time to be able to relate the DO to the temperature. DO is expressed as mg of oxygen/litre of water (mg/l), while temperature is expressed in Celsius. Dissolved oxygen (DO) is indispensable for respiration and decomposition. DO in water comes from atmospheric oxygen and photosynthesis. Through air pipes atmospheric oxygen is slowly diffused and dissolved into the water. DO can be measured by chemical or by digital devices. Chemical methods rely on the use of kits which are available online from many vendors. The test kits contain necessary medium to determine the DO content with sufficient accuracy for tank management purposes. Digital methods use probes to record oxygen.
The parameters of water quality, temperature, and chemical content are species specific and vary a great deal. The parameters for Tilapia culture are given in the table below.

Table 5: Parameters for Tilapia Culture

Parameter	**Unit**	**Min**	**Ideal**	**Max**
pH		6.5	7.5	8.5
TDS	PPM	600	900	1500
Salinity	PPT	0.8	1	1.5
Alkalinity	PPM	50	70	120
DO	PPM	5.5	7	8.5
Soluble Iron	PPM	0.00	0.001	0.003
Temperature	Celsius	25	28	32
Ammonia (NH_3)	PPM	0	0.2	0.25
Nitrogen dioxide (NO_2)	PPM	0	0	0.25
Nitrate (NO_3)	PPM	0	0	2
Floc	ML	15	15	20

Box item 14: Box 1: Relationship between CO2, pH, and Alkalinity



Throughout the day in a tank pH levels change in response to CO_2 levels. CO_2 dissolved in water forms a mild acid. The higher the CO_2 level is in the atmosphere, the lower the pH falls (more acidic). In the morning, CO_2 levels are high as a result of the respiration of floc and fishes that occurred in the tank overnight. As the sun rises, plants and algae begin photosynthesis thereby and consume CO2, causing the pH to rise as the day progresses. Algal blooms can also significantly increase this effect. There is close relationship between alkalinity and pH level. In low alkalinity water, pH fluctuates like a bell curve, while in high alkalinity water, pH level is more static as shown in the graph below.

To maintain both alkalinity and hardness, calcium carbonate or zeolite well mixed in water bucket may be evenly spread over the water surface to obtain desirable alkalinity level. Proper management of hardness and alkalinity will usually eliminate the problems associated with pH. API Fresh Water Master Kit can be used to test alkalinity, hardness, and pH level. Un-ionized ammonia (NH_3) concentrations in tank water should be kept below 0.5 mg/l. DO, pH, and alkalinity influence the generation of ammonia, therefore it is important to manage this by maintaining water alkalinity at 40 mg Calcium carbonate per litre or above, keeping pH between 7.4 and 8,.5, and keeping DO concentrations high. Substances toxic to fish and other organisms (herbicides, insecticides, and other chemicals) can devastate fish stock and should be kept very far from the tanks, or feed store area.

Organic carbon addition can control nitrite levels. Any carbon that is added is first used by heterotrophic bacteria in combination with ammonia to build protein. When there is an excess of organic carbon, bacteria will use nitrites as a nitrogen source to build protein. Nitrites are slow to respond organic carbon input because first the bacteria need to reduce nitrites to ammonia by enzymatic action. Fortunately, any form of inorganic nitrogen is controllable by addition of organic carbon.

Box item 15: Ammonia Level

Ammonia is a natural chemical occurrence in fish tanks created by the decomposition of fish food and excrement. Inadequate filtration, high density fish stocking, over feeding of fish, and high temperatures contribute to ammonia release.

In water, ammonia (NH3) exists in equilibrium with dissolved ammonium ions (NH4+). Un- ionized form of ammonia (NH3) is very toxic while the ionized form (NH4+) is harmless. Un- ionized ammonia (NH3) levels increase with rise of temperature and pH. Un- ionized ammonia (NH3) levels increase with rise of temperature and pH. Toxicity levels for un-ionized ammonia (NH3) less than <0.5 ppm is considered safe. At high levels of ammonia, fish act fidgety, jumping, breathing at the water's surface with mouths open, gasping, and rapidly moving gills. TAN (total ammonia nitrogen) is the total amount of nitrogen in the forms of NH3 and NH4+ in water. TAN below 0.1 ppm is considered ideal.

If ammonia reading 2 ppm and tank volume 10000 litres, the total nitrogen (N) is given by the formula

= Ammonia in g x Volume of Water x Molecular weight of Ammonia/Molecular weight of Nitrogen

= 0.002X10000 x 14/17= 16.47 g

Add 20 times carbon for maintaining 20:1 C:N ratio i.e. 16.47 x 20 = 329.41 g. carbohydrate required to neutralize nitrogen. The protein content in molasses and sugar are 24% and 40% respectively. The amount of molasses required is 329.41 x 100/24 = = 1372.5 g. If we are using sugar, 329.41 x 100/40 = 823.52 g of sugar need to be added.

Both biological and mechanical means are available to control ammonia. With proper aeration and tight feeding regime, enough bacteria is generated to set in a process called Nitrogen Cycle, which degrades toxic ammonia into harmless nitrates. In emergencies, a quick corrective step involves 25% water change and retesting water quality parameters after a few hours. Mechanical filtration trap and remove sludge, whilst the biological filter breakdown the chemicals released by waste through the nitrogen cycle.

Wherever possible, use feed with 25-30% protein content, because higher protein content accelerates the formation of nitrogenous metabolites like ammonia (NH_3), nitrate (NO_3) and nitrogen dioxide (NO_2). 25-30% protein content feed is good enough to generate enough single cell microbial protein, so much so that less protein content feed is needed with passing weeks. A top-quality functional probiotic with synergistic species of bacteria can utilize nitrogen-based metabolites to reduce the NO_2 level.

Box item 16: Sludge Removal

Tank sludge is simply an accumulation of organic debris that settles in the tank bottom. The sludge is a messy mix of decaying leaves, wasted fish feed, dead algae, and dust particles deposited into the tank with wind flow. An incremental thin build up is to be expected. In the initial 3-4 months, this is not going to pose any significant problems. With the passage of time, the decomposition process of the organic material will reduce oxygen levels in the tank. The sludge will remove available oxygen. This anaerobic zone can shelter harmful bacteria as well as produce hydrogen sulfide, a colourless gas with the smell of rotten eggs. The hydrogen sulfide will damage fish in the tank environment and eliminate the beneficial bacteria. It also can turn water colour darker and create unpleasant odors in the tank. Sludge formation can be reduced but not eliminated. There are many ways that are effective in checking the level of sludge buildup and thus, mitigate the potential damaging effects.

1. Right Filtration. Right mechanical and biological filtration are effective in decreasing the sludge build-up and keeping the water in a good state.
2. No overstocking or overfeeding. Overstocking and overfeeding both means more fish waste and less oxygen to assist in the decomposition. Uneaten food immediately swells the debris in the bottom.
3. Aeration. Raising the level of DO in the water will improve the ability of the biofloc colonies to absorb the feed. Higher levels of aeration also help save fish if the sludge build-up is reducing the oxygen within the water.
4. Leaf netting. An additional layer of garden net can be one of the most important steps in preventing leaves falling on the tank and deter birds hovering around. Fallen leaves will rot at the bottom and add to the debris.

If the sludge is an inch or more thick or perhaps the fish stir it up causing turbidity in the tank, then it is time to remove the muck. There are different methods and products that can be used.

1. Add oxygen tablets: Some strains of bacteria are more suited to help accelerate the decomposition process. Adding oxygen tablets will prevent dying of fishes till more effective solutions are applied. This would partially relieve the acuteness of the problem but is generally not enough.
2. Try Water Exchange: Remove 10-15% of water from the tank and add fresh water. This will involve removal of a significant amount of water and biofloc so you will need to add water and top up with FCO.
3. Airlift, siphon and recycle water: Use airlift pumps to siphon water long the tank bottom where the bulk of debris is located. The water with muck pass through a physical filter (such as a nylon saree, or fine plastic membrane) before recycling the water back into the tank. In this process no water or biofloc colonies are lost. Please see https://www.youtube.com/watch?v=5Ex9lmYUv2w for a smart application (in Nepali).
4. Use vacuum. Vacuum all sludge from the centre and other spots where sludge is present. There are several good vacuums that can remove both large and fine debris from the tank. This is the most effective way for regular maintenance and also effective when sludge build is on the higher side. Please see https://www.youtube.com/watch?v=KEnpjeE7v-Qfor a practical demonstration (in Hindi).
5. Complete pond drain. If the sludge and debris build-up is more than two inches or other sludge removal methods are not successful, a complete cleaning of the tank is unavoidable. Under this step, all fish is moved to a temporary tank. Pump out the bulk of the water and then either manually or with a wet/dry vacuum to remove the sludge and remaining water from the bottom.

4.4.Step 8: Disease and Morbidity Control

Disease remains a limiting factor for the biofloc aquaculture industry. Disease outbreaks have caused havoc to shrimp production in many countries. Disease outbreaks not only result from the mere presence of a pathogen in the system but are aggravated by poor hygiene practices in combination with suboptimal environmental conditions. Therefore, disease prevention, control and surveillance should focus on implementing biosecurity measures in an integral manner involving, inter alia, adequate nutrition, improving ng the immunity of the cultured stock and maintaining healthy water quality. The basic operating principle of the biofloc system is to recycle nitrogen and waste nutrientsinto microbial biomass that ready for consumption *in situ* by the cultured fish as feed. There are not many studies which has investigated the immunological potential of the BFT although it is widely known that microorganisms, their cell components or their metabolites can act as immunostimulants that improves the innate immune system of species and provide some protection against pathogens.

Species grown under biofloc conditions are inherently robust but not immune to bacterial, parasitic, or fungal diseases. The key to successful morbidity control is early recognition of symptoms and starting the proper treatment as soon as possible. Here are eight common koi diseases as well as their symptoms and treatments. At the onset of disease, the biofloc farmer should contact qualified vet at Fisheries Department or private practitioner. A photo of diseased individual shared on WhatsApp can help in quick diagnosis. In addition, steps are taken to discard the dead individuals and isolate the diseased individuals in a separate tank often dubbed as “hospital tank”. The concerned pond is thoroughly disinfected using Benzalkonium chloride (BKC) and other anti-molting anti-parasitic formulations. In any case, the diseased fish and water from the affected tank should not be mixed with other tanks.

It is a good idea for every biofloc enterprise to keep emergency supplies of Potassium permanganate, lime, raw sea salt, Benzalkonium chloride (BKC), and feed supplements.

4.5.Step 9: Monitoring of Fish Stock

Regular and careful monitoring of the performance of the fish stock, calculating and recording growth rates, overall appearance, FCR and stock survival is advised. It has been estimated that for every unit of growth in fish stock from feed, an additional 0.25 to 0.5 units of growth can come from the biofloc in the system. Biofloc system succeeds over traditional systems when water quality is maintained at lower cost without water exchange, and sustain higher growth rates and feeding efficiencies, thereby improving the profitability and sustainability of farming operations (Sanchez-Estrada et al., 2018). Cost advantage and feed efficiencies are compromised when water is exchanged to remove sludge, and valuable floc is lost due to draining out curated water.

The practice for measuring fish weight gain and growth is to randomly net 10 fishes from few tanks containing same species of the same age group, weigh them on digital scale and calculate the average weight. The weight of fishes is then compared to expected values for the fish. Any discrepancy of 10% ± between expected value and actual value is tolerable, any higher discrepancy range may warrant deeper examination. Where time and resources permit, it is encouraged to collect data on growth, survival, and production of the fishes. The formula is used to calculate mean weight, mean length, specific growth rate, survival rate, and net production. Once analyzed, the data can guide on areas for improvement in operations, and selection of species.

a) Food Conversion ratio (FCR) = Feed fed (dry weight) / Live weight gain

b) Mean weight gain was calculated as Weight gain (g) = Mean final weight (g) – Mean initial weight (g)

c) Mean length gain (g) = Mean final length (cm) – Mean initial length (cm)

d) Percent weight gain (g) = $\frac{Mean\ final\ weight\ (g) - Mean\ initial\ weight\ (g)}{Mean\ initial\ weight\ (g)}\ x\ 100$

e) Specific growth rate (SGR %) of each species is calculated as

$$\text{SGR (\% day)} = \frac{(\log W2 - \log W1)}{T2 - T1}\ x\ 100$$

Here, W_2 = The final live body weight (g) at time T_2 day

W_1 = The initial live body weight (g) at time T_1 day

T_2 = Time duration at the end of the rearing

$T_2 - T_1$ = Duration of the rearing (day).

f) Survival rate (%)

Survival (%) $\frac{Number\ of\ fish\ harvested}{Number\ of\ fish\ stocked}\ x\ 100$

g) Production of fishes

Net production= No. of fish caught × average final weight (g).

In India, objectively verified information on various fish species under biofloc conditions is not available. Based on information received from many practitioners, the growth rate per day, growing period and feeding rate has been calculated below for various species. The growth rate of fish varies according to the species characteristics, feed, external conditions, and morbidity.

Table 3 provides indicative growth rate of some freshwater species. The reported FCR for various species under biofloc conditions are FCR Tilapia 0.6:1, Pangasius 0.8:1, Koi 1:1, Singhi and Pabda.1.5:1. Tilapia is among the fastest weight gainers, and Pabda gains weight slowly. It is best to consult feed charts of each species for more accurate determination of feed and body weight. The frequency of feeding and feed as % of body weight are both gradually reduced overtime. The frequency of feed is reduced from 4 times when young to 2 times in months before harvest. The fishes in nursery start with powder crumbles, followed by 1-1.5 mm pellets for the first 30 days, 2.0 -4mm for the period till harvest.

Table 6: Indicative Growth and Feed Rates of Some Species

# Days	Feed times	Weight				
		Tilapia	Pangasius	Koi	Singhi	Pabda
0-30	4	<3g	<3g	3g	<3g	<3g
30-60	3	5g	5g	3.5g	4.5g	4.5g
60-90	3	45g	40g	15g	40g	45g
90-120	2	150g	140g	35g	130g	150g
120-150	2	300g	280g	110g	270g	260g
150-180	2	500g	460g	175g	450g	440g
180-210	2	700g	680g	240g	550g	530g
210-240	2	1000g	980g		770g	7500g
240-270	2		1150g		1100g	1000g

Some fishes are fast growers requiring more feed while others grow slowly consuming less. The table below is an indicative regime which may be adjusted to suit individual circumstances. So long as fish is consuming well and digesting, the feed rate is maintainable. If fish is not eating feed within 5 minutes of broadcasting feed, it is a clear sign of problem which should be attended to.

Table 7: Fish Feed Chart

Fish body weight (g)	Feed as % of total body weight	Floating feed size (mm)	Protein content
1-5	1.5-2.5	0.8 -1.2	32%
5-50	4-5%	1.5-2.0	32%
50-200	3-4%	2.0-3.0	28%
200-400	2-3%	3.0-4.0	28-24%
400-800	1-1.5%	4	24%
2 days before harvest	1%	4	24%

Box item 17: Azolla and Wolffia Feed

Both Azolla and Wolffia are prolific aquatic ferns doubling its size just in 3 days. Azolla feeds can be given to young tilapia but not 15% of the formulated ration. *Azolla pinnata* (also called mosquito fern, duckweed fern, fairy moss, water fern) is used by fishgrowers as tilapia feeds because of its high protein content, almost the same in concentrated fish feed. Results of a study (El-Sayed. 1992) indicate that young Nile tilapia under 7 weeks utilizes *Azolla* more efficiently than the adults. Wolffia (also called water meal or duckweed) resemble specks of green dots floating on the water. A study by Chareontesprasit & Jiwyam (2001) found the highest total production occurred in Nile Tilapia (Oreochromis niloticus L.) being fed on formulated ration containing 15% Wolffia meal. Hence, both Azolla and Wolffia are good supplements to concentrated feed when these are used in the ratio of 15:85. An increase in duckweed meal beyond 15 % in the formulated ration and in adult fish can decrease the survival rate and total production of the cultured fish.

4.6.Step 10: Harvest, clean-up, and discharge of water

A proper strategy for harvesting is needed to deliver good financial results. The farmer has 3 main options to maximize bumper production:

a) <u>Start to finish:</u> Raise young fingerlings in rearing tank and growth them to full size before harvest. This takes 5-6 months' time in most species but fetches good price for harvest. The disadvantage is sludge build up and cash lockdown for 5-6 months.
b) <u>Head start but harvest late</u>: Head start with 30-40 gms seed stock (1-2 months old) in the biofloc tank which can be grown for another 4-5 months before harvesting. The advantage of this strategy is significant amount of time gained due grown up fingerlings, and savings on mortality and labor. The disadvantage is managing sludge and maintaining C:N ratio after 2-3 months of BFT culture. In case where 40-50 gm seed stock is not available, fries could be raised in rearing tank by the farmer himself/herself.
c) <u>Head Start with short harvest cycle:</u> An alternate way is to introduce 40-50 gm seed stock and harvest them regularly after 3 months. The advantage of this strategy is avoidance of sludge build up, and more frequent of cash from sales. The disadvantage is that the fish size is not optimal; most consumers in India prefer large size of fish rather than small ones.
d) All the strategic paths are viable. It is for the farmer to make choice according to own preference, and cash flow objectives. The decision to harvest is closely related to prevailing market conditions. The 4Ps (product, promotion, place, price) are unpredictable. Winters and festive seasons fetch better prices. If possible, harvest time may coincide with spikes in prices of fish stock

Before harvest, tank is emptied, all fish netted, and separated by their size. The small fishes are put back in another tank. For Vietnam Koi, a harvest of 300 - 400 kgs per tank is a safe expectation. With more experience, and adherence to right methods, a farmer can boost growth rates and survival, thus adding to profitability.

Picture 10: Tilapia (Orechromis niloticus)

Picture 11: Singhi Fish (Heteropneustes fossilis)

Picture 12: Vietnam Koi (Anabas testudineus)

Picture 13: Pabba Fish (Ompok pabda)

An often forgotten aspect of post-harvest operations is proper cleaning and reading the tank for next culture. Though it might seem appealing to reuse the culture water because of the presence of microorganisms, it is best avoided. Pathogens growing in the culture, and accumulated sludge can pose a serious biosecurity risk. A worrying fact is heavy metals can build up in the culture water, which can accumulate in fish stock, making it unfit for human consumption. It is always safe to thoroughly clean up the tank, infuse new water, and start operations afresh for the next profitable batch.

As fish pellet usually contain protein no less than 25%, the consequence of high feed input in intensive aquaculture system is a high accumulation of ammonia, which is highly toxic for aquatic organism. If the discharged water of an aquaculture unit is released without any further treatment, it may not only harm aquatic wildlife but also contribute to the eutrophication of surrounding water. Generally, in BFT farming systems wastewater is stored in a holding tank and treated to reduce ammonia content. Wastewater is stored in a holding tank and treated to reduce ammonia content. There are many small biofloc units who discharge waste into water bodies or drains. This puts unnecessary pressure on the environment.

In addition, a routine involving checks of water quality parameters, growth in fish sample, inventory levels, and state of infrastructure will help in smooth operations. The observations of each tank should be recorded in the Status column as shown in the Table 5.

Table 8: Daily Routine

Tank No. # -------		**Day**							**Status**
Sl. #	**Activity**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	
A	**Water Monitoring**								
	pH (7.5-8.0)	*	*	*	*	*	*	*	
	DO (5mg/l)	*	*	*	*	*	*	*	
	TDS (600 ppm)	*							
	Ammonia (NH_3) (0.5 ppm)	*							
	Alkalinity (120-280 ppm)								
	Nitrate (NO_3) (150 ppm)	*							
	Nitrite (NO_2) 0.3 ppm	*							
	Salinity (0.8-1.5 ppm)	*							
	Temperature $26-34^0$ C	*							
	Floc (25-40 mg/l)	*							
	Sludge in inch at bottom of the tank (<1 -Ok, >1<2 Bad, >2 Emergency)	*							
B	**Growth monitoring**								
	Feed uptake		*	*	*	*	*	*	
	Fish weight measurement		*						
	Disease check		*				*		
C	**Stock taking**								
	Probiotic		*						
	FCO								
	Calcium Carbonate		*						
	Sea Salt		*						

Tank No. # -------		Day							Status
Sl. #	**Activity**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	
	Zeolite		*						
	Potassium permanganate		*						
	Medicine		*						
D	**Infrastructure**								
	Water pump			*					
	Aeration pump			*					
	Air pressure			*					
	Inverter and battery			*					
	Generator			*					
	Diesel stock			*					
	Conditions of tanks			*					
E	**Accounts management**								
	Receivable (suppliers)			*					
	Payable (vendors, utilities, labour)			*					

NB: After inspection, please note status as 1- Ok; 2 – Bad; 3 – Emergency

4.7.Conclusion

No doubt Biofloc requires utmost attention, scientific understanding, and timely action on and before things go wrong. The Ten Steps outlined in this and previous chapter will go a long way in managing risks and nasty surprises. Start-ups commit some common mistakes outlined in Annexure 3.2. With good training and mentoring such mistakes can be avoided.

Chapter 5: Economics of Biofloc Farming

5.1.Introduction

Fish is among the most inexpensive, palatable animal protein obtained from natural sources from ancient times for consumption. However, caused by continuous expansion of cereal production, loss of wetlands, and pollution, open access fisheries have declined considerably, forcing technologists to adopt more intensive ways to expand its production. Fish farming in controlled or under artificial conditions has gained popularity for increasing the fish production and its availability for consumption. Farmers can easily take up fish culture on limited land, generate self-employment for youth and earn decent financial returns. Biofloc fish culture in which a single species is cultured in one tank is suitable for mass production. Technology, artificial feeding and scientific management drives biological productivity. The special purpose water tanks are erected with a minimum freshwater retaining depth of 1.0 metre. The tank size can vary to suit individual need. The most popular size is tank with 4 metre diameters, circular in design holding 10,000 litres of water.

In this chapter, we examine economic and financial issues related with biofloc fish farming in India. Based on technical and financial data available, we attempt to answer whether biofloc is a bankable, viable enterprise. Some biofloc projects are fully self-funded, but most are a mix of self-funding and debt from external sources. Since there are backend credit subsidies available under many government schemes, it is advisable that all attempts are made to avail bank credit. The margin money for bank borrowing differs according to the status of entrepreneur; 5, 10 & 15% of margin money is the norm for small, medium, and large farmers respectively and 25% for companies and partnership firms.

Organisations such as farmer producer companies, farmer groups, SHG Federation, Cooperative Societies may start with a ten-tank unit to begin with. Individuals with lesser means can start with 2 tanks of 10,000 litres each. The expansion of the units can proceed in a gradual, incremental manner based on experiential learning.

Entrepreneurs and organisations should avail bank loans. This is important for two ‘reasons: the burden on individual’s own savings is reduced, while bank loans open opportunities for repeat loans in case further expansion in business is envisaged.

Bank loans may be taken even without any credit linked subsidy. The National Fisheries Development Board provide support of Rs. 1 lakh or 40% of project cost, whichever is lower, under its Innovative Farming initiative. The subsidy amount is small, however the process of sanction is time consuming.

It is a general practice that the lending bank will insist on some fixed assets as collateral plus one or two guarantors. Security from the borrowers may be obtained as per the guidelines of RBI issued from time to time.

Before an entrepreneur embarks upon setting up a biofloc unit, s/he should obtain good training and exposure in the tricks of trade.Training in fish farming is available from State fisheries department and many private institutions. It is important that eligible borrowers are well informed about biofloc farming before commencing fish business. National Fisheries Development Board (NFDB) suggest all the fish farmers/Entrepreneur to undergo training courses which is from a recognized farm/institute/organization by govt. of India or NFDB. A certified course with hands on training is more reliable.

Though marketing small quantity of fish is not a problem, the entrepreneur should contact few fish vendors in advance to discuss their interest in the produce. There are many fish vendors who are willing to purchase fish at doorstep. Alternatively, fish can be sold at regular markets. Offtake of fish is not considered to be a problem.

5.2.A Simple Model for Financial Calculation

5.2.1. Assumptions

In order to examine how profitable is biofloc fish farming, it is necessary to make certain assumptions and technical constraints. The main assumptions are:

- Land is owned by the farmer
- Source of financing: 25% own margin money, 75% borrowing from bank.
- Rate of annual interest – 12%.
- No subsidy amount has been considered.
- Repayment period 5 years.
- Only one single species (Vietnam koi) is reared
- Stocking density for fingerlings is 1667 per tank
- Total growing time – 30 days as fingerling, plus 120 days as juvenile/adult. Thus, the length of production is cycle is 150 days.
- The weight of fish at time of sale is 180 grams.
- Survival rate is 90%.
- Feeding rate as of body weight 5% in the first 30 days and 4% for the next 120 days
- Each cycle takes 180 days – 150 days of growing plus 30 extra days to account for tank cleaning, unexpected work stoppages and peak winter. Thus, 2.03 cycles are possible every year.

5.2.2. Technical Parameters

Technical parameters of intensive fish culture include site selection, pond development, pre and post stocking operations, stocking, feeding etc. which is given below in Section C of Financial results. To keep the calculations simple, only Vietnamese Koi cultivation in 10 tanks each of 10,000 litres tank (100 m^3) has been considered.

The stocking density is 1667 individuals per tank. Fingerlings of 30 grams (30-35 days old) are introduced in the tank. The fishes are reared for 150 days. The mortality rate assumed is 10%. The average weight per fish at the time of harvest is 180 grams which is reasonable. The price taken is Rs. 300/kg which is on conservative side for Vietnam koi.

5.2.3. Financial Results

The details of capital Cost, recurring cost, revenue, and profit has been calculated. The total financial outlay for 10 tanks is Rs. 7.06 lakhs. The entrepreneurs share is 25%, the remaining 75% could come through bank debt. The interest rate assumed is 12% and repayment period 5 years. The internal rate of return is 28% which is reasonable.

Table 9: Financials

Economics of 10 tanks Model

S.No	Particulars	Units	Quantum	Rate (Rs.)	Total Amt Rs.
A	**Capital Cost**				
1	Site clearance, brick lining	LS	10.00	1000	10,000
2	Biofloc tank 10000 litres, 4 mtr dia, 1.25 mtr height (iron mesh, inner lining, tarpaulin 650GSM, aerator pipes)	LS	10.00	30000	300,000
3	Water quality meters	LS	1.00	30000	30,000
4	Ring Blower (Voltage: 220v/50Hz, Pressure: 35kPa, Output: 200lpm)	1	1.00	21240	21,240
5	Diesel Pump Set	5HP	1.00	40000	40,000
6	Inlet/outlet sluices	LS	10.00	2000	20,000
7	Store Room/ Office Room	Sq ft	30.00	600	18,000
8	Nets and other implements	LS	2.00	5000	10,000
	Total "A"				**449,240**

B	**Operational cost for one year**				
S.No	**Particulars**	**Units**	**Quantum**	**Rate (Rs.)**	**Total Amt Rs.**
1	Lime and sea salt	Kgs	6,083	5	30,417
2	Fish seed	Nos	81,111	5	405,556
3	Fish feed -probiotics	Kgs	81	1500.00	121,667
4	Fish feed - Aquatic floating	Kgs	26,499	46	1,218,954
5	FCO (Mollases, lime, salt etc) per tank	Kgs	608	10	6,083
6	Staff for watch and ward, feeding	1	12	6000	72,000
7	Harvesting charges per kg		7,300	10	73,000
8	Utilities	1	12	1000	12,000
9	Diesel for generator	1	12	1000	12,000
10	Miscellaneous	1	1	10000	10,000
	Total "B"				**1,961,676**
	Total A +B				**2,410,916**

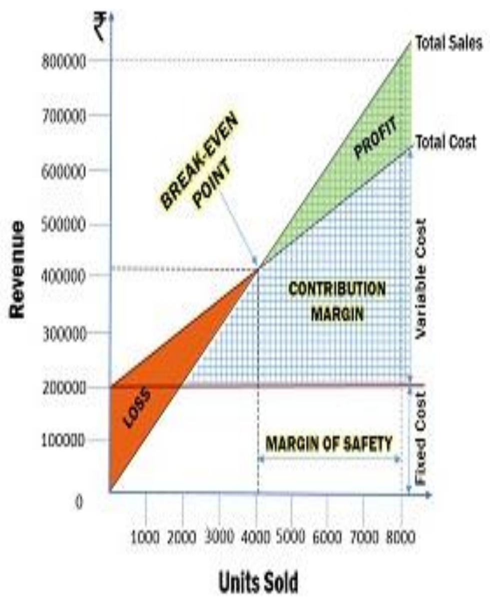
C	Production Norms:	Unit	Quantum/Amt.
1	Tank capacity in liters		10,000
2	No. of tanks		10
3	Stocking per tank	2.5	4,000
4	No. of crops per annum		2.03
5	Survival (%)		90%
6	Net no. of fish harvested per year per tank		7,300
7	Average weight at harvest (kg)		0.17
8	Total production (Kg) per annum		12,410
9	Farm gate price (Rs.) per kg		₹300
10	Recurring costs per kg of fish		₹158
11	Income during 1st year		₹3,723,000
12	Contribution margin per kg		₹142
13	FCO (Mollases, lime, salt etc) per tank 1.1 k	30	
14	Probiotics only once per tank 400 g		400.00
15	Aquatic Fish feed floating for 150 days @2.42% of avg body weight 100 gms		0.36

D	Financial Analysis Summary		
	Year	1	2 - 7 years
1	Capital Cost	₹449,240	-
2	Recurring Cost	₹ 1,961,676	₹ 11,770,057
3	Total Cost	₹ 2,410,916	₹ 11,770,057
4	Gross Benefit	₹ 3,723,000	₹ 22,338,000
5	Net Benefit (B-C)	₹ 1,312,084	₹ 10,567,943
6	Present Worth of Costs at 15% DF		₹ 5,331,153
7	Present Worth of Benefit at 15% DF		₹ 9,797,295
8	Net Present Worth (PW Benefit - PW Cost)		₹ 4,466,142
9	Benefit Cost Ratio (PW of Benefit / PW of Costs)		1.8
10	Internal Rate of Return		100%
11	Breakeven point (Fixed Cost/(Revenue - Recurring Cost)		0.26
12	Months required to reach breakeven point		3.06

E.	Financing Mix		
	Total financial outlay		₹ 2,410,916
	Margin by beneficiary @25%		₹ 602,729
	Bank loan		₹ 935,099
	Interest rate		12%
	Repayment period (years)		5

The loan will be completely paid out from internal earnings in 5 years. The average debt service cover ratio is 8.35.

Box item 18: Breakeven Point Explained



The break-even point in business is the point at which total cost and total revenue are equal, i.e. "even". All losses and gains have evened out. For capital intensive projects, the breakeven point is long. For biofloc fish projects it is 6-8 months. The break-even point is determined by dividing the total fixed costs associated with production by the revenue per individual unit minus the variable costs per unit. In this case, fixed costs refer to those which do not change depending upon the number of units sold. Revenue earned less variable costs divided by total units produced is the contribution margin from each unit produced. Variable costs are the recurring costs incurred on fish seeds, labour transport, utilities, medicine etc.

The formula for calculating breakeven point is Fixed Costs/ (Sales Revenue -Variable Costs).

5.3.Which Species is Most Profitable?

A back of the envelope calculation done by Abhijit Pasalkar of Vihaan Trading Company, Pune shows that most profitable specie is shrimp/prawn. For his calculation, the tank size (22500 litres), mortality rate (10%), duration of culture (6 months), was kept the same for all species. The FCR ratio taken for monosex Tilapia, Singhi, Pabda, and Shrimp/prawn was 1:1, 1:2, 1:2, and 1:1 respectively.

Table 10: Most Profitable Species – FCR Ratio

	Monosex Tilapia			Singhi Fish			Pabda Fish			Shrimp/Prawn Fish		
Particulars	Quantity	Rate	Amount	Quantity	Rate	Amount	Quantity	Rate	Amount	Quantity	Rate	Amount
Seed	40000	2.5	100,000	140000	4	560,000	140000	4	560,000	400000	0.6	240,000
Feed	18000	40	720,000	18000	40	720,000	18000	40	720,000	10000	95	950,000
Minerals/Medicine	10	10000	100,000	10	10000	100,000	10	10000	100,000	10	10000	100,000
Salary (2 persons)	6	20000	120,000	6	20000	120,000	6	20000	120,000	6	20000	120,000
Other exp (utiity, repairs)	6	15000	90,000	6	15000	90,000	6	15000	90,000	6	15000	90,000
Total Expenses			**1,130,000**			**1,590,000**			**1,590,000**			**1,500,000**
Value of production	16200	120	1,944,000	13500	220	2,970,000	13500	220	2,970,000	9000	340	3,060,000
Less Total Expenses			1,130,000			1,590,000			1,590,000			1,500,000
Profit			**814,000**			**1,380,000**			**1,380,000**			**1,560,000**
Return on Expense			**72%**			**87%**			**87%**			**104%**

The profit drivers were found to be sale price of fish, and feed cost. The latter constituted 64%, 45%, 45%, and 63% for monosex Tilapia, Singhi, Pabda, and Shrimp/prawn.
The drivers of expense, revenue and profitability differ widely according to production and marketing conditions. Each enterprise must make its own calculations and reach conclusion based on evidence-based analysis.

5.4.Managing the Enterprise Well is the Key!

Biofloc is hard job. Water quality monitoring, fish health, and fluctuations in market price of the final output requires 24/7 attention. Profits can evaporate overnight due to catastrophic fish mortality. However, if managed well, fish farming offer decent livelihood to new rural entrepreneurs.
Some of the thumb rules which keep biofloc fish entrepreneurs in good stead are explained below.

- **Rule no. 1: Prepare well before Jumping In**: Fully prepare yourself before jumping into the business. Trust yourself more than others. Only when you are convinced that you can the enterprise as a business and generate profit, start your journey.

- **Rule no. 2: Learn and teach**: Undergo some organized biofloc training course. Videos are good supplement but not a substitute for structured immersion. Selection of the trainer is very important. Choose the training course carefully. Update your learning by reading books on the subject. Teach your workers every day.

- **Rule No. 3: Networking**: Establish firsthand contact with nearby government fisheries department, research centers, fisheries consultants and feed suppliers who all are valuable source of technical assistance and information at time of need. Network with local business associations. Participate in WhatsApp groups for problem solving and networking.
- **Rule No. 4: Be on the top of all vital technical parameters**: Check your water quality, air flow, and health of fish as often as possible. Being extra cautious is not expensive, being negligent is.

- **Rule no. 5: Keep mortality of fish down to the minimum**: Always keep some stock for emergencies till expert help arrive. A rise in mortality is psychologically depressing for the workforce, and drives a big hole into profit.

- **Rule No. 6: Manage your enterprise as a business, not family charity**: It is your duty to generate profit most of the time and avoid losses. Keep costs down. Be frugal, not penny wise, pound foolish. Do the essential expenses. Minimise capital cost. Do not go for fancy tanks, or oversized inverters, or pumps. Sell when fish prices are high, festive seasons are a good bet.

- **Rule No. 7: Put in Hard work**: Working long hours smartly, diligently and faithfully is the sure shot to success.

5.5.Conclusion

By all indications, biofloc fish farming is financially viable even without subsidy. Any freebie or financial incentives is bonus. The window for financial assistance for biofloc is currently small. With greater recognition of BFT, current apathy of bankers is likely to change in the coming months. For those who are aspiring for larger credit or equity flow, the business case for biofloc as a mainstream fishing options must be put forward with lot of vigour.

Chapter 6: Financial Assistance for Biofloc

6.1.Introduction

Access to finance for aquaculture is a challenge everywhere because it is regarded among high risk and capital-intensive investments with long payback periods. The mixed results of Recirculating Aquaculture System (RAS) ventures have somewhat clouded attitude of the market towards innovative land based intensive fisheries. So long as biofloc is not mainstreamed as a regular venture, it will not attract big money. The need is therefore to have a sound business case with standard operating procedure for production, disease management, marketing, and risk mitigation. Biofloc is profitable, viable and scalable, hence bankable. Once the business potential is amply demonstrated, funding is not a limitation. In this chapter the main sources of biofloc finance in India is elaborated and some ways to prepare proposal is discussed.

6.2.Central Government Schemes

The central government is far the major player in aquaculture field because of its unique position as the policy maker, regulator, and funder of various schemes. Favourable government policies are indispensable for citizens and business to invest their time, energy and money in fisheries sector. Only countries that balanced welfare goals of fishermen/farmers, need for business investment, ease of access to credit, technology and veterinary care have seen flourish in the fisheries sector. Supportive Government policies and administrative action is necessary for aquaculture to thrive, garner investment, and access to technology suitable for small biofloc farmers.

To some degree India suffers from a poor public perception of the fisheries industry and there is no strong perception in Indian society that the country needs aquaculture to meet protein needs of a growing population, jobs, and income generation. Now is the time to strengthen preparedness, food access and supplychains, as well as build new tools to secure food systems and nutrition

Centrally assisted schemes are of two types a) Central Sector Schemes are 100% funded and executed by Central Government; and b) Centrally sponsored Plan Schemes that have co-contribution by the States. The central sector schemes are entirely and directly funded and executed by the central government. The schemes are formulated by the Ministry of Fisheries, Animal Husbandry and Dairying, based on subjects from the Union List.The Central Sector schemes are not of immediate relevance to biofloc farmers hence is not discussed further.

Centrally Sponsored Plan Schemes

Blue Revolution – Integrated Development and Management of Fisheries

The Blue Revolution is part of the Government's efforts to promote fishing as an allied activity for farmers to double their incomes. It refers to an explosive growth in the aquaculture industry. In the **budget** 2019-20, the government allocated an estimated 3,737 crore rupees for the newly carved out Ministry of Fisheries, Animal Husbandry and Dairying. The Central Sector Scheme covers development and management of marine fisheries, aquaculture, mariculture, and inland fisheries. The National Fisheries Development Board (NFDB) plays a pivotal role in realizing "Blue Revolution" are under Central Sector Schemes. Like its predecessor schemes, there is a strong emphasis under Blue Revolution to encourage strong participation of Scheduled Castes (SCs), Scheduled Tribes (STs), Women and co-operatives to take up fishing and fisheries related activities. The participation of private sector in creation of post-harvest and cold chain infrastructure facilities is crucial.

The scheme does envisage expanded private investment, more Public Private Partnership (PPP) and better leveraging of institutional finance. However, the mechanism for these is not elaborated in the Scheme. Besides, the scheme encompasses entrepreneurship development, skill development and capacity building in fisheries and allied activities. The scheme has the following six broad components:

i. National Fisheries Development Board (NFDB) and its activities,
ii. Development of Inland Fisheries and Aquaculture
iii. Development of Marine Fisheries, Infrastructure and Post-Harvest Operations
iv. Strengthening of Database & Geographical Information System of the Fisheries Sector
v. Institutional Arrangement for Fisheries Sector Monitoring
vi. Control and Surveillance (MCS) and other need-based Interventions,
vii. National Scheme for Welfare of Fishermen.

The Department of Animal Husbandry, Dairying and Fisheries (DADF)) with 100% central funding will implement components for Strengthening of Database & geographical Information System of the Fisheries Sector, Institutional Arrangement for the Fisheries Sector and Monitoring, Control and Surveillance (MCS).

The scheme provides for suitable linkages and convergence with the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNAREGA), Rashtriya Krishi VikasYojana (RKVY), National Rural Livelihoods Mission (NRLM), and "Sagarmala Project" of the Ministry of Shipping. The government under the MGNREGA has started to **develop the farm ponds,** where pisciculture is taking place.

As per the guideline issued by DADF in August 2018, the pattern for financial assistance is as follows:

i) Beneficiary Oriented Projects Funded by DADF, Government of India
   a. Approved project cost shares Central 24%, State 16%, and general category beneficiary share 60%
   b. Projects implemented through NFDB by States/Union Territories – Centre 80%, 20% in NE & Hilly States; in other States, 50% Centre, 50% State
ii) Development of Marine Fisheries, Infrastructure and Post-Harvest Operations
   a. Development of Marine Fisheries – Actual or ceiling amount whichever is lower
   b. Development of Infrastructure and Post-Harvest Operation such fishing harbors, fish landing centers, dredging of fishing harbors -actual approved cost
   c. Strengthening of Post-Harvest Infrastructure such as cold chain, retail outlets – As per actual with a ceiling amount.
iii) Assistance for Fish Transport Infrastructure – Actual cost or up to ceiling amount
iv) Innovative Activities – As per actual with a ceiling
v) National Scheme for the Welfare of Fishermen
vi) Development of Inland Fisheries and Aquaculture
   a. Development of Freshwater/Brackishwater Aquaculture -Actual or ceiling of Rs. 7 lakh/ha
   b. Input cost for freshwater Fish Culture and Brackishwater Fish/Shrimp Culture -actual cost or ceiling amount
   c. Cold water Fisheries and Aquaculture -actual or ceiling amount of Rs. 2 lakh/unit
   d. Development of Waterlogged Areas -Actual or ceiling amount of Rs. 5 L/ha
   e. Productive Utilization of Inland Saline/Alkaline Waters for Aquaculture – Actual or ceiling amount of Rs. 7 lakhs/ha
   f. Inland Capture Fisheries (Village Ponds, Tanks etc.) – Actual with a ceiling amount of Rs. 6 lakhs/ha
   g. Integrated Development of Reservoirs -Rs. 2 crore/project
   h. Establishing Fish Feed Mills/Plants -As per actual, with a ceiling of Rs. 2 crore/unit
   i. Installation of cages/pens in reservoirs and other water bodies -Actual with a ceiling Rs. 3 lakh/cage
   j. Recirculatory Aquaculture Systems (RAS) -Rs. 15 lakh/unit
   k. Stocking Fish Fingerings in Beels/Wetland -Rs. Rs 2.50/fingerling
   l. Creation of Portal for Advisory Services to Farmers on mobile and Internet – As per actual cost
   m. Training Skill Development and Capacity Building to Fish Farmers and other Stakeholders – 100% of Actual Cost
   n. National Fisheries Development Board and its activities

A model Detailed Project Report (DPR) for a biofloc project for 5 tanks each of 15000 litres is attached in Annex 6.1. The proposal under the Indicative List of Fisheries & Aquaculture Projects #11 Backyard Biofloc-based Aquaculture Unit must be submitted through the District Office of the State Fisheries Department to the NFDB. On a project of Rs. 7.5 lakhs, the maximum subsidy is 60% of the amount for SC/ST/Woman applicants, and 40% for people from General Category. This amounts to Rs. 3.5 L for SC/ST/Woman, and Rs. 3.0 lakhs for General category applicants. The States which are not financially co-contributing to the Blue Revolution scheme, the subsidy amount is restricted to only Central portion which is 60% of the maximum subsidy amount i.e. Rs. 2.10 L for SC/ST/Woman applicants, and Rs. 1.80 L for General Category applicants.

Pradhan Mantri Matsya Sampada Yojana (PMMSY)

On 20th May 2020, the Union Cabinet of Ministers approved the “Pradhan Mantri Matsya Sampada Yojana - A scheme to bring about Blue Revolution through sustainable and responsible development of fisheries sector in India” with highest ever investment of Rs. 20050 crores in fisheries sector comprising of Central share of Rs. 9407 crore, State share of Rs 4880 crore and Beneficiaries contribution of Rs. 5763 crores. PMMSY will be implemented over a period of 5 years from FY 2020-21 to FY 2024-25 in all States/Union Territories. The PMMSY will be implemented as an umbrella scheme with two separate Components namely (a) Central Sector Scheme (CS) and (b) Centrally Sponsored Scheme (CSS). For effective implementation at the State level, a three-tiered implementation framework is conceived for effective planning and implementation of PMMSY. There shall be State Programme Units in all States/UTs & District Programme Units and Block level units within high fisheries potential districts. Further, a ‘Cluster or area-based approach’ would seek forward and backward linkages and end to end solutions. PMMSY shall search for appropriate linkages and convergences with other center and state government schemes wherever feasible. Thrust will be given for infusing new and emerging technologies like Re-circulatory Aquaculture Systems, Biofloc, Aquaponics, Cage Cultivation etc. to enhance production and productivity, quality, productive utilization of waste lands and water for Aquaculture. Special focus on Coldwater fisheries development and expansion of Aquaculture in Brackish Water and Saline Areas. Area specific plans are proposed for development of fisheries in the recently formed Union Territories of Jammu, Kashmir and Ladakh, North East and 117 Aspirational Districts from 28 States. PMMSY envisages promotion of high value species, establishing a national network of Brood Banks for all commercially important species, Genetic improvement and establishing Nucleus Breeding Center for self-reliance in Shrimp Brood stock, organic aquaculture promotion and certification, promotion of best aquaculture practices, traceability from ‘catch to consumer’, use of Block Chain Technology, Global Standards and Certification, Accreditation of Brood banks, Hatcheries, Farms, residues issues and aquatic health management supported by a modern laboratory network. Like earlier schemes, most of these transformative technology-oriented work will be led, and executed by Central Government agencies and their State counterparts. It is not clear how private participation will realize within the current scheme. Fish Farmer Producer Organizations (FFPOs) in the form of cooperatives, producer companies, or societies are envisaged to collectivize fishers and fisher farmer to increase their bargaining power in the market. A new cadre of called 3347[15] *Sagar Mitras* has been created to provide extension services in coastal fisher villages. Further, large number of Fisheries Extension Services Centers managed by self-employed young professionals will fill the void for technical assistance which Government has not succeeded in the last seven decades. The intended beneficiaries of the scheme are people from vulnerable sections of the society and organisations serving them. The Scheme hopes to reach ". fishers, fish farmers, fish workers, fish vendors, SCs/STs/women/Differently abled persons, Fisheries cooperatives/Federations, FFPOs, Fisheries Development corporations, Self Help Groups (SHGs)/Joint Liability Groups (JLGs) and Individual Entrepreneurs."

6.3. State Schemes

The State Government schemes closely mirror that of the Centre, States have limited financial resources and depend on the Centre for execution of many of the schemes. For State plan schemes, it is best to consult websites of respective fisheries departments. Broadly, the schemes fall into major categories:

(a) those implemented with 100% State Assistance, and
(b) those implemented with cooperation of NABARD

Those implemented with 100% State assistance focus on promoting welfare of fish farmers, strengthening the capital base of cooperatives, small scale aquaculture, fish seed hatchery, and other capital-intensive projects; integrating fishermen through mobile phone-based extension service networks. In State Governments, notably Odisha and Haryana, provide interest subvention on short term and long-term credit to fish farmers.

Under NABARD assisted Rural Infrastructure Development Fund (20% state share: 80% NABARD), the States have benefited from construction of fish landing centers, establishment of fishing jetties with landing auction platform & other associated facilities, construction of feeder roads, building fish marketing infrastructure and cold chain, and modernisation of fishing fleet.

Annex 4.1 details various fisheries schemes promoted by Fisheries Department, Haryana.

6.4. Philanthropic Foundations

Foundations engaged in poverty alleviation, livelihood or nutrition missions may find biofloc interesting as this creates employment, enhances household food security, and nutrition richness. Among the potential sources of funding are:

[15] In 2018, the eastern state of Odisha had the greatest number of fishing villages across India with about 740 villages, followed by the southern state of Tamil Nadu with 575 villages. The union territory of Lakshadweep had the least number of fishing villages in the country.

- Trickle Up, USA (https://Trickleup.org)
- Welthungerhilfe (WHH), Germany. https://www.welthungerhilfe.org/
- Marr Munning Trust, UK http://www.marrmunningtrust.org.uk/

Environmental organizations interested in water conservation might be interested to gain deeper insights from biofloc interventions. Among the potential sources are:

- WWF, Switzerland https://www.worldwildlife.org/
- Mlinda Foundation, France https://www.mlinda.org/
- Martha Farrell Foundation, India http://www.marthafarrellfoundation.org/

6.5.Bank and Finance Providers

In October 2018, Union Cabinet approved the creation of Fisheries and Aquaculture Infrastructure Development Fund (FIDF) to boost fish production and related infrastructure. From the FIDF, government entities, entrepreneurs, companies, fishermen and cooperatives will get loans at subsidized interest rate. The approved fund size is Rs. 7,522 crores, comprising Rs 5,266 crore to be raised by the nodal loaning entities (NLEs), Rs 1,316 crore from beneficiaries' contribution and Rs 939.48 crore by budgetary support from Government of India. The credit from the FIDF will have to be disbursed by 2022-23. The National Bank for Agriculture and Rural Development (NABARD), National Cooperatives Development Corporation (NCDC) and all scheduled banks are the designated NLEs. The source of financing for FIDF is fresh market borrowings by NABARD and NCDC and refinancing by scheduled bank. The Department of Fisheries under the FIDF will pprovide interest subvention up to 3% per annum for providing the concessional finance by the NLEs at the interest rate not lower than 5% per annum. The loan repayment period is a maximum 12 years including moratorium of two years on principal amount. The project under the FIDF are eligible for loan up to 80%, and the balance coming from the beneficiaries. The National Fisheries Development Board, Hyderabad is the Nodal Implementing Agency (NIA) which shall scrutinize, evaluate, apprise the proposal submitted by eligible entities and place before the Central Approval and Monitoring Committee (CMAC) for approval. Till December 2019 pproposals to the tune of Rs.1715.04 crore received from various State Governments and other Eligible Entities (EEs) have been are under consideration of CMAC under FIDF. The project proposals of Government of Tamil Nadu and Andhra Pradesh for development of fishing harbours in their respective States form the bulk of these recommended projects.

The Government of India is expecting that FIDF linked credit will help attract investment in fisheries development and boost fish production by 67% in next four years from current level of 12 million tons to 20 million tons by 2022-23. Besides generating employment opportunities to over 9.40 lakh fishers and other entrepreneurs in fishing and allied activities, the Fund expects to attract private investment in building new fisheries infrastructure facilities and acquisition of new technologies. The competent authorities in State/UTs are responsible for developing specific action plan, strategy, road maps, and proposals to benefit from the scheme.

Some of the eligible investment activities are potentially attractive to Medium and Small Enterprises. Mention may be made of the following:

- Construction of Ice Plants (both for marine and inland fisheries)
- Development of Cold Storages (both for marine and inland fisheries)
- Fish Transport and Cold Chain Network Infrastructure
- Development of Modern Fish Markets
- Setting up of Brood Banks
- Development of Hatcheries
- Development of Aquaculture
- Fish Processing Units
- Fish Feed Mills/Plants
- Establishment of Cage culture in Reservoirs
- Establishment of Disease Diagnostic Laboratories
- Any other innovative projects/activities designed to enhance fish production/productivity/value.

Public Sector and Private Banks

Grants and credit linked subsidies for the development of small-scale fisheries of India are extended by the central and state governments through their development projects, Fisheries Cooperative Societies and special programmes such as Blue Revolution: Integrated Development and Management of Fisheries, Small Farmers Agri-Business Consortium, and The National Federation of Fishers Cooperatives Ltd. (FISHCOPFED). Besides, various development financial institutions, agriculture banks and scheduled banks also provide credit and loan facilities. Yet, the flow of finance and credit to artisanal fisheries sector is small, and a major factor responsible for the slow pace of development of the small-scale fisheries despite repeated articulation of its national importance in policy circles. Where such a facility is available, it is frequently underutilised due to lack of awareness about the potential opportunities. Many entrepreneurs are diffident in approaching banks due to their red tape, heavy paper work, and the need for pledging assets as collateral. The institutions are frequently unaware of the resources and potentials available in the fisheries sector. More dialogue between the financial institutions and biofloc farmers can raise mutual awareness, and address underlying concerns. There is a need for a functional credit and loan system which considers the prevailing socio- economic conditions of the fishermen. This system must be linked to technology, to production systems and to output price to stimulate growth and development in this sector.

There is very limited access to both formal and informal credit system among the enterprising, labouring and low-income fishermen.

Availability of timely and adequate funds at reasonable cost can ease of one of perennial woes faced by the MSME sector – the need for more working capital. Though under the Priority Sector lending criteria all banks are obliged to lend to small business, there is remarkable resistance among bankers to address credit needs of star-ups and fish farmers. Repeated loan waivers to farmers followed by significant loan default have further fuelled fears among bankers that small business is risky.

Small fishermen are not considered credit worthy mainly because: (1) they lack fixed assets, including land and fixed cash deposits that can be can be used as collateral; (2) they cannot demonstrate business models that are risk savvy and can weather ups and downs in business cycles; (3) they operate individually, and not functionally organized in collectives like cooperatives or farmer producer organizations and (4) they do not have good credit history. Also, the banks do not have a reliable.

Lack of inadequate data about household cash flows, and capacity to, high transaction cost associated with processing micro loans and poor paper work by applicants have all compounded lending appetite of banks. Hence, biofloc farmers may have to rely on internal accrual and equity from non-commercial sources for growth. The public sector banks are relatively more sympathetic to weaker sections than their private counter parts; both are competing with each other for large ticket asset business. The insistence and lack of adequate collateral further complicates loan sanction even when banks are flush with liquidity. Many public banks, notably State Bank of India have financial products specially designed for freshwater artisanal fisheries operation. These opportunities, however limited, should be availed by biofloc farmers.

Box item 19: Lending from a Banker's Perspective

Bankers in India are "risk averse" because they finance on the basis of balance sheet strength and collaterals obtained to provide further comfort. So, unless, an entrepreneur fulfils 4-5 of the below "6 C's of lending" criteria, it is unlikely that a banker would entertain any application from someone interested to a start a small biofloc unit. The trick though is to diligent work towards developing a strong businesses case for lending. There are well developed tool kits available that guide the interaction between entrepreneurs and banks looking for a meaning relationship. For loans, the banks insist on margin money, collateral and guarantors, track record of professional experience and capability, and regularity of cash flow. Social connections also matter. The bank would demand a detailed project report before sanctioning any loan.

Figure 7: Six C's of Lenders

Several nationalized banks have loan schemes for fishermen. Here are the salient features of SBI Loan Scheme for Fisheries.

Features and benefits

- SBI Fisheries loan featuring farmers to generate additional income by providing loan for buying **Integrated Fish Farming, Fish Seeds, Fish Net, Construction of New Ponds, Renovation / Reclamation of Ponds and Tanks, Construction of Fresh Water Prawn, Fish Hatchery, and other equipment.**
- Collateral requirement - Loan up to Rs.1.00 lakhs: No collateral needed, Loan above Rs.1.00 lakh: Mortgage of land.
- Interest rate 10.5% or above
- Loan Amount Working capital up to Rs. 50 lakhs, term loan up to Rs. 50 crores
- Margin is 15-25% of the project cost
- Repayable in maximum 48 months
- Professional fisherman and farmers with working knowledge of fish farming are eligible to apply for loan.

Along with duly filled in application form, the applicant must submit identify proof and address proof such as Voter ID card/PAN card/Passport/ Aadhaar card, /Driving License etc. issued by a competent government authority.

Banks also provide group loans to Self-Help Groups, Joint Liability Groups, and tenant farmers. JLG is an informal group compromising preferably 4 to 10 individuals engaged in similar economic activity and formed for the specific purpose of unsecured bank loan either singly or through group mechanism against mutual guarantee. The JLG members are jointly responsible to do good any shortfall in repayment due to default of any member. Repayments are jointly pooled for deposit with the bank representatives; a receipt against payment is obtained for records. The maximum loan amount is Rs. 50,000/- per individual. No margin money needed, though most banks asks borrowers to open a recurring savings deposit.

Box item 20: Start with Jugaad Loans -Right for Small Start Ups

Small entrepreneurs wishing to start with two tanks with 10K litters capacity can consider obtaining a Mudra loan and KCC loan. Pradhan Mantri Mudra Loan is offered by nearly all public sector banks in India. For microenterprises seeking credit below Rs. 10 lakhs, Mudra is an interesting option because of low interest band (between 8.40% and 12.45% p.a.), and reasonable repayment tenure (between 1 and 5 years). The loans are stratified into 3 categories: Shishu Loan up to Rs. 50,000; Kishor loan between Rs. 50,000 and Rs. 5 lakhs for established businesses, and Tarun Loan between Rs. 5 lakhs to Rs 10 lakhs for businesses on expansion drive.

Kisan Credit Card Scheme is a Government of India scheme under NABARD. The KCC provides short term credit support to the farmers for their cultivation needs as well as non-farm activities and cost-effective manner. KCC loans attract an interest rate of 4 per cent on the condition of timely payment. Another 3 per cent is waived off if the farmer repays the loan promptly.

For short term credit for consumption / domestic needs, the limit is 25 percent of gross estimated income of the farmer or a maximum Rs.50,000/. Finance against storage receipts / produce marketing may be considered maximum up to 50 percent of the price of the produce prevailing at the time of storage / sanction of loan. Limits / advances up to Rs.10 lakhs per farmer can be extended for a maximum period of 12 months. For loan limit up to Rs. 160,000 only Demand Promissory Note hypothecating standing crops is needed. For loans above Rs. 160,000, in addition to hypothecation of standing crop, mortgage of land and collateral security is needed.

Separate documentation for both loans is needed including duly filled application forms, borrower's passport size photos, proof of address, identity, business, and caste status (SC/ST/OBC). Generally, Aadhaar card, PAN card, utility bill, GST registration certificate should suffice. The loan sanction authority for MUDRA loan and KCC Card is the bank manager.

Both Mudra Shishu loan of Rs. 50,000 and KCC card limit of Rs. 50,000 are relatively easy to obtain. The combination of the two loans will generate Rs. 100,000 which is sufficient funds to start biofloc operations with two tanks. As the business progresses, larger loans can be availed after completely paying off existing loans.

6.6.Equity Support & Risk Capital

Availability of risk capital is a big handicap faced by start-ups and innovative / fast growing companies. For a long time, there were limited sources of risk capital in India; fortunately, the situation has changed for better in the last decade. Majority of the MSMEs are owner driven with lesser inclination towards formalization of organizational processes and opening the company to institutional investors. The non-corporate structure, lack of verifiable track record, and small size operations of the majority of MSMEs in India have kept the venture capitalists and other risk capital away. External

investors generally have high transaction costs and find it difficult to exit out of such investments, because only few MSMEs are listed in national stock exchanges. It is clear that the needs of MSMEs are very different from large companies. Therefore, it is vital to have appropriate risk capital products and focused funds for MSMEs of different size and constitution.
Some of the major risk capital options available for MSME sector internationally and in India are:

Pre-seed Funding
MSMEs often raise their seed capital from friends, relatives, and own family savings. Indian entrepreneurs generally wish to retain ownership and control, hence their reluctance in giving stakes to outsiders. This kind of funding is important to establish "proof of concept" and demonstrate seriousness of the entrepreneur in taking the business forward.

Venture Capital
Venture funds typically provide equity and may or may not provide debt. They make large investments, and expect good return over short period of time. The participation of VC enhances standing of investee companies allowing it to access commercial loans or other forms of finance. It also helps to attract new managerial and technical talent into the company. However, VCs may not be suitable for MSMEs because their requirement for equity is relatively modest. VC funding comes with significant dilution of ownership and reduction in the autonomy of original promoters on operational matters.

Venture capital funds are the investments made in exchange of equity stakes in early stage businesses with plenty of promise to grow. These investments are generally high-risk/high-reward prospects. The investors who take a stake in the business in expectation of significant financial gain are called venture capitalist. The venture capital invests in five stages namely Seed capital**,** Startup capital, Early stage/first stage, Expansion stage/second stage/third stage capital, and finally, Mezzanine/bridge/pre-public stage. Given the stage of development in biofloc industry, seed capital round and early stage round of capital infusion assumes importance.

Seed funding is the stepping point of institutional equity. This is the first entry of external institutional capital that a business venture or enterprise raises. The descriptor "seed" signifies that investors are betting on the potent of the seed, and that their participation will support an early blossom. Seed funding is applied to market research, product development, and support the ongoing salary bill of key staff. With seed funding, a company has the wherewithal to devote its energy in figuring out the features of its final product offering, and determining and who its target demographic is.

Seed funding is contributed by founders, friends and family of promoters, incubators, and venture capital firms. Seed funding attracts a special class of investors called "angel investor." These class of investors tend to appreciate riskier ventures (with good ideas, great team, but no proof of concept so far) and expect an equity stake in the company in exchange for their investment.

Angels are typically high net worth individuals (HNI) who look for opportunities to invest some of their surplus funds in good, high growth ventures. Angels are easy to tap, and play positive role in bring money and sound technical advice to early stage enterprises. Make no mistake, angels are looking to earn good return in return of the high risk that is inherent in early stage investments. Angel investment works best for MSME looking for an active investor and have the ability to manage mutual expectations. Recent experience shows that the angel investors prefer start-ups and graduates from leading institutions. Angel investors themselves come from similar background. There are number of angel investor networks which receives proposals from investees for consideration of their members. According to business intelligence firm DataLabs Analysis, there are around 30 active angel networks in India. Some of the well-known startups such as Myntra, Khatabook, Wow! Momo, BharatPe have raised funds from angel networks. Indian Angel Network, Venture Capitalists, Lead Angels Network, AngelList, LetsVenture are some of the most active angel networks in India.

Venture capital love large ticket size items with high returns. Most avoid investments with long gestation period. Technology driven business, IT industry and others with strong IPR protection have witnessed significant traction from VCs. Biofloc fortunately has limited appetite for funding, hence typical venture capital may not be suitable.

It is increasingly common for companies to use equity crowdfunding to generate capital as part of both seed funding and more. Through crowd funding platforms, the promoters can reach out to millions of potential small investors. The funding raised run into several hundred thousand dollars, and even millions. However, past successes is no guarantee for success in future. Even those who have raised large ticket seed funding have faltered in attracting institutions in their Series A funding effort. The ticket size for Series A rounds varies between $2 million to $15 million. For those looking for funding below US$ 2 million, Series A may not be appropriate. Series A investors come from traditional investment banks and VCs.Sequoia, Benchmark, Greylock, and Accel are some of the leading VCs which actively participate in Series A funding.

Public Listing

A less explored for MSMEs is listing at MSME exchange. BSE and NSE are good for big companies seeking to raise considerable resources through the initial public offer (IPO) route. However, this route is limited to established companies and business houses having a good track record of past performance and reputation in the market.

Small private equity investors and employees benefiting from ESOP find hard to sell their shares unless there is active trading in scripts. SME listing eases concerns of small investors to the extent it offers a platform for purchase and sale in small caps. The investors draw comfort from the fact that only companies with track record in good corporate governance, and strong financials are permitted by the regulator to list themselves.

Listing advances a company's public profile by several notch with customers, suppliers, investors, financial institutions and the media. The investors are assured of continuing liquidity, and an avenue to raise more resources, should situation demand so. The BSE SME and NSE Emerge platforms eligibility criteria, issue size, underwriting conditions, and minimum number of allottees is less demanding than the main board of BSE and NSE. (see Table 11).

Table 11: Comparison between Main Board and SME Stock Exchange

Particulars	**Main Board**	**SME Platform**
Post issue paid up capital	Not less than Rs. 100 cr	Less than Rs. 25 lakhs
Underwriting	Compulsory, except where 75% is allotted to qualified institutional bodies.	100% underwritten
Minimum application value	Rs. 1 Lakh	Between Rs. 10 – 14k
Minimum Allottees	1000	50
Market Making	NA	Compulsory for 3 years
Offer document	Red Herring Prospectus approved by SEBI	Soft Copy of prospectus for uploading on website
Procedure	Cumbersome	Less cumbersome

Incubators

Incubation programmes are designed to speed up the evolution of successful enterprises through a range of business support resources and services. The incubators offer common facilities, administrative back up, a platform to share knowledge, and connection with banking and financial network. Unlike research and technology parks incubators exclusively focus on startup and early-stage companies. Incubators help in many different ways; apart from helping the potential entrepreneur in the early stages, they also introduce the potential entrepreneur to the networks, commercial mind-set, mentoring, etc.

Under the Atal Innovation Mission, Niti Aayog has set up Atal Incubation Centres (AICs) in public and private sector as well as scaling up Established Incubation Centres (EICs). 22 AICs have received grant approval of Rs. 10 crore each. Eight EICs have received grant in aid of INR 10 crore each. Besides, these there are reputable private incubation centers such as Indigram Labs, Villigro, ThinkAg etc. which provide mentoring, technical and financial support to entrepreneurs.

In MP, start-ups running in the Government approved incubators benefit from following incentives:

a) Interest Subsidy

Startups are eligible for an interest subsidy of 8% per annum for three years on the interest amount on loans drawn from scheduled banks/ financial institutions subject to a limit of INR 4 Lakhs per annum.

b) Lease Rental Subsidy

25% of the lease rental with a limit of INR 3 Lakhs per annum is paid to the Incubation centre hosting the start up.

c) Patent/ Quality Promotion Subsidy

To encourage innovation and securing intellectual rights over it, a maximum of Rs. 2 Lakhs for Domestic and INR 5 Lakhs for International Patent/ Quality Certification are reimbursed upon successfully obtaining them is available to all entrepreneurs. Within the five years of incubation, a maximum of 2 Patent/ Quality Certification in each domestic and international category would be considered.

The incubated start-ups with emerging potential also have access to equity from MSME Fund managed by MP Venture Finance Limited. Further, the Government provides credit guarantee facility through banks and provision of Interest subsidy etc. to support young business startups/entrepreneurs in MP. GoMP has increased the interest subsidy limit for women entrepreneurs at 6% for 7 years within Mukhamantri Yuva Udham Yojana. The Financial support limit to entrepreneurs is Rs. 50 lakhs under the Mukhyamantri Swarojgar Yojana.

6.7.Impact Investors

Impact capital firms finance socially relevant innovation using funds largely from capital-rich institutions such as superannuation funds. These risk-taking sources of capital seek generous financial returns (around 15-20% annually), exit between five to eight years and demand strong adherence by the management to social objectives.

Impact capital investment criteria do match with intensive small holder biofloc farming. Few impact capitalists know about biofloc; hence the task of investment seeker is to demonstrate a convincing business case backed up a good track record, facts and figures. A challenge is to prove to the impact investors that biofloc is an attractive investment category in the same class as information technology, biomedical, social networks, and similar fast-moving industries. No major biofloc manufacturer or fresh water fish feed company is listed in BSE/NSE stock exchange. The small ticket size of the investment required is attractive to bellwether investors, not large fund houses.

6.8.Major Corporations

Fish mill ventures have attracted private investment. In 2018, Cargill opened its first fish feed mill in India. Cargill invested USD 10 million targeted at the production of tilapia and other warm water species. This investment is regarded as a milestone in Cargill’s intention to build aqua feed business in India and export market in Asia. Avanti Feed, Coastal Corporation, and The Waterbase have invested in shrimp feed and processing, but less so in fresh water fish feed.

Large retailers such as FreshToHome, Licious, BigBasket, Freshfish Basket, Zappfresh, Fleshkart seeking assured supply of fresh fish might naturally invest in contract farming arrangements which should help open working capital financing from banks and other finance institutions.

6.9.Individual Private Investors

In Indian villages, there is considerable idle capital in the hands of small businessman, landlords, professional, government servant and just retired individuals for investment as debt or equity in biofloc ventures. Promoters not wanting to dilute ownership rely on debt financing and small amount of equity from trusted associates, friends and fellow promoters to expand business.

6.10. Conclusion

Biofloc is a sunrise segment in aquaculture. It has tremendous scope because of positive government policy, entrepreneurial skills of progressive farmers, and a proven technology which makes scalability feasible. Entrepreneurs should be wary of government subsidy which is too little and completely unreliable. Without subsidy also, biofloc is financially attractive. One of the likely impacts of COVID-19 is change in customer preference to locally produced food. Biofloc fish farming is future ready to meet the local and national demand.

Chapter 7: Fish Health Management

7.1. Introduction

Like all other living animals, fish suffer from diseases and parasite. All fish carry pathogens and parasites. Young fish are very vulnerable to diseases as they have low immunity. Mortality and morbidity are major constraints to aquaculture and have detrimental effect on business sustainability. Many diseases affecting present day aquaculture is resultant of intensification of culture practices without attention to support intricate balance between host, pathogen and environment. Important measures adopted in the vertical expansion of fish culture are heavy stocking and multiple harvesting, use of aerators, and bacteria generating feed has resulted predictable occurrence of bacterial, parasitic and virus, often leading to higher morbidity or mass mortalities and lowered productivity. More than one billion US $ was reported due to diseases in shrimp culture in parts of Asia and Latin America. Fish enthusiast and small farmers with little or no knowledge of fish health management and skill to prevent and control disease outbreaks are quite vulnerable to losses due to disease outbreak.

This chapter is intended provide some basic theoretical about factors responsible for common fish diseases, a scientific description of the diseases and the precautions as well as routine treatment available to fish growers. In no way the suggestions provided in this chapter is a substitute to qualified professional help, but merely a basic introduction to appreciate the diseases that affect fish stock.

7.2. Causes of Fish Disease

The physical well-being of fish is conditioned by complex interaction between the host, the pathogen, and the environment. Immunological weakness in the host, pathogen excess, or environmental changes can result in abnormal condition that negatively affects the functioning of organs or the body of the fish. Disease is characterized by a gradual degeneration of a fish's ability to maintain normal physiologic functions. The fish is out of balance with itself or its surrounding environment. Diseases are associated with specific symptoms and signs. The typical causes of disease in fish are due to inter related factors like environmental stress, excess pathogen, poor water quality, nutrition and genetic deficiency, and physical damage from co-habitants (see Figure 8 below). Each of these factors are discussed in detail in the next section.

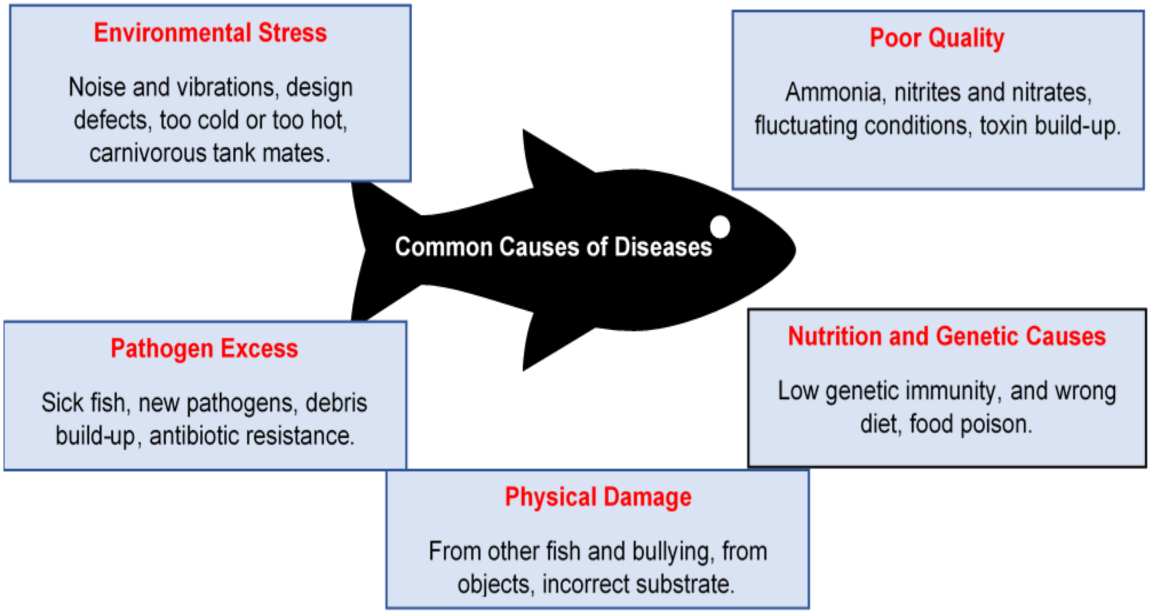


Figure 8: Causes of Fish Diseases

Environmental Stress

Many environmental factors contribute to occurrence of stress and disease**.** Environment plays a vital role in disrupting the balance between the pathogen and the host. Environmental stress tips the balance in favor of the disease. pH that is too high or too low is source of stress, but stability is what is most important. Temperature plays a vital role on number of other variables in the environment. In cold water, fish shows congestion of gill apparatus and dull look. In high temperature, solubility of toxic compounds increases creating unfavorable conditions. In alkaline environment, mucus secretion increase, the gills look burnt and fins start rotting. Formation of antibodies is temperature dependent. In low temperature, healing of dermis is slow.

Poor Water Quality

Without doubt an important cause of freshwater disease and mortality is poor water quality. When water parameters are outside the normal range for fish species, they induce stress, weaken immune system and making them prone to attack by pathogens. Increased levels of CO_2 with insufficient levels of dissolved oxygen can cause respiratory acidity of blood plasma and granulomas in many internal organs. Increased levels of ammonia together with high pH can damage the gills, liver and kidney. Water pollution are causative factors in fin erosion, abnormal epidermal growth or tumour and degenerative and death of tissues in in many internal organs. Due to farming in closed environment, cultured fish tend to exhibit increased rate of body malformation compared to those in open water bodies.

Pathogen Excess

In aquaculture, major diseases are caused through infection by pathogens of viral, fungal or protozoan origin. Disease is not a simple association between a pathogen and a host fish. Many factors combine for active disease to develop in a population. These factors are generally referred under the umbrella term "Stress". Stress may lead to an infection to flare, causing more stress, thereby making the fish even more vulnerable to further infection and limiting their immunological resistance. There is no therapy available to eliminate pathogens. Even use of ultraviolet sterilizers, and ozonation does not eliminate all potential pathogens from the environment. Therapy and good fish management practices can reduce the damage caused by bad bacteria, fungi, and parasites.

Physical Damage

Common injuries for cultured fish include nipped fins, missing scales, damaged eyes, abraded sensory organs near the mouth and dislocated jaws. Physical damage appears suddenly, so should be easy to tell apart from developmental abnormalities caused by poor genes or diet. During transport and transport of fish from hatcheries to new destination can contribute to brushing of scales and tearing of skin. The trauma caused by fighting too can cause breaks in the skin or scale loss. The physical damages to gills, skin, fins and loss of scales are often self- mending. Many times, parasites find a way to enter fish body through the openings provided by the physical damage, and ultimately die of bacterial infections.

Genetic and Nutrition Deficiency

Abnormal changes in the body arises from alterations in the aquatic environment due to dietary deficiency, attack of pathogens and other stresses and due to cold-bloodedness of the fish (fish's inability to maintain its body temperature). Fish need a regular nutritious balanced diet. Nutritional imbalance results in formation of thyroid tumors, anemia, liver degeneration, visceral granuloma, pigmentation impairment and deficiency symptoms associated with vitamin imbalance. An important means of disease resistance is the immune system of fishes and its response to hostile biological agents such as viruses, bacteria and parasites. In the wake of attack by hostile force, the immune system is set for a series of antigen-antibody reactions. The fish body synthesize an antibody called immunoglobins protein to neutralise the attack foreign substances (antigens). Young fish are more susceptible to disease than older ones because of previous encounter to many antigens.

Fish diseases are caused by various types of micro-organisms like virus, bacteria, fungi, protozoa, etc. Most bacterial, parasitic, and fungal pathogens are not mere parasitic micro-organisms. These pathogens have a highly flexible to environmental changes. If the situation for parasitism are not right, they can obtain nourishment osmotically from organic material and decay saprophytic fungi. Environmental stress factors caused by higher organic loadings can lead to rise in fungal infections such as *Saprolegnia parasitica*. The common diseases recorded from cultivable species of fish in India are described in detail in Mishra et al., 2017.

7.3. Types of Fish Diseases

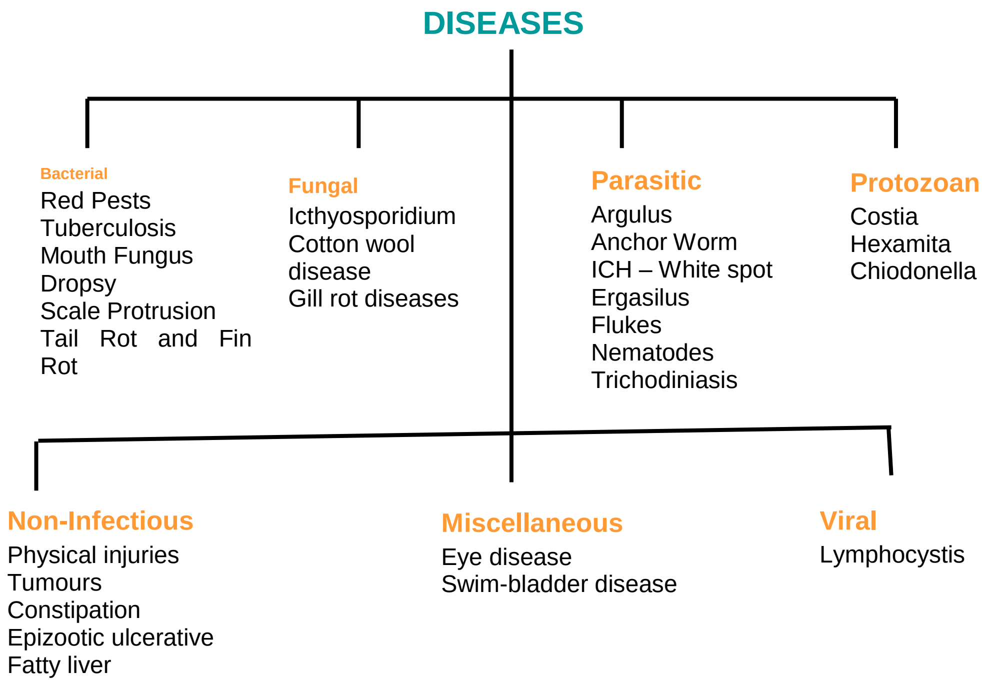
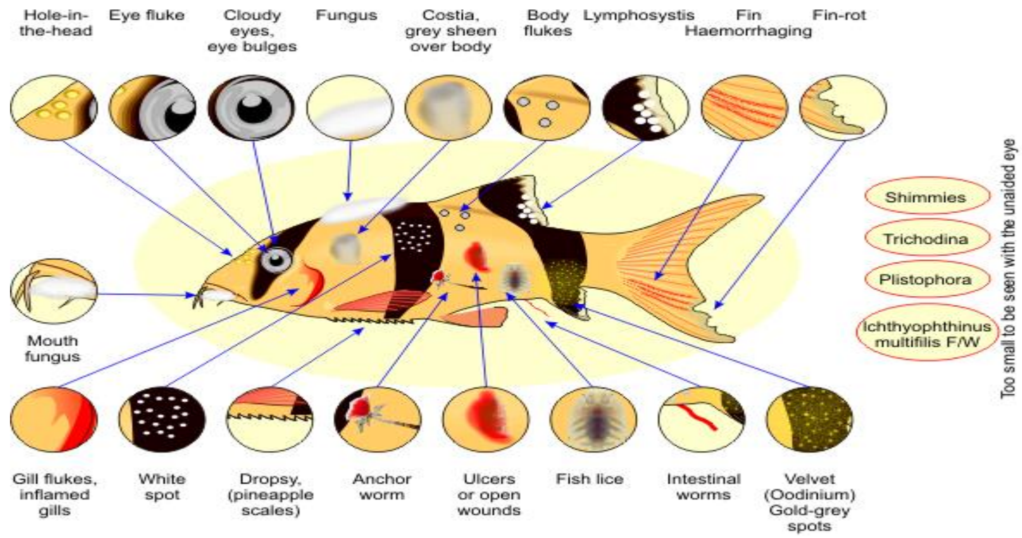


Figure 9 Classification of Fish Diseases by Types

All diseases that affect fish lend themselves to convenient labelling as infectious and non-infectious diseases. Infectious diseases are diseases caused by microorganism that live in and on fish bodies, and present in the environment. They are normally harmless or even beneficial. But in certain circumstances they may cause disease. Infectious disease, being contagious, require intervention to stop spread. In contrast, non-infectious diseases are not caused by pathogens, and cannot be cured by medical intervention. These types of diseases are rooted in environmental imbalances, nutritional deficiencies, or genetic failings.



Picture 14: Diseases Affecting Different Parts of Fish Body

Infectious diseases are categorized by their causative origin as bacterial, parasitic, viral, or fungal diseases.

Bacterial diseases are any disease caused by bacteria. Examples are abdominal drops of carps caused by *Aeromonas punctata*, or Columnaris caused by the bacterium *Flexibacter columnaris*. Bacterial infections are generally internal and require treatment with medicated feeds containing antibiotics which are approved for use in fish by the Ministry of Health and Family Welfare. Typically, fish infected with a bacterial disease will have discolored grey patches on the dorsal fin, and hemorrhagic spots, gill rots or signs of ulcers along the body wall, around the eyes, head and mouth. The affected fish may also show a bloated, fluid-filled abdomen, and bulging eyes.

Parasitic diseases of fish are most frequently caused by small single celled organisms called protozoa (protozoan in plural) which live in the tank environment. These parasites cause many diseases to fishes. There are a variety of protozoans which infest the gills and skin of fish causing irritation, weight loss, and eventually death. Examples are Ichtyobodosis (or Costiosis) caused by Costia neatrix and Ichtyophthiriasis (white spot itch disease). Most protozoan infections respond well to standard fishery chemicals such as copper sulfate, formalin, or potassium permanganate which feed on organic matter such as other microorganisms or organic tissues and debris.

Viral diseases are transmitted from one host to another through a process called “virion”. Viruses cause disease by weakening the host tissue or by forming tumors in the host tissues. They are difficult impossible to diagnose without special laboratory tests. Since no cure is available to treat viral disease, only prophylactic measures are applied to contain the infections caused. Among the viral diseases, lymphocystis, Carp pox, infection dropsy of carp, Channel cat fish virus is observed in freshwater cultures in

India. Consultation with a fish health doctors is recommended if you suspect a bacterial or viral disease has affected your fish.

Fungal diseases are among the widespread diseases of freshwater fishes. Fungal spores are common in the aquatic environment, but do not usually cause disease in healthy fish. When fish are infected with an external parasite, bacterial infection, or injured by handling, the saprophytic opportunist fungi can colonize damaged tissue on the exterior of the fish. These areas appear to have a cottony growth or may appear as brown matted areas when the fish are removed from the water.

Non-infectious diseases can be broadly categorized as environmental, nutritional, or genetic.

Environmental diseases are the most important in biofloc culture. Environmental stress is a major factor adversely affecting physical wellness of fish. Environmental stress is caused by low dissolved oxygen, high ammonia, high nitrite or natural or man-made toxins in the water. Proper techniques of managing water quality will enable farmers to prevent most environmental diseases.

Nutritional diseases are due to malnutrition, or arising from imbalances in the feed, or caused by the toxic effect of diet. Lipids (fat, oil, Vitamins), carbohydrate, proteins, irons, salts and trace minerals are some of the important nutrient for proper fish growth. Reduced reproduction, slow growth rate, reduced food uptake, appearance of lesions and mortality are some of the important signs of nutritional deficiency. The condition magically disappears when the deficient feed is replaced by balanced diet.

Box item 21: Herbal Remedies to Combat Fish Disease

The appeal for Ayurvedic preparations among Indian farmers is high. Herbal remedies have been hailed as natural growth promoters, appetizers, tonic and immunostimulants. Among the preparations. Among the preparations used are:

- Neem twigs, oil and barks to benefit from the presence of immunomodulatory polysaccharide compounds.
- Kalmegh (Andrographis paniculata) leaves was 31.25 μg/mL for treatment of Columnaris.
- Garlic, banana, broken catechu nut extract, castor oil plant (Ricinus communis), Little Hog Weed (Portulaca oleracea), Bhringaraj (Eclipta alba) – all have been used for parasites control.

Genetic factors play an important part in the ability of a host to resist *infection* with a broad array of viral, bacterial and parasitic pathogens. Genetic abnormalities include conformational oddities are relatively few in biofloc culture which prefers cultivation of mono species rather than hybrids, and is not engaged in breeding in a big way. Most of genetic oddities are in any case of minimal significance.

It is common for cultured fish show signs of mineral deficiency (Table 12 below).

Table 12: Mineral Deficiency Symptoms of Fin Fishes

Mineral	Deficiency Symptoms
Calcium	Poor growth and feed efficiency, high mortality.
Phosphorous	Skeletal abnormalities, poor growth and feed efficiency.
Magnesium	Renal calcinosis, loss of appetite, sluggishness
Iron	Hyperchromic microcytic anemia
Copper	Poor growth
Manganese	Abnormal tail growth
Iodine	Thyroid hyperplasia
Zinc	Cataract, fin and skin erosion
Selenium	Muscular dystrophy, exudative diathesis

Many farmers claim to have positive results by adding Ascorbic acid (Vitamin C), Cobalamin (B12), and Folic Acid. Some even add Liv 52, a patented Ayurvedic to improve appetite, set right damaged liver, and reduce constipation in fish. The scientific opinion on whether supplements improve fish health is equivocal. k. According to Bossier and Ekasari, 2017, flocs contain various bioactive compounds including essential fatty acids, carotenoids, free amino acids and chlorophylls, trace minerals, and vitamin C which are known to have positive effects on aquaculture animals including the enhancement of antioxidant status, growth, reproduction and immune response. Hence, the biofloc system does not require the inclusion of vitamin and mineral supplementation in the feed (Ballester et al, 2018).

Box item 22: Typhoon Disaster Preparedness

If a typhoon or cyclone in the neighbourhood is imminent, it is better to prepare for severe disruptions in power, supplies, and other incidental damages. Assuming that there will be no power for a week:

- Arrange for an inverter/power backup as stand-by
- If possible, fully, or partially harvest the tank and sell the larger fish at local market.
- Move small fishes to another tank.
- Take out 200 liters of biofloc water in a drum for future usage.
- Drain all water from the biofloc tank, replace with fresh water. Change water gradually to minimize stress on fish stock.
- Take care in case of overflow, fish do not escape.
- Secure all loose objects around the culture tank, so that objects do not fly and damage the tanks.
- Trim branches of large trees for gushing wind to pass with minimum fuss.
- Reduce feed to minimum to avoid ammonia build up.
- Keep a low wattage pump as stand by in case air pump fails.
- Hang an old bucket with few small holes, gently water through the bucket to maximize natural aeration.
- Keep small stock of medicine, vitamins, hydrogen peroxide, potassium permanganate etc.
- A gas operated generator would be handy for aeration.

7.4. Diagnosis of Fish Diseases

If you notice something is unusual in your fish, a proper diagnosis is a good beginning. In most cases, fish medications purchased from local veterinary store or medical shop will work very well.

Steps to diagnosing and treating your fish:

1. ***Appearance:*** Match the condition of your fish with that of the photo it closely resembles.
2. ***Symptom:*** Cross check the symptoms shown by the fish with those listed under the 'Symptom' row.
3. ***Possible Cause:*** Learn more about the causative agent of each disease online.
4. ***Treatment:*** Find the right the medication of the disease in row column.

Table 13 provides diagnosis and treatment for many fish common diseases encountered in fresh water.

Table 13: Common Diseases in Fishes

Type of disease	Bacterial Disease
Name of disease	Aeromoniasis / Red pest leading to ulcer
Symptoms	Sores and ulcers on the body
Possible cause	*Aeromonas hydrophilia*
Treatment	Dip treatment for 1 minute in 0.5mg/liter copper sulphate solution for 3-4 days.

Type of disease	Bacterial diseases.
Name of disease	Fish tuberculosis, piscine tuberculosis, acid-fast disease, granuloma disease.
Symptoms	Emaciation, hollow belly, possibly sores.
Possible cause	Bacterium Mycobacterium piscium
Treatment	Generic drug Kanamycin and Vitamin B-6 for 30 days. Add one drop per every 5 gallons of aquarium water during treatment. If the fish does not respond to the treatment, the best recourse is to destroy the infected fish. If either poor conditions or overcrowding are the suspected cause, correct the condition.

Type of disease	Bacterial Disease
Name of disease	Mouth fungus (*Columnaris*)
Symptoms	• Greyish patches overhead and dorsalsurface, and on outer margin offins
Possible cause	• Flavobacterium columnare
Treatment	Dip treatment500mg/l potassiumpermanganate

Type of disease	Bacterial Disease
Name of disease	Abdominal Dropsy
Symptoms	Accumulation of fluid in the body, protrusion of scales and eyeball (exophthalmic condition)
Possible cause	*Aeromonas hydrophilia*
Treatment	Dip treatment in 5 mg/l potassium permanganate solution

Type of disease	Bacterial diseases.
Name of disease	Scale protrusion
Symptoms	Protruding scales without body bloat.
Possible cause	A variety of bacterium, physical damage or infections.
Treatment	Mix chloromycetin or tetracycline with flake food in water. 25 grams of flake food and 250 mg capsule should be enough to treat dozens of fish. Improve the water conditions.

Type of disease	Bacterial diseases.
Name of disease	Fin rot and tail rot
Symptoms	White line on the margin of the fin; fraying of the tails and fins.
Possible cause	Filamentous bacteria, most often F. branchiophilum.
Treatment	1-minute dip treatment in Methylene Blue 1 gram/L or mix Fluconazole 100mg/1 kg feed.

Type of disease	Bacterial Disease
Name of disease	Bacterial gill disease
Symptoms	Fusion of gillfilaments
Possible cause	Myxobacteria pathogens
Treatment	Bath treatment with alkyl benzalkonium -2 mg/l conc for 1hr.

Type of disease	Fungal disease
Name of disease	Ichthyosporidium
Symptoms	The fungus affects the internal organs. Symptoms include sluggishness, abnormal swimming behavior, protrusion of the eyes, external cysts and sores.
Possible cause	*Ichthyosporidium hoferi*

Treatment	Treatment includes Phenoxyethanol or chloromycetin added to the food which is also a good prophylactic measure. Early diagnosis and treatment are key to achieving satisfactory results.

Type of disease	Fungal disease
Name of disease	Cotton wool disease or water mold disease
Symptoms	• Skin and gillslesions, grey white patches onskin. • Dies after ulceration or exfoliation of skin followed by hemorrhage.
Possible cause	*Saprolegnia parasitica*or*Achlya hoferi.*
Treatment	Dip treatment for 5 -10 minutes in 3% common salt solution or 1: 1000 solution of potassium permanganate.

Type of disease	Fungal disease
Name of disease	Gill rot diseases
Symptoms	Appearance of white necrotic tipof primary gilllamella, gills turn yellowishbrown
Possible cause	*Branchiomyces sanguinis* and *Branchiomyces demigrans*
Treatment	• Liming -50 kg /ha • Bath treatment- Sod.chloride @ 3 - 5% conc. Preventsinfections

Type of disease	Parasitic diseases
Name of disease	Copepods Argulosis (fish louse)
Symptoms	The fish rubs itself against objects, is restless and parasites about 1/4 inch in diameter are visible on the body of the fish.
Possible cause	Argulus sp.
Treatment	In larger fishes, the lice can be picked off with a pair of forceps. Treatment is best done with a 10 to 20-minute bath in 10 mg/L of potassium permanganate. The tank may be disinfected by applying Lindane at the rate of 8 ml/1 liter of water.

Type of disease	Parasitic diseases
Name of disease	Anchor worm infection
Symptoms	The fish scrapes itself against tank wall, whitish-green threads hang out of the fish's skin with a swollen area at the point of attachment.
Possible cause	Lernaenicus sp.,
Treatment	Lice is too deeply embedded and cannot be

		picked off with a pair of forceps. Treatment is best done with a 10-20-minute bath in 10 mg per liter of potassium permanganate. The tank may be disinfected by applying Lindane at the rate of 8 ml/L of water.

	**Type of disease**	Parasitic diseases
	Name of disease	Icthyophthiriasis (White spot disease)
	Symptoms	• Small whitish cysts of about 1 mm diameter on the skin, gills and fins. • Erraticswimming
	Possible cause	Icthyophthirius multifilis
	Treatment	5 days bathing in 2 ppm methylene blue; hourly dip treatment in1: 5000 formalin solution for 7-10 days.

	**Type of disease**	Parasitic diseases
	Name of disease	Gill and skin fluke
	Symptoms	• Fading colours, drooping of scales; peeling of skin. • Fishes gasp forair,gills covered with thick mucuslayer,
	Possible cause	dactylogyrus sp. (gillinfecting) and *gyrodactylus sp.*(skininfecting)
	Treatment	Dip treatment in in 5% common salt solution or in 1:5000 formalin solution for 5 minutes.

	**Type of disease**	Parasitic diseases
	Name of disease	Ergasilius (also called gill lice)
	Symptoms	These parasites cause epithelial hyperplasia (breast lesion) and necrosis virus to the gill at the point of attachment. The fish rubs itself against objects, whitish-green threads hang out of the fish's gills.
	Possible cause	Argulus sp.
	Treatment	These lices are similar to the anchor worm on many aspects, but is smaller and attacks the gills instead of the skin. A good treatment is a 10 to 30-minute bath in 10 mg/L of potassium permanganate.

	**Type of disease**	Parasitic diseases
	Name of disease	Nematodes (commonly called roundworm and threadworm)
	Symptoms	Worms hanging from the anus.
	Possible cause	Infection by threadworms, particularly around belly.
	Treatment	First treatment; soak the food in parachlorometaxylenol and give the fish a bath or treat the tank with 10 ml/L. Repeat the bath

		after two weeks. Second treatment; administer food containing thiabendazole (viz. banana, potato, apple) as a threadworm cure and pray that the fish will eat it.

Type of disease	Parasitic diseases
Name of disease	Trichodiniasis
Symptoms	Darkening ofskin, excessive mucusproduction, gill turn pale incolor
Possible cause	*Trichodina sp.*
Treatment	Bath for 5-10 minutes in 2-3% common salt (NaCl) or 4 ppm $KMnO_4$ batch for 5-10 minutes. The affected tanks are cleaned with 25 ppmformalin**.**

Type of disease	Protozoan diseases
Name of disease	Costia
Symptoms	Milky cloudiness on skin
Possible cause	Ichthyobodo or Costia parasites
Treatment	A good treatment is with copper sulphate at 0.2 mg/L to be repeated once after 3 days if necessary. Acriflavine or trypaflavine powder may be used instead at 0.2% solution (1 ml/L). As acriflavine can possibly sterilize fish and copper can lead to poisoning, the water should be gradually changed after a cure has been affected. Raising the water temperature to 26° C – 29° C for a few days is recommended.

Type of disease	Protozoan diseases
Name of disease	Hexamita
Symptoms	The protozoa attack the lower intestine. The initial symptom is of slimy, white mucous feces, even while still eating and acting normal. More advanced signs are the fish hiding in the corner with its head down, the head above the eyes gets thin, they blacken in color, and swim backwards. Infected fish lose their appetite and lose condition as a result, this makes the fish lethargic.
Possible cause	***Hexamita****(Spironucleus)*
Treatment	Mix metronidazole 400 mg in any food the fish will eat and, in the water, (12 mg per/L). Repeat the treatment every alternate day thrice.

Type of disease	Protozoan diseases
Name of disease	Chilodonella
Symptoms	Blue white cloudiness on the skin due to excessive slime, fraying of the fins, weakness, gill damage
Possible cause	*Chilodonella* spp.
Treatment	Acriflavine or trypaflavine powder may be used at 1% solution (5 ml/L). As acriflavine can possibly sterilize fish and copper can lead to poisoning, the water should be gradually changed after a cure has been ad,omostered. Raising the water temperature to 26°C for a few days is recommended.

Type of disease	Noninfectious diseases
Name of disease	Physical injury
Possible cause	Bully fish, accidents, sharp edges in the tank.
Symptoms	Cuts, wounds
Treatment	Identify the source of injury, and if possible, remove it. Apply 2% Mercurochrome/Merbromin N.F. on external cuts and wounds. Minor injuries will cure on its own. Recovery is faster if fish is kept in slightly alkaline (pH 6.6) condition.

Type of disease	Noninfectious diseases
Name of disease	Tumour
Possible cause	Indigestion due to lack of dietary fiber resulting into poor functioning of digestive track.
Symptoms	*Fish* is swollen, lethargic and losing his appetite.
Treatment	Replace high meat protein meals with nutrient-dense high-fiber, low-medium carbohydrate meals. Stop feeding high carbohydrate foods such as corn, sweet potato, parsnips and bananas till fish condition improve.

Type of disease	Noninfectious diseases
Name of disease	Constipation
Possible cause	Indigestion due to lack of dietary fiber resulting into poor functioning of digestive track.
Symptoms	*Fish* is swollen, lethargic and losing his appetite.

	Treatment	Replace high meat protein meals with nutrient-dense high-fiber, low-medium carbohydrate meals. Stop feeding high carbohydrate foods such as corn, sweet potato, parsnips and bananas till fish condition improve.

Type of disease	Noninfectious diseases
Name of disease	EUS (epizootic ulcerative)
Possible cause	*Aphanomyces invadans or A. piscicida.*
Symptoms	Hemorrhagesandulcer
Treatment	There is no effective treatment for EUS-infected fish. To minimize fish losses in infected fish tanks, apply lime or salt, or ash, or neem seeds (*Azadirachta indica*) for prophylactic treatments of the EUS-infected fish tank.

Type of disease	Noninfectious diseases
Name of disease	Fatty liver
Possible cause	Unbalanced nutrition.
Symptoms	Toxic reaction, poor appetite, slow growth, bone defect, hemorrhages, and ulcer.
Treatment	Improve feed quality, feed properly and use suitable additives.

Type of disease	Miscellaneous
Name of disease	Eye diseases
Symptoms	Cloudy cornea, opaque lens, pop eye, swelling, blindness.
Possible cause	Bacterial invasion, nutrition deficiency, rough handling,
Treatment	Bacterial infection can be treated with penicillin or amoxicillin and deficiency in vitamin with better nutritious food medicated with vit A, and B6.

Type of disease	Miscellaneous
Name of disease	Swim-bladder disease
Symptoms	Abnormal swimming behaviour, difficulty in maintaining equilibrium.
Possible cause	Bacterial invasion, nutrition deficiency, rough handling,

	Treatment	For a proper diagnosis, check if the fish is suffering from tuberculosis, constipation, poor nutrition, parasitic or bacterial infestation. Once these possible causes are dismissed, make sure that fish has enough roughage in diet. Also, the temperature of tank at a level comfortable to fish.

<table>
<tr><td rowspan="5"></td><td>Type of disease</td><td>Virus</td></tr>
<tr><td>Name of disease</td><td>Lymphocysitis, Viraemia</td></tr>
<tr><td>Symptoms</td><td>The sick fish may swim abnormally or show poor appetite, body wounds or darkened body colour.</td></tr>
<tr><td>Possible cause</td><td>Irido virus or viraemia virus</td></tr>
<tr><td>Treatment</td><td>No cure. Contaminated water should be thoroughly disinfected before use.</td></tr>
</table>

Source: Pictures used in the table are for representation purpose. Most of the pictures have been downloaded from website / unknown sources.

7.5. Treatment of Fish Diseases

Before initiating any treatment, check water quality thoroughly, in particular the temperature, dissolved oxygen, pH and total alkalinity. Water quality may be the root cause of the disease, it essential to ensure good quality water all the time in sufficient pressure and flow rate. Increase water flow, if necessary. Gently view the condition of the gills of the fish to be treated. In case, there is surfeit of mucus deposit and/or are badly shaped or glued together, the fish may be suffering from low oxygen levels.

Stop feeding diseased fish for at least 24 hours immediately before treatment. After having identified the parasite responsible for the disease, select the most appropriate curative treatment after due consideration of the efficacy of the medicine and chemical and the cost of the treatment. Double check the dosage of medicine and chemical for the treatment, preferably with the help of a fellow colleague.

Test out the selected treatment dosage[16] *on a small* sample of fish, using exactly the same procedure as for the planned treatment. Carefully observe the effects and after-effects for half an hour. If deemed necessary, modify the dosage accordingly.

[16] As per the Ministry of Commerce and Industry (MOCI), Government of India (Notification SO 792 (E) dated August 17, 2001), use of antibiotics viz., chloramphenicol, furazolidone, neomycin, nalidixic acid, and sulphamethoxazole are banned, and no residues should be left in the animal body meant for marine exports. According to the said notification, a certain level of residue of tetracycline, oxytetracycline, trimethoprim, and oxalinic acid; heavy metals like mercury, cadmium, arsenic, lead, tin, nickel and chromium and pesticides such as BHC, aldrin, dieldrin, endrin, and DDT can be permitted.

During the treatment, make sure of the following conditions.

- *Start early morning or just before the sunset when the water temperature is as low as possible*.
- *The flow rate of air and level of dissolved oxygen content remains adequate*. Raise the level of *oxygenation*, whenever possible.
- *Thoroughly mix the chemical in a small bucket before applying it over the whole surface area*.
- Keep a watch on fish that is being treated. If the fish shows sign of distress such as gasping for air, erratic jumping, or coming to the water surface, immediately stop treatment and increase the supply of well aerated water to the fish.
- Keep a proper record of the treatment, dosage, water quality data, changes in fish behaviour and mortality.
- After 24 hours of the treatment, watch the behavior of fish and signs of presence of external parasites.
- Repeat treatment only if absolute necessary, and not before two or three days after the first treatment.

7.6. Conclusion

There are many diseases of fish which can be troublesome fish farmers. Many disease outbreaks in cultured fish stocks are associated with stressful conditions such as poor water quality, over stocking, or improper nutrition. Daily observation of fish behaviour and feeding activity allows early detection of problems, allowing sufficient time for rapid diagnosis and intervention before the majority of the population becomes sick. The chances of success of treatment is higher if started in early phase of the disease when the fish are still in good shape.

The best source of medical advice is the nearest Fisheries Officer in Government Fisheries Department. Private veterinary doctors and paravets can render timely assistance. If professional help is not available, fish farmers should form WhatsApp group for exchange of information and possible remedies. Antibiotics is a double-edged sword – it quickly cures disease but the residues can linger and pass on to human body. Indian consumers are conscious of healthy food after COVID-19 experience. High safety standards are good for all human beings.

Chapter 8: Purchasing, Selling and Marketing

8.1.Introduction

Purchasing, selling and marketing are the three pivots around which business transactions revolve. Biofloc purchase both capital items and recurring goods and services for their business. In addition to purchasing material from the right place at right place, entrepreneurs also have to expedite, assess supplier quality, transport and arrange logistics. The main output that fishers sell is fish either for consumption, processing, or further reproduction. Marketing starts by asking consumers who they are, what they want, and what they care about. A business which meets customers' expectations will survive many storms. Marketing lies at the intersection of the business and the customer equally pulled by the self-interest of business and satisfying the demands of the buyer. Management guru Peter F. Drucker had famously said that the aim of marketing is to know and understand the customer so well that the product or service fits him and sells itself. In this chapter, we will explore the fish marketing scene in India, and how a small biofloc fish farmer can sell own produce.

8.2.Purchase and Procurement of Material

Foremost among the items required to start biofloc operations are tanks to store water, and cultivate fish. For tarpaulin tanks, entrepreneurs themselves source the material from online or offline suppliers, or contract out to a specialist vendor who sets up the tank through labour cum material contract. While the former is a cost-effective solution, many first-time enterprises may opt for material contract for peace of mind. Many of the WhatsApp/Telegram group have contractors who will give a quote for asking. The vendor will also arrange for wire mesh, protective lining, chord to fasten the sheets on the mesh, cement and brick for tank foundation, PVC, L-shape pipe connectors, silicon or plastic pipes and plumber fittings. In most case, the vendor will ask the entrepreneur to make local labour available to assist master technician. Civil works like central drainage chamber is the responsibility of the entrepreneur. The time taken to install a mesh, tarpaulin, liner and pipe fittings is 2 -3 days hours. In addition, land levelling, brick and cement work is required in advance of fitting the tanks.

The table below shows wide variation in prices and tarpaulin standards. This shows room for bargaining with the supplier on what exactly you can expect from the purchase.

Table 14: Tarpaulin Prices for 10000 litre Tank

Price	Vendor	Tarpaulin GSM
Rs. 10,000	Sabsesastakart	650 GSSM
Rs 9,200	Mohan Tarp	650 GSM
Rs. 8,000	Karnawat & C0	550 GSM
Rs. 11,999	Amazon	550 GSM, TCLPVC coated

Air pumps, inverter, battery, are generators available from standard stores across the country. Any expert can help in purchasing the right type and capacity of the item to be purchased. Shopping around online will prepare the buyer on the various options available and their respective technical and commercial attractiveness.

There are quite few items for monitoring quality parameters. All these parameters fluctuate over time and all are invisible to the naked eye. Regular testing, at least once a week, is important to understand the tank conditions.An API Freshwater Master Waster Test Kit (Amazon India advertised price Rs. 7909) can measure quality parameters for Ammonia, Nitrite, Nitrate, and pH. An alternate is API 5-in-1 Test strips does pH, Nitrogen dioxide (NO_2), Nitrate (NO_3), Carbonates (KH), and Hardness (GH). For temperature, salinity, and TDS, there are special instruments available from a wide range of manufacturers who sell online. Price range of some of this equipment is given in Table 15 below:

Table 15: Water Testing Equipment

	Price Range	
Equipment	**Low**	**High**
pH Meter	460	2195
Temperature sensor	270	399
TDS meter	329	699
Ammonia Master Test kit	1025	1100
Nitrate (0.25 kg, 90 tests)	929	1133
Nitrite (0.5 kg, 180 tests)	723	781
Alkalinity Test Kit (100 tests)	649	1085
Weighing Machine (up to 5kg)	319	549
Salinity Meter	350	1500
DO test kit (1000 tests)	800	925
Chlorine test kit (200 tests)	239	499
Measuring Cone (1000 ml)	1800	13121
Total	7893	23986

There are other items like fish medicine, sea salt, molasses, and feed that is available from neighbourhoods' shops in small town.

Fish seed is a major undertaking for all entrepreneurs. Wrong seeds can considerably dent business profitability. For the cultivation of biofloc, it is very important to have seeds of good and healthy fish. All fish fries, fingerlings and yearlings used for fish culture are called fish seedling. The availability of quality fish seedling is limited, since the bulk of the seed suppliers are small proprietors, are neither regulated nor licensed. There are no system of standardization or certification that classifies fish seed based on their size, health or growth potential. Most traders found in the market are of poor quality, in which the growth is very slow and low weight, such fish are more likely to die.

For biofloc farmers best is to cultivate fingerlings that has grown to the size of a finger. This size of fishes is suitable for commercial production. Direct procurement of fingerlings from a reputed nursery offers the opportunity of checking out rearing conditions of fishes, and also minimizing stress due to transportation.

Getting the right fingerlings is both a science and art. It requires good deal of experience and knowledge of what species of fish and age of fingerlings that would suit your best. Quality fingerlings are the basis for good harvest in future. Bad seeds have a direct bearing on the final harvest. Not having quality fingerlings in time could hurt production, and even lead to crop failure. Fingerlings that are diseased or stressed might eventually die off in the end, or gain little body weight due to stunting that it becomes a problem to dispose the harvest at a good price. The quality of fingerlings is checked against five parameters, namely size, age, fish type, uniformity, and health condition.

Size

Good quality fingerlings are of uniform size. Same size fingerlings grow in similar fashion with the same feed. Different sized carnivores can lead to cannibalism due to need for greater amount of food among the larger individuals. Production planning with stock that tend to grow over even time yield better profit. Based on growth forecast, the farmer can properly plan schedule for harvest and sale.

Table 16: Terminology of Various Life Stages of Fish

Stage	Description	Size mm
Spawn	Fish spawns Freshly hatched and baby fishes	<8
Fish fries	Few days old baby fishes	8-25
Fingerlings	Few weeks old baby fishes	26-90
Juveniles	Fish fingerlings maintained on higher density and limited feeds in ponds or WHS to stunt growth over a year or season, to be used for subsequent stocking or culture.	91-100
Brood fishes	Sexually mature fishes harvested for breeding or reproduction.	>101

Source: Stage and description notation from Muruganandam. (2012) and size data from Price List issued by Gujarat Fisheries Central Cooperative Association Limited, dated 1/7/2019

Age

There is a correlation between size and age of fish. Each specie follows known growth and age trajectory. If the size of the fingerlings is too small or too big for their age type there is close correspondence between size and the age of a fingerling. Those that lack age appropriate size might not be good for fish production. The inappropriateness of their size is indicative of an underlying problem with them. Always carefully check that there is a close match between the sizes of the fish and their age. Subtly confirm the age of the fingerlings you are buying. A four week old fish should be 1.5 inches long, a six week old fish should be about 2 inches long, and an eight week old juvenile 3-5 inches (76-127 mm) long. For newbies, it is advisable to start production with juveniles primarily because of reduced chances of mortality.

Fish type

Biofloc is suitable for monoculture, not poly culture. Mixing different species of fingerlings is courting trouble. Avoid selecting fingerlings that are of different species. Only buy the specie that you have decided beforehand.

Uniformity

Some farmers transfer their fingerlings from pond to biofloc tanks. Mix of species and age would lead to an uneven growth of the fingerling, with some growing faster and out competing smaller ones in the fight for resources. It is not good practice to groom fish of different ages or species in the same tank.

Health condition

Good quality fingerlings must be free of diseases, injury or any form of deformity that could stunt growth or lead to tragic mortality. Deceased fish could pose a health risk to other fishes in the farm.

Proper seed, nutritious feed and right hygiene practices are essential to having a good harvest. Use only good quality seeds that provide the best prospects for your investment.

Below is the indicative price of selected species collected from various Internet sites, and Naihati market, near Kolkata. Government and local hatcheries are likely to sell at lower prices.

Table 17: Indicative Price of Fish Seedling

Species	Internet sites	Naihati market
Koi	Rs 1	Rs. 1.5
Singhi	Rs 2	Rs. 2.6
Pangasius	Rs. 2.5	Rs. 0.7
Hybrid Magur	Rs. 0.8	Rs. 0.30
Desi Magur	Rs. 3	Rs. 1.70
Monosex Tilapia	Rs. 0.6	Rs. 0.5
Tilapia	Rs. 0.5	Rs. 0.4

Transporting Fish

Conditioning of fish seedlings or live fishes (preparing for transport) and their transport with least stress from source to water harvesting structure (WHS) or ponds, rivers, markets etc., as the case may be increase fish survival rate, better the transport economics and provide healthy fish seeds for stocking or live fishes for other intended purposes.

Two basic transportation systems are available for transport of live fishes, i.e. (i) The closed system of transport: packing of fishes in polythene bags under oxygen pressure and (ii) the open system, where fishes are transported in water-filled open carrier of trucks (Muruganandam, 2012). Transport of fish seedlings in polythene bags filled with limited water and oxygen is a cost-effective transport option for destinations within 2 days journey from the source point. Oxygen content in pressurised oxygen containers is not a limiting factor during transportation. Larger fishes in higher quantity can only be transported with ease in open carrier of trucks up to a short distance, which can be covered in a maximum of 12-14 hours.

During transport of live fishes, fishes remain in a limited quantity of water that causes crowding and increased oxygen consumption due to increased metabolism in them leading to higher concentration of CO_2 and ammonia, reduction of pH and increased bacterial contamination in transport water.

After packing fish seedlings, they should be transported immediately to the destination through shortest and smooth routes without undue delay so as to minimize fish mortality during transportation. Transport the seeds either during morning or evening or night to have the benefit of cooler journey transit.

If fish seedlings are being purchased from a nursery, give a bath in diluted (1-2 parts per million) potassium permanganate (KMnO) before packing for disinfection. Addition of 0.3-0.5% sodium chloride (NaCl) or calcium chloride (CaCl) salt to transport water reduces handling stress and later-stage mortality in transported fishes.

Pack the seedlings in strong plastic bags of 15-25 kg capacity with 65-75 cm length, 40-45 cm width and 30-50-micron (0.03-0.05 mm) thickness and have moderate softness, flexibility for better handling or knot making and tensile strength. Place a bag inside another one to provide safety and sufficient resistance to puncturing, if thinner bags are used unavoidably.
Tie the bottom of the bag in a zigzag folding and tie the folded bottom end tightly to avoid leakage and give a cylindrical shape to the bag after packing for protection and easy stacking while transportation. Put the polythene bag with a closed bottom end in the outer transport case such as cardboard carton or tin case, if used. Add oxygen to the bag using an aerator pipe.

Pour transport (source) water taken from the water pool where fishes are maintained or conditioned to 20-30% capacity of the bag, check for leakage, if any and place inside the pre-decided number of fish seedlings.

The fish transport techniques refined provides 90-95% transport survivability with only 2-3% delayed mortality after stocking, and reduces the cost of fish cultivation at least by 10-20% through increasing fish survivability and reducing the need for additional fish seeds.

Box item 23: Local Seeds or from Kolkata?

Kolkata and surrounding areas boast of many hatcheries. Naihati has one of the largest fish seed market in the country. Transporting truck load of seeds from Kolkata too far off places like Mumbai can save Rs. 80,000 to Rs. 1 lakh. An outstation buyer has to take into account a number of factors while make a decision on where to purchase. There is no quality assurance on the seed purchased as few, if any maintain system of tracking. On the positive side, Kolkata seed buying is a great educational experience. One can make a purchase after visiting a number of hatching ponds. If fish quality, variety, price or other commercial terms are not suitable, there are others who might provide a better deal. On the negative side, the minimum purchase from Kolkata is a truckload (approximately 2500 kgs). The dealer will arrange for a truck and an experienced person to take care of fish on the way. Small fisher with 10,00,000 litre capacity will need at most 5000 fingerlings weighing around 20 kgs. For remaining fish seedling, he has to find other buyers, or pool in like-minded buyers. The buyer also bears the cost of toll taxes, '*bakshish*' and speed money. Hold up on the highway is a risk to fish survival. More the time spent in confined space, the higher are the chances of mortality. On the way, 15% of the purchase will die which is borne by the buyer. Good and diseased fish are often mixed by traders in the lot. Often the disease manifest upon arrival of the stock. Treating diseased fish is an extra cost. Some Kolkata dealers do transport small quantities of fish by air, which could be an interesting option for high value seed not available locally.

For those new to the fish raising, the best is to visit and buy from a local hatchery. Buy in small quantities and quickly transport them to a receiving tank within your premises. Though the cost of seed per unit might be higher than Kolkata, the hassle is not worth for small lots. In case of any confusion, contact a fisheries expert in your region, s/he can help with an introduction to a quality hatchery.

8.3.Fish Marketing in India

Fishery is a state subject under the Constitution of India but only a few states have a policy specifically aimed at fish marketing. The only legislation for fish marketing is the West Bengal Fish Dealer's Licensing Order, 1975. The Act has a variety of legal procedures to control the process of supply of fish to other states from West Bengal. It was constituted as a welfare measure for the people of the state, with amendments from time to time till 1997. Every fish merchant must get a license to conduct business by paying an annual fee. All the fish commission agents and wholesaler-cum-retailers are to be registered with the Directorate of Fisheries under this Order. All state fisheries departments, state fish development corporations and apex fishermen cooperative societies have schemes to help fishermen to market their catch efficiently. The schemes include provision of vehicles for transporting fish from landing centres to markets, fish kiosks and marketing implements like insulated boxes, utensils, dressing knives, etc. Several organizations have been set up at the national level to promote the fisheries sector and help the fishermen. These include organizations such as the National Cooperative Development Corporation (NCDC), the National Federation of Fishermen's Cooperatives Ltd. (FISHCOPFED) and the National Fisheries Development Board (NFDB). NCDC's fisheries related activities include creation of infrastructural facilities for fish marketing, ice plants, cold storages, retail outlets, etc. FISHCOPFED promotes fishery cooperatives and assists fishermen to market their produce efficiently through hygienic retail fish centres in metropolitan cities thereby providing remunerative prices to fish farmers. NFDB is promoting domestic fish marketing through modernization of wholesale markets, establishment of cold chains, popularization of hygienic retail outlets and technology upgradation. Fish is not a notified commodity under the APMC Act of 1966, leading to the exploitation of fishermen by commission agents. Unlike in other agricultural commodities, where commission charges are paid by the traders, in fisheries, all commission charges are paid by fishermen. This reduces the share of fishermen in consumer's rupee and makes fishing a non-viable venture. Suitable modifications need to be introduced in the Act to overcome this situation.

In the tropics, raw fish decomposes very fast. India lacks temperature-controlled supply to ensure freshness of catch. India lacks an unbroken *cold chain* starting with quick refrigeration of production, warehousing and distribution activities, along with specially equipped motor vehicles and freight carriers, which maintain a desired low-temperature range. The result is that fish tends to be locally produced and consumed within few hours of the catch. Guess estimates suggest that about 70% of the fish catch in India comes to the market raw and the remaining 30% of the production is processed, dried, smoked, and reduced to fishmeal. The harvested fish is largely consumed at the production centres and nearby towns. The harvested fish hardly reach interior areas due to lack of transportation and non-availability of proper warehouse facilities. There is 8-10 hours' time lag during the transportation of fish from the landing center to the urban markets which results in poor quality of material leading to food borne diseases, nutritional and post-harvest loss. Therefore, there is a need for balanced system of distribution to move fish fast without losing its nutritional value. The activities proposed under the Blue Revolution and Pradhan Mantri Matsya Sampada Yojana (PMSSY) for development of domestic marketing are expected to make a major contribution in reducing post-harvest losses, enhance revenue and improve the Phyto-sanitary conditions in fish markets.

Much of the value addition in fish takes place post-harvest. Veterinary service providers, fish producers and harvesters, sourcing agents, wholesalers, retailers and other traders, fish processors, manufacturers of fish food, logistics & distribution companies, marketing & sales force, and end-use industries are important players in the value chain. Fish processors and manufacturers do collaborate with commercial counterparts and R&D institutions to develop a new variety or improved version of existing fish by tapping new proprietary and publicly available technology for value additions. Fish procurement, processing, and packaging offers significant opportunities for value addition. Processed fish is used in various food applications and is used as a natural ingredient in production of probiotics, fish oil, cosmetics, manures and fertilizers.

The importance of domestic marketing can be appreciated from the fact that only about 85% of the fish landing is utilized within the country, leaving only 15% for export. With growing phyto-sanitary restrictions on exports to the West, a well-developed domestic marketing system is essential for the sustainability of the fisheries sector.

Irrespective of whether the market is primary, intermediary or terminal level, most domestic markets are unhygienic and the fish storing, and handling facilities are abysmal. Availability of potable water, good quality ice, electricity, waste disposal system etc. is poor. The labourers loading and unloading fish are not trained, and the vehicles themselves are in sorry state due to wear and tear from jumpy rides over potholed roads, and poor maintenance.

8.4.Market Drivers of Demand

Increasing Per Capita Consumption: The growing protein intake in the country would lead to more people opting for fish. As against a global average of 25 kg per annum, an average Indian citizen's protein intake is less than 5 kg per year. With growing income levels, meat and fish intake is expected to continue rise in future.

Growth of Organized Food Retail: The expansion of the organized food retail market in Tier II and Tier III towns is projected to improve the accessibility of processed fish, particularly, canned, and frozen fish products for new consumers. This will create a boost the demand for fish and fish products in the domestic market. The Indian retail market is estimated to be US$ 600 billion which would increase from about 12% in 2017 to about 22-25% by 2021. A large part of the growth will come from e-commerce market that is expected to reach to $84 billion in 2021.

Increasing Awareness on the Health Benefits of Fishes: The market for health and wellness foods in India has exhibited robust growth in recent years. Fishes are seen as a healthy food containing high levels of low-fat high-quality protein, Omega-3 fatty acids, and vitamins such as D and B2 (riboflavin).Fish is rich in calcium and phosphorus and a great source of minerals, such as iron, zinc, iodine, magnesium, and potassium. Increasing awareness of fish as a quality choice food is expected to create a positive impact on its consumption in the coming years.

Growth in Exports: Fish export values are showing double digit growth rates. The country has emerged as one key source countries for supply of frozen shrimp and frozen fish in Europe, USA and Asia. Indian fisheries exports are dominated by shrimp and sea food. During 2018-19, the export of marine products stood at 13, 92, 559 metric tons and valued at Rs.46, 589 crores (USD 6.73 billion) -which is approximately 5% of the country's total exports and 19% of agri-exports. Fish exports have faced volatility in the past 3 years. Shrimp and prawns are exported to the United States of America, Japan, and Europe. The export destinations for common carps, tilapia, rohu, and mrigal carp and other similar freshwater is South East Asia while catfish (*Pangasius*) is exported mostly to Europe and Japan.

Fish accounts for 12.8 percent of total animal protein intake. The fish protein availability at 5.04 kg per person per year is nearly quarter compared to world consumption at 20.5 kg per person in 2019. Chicken consumption is galloping in India, much higher than fish. There are a number of reasons for lower preference of fish protein/fish consumption. Some of these include 1) the presence of intermuscular spines in carps is a deterrent to novice fish eaters. In the Indian market there are few freshwater fish varieties with no intermuscular bones. 2) There are concerns about overall food safety and hygiene factors, particularly presence of mercury. Some of the types of bacteria found in seafood can cause foodborne illness by infection. 3) in many communities fish eating is novel. They lack of knowledge on where and how to buy fish, what to buy and cooking recipes. 4) In a predominantly vegetarian country there is lot of resistance to animal protein. The poultry industry for several years ran campaign to encourage egg and chicken meat consumption. Fish industry has no public education drive to win over new customers. 5) Raw fish is the main type of fish product available across India. There is very little value addition in fish, and variety in product offering. Many people do not like to handle raw fish because of its odour. If these inhibiting factors can be satisfactorily addressed, the fisheries sector would gain largely in terms of improving customer preference for fish (Anand, 2019).

8.5.Fish Marketing Structure and Channels

To make fish available to consumers at the right time and in the right place requires a well-oiled marketing machinery. Fish trading - both for domestic and export purpose - is largely in private hands. The domestic market is dominated by large number of intermediaries, who often work in unison to fix prices within their own domain. Within the freshwater segment, 85% of total cultured freshwater fish is consumed domestically. More than 85% of the catch is bought fresh/alive and 15% is bought in several processed forms (dried, dehydrated, smoked or salted). Exports account for 11% of total freshwater fish production, mostly in chilled/frozen form.

In India, of the total catch, about 74% is sold through wholesalers and retailers, and 19% through small traders. Fishermen used 7% of their catches for household consumption.

Freshwater fish market is classified into three main levels: primary markets, intermediate markets, and terminal markets. The primary markets are the points where fish farmers bring their produce located at Panchayat level; intermediate markets are those in small towns or block headquarter; and the terminal markets are those where supplies from intermediate markets are received for distribution to other markets and consumption centres. Fish farmers deliver their catch to every level but the highest proportion (35%) is sold to primary markets through fish collectors/agents. These agents have close personal relationship with fisherfolks, good appreciation of the trends in fish industry and an established network for disposal of catches. They general work on commission basis for traders in intermediate and terminal markets. The farmers like to deal with agents because it saves them hassles of transporting small volumes of fish to distant locations. The fish produced in the country both from marine and inland sectors, is marketed domestically through a network of wholesale, major, minor retail, roadside markets, etc. The export grade fishes and fish products are distributed by more sophisticated processing houses and corporate bodies.

After buying fish from individual fishermen, collectors will transport and sell the product in the intermediate markets, which are either state-owned or private. State markets are managed by district level fishermen cooperatives, or market associations and fish sold through registered members. There are also large number of wet markets, run by private parties, where un-registered fish collectors operate. Fish collectors/agents collecting fish from the primary markets are involved directly in selling. Fish farmers can bring their produce directly to these markets but prefer to handover their produce to fish collectors/agents. Where the farmers seek services of agents for disposing off their products, they pay a nominal amount as commission.

Fish traders obtain their fish supply 5 -60 km away from the trading market. Sourcing from areas nearby the physical market location has implications for their transport and marketing costs and ultimately for their profit. Reduced travel time due to shorter distance reduces spoilage, and quick turnaround the purchase. Most fish traders use jeeps or 3 wheelers to transport the catch from the source to market, as this is cheap and convenient mode of transport in rural India.
Fish agents, both cooperative and private, as well as fish collectors in the assembly markets distribute 54% of their fish to wholesalers, 26% to retailers and 16% to fish processors/cold storage, and 4% to exporters.

Retailers are the ones that connect to the end consumers. In rural areas, small scale retailers buy the fish directly at the fish farms nearby. Low priced, small sized species are preferred by price conscious rural buyers. In urban areas, fish with less bones have good value.

8.6.Profit Margin in Fish Trade

Interesting to note that a fish farmer's share of the consumer's rupee is less than 2/3rd of the final consumer price. While fish farmers receive 50-60% of the final produce, wholesalers and retailers together often grab as much as 40-50% out of every rupee paid by the consumer. A study by Devi and Saikia (2014) of Ujanbazar fish market of Guwahati revealed that consumers prefer marketing channels which are short so that freshness and taste of fishes are remain intact, and the marketing costs and margins are kept at the minimum.

Ujanbazar fish market has three types of market players a) dealers, b) wholesalers, and c) retailers.

Dealers are traders who buy major part of the fishes arriving in the bazaar. Being the buyers of large lots (several hundred kilos) of market arrivals, they purchase the fishes at an incredibly low prices and sell them to the whole-sellers and large retailers with 2-3% margin. They transport the fishes from far off places to the market, organise loading, and unloading of large drums and cartons of fishes with the help of casual labourers. The dealers never deal with the end consumers directly. The wholesalers sell the catch to the retailers and rarely directly to the consumers. After buying fishes from whole-sellers, the retailers sell them to consumers and smaller retailers or fish-hawkers who in turn sell them close to the dwellings of the consumers.

This clearly portrays the multi-layered nature of fish marketing. There are five types of channels observed in Ujanbazar. These are:

1) "Large retailers" who buy 30-50 kg of fishes and sell them to other retailers.
2) "Small retailers" buy small lots of 4-5 kg.
3) Footpath sellers retail their fishes outside the market premise on the pedestrian ways.
4) Some retailers carry fishes from Ujanbazar fish market and sell them in small towns (Mofussil) within 50-60 kms radius of Guwahati.
5) "Fish hawkers" are those who hawk fishes loaded on their bicycles or small vans parked at the doorsteps of the consumers.

Table 18 estimates the profit margin of some of these channels in Ujanbazar, Guwahati market.

Table 18: Profit of Retailers Out of Sale of 1kg of Fish (in Rs)

	Different Categories of Retailers			
Item	Wholesalers selling to other retailers	Large retailers	Small retailers	Vendors who sell on footpath
Selling price	150	180	130	260
Buying price	80	120	100	200
Gross profit	70	60	30	60
Expenditure	45	30	10	25
Net profit	35	30	20	35
Net profit as % of selling price	23.3%	16.7%	15.3%	13.4%

The profit margin of the wholesalers is the highest, followed by large retailers, small retailers and vendors who sell on foot path.

In another study of price spread for Indian major carps for three prevalent marketing channels (Table 7.3), Kumar et. al. (2008) in the Howrah fish market found that fisherman's share in consumer rupee was highest for Channel III at 63.76 per cent. This marketing efficiency was estimated using Shepherd's Index. Shepherd has suggested that the ratio of the total value of goods marketed to the marketing cost may be used as a measure of marketing efficiency. The higher the ratio, the higher the efficiency and vice versa. Incidentally, the marketing efficiency was highest in Channel III having a smaller number of intermediaries than Channel I.

Table 19: Prevalent Fish Marketing Channels at Howrah Fish Market

Channel No.	**Marketing channel**
Channel I	Fishermen → Fish collector/local dealer →Auctioneer →Wholesaler → Retailer →Consumer
Channel II	Fishermen → Auctioneer → Retailer → Consumer
Channel III	Fishermen → Wholesaler → Retailer → Consumer

Picture 15: Local Fish Market and Corporate Fish Retailer

Fisherfolks sell their products in an atomistic, competitive market, where the profit margin is minimal due to cartels operating among the buyers, and information asymmetry loaded against the disorganized individual seller. Sellers of fish catch are uncertain about trends in price, demand and supply. Indian freshwater fisheries are plagued by low capital and low productivity. Biofloc fish growers compete with those who catch fish from open access commons. Both use the same market channels. Open source fisher folk operating on commons have cost advantage over biofloc producers who pay for every input.

8.7.Licensing Requirements

Biofloc fish farming does not require any licensing to cultivate fishing or sell fish in bulk. However, fish mongering within city limits requires a trade license from the municipal authorities. These are easily obtained against an annual fee of few hundred rupees. Food License is issued in India by the Food Standards and Safety Authority of India (FSSAI). FSSAI requires that small businesses or start-ups having annual turnover below Rs.12 lakhs can apply for basic FSSAI Food safety registration. However, very few apply for basic registration. Once turnover exceeds Rs. 12 lakhs, the basic registration will need to be upgraded to state license.

All fish, crustaceans, molluscs & other aquatic invertebrates in live, fresh, or unprocessed form is exempted from GST in India. GST is not applicable to fish, fish seeds, fish fillets, fish meat (minced, chilled or frozen). A GST of 5% is levied on all fish, crustaceans, molluscs & other aquatic invertebrates attract in processed, cured, or frozen state.

Income from biofloc fishing is taxable to an individual. However, the same is exempt to Co-operative society. In the landmark case between Karra Jayabharathi vs. Income Tax Officer, Hyderabad (ITA No. 48/Hyd/2004 31st May, 2005 (2006) 100 TTJ (Hyd) 257 : (2005) 96 ITD 414 (Hyd), the learned Judicial Magistrate Hon D. Manmohan held that "income derived from fishing over land covered by water and which is not used for any agricultural purpose cannot be treated as income from agriculture inasmuch as fish cannot be treated as the produce of the land, since their element is water and, therefore, their cultivation and welfare depend in no sense upon agriculture"[17]. Most fishermen do not wish to come under the scanner of IT officer; hence, they do not maintain proper records of output and income. Without these basic documents, banks have difficulty in determining the track record of the business and its credit worthiness.

Simple Ways to Market Your Business Offline

Marketing lends itself to both online and offline ways. Though some corporate houses like FreshToHome, Licious, BigBasket and Grofers have been successful in fish ecommerce, the channel for small business is likely to be offline. Certainly, small farmers can supply to e-retailers and marketplaces, but they themselves on their own cannot conceive of direct marketing to far flung clients.

Box item 24: FreshToHome Story

FreshToHome was launched in 2015 by Shan Kadavil and Mathew Joseph and is based in Bangalore. This is one of the many successful ecommerce players that produce fresh fish and livestock produce from farmers and supplies them to the customers at below the wet market prices. Direct sourcing eliminates middlemen, and benefits both farmers through reduced transaction costs and consumers receive a superior quality product at lesser price.

Presently, FreshToHome sources from over 1,000 fishermen, covering around 125 landing berths. Marine catches mainly sourced from smaller ports in the Kerala coastal belt while freshwater supplies are sourced from areas closer to Bangalore.

Though fishermen are illiterate, unorganized and operate individually, they are fortunately tech-savvy. All the farmers supplying to FreshToHome are connected with an app which allows them to trade directly with the company. The app works like an electronic commodities exchange where they can bid for their catch directly with the company. Once the bid is successful, the system generates a purchase agreement which is transmitted back to the farmer. As a matter of policy, FreshToHome sources from the small fishermen with fresh catch, not large Since best quality is fish are those that are fresh, FreshToHome purchases only fresh catch from small fish farmers, not from large trawlers who freeze the fish.

Soon after the purchase order has been generated, the company dispatch trucks (one for every 100 km) to collect the catch close to the fishermen. The fish is packed in insulated boxes with RO-treated ice before transporting the catch to the FreshToHome factory in Hennur, Bengaluru. The factory has a capacity to store 40 tonnes of produce. No fish is frozen because that alters the taste. Lab-testing for chlorine, antibiotics, hormones on fish purchased is regularly done. At the factory, the fish is processed, packaged, and labelled before it is made available for online purchase or doorstep delivery. The entire cycle takes between 24-36 hours.

Regular deliveries are carried out in morning, noon, and evening, while some pockets can avail express delivery within two hours of order. Delivery boys run sorties carrying the produce by bike in ice boxes, all the while maintaining the optimum temperature of 0-4 degree Celsius. Freshtohome sells close to 6 tons of produce every day. Currently it has a customer base of around 1.4 lakh customers with 60% month-on-month retention.

FreshToHome was initially self-funded, but early on attracted seed investment from the likes of Mark Pincus of Zynga, Walter Kortschak of Kortschak Investments, SignalFire, Pete Briger of the Fortress Investment Group, Rajan Anandan from Google, Abdul Azeez Al-Ghurair of Mashreq

[17] Source: https://www.caclubindia.com/experts/income-from-fishing-543905.asp

Bank, David Krane from Google Ventures and.

In May 2019, the team had raised $11 million (Rs 76 crores) in Series A funding from a group of investors led by Hong Kong-based CE Ventures and joined by Kortschak Investments, Das Capital, TTCER Partners and some other Asian and Silicon Valley investors to fund its expansion into more cities and strengthen supply chain.

Again, in August 2019, raised $20 million Series B finding led by Iron Pillar, with key participation from Joe Hirao, the Founder of ZIGExN, Japan. Existing investors including CE Ventures, Massar International, Al Nassar Holdings, TTCER Partners, and Sin Growth Partners participated in the round.

Source: https://scroll.in/magazine/841904/a-start-up-is-changing-the-way-fish-has-been-sold-and-bought-in-india-for-centuries

Here are some low-cost smart ways that can significantly boost sales by small entrepreneurs:

1. **Start with what your customers demand**
   A visit to the local market would reveal what species of fish consumers prefer. Further discussion with consumers and fish mongers on size, weight, colour, and price can provide good clues on what should be cultivated for the local market.

2. **Choose multiple channels for marketing**
   Before the harvest, it is good to check out with potential buyers if they are interested to buy all or part of the output. The deal should be against hard cash on delivery. Options for selling include farm gate, primary and secondary market. Direct messaging using WhatsApp is a low-cost strategy for targeting distinct geographic pockets. The cost per message is around 2 paisa, and a 2 to 3 percent response rate can cover the entire campaign cost.

3. **Free publicity**
   Newspapers, FM radio stations, and regional TV networks are always looking for interesting stories – so why not yours? Get in touch with local journalists, reporters, freelancers, YouTube video makers and story letters and provide interesting facts about you, your products and why you started your business.

4. **Endorsements**
   Free samples to prominent local, regional, and national individuals can bring positive written endorsement or word of mouth praise. If they like it, they will use it, tell other people about it, and maybe even endorse it in public forums. Avoid giving free samples to policemen, tax officials, and health inspectors because once they get a taste for your product, they may ask for more free supplies.

5. **Networking**
   Join local clubs, business associations, and incubation centres that attract prominent notables of the society and corporate honchos. Knowing these people may turn them

into investors, mentors, or even customers. They can introduce other potential customers to your business.

6. **Free Exposure Tours**
   Invite potential customers to a free exposure tour followed by a cup of tea. This works well with business-to-business models. For a few hundred rupees you can introduce potential buyers to your products and services.

7. **Attend Expositions and Trade Fairs**
   There are many signature trade events aimed to cater to the needs of every facade of the industry right from farmers, buyers, suppliers, scientists, consultants, professionals, enthusiasts, and prospective entrants. The AquaEX India exhibition is one such event having the main motto is to bring the whole fisheries and aquaculture ecosystem under one roof to enable knowledge transfer which in turn facilitates all round growth of the sector.

8. **Pamphlets, flyers, and coupons**
   With access to new software, attractive pamphlets and flyers have become super easy to create at truly little cost. Discount coupons are a great draw for new customers and a way to boost sales during slag seasons. Distribute these wherever potential customers congregate.

9. **Cross promotions**
   Cross promotions are popular in retailing because they complement cross sales of products. Fish purchase can go along with promotions for healthy diet. Find companies with related products or services, and then explore how the two businesses can promote each other's business. Joint advertising and with links to each other's YouTube videos, websites and wall paintings are obvious media for projections goodness of each other's product.

8.8.Conclusion

Good purchasing can reduce costs. But it is a well-organised marketing arrangement that can bring revenue, and make or break any business. Without revenue flow, no business can survive. Marketing function is the one which brings hard cash to the business. Marketing is a long term, forward looking game plan to win over the customers by their needs and wants. How well this function is managed determines whether the enterprise will have a competitive advantage over its rivals. Biofloc fish farmers are small producers who must find the best strategy to suit their needs. Tie ups with large retailers and direct sale to small retailers are some of the ways they could dispose their output.

Chapter 9: Home Preparation of Feed and Probiotics

9.1.Introduction

Among biofloc practitioner's preparation at home of substitutes to commercial feed and probiotics is both a hobby and a serious pursuit. Many consider that commercial inputs are overpriced, less nutritious, and even could contain harmful substances. Commercial suppliers and trainer cum supplier YouTube experts dismiss such claims as ill-conceived diatribes. On the other hand, they claim superiority of their supplies on grounds of nutrition, price, and convenience. This chapter is not designed to take a position on the ongoing debate; it shall merely try to present the mechanics of preparation fish feed and probiotics at home. In the process, it will try to estimate the cost of home preparation with their comparable commercial variants.

9.2.Fish Feed

To survive, grow and reproduce, in the wild fish feed on *organic materials* such as plants, *detritus, bacteria, plankton*, worms, insects, snails, aquatic plants and other fish. In closed system like biofloc tank, the regular source of nutrition are prepared feeds containing plant and/or animal material and the bacteria and algae that is generated by conducive environment.

Modern commercial aquaculture relies on manufacturers to supply balanced feed n needed by farmed fish. The concentrated feeds, in granular or pellets form, are the main source of nutrition enabling the fish to grow to their true size and weight.

Fish feeds, like any other animal feeds, can be divided into six main compounds: (1) protein; (2) fat; (3) crude fiber (4) nitrogen-free extract (6) water, and (6) ash. The primary component of fish feed are its protein and fat content. The protein in the diet is chiefly used for the growth of tissues, fat is the key source of energy and the increase of adipose tissue. The amount of carbohydrates in fish feed is usually minimal because fish, especially carnivorous fish like Koi, Magur, and Tilapia, because of their less ability to digest carbohydrates. Hence, the energy in the diet must be substituted from fats as it has a higher energy density than carbohydrates. Therefore, fish feed is more concentrated than that of farm animals on land, so protein levels (up to about 40-45%) and energy density are higher. The digestible protein/digestible energy ratio is a critical feature of a fish feed and, as a thumb rule, should more or less resemble the protein/energy ratio of the growing fish itself. In this way, maximum retention of dietary protein (an expensive component of fish feed) is achieved.

The prerequisites for essential nutrients for fish feed formulation are protein, minerals, and vitamins. Protein is a very essential nutrient for fish feed formulation. This is because protein is the major source of energy for fish. Fish need twice or thrice times as much higher protein as other animals for energy. Minerals are another essential nutrient in fish feed formulations. This is a crucial condition for the development of fish bones. Therefore, the production of fish feed must include minerals such as manganese and calcium, zinc, copper, iodine, iron. Fish are extremely susceptible to bacteria. So, fish require vitamins to develop a strong immune system. It should be noted that the number of vitamins contained in the fish feed formula should be minimal.

9.2.1. Basic Ingredients

The basic ingredients of fish feed formulation vary according to cultural preferences and local availability of ingredients. The most common ingredients that are used are:

- **Animal protein**: Fish meal, soybean meal, fish hydroxylate, milk powder, legumes, and wheat gluten are excellent sources of protein. Soybean cake, mustard oil cake, cotton seed cake is also used as substitute to animal protein.
- **Lipids**: Fish oil, mustard oil, sunflower, linseed, soybean oil, vegetable oil are common sources of lipids in fish feeds.
- **Carbohydrates***.* Cooked carbohydrates, from flours of rice, corn, wheat, millets potato powder, brans (rice, shrimp, wheat) are relatively inexpensive sources of energy.
- **Vitamins and Minerals***.* Vitamin B, C, and E premix along with minerals are added as per dietary requirements. Calcium tablets and Soybean meal (rich in phosphate) is used.
- **Pigments***.* Natural pigment is available to enhance coloration in the flesh of salmonid fish and the skin of freshwater and marine ornamental fish. Cyanobacteria (blue-green algae such as *Spirulina*), shrimp and palm oils, dried shrimp meal, and extracts from red peppers, marigold, and Phaffia yeast are outstanding natural sources of pigments.
- **Binding Agents***.* One of the key ingredients in fish diets is a binding agent to provide stability to the pellet and reduce leaching of nutrients into the water. The building blocks of proteins (free amino acids) such as methionine and lysine, Carbohydrates (cellulose, pectin , and starch,) and various other polysaccharides, such as extracts or derivatives from plants (gum Arabic, locust bean) animals (gelatin), and seaweeds (agar, carragheenin, and other alginates). Liv 52 are commercially available to supplement the diet.
- **Preservatives***.* Preservatives, such as antimicrobials and antioxidants, are commonly added to prolong the shelf-life of fish diets and diminish the rancidity of the fats. Vitamin E is an effective, but high-priced, antioxidant that can be applied in laboratory formulated formulations. Commonly available commercial antioxidants are butylated hydroxy anisole (BHA), or butylated hydroxytoluene (BHT), and ethoxyquin. Sodium and potassium salts of propionic, benzoic or sorbic acids, are commonly available antimicrobials added at less than 0.1% in the manufacturing of fish feeds.
- **Attractants***.* Other common additives incorporated into fish feeds are chemoattractant and flavorings, such as fish hydrolysates and condensed fish soluble (typically added at 5% of the diet). The amino acids glycine and alanine, and the chemical betaine are also known to stimulate strong feeding behavior in fish. Basically, attractants boost feed palatability and its intake.

- **Other Feedstuffs***.* Fiber and ash are commonly found in most feedstuffs. Fiber is a filler, and ash is a source of calcium and phosphorus. In diet, fiber and ash should not be higher than 8–12% of the formulation. Fiber and ash are not easy to digest, too much of these ingredients result in poor growth of the fish.

9.2.2. Preparation Procedure of Fish Feed

The first task is to arrange all ingredients. For a 1 kg diet, the following ingredients are required:

Table 20: Ingredients for fish feed preparation

Component	Ingredients
Protein	• 222 g skim milk powder or casein • 390 g marine fish meal
Carbohydrates	• 117 g wheat or rice starch
Non-nutritive binder	• 30 g Sodium Carboxymethyl Cellulose (CMC)
Non-nutritive bulk (or filler)	• 105 g cellulose
Vitamins	• 4 gm Vitamin C • 8 g Vitamin B or Choline chloride ($C_5H_{14}ClNO$) • 10 g Vitamin premix (Vitamin A, Vitamin D, Vitamin C, Vitamin E, Vitamin B)
Minerals	• 10 g Mineral premix
Lipids	• 25 g Soybean oil • 25 g Mustard oil
Pigments	May add *Spirulina*[18] (0.5-1.0% of diet), marigold, red peppers and baker yeast (10-40 mg/100 g of diet)

Modern fish feeds are made by grinding and mixing together ingredients such as fishmeal, vegetable proteins, rice bran, vitamins and mineral and binding agents such as wheat starch. Water is added and the resulting paste is forced through holes in a metal plate. The diameter of the dyes determines the diameter of the pellets, which can range from less than a millimeter to over two millimeters. As the feed is extruded it is chopped to form pellets of the desired length. After drying the pellets, vegetable oils are added to increase the energy content and improve the floatability of pellets in water. The dry feed pellets last for 3-6 months, for convenient storage and distribution.

1. Weigh all the specified ingredients and set each aside on a separate plate/container.
2. In a bowl, combine all protein, carbohydrate, non-nutritive binder bulk ingredients. Mix together by hand for 5 minutes, or just mix and grind them in an electric mixer cum grinder.
3. Continue mixing, create a gap in the center of the mixture and add the Vitamin C powder and vitamin B and premix separately.
4. Mix for a couple of minutes, then add the mineral premix in the same way.
5. Total mixing time for all above dry ingredients should be about 10 minutes.

[18]*Spirulina* is blue-green algae contains vitamins, as well trace minerals such as calcium, magnesium, zinc and selenium.

6. Add Lipids (oil) mix for an additional 5 minutes.
7. Boil equal portions of water to ingredients. Add boiling water slowly to the mixture a semi-moist (like Atta dough, soft but not wet) dough is formed. More water may be added until the correct consistency of the dough is achieved. Maintain water temperature around 70 to 90^0 C to aid gelling while minimizing deterioration of proteins and vitamins.
8. While hot extrude dough through a mince meat grinder (keema machine or spaghetti machine) like strands. Be sure to use the corresponding die size to make the appropriate pellet size. The size of the pellets (2 mm or 4 mm) will depend on the size of the fish that wants to be feed.
9. Cut strands into pellets for desired length and spread on to clean cloth sheet.
10. After granulated mash is formed, dry the fish pellets in an oven to reduce the moisture content to 10%. Pellets should be dried at a lower temperature than 60^0 C. This is because high temperatures can destroy micronutrients found in the feed.
11. When the pellets are dry and cool, they can be double bagged using Zip-lock freezer bags, dated and stored in the refrigerator. If the pellets are not dried before cooling, the pellets will crack deep down, due to evaporation of moisture in the coming days. Ideally pellets should be dried in an oven at 87^0 C, and then cooled to normal room temperature. The desirable moisture content is 17-18%.

9.2.3. Cost of Ingredients

The cost of various ingredients used are presented below.

Table 21: Cost of Fish Feed Ingredients

Ingredient	**Unit consumed gram**	**Price**	**Exp. Rs**
Skim powder milk	222	Rs. 240/kg	53.28
Marine fish	390	Rs. 35/kg	13.65
Wheat starch	117	Rs. 22/kg	2.57
Sodium Carboxymethyl Cellulose (CMC)	30	Rs. 150	4.50
Cellulose	105	Rs. 80/kg	8.40
Vit. B tablets	4	Rs 1.70/tablet	3.40
Vit. C tablets	4	Rs 1.25/tablet	2.50
Vitamin premix	10	Rs 1.25/tablet	6.25
Mineral premix	10	Rs. 250/kg	2.50
Soybean oil	25	Rs. 95/kg	2.38
Mustard oil	25	Rs. 100/kg	2.50
Baker's yeast etc.	10	Rs. 1080/kg	10.80
Other material	48	Rs.100	4.80
Total Expense per kg	1000		117.53

9.2.4. Feed Value

The protein content of homemade feed per kg is 7.86%.

Table 22: Protein Content of Homemade Feed

Ingredient	Consumed in g	Protein content per g	Protein Content
Skim powder milk	222	34.00	75.48
Marine fish	390	65%	2.54
Wheat starch	117	68.20%	0.80
Sodium Carboxymethyl Cellulose (CMC)	30	0	0.00
Cellulose	105	0	0.00
Vit. B tablets	4	0	0.00
Vit. C tablets	4	0	0.00
Vitamin premix	10	0	0.00
Mineral premix	10	0	0.00
Soybean oil	25	0	0.00
Mustard oil	25	0.00%	0.00
Baker's yeast etc.	10	8%	0.01
Other material	48	8%	0.04
Total Expense per kg	1000		78.86

9.2.5. Cost Comparison

Floating fish feed for tilapia, Red belly, carp, pearl spot, pangasius etc. from leading fish company costs Rs. 36.75 per kg. In comparison, the cost of preparing feed at home is Rs. 117.53/kg. Commercial feed is way cheaper than preparing fish feed at home.

9.3. Homemade Probiotics

Probiotic feed is recognized for its positive role in boosting growth performance and other rearing parameters such as FCR, protein uptake, digestibility and body weight gain. Probiotic is an alternative to chemical or hormone laced feed. Probiotic used in fish farming is combination of naturally occurring minerals, bacteria, phytoplankton and nutrients. Probiotics are living microbial cells (although heat-inactivated versions have been shown to retain benefits for the host). Although probiotics were initially used for disease control, their use in aquaculture has now extended to improving fish growth and reproduction through addition to the body of water or feed.

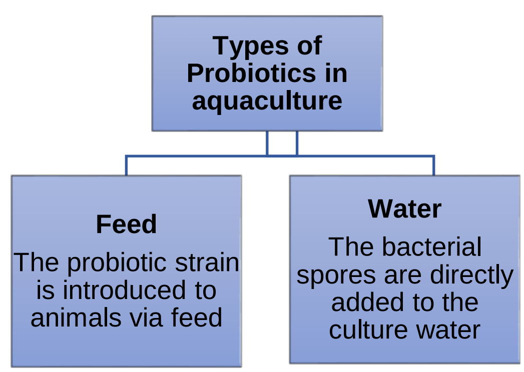


Figure 10: Home made probiotics

Table 23: Use of Probiotics in Biofloc tanks

S. No.	Use of probiotics
1	Improve feed conversion ratio.
2	Improve economic and productive efficiency of biofloc fisheries. Constitutes small cost portion from total or variables costs of poultry production.
3	Increases the performance of fingerlings and can be used as antibiotic growth promoter substitution in fish diet.
4	Improve productive and economic efficiency of fingerlings.
5	Competitively exclude certain bacteria from the intestinal tract of the treated fish. Increase the number of antibodies. Increase the effectiveness of macrophages (a large phagocytic cell found in tissues, especially at sites of infection).
6	Used as non-antibiotic growth promoter in FCO.

Table 24: Characteristics of an ideal probiotic

Characteristics of an ideal Probiotic

- It should be non-pathogenic to host.
- It taxonomy must have confirmed.
- It should have a potential to grow and survive in the host.
- It must survive even during unfavorable conditions generated in the digestive tract due to the production of gastric acid and bile juices.
- It should have capable enough to produce antimicrobial constituents to kill the invading pathogenic bacteria.
- It should modulate the host immune response and offer a health benefit.
- It must be genetically stable.
- It must survive during processing and storage conditions.
- It should be viable even at high centration.
- It should have desired organoleptic and technological characteristics to be included for fermentation methods.

Each kilo of probiotic contains at least 15 Billion CFU/gm with other Enzymes and excipients Stabilisers[19].Popular commercial brands of probiotic contain Bacillus Subtilis, Bacillus Licheniformis, Bacillus Megaterium, and Bacillus Pumilis, and enzymes Amylase, Protease, Cellulase and Xylanase.Few manufactures also add B. Coagulans, B. Polymixa, B. Cereus, B. Amyloliquefaciens, Pseudomonas Putida, P. Denitrificans, P. Bantotrophus, and Rhodobacter. Nitrobacter, and T. Denitrificans. Saccharmyces boulardii, a kind of yeast, is commonly applied to release aniti-microbial compounds such as antifungal killer toxins and antibacterial compounds (Hatoum et al., 2012). The use of nitrite oxidizing bacteria (NOB) such as *Theobacillus denitrificans* and *Rhodobacter* sphaeroides can remediate tank water by removing excess nitrate.

[19]Stabilisers improves solubility, stability, bioavailability and dosing of the active pharmaceutical ingredient (API). They maintain the desirable properties of the product until it is consumed by the fish.

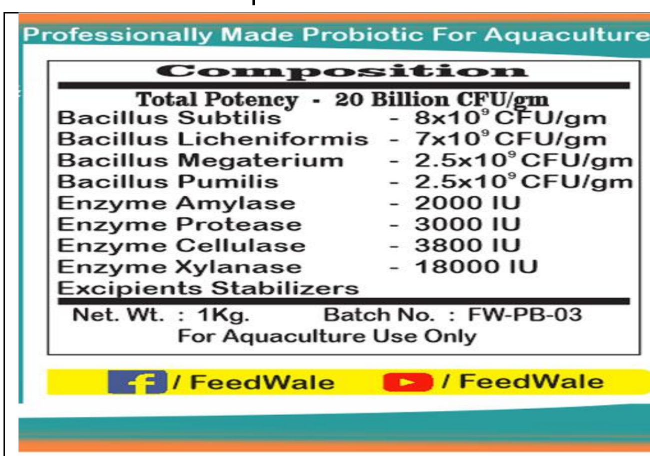
Various bacillus and enzymes are applied to promote growth, inhibit pathogen, improve nutrient digestibility, maintain water quality, withstand environmental stress or boost reproduction. Enzymes such as Lipase perform essential roles in digestion, transport and processing of dietary lipids (e.g. triglycerides, fats, oils) in fish. Cellulase and *hemicellulase* convert cellulose and hemicellulose to sugars.

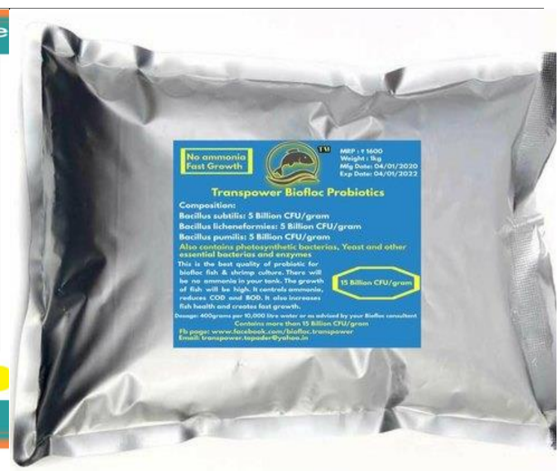
Table 25: Application of Probiotic

Application	**Identity of the probiotic**
Pathogen inhibition	Saccharomyces cerevisiae
	Bacillus Pumilis
Nutrient digestibility	Shewanella putrefacient Ppdp11
	Bacillus Megaterium
	Lactobacillus Cassei and Shirota
	Bacillus Coagullans
	Enzymes Amylase, Protease, Cellulase, Xylanase, Lipase, Hemicellulase
Water quality	Saccharomyces cerevisiae
	Bacillus Licheniformis
	Bacillus Megaterium
	Enzyme Xylanase
Stress tolerance	Bacillus subtilis
	Shewanella putrefacient Ppdp11
Reproduction improvement	Bacillus subtilis

9.3.1. Basic Ingredients

Commercially produced probiotics are an established management tool for improving fish gastrointestinal health and environmental quality. There are many different probiotics for biofloc tanks products. Major categories in commercial formulations include Bacillus spp., lactic acid bacteria (LAB), yeast, and nitrifying/ denitrifying bacteria. These ingredients are available from the market for preparation of probiotics at home. *Probiotic* bacteria are wonderful little chemical making plants. These bacteria break down dietary fibers and convert them into a wide range of compounds that are called as postbiotic *metabolites.*





Picture 16: Probiotics

Probiotics production use fermentation process. Probiotic fermentation is unique in that it seeks to grow the bacteria for future consumption rather than use it to produce a metabolite for immediate use. FCO for instance has to be used within 20 days, if produced at home before its quality deteriorate. Unlike other food fermentation processes, the metabolite in probiotic feed production process is disposed of and the end- product is a concentrated powder or in liquid form. In home preparations, liquid form of probiotic is most attempted.

Table 26: Ingredients for homemade preparation of 1Kg probiotics

Ingredients	Quantity
Water	10 liters
Sugar	300 grams
Egg Yolk	4 pieces
Pineapple	200 grams
Banana	3 pieces
Vitamin B	2 tablets (10000 MCG)
Vitamin C	2 tablets (10000 MCG)
Yakult (Lactic Bacillus Drink)[20]	4 bottles (325 ml each)
Saccharomyces yeast (also known as baker's yeast)	20 grams
Bakery yeast[21]	10 grams
Probiotic powder	25 grams
Broken rice boiled water	1 kg
Molasses	1 Kg
Black pepper	50 grams
Red chili powder	50 grams
Garlic	50 grams
Alpinia Officinarum (Sitharathai or Lesser Galangal in English, Chitharathai in Tamil, and Kulanjan in Hindi)	7.5 grams

9.3.2. Preparation Procedure of Probiotic

Without means to fast drying, home preparation is served liquid form only. Homes lack electro-mechanical dryers, extruding machines and cooling chambers. There is no evidence to show that probiotic in liquid form is less effective than its powder form. Both contain a special blend of nutrients which give bacteria the energy to grow, and continue grow through binary fission into trillions of times in just one batch of probiotics! Homes are well equipped to produce liquid fermented probiotics.

Pour water in a 15-liter drum with aeration on. Pour the molasses into the drum followed by rice water. Stir well the water. Grind the banana, pineapples, and egg yolks together, and grind black pepper, chili powder, garlic and *Alpinia Officinarum*. Mix all the grinded pastes well with Yakult, rice water, vitamins and yeast before tipping it over on the drum. Immediately add probiotics into the water. The drum is sealed in an air tight container for four days. Start using FCO from the 4 day.

[20]Yakult ingredients are water, skimmed milk, glucose-fructose syrup, sucrose, and live Lactobacillus casei and Shirota bacteria.
[21]Contains enzyme Xylanase.

Homemade Probiotic Preparation for Water Application:

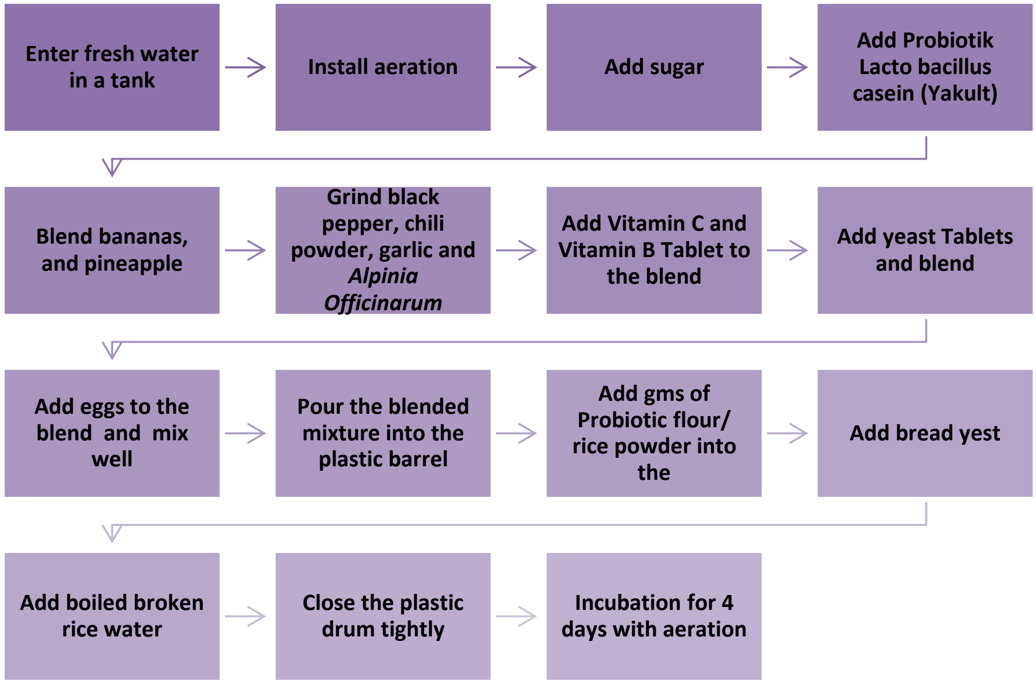


Figure 11: Homemade probiotic preparation for Water

Homemade Probiotic preparation for Feed Applications:

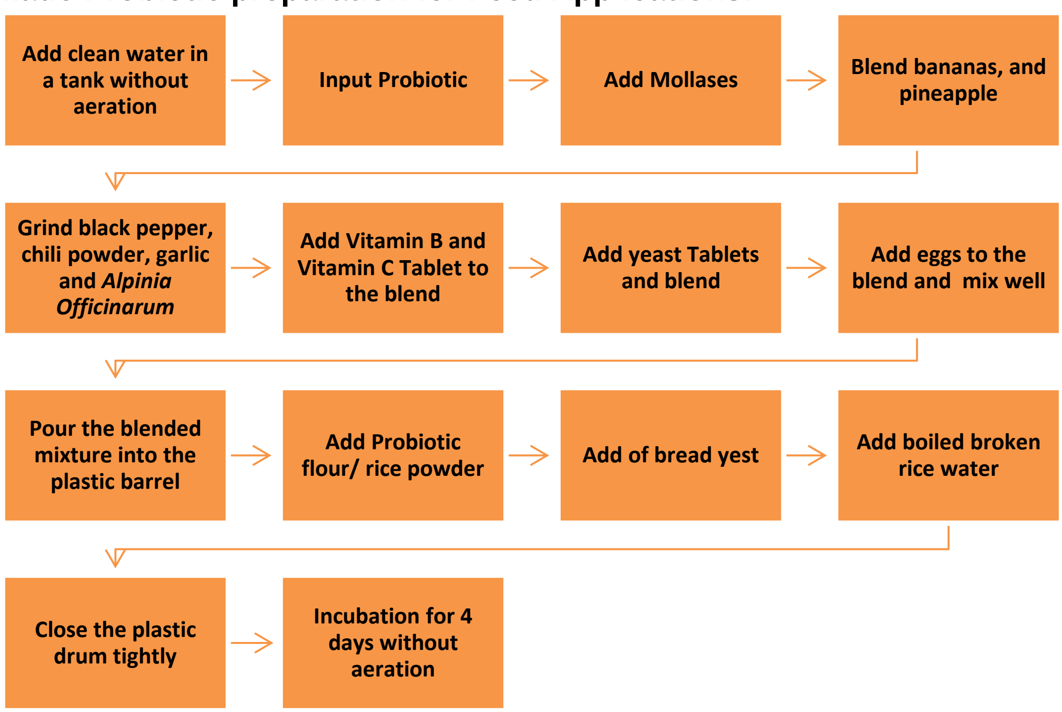


Figure 12: Home based probiotic preparation for feed applications

When preparing probiotic cultures, all care should be taken to make sure that no unwanted or harmful pathogens are also unknowingly grown in the process. If pathogens are found in the probiotic, the whole lot must be discarded. Good sterilization and sanitation will minimize chances of pathogen invasion.

9.3.3. Cost of Ingredients

Cost of each ingredient used in calculated. For preparing 10 litre of FCO, the total cost is Rs. 330, or Rs. 33 per liter.

Table 27:Cost of Homemade Probiotic Ingredients

Ingredient	Unit consumed	Price	Expenditure Rs
Sugar	300 grams	Rs. 50/kg	₹15.00
Egg yolk[22]	4 pieces	Rs. 4/piece	₹16.00
Pineapple[23]	200 grams	Rs. 62/kg	₹12.40
Banana[24]	3 pieces	Rs. 22/kg	₹10.00
Vit. B tablets	2 tablets	Rs 1.70/tablet	₹3.40
Vit. C tablets	2 tablets	Rs 1.25/tablet	₹2.50
Yakult bottles	4 bottles	Rs. 12	₹48.00
Baker's yeast	20 grams	Rs. 2.25/gm	₹45.00
Probiotics	25 grams	Rs. 59/kg	₹150.00
Broken rice powder	1 kg	Rs. 16/kg	₹16.00
Molasses	1 kg	Rs. 9/kg	₹9.00
Other material			₹2.70
Total Expense			₹330.00
Cost per liter			₹33.00

9.3.4. Feed Value

The protein content of homemade probiotic is around 2%.

[22]Egg yolk and shells contain enzyme Cellulase which break down the cellulose molecule into monosaccharides ("simple sugars"). Each egg yolk contains cholesterol 1085 mg, protein 15.86 g, phosphorus 390 mg, and Vitamins.

[23] Pineapple, papaya, kiwifruit contains enzyme Protease.

[24] Banana and mango contain enzyme Amylase.

Table 28:Protein Content in Homemade Probiotic Ingredients

Ingredient	Consumed in g	Protein content per g	Protein Content
Sugar	300	0.00	0.00
Egg yolk	60	16.00	9.60
Pineapple	200	0.50	1.00
Banana	408	1.10	4.49
Vit. B tablets	5	0.00	0.00
Vit. C tablets	5	0.00	0.00
Yakult bottles	320	1.00	3.20
Baker's yeast	20	8.00	1.60
Probiotics	25	42.00	10.50
Broken rice powder	1000	2.60	26.00
Molasses	1000	0.00	0.00
Total	3343		56.39

Currently no enzymes are applied in domestic probiotic making. Ifenzymes are added, then the feed value will increase significantly.

9.3.5. Cost Comparison

Drawbacks of homemade FCO is that it is available only in wet form, since pelletisation is not possible. The preparation is 80% water, as such has low feed value compared to same amount of probiotic in dry powder form.

If a kg of commercial probiotic cost Rs. 1300 and the mixing dose is 0.04 gram/liter, then the price liter works out to be Rs. 52/liter. Thus, if all other things are being equal, homemade FCO is 58% cheaper.

9.4.Conclusion

A great deal of culinary skill, scientific knowledge, and patience is required to be a good fish feed producer, but it is all worth it! The end-product is sustaining thousands of fish in a healthy manner. The farmer, and consumers all benefit when fishes are healthy and joyful.Feed and probiotics are the essential part in Biofloc Technology. The potentiality of profit depends primarily on these components other than the species. This chapter not only compares the cost efficiency of commercially available feeds and probiotics vs domestic preparation of feed and probiotics but also gives a basic idea on its application and usage. The detailed analysis of the ingredients used along with the nutrition values portrays a clear picture to the customers. Considering the wet form of feed that can be prepared at home in comparison with the commercially available dry pellets, it gives a cost advantage of more than 50%. Thus, decreasing the cost of production and making it more economically viable for small and marginal farmers.

Annexures

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ANNEXURES

Annexure 1.1: Curriculum for Biofloc Training of Entrepreneurs

Duration: 5 day, 8 hours a day
Style: Interactive, Q&A, videos, photos. Written exam for qualify certificate.
Batch size: 20, non-residential
Instructor: Resource persons, biofloc entrepreneurs

Module	**Subject**	**Hours**	
		Theory	**Practical**
1	Greetings, Self-introduction and Training Rules	0.5	
2	Traditional Fish Farming & Bio-Security	0.5	
3	Introduction to Biofloc - how does the system work	1	
4	Field Visit		5
5	Biofloc Tank Management	1	
6	Importance of CN Ratio	1	
7	Aeration Management in Biofloc	0.5	
8	Introduction to Testing Kits & Tools	1	
9	Water Testing (pH, Temperature, Salinity)		2
10	Post-Water Treatment Process	1	
11	Water Testing (Ammonia, Nitrate, Nitrite)		2
12	FCO Preparation - Practical		2
13	Feed and Probiotic Preparation	1	
14	Choose Right Fish for Biofloc	1	
15	Seed Stocking Management	1	
16	Feeding Management Process	0.5	
17	Power Backup Management	1	
18	Sludge removal	1	
19	Everyday Op. Management -labour, stores, equipment	0.5	2
20	Purchasing Management	1	
21	Grants, Subsidies and Loans	1	
22	Preparing a grant/loan application		2
23	Record keeping	1	
24	Fish Disease Management	1	
25	Treatment of Fish Disease in home remedies	0.5	2
26	Interaction with a biofloc fish entrepreneur		1
27	Marketing of Fish	1	
28	How to use Internet Resources		2
29	Profit and Loss Statement Analysis	1	
30	How to make business profitable	1	
	Total	**20**	**20**
	Grand Total		**40**

Annexure 2.1: Biofloc Tarpaulin Tank Setup

The procedure for a setting up a tarpaulin tank described here is based on the literature made available by Mr. Kallol Parida of Road to Biofloc, Odisha. The basic information about the set-up is as follows.

- Tank Capacity 12,000L
- Tank Diameter 4 Meter
- GI Mesh Circumference 12.56 Meter (We suggest to buy 13 Meter)
- GI Mesh Height 1.2 Meter
- Tarpaulin Size 4 Diameter
- Tarpaulin Height 1.3 Meter
- Tarpaulin Circumference 12.56 Meter
- Drain pipe 1 PCS (3 Inch)
- Drain pipe L Connector 1 PCS (3 Inch)
- Drain pipe Stopper 1 PCS (3 Inch)

The chosen site is free of water logging or subsidence. Begin by making the surface plain, fit to seat the tank. A BioFloc tank of 10,000L capacity would require 5 x 5-meter space.

Step 1: Mark the center of the place and draw a circle with a 2 metre radius (4 meter diameter).

Step 2: Arrange the bricks aligned to the circular line.

Step 3: Next install a 3-inch drainage PVC pipe at the center to make the drainage outlet. Dig the earth for installing a 3-inch pipe in the center with a slope of around 2 ft right up to the central drainage chamber. Cover the L-Shape 3-inch PVC Connector, cement that will help to stop the movement of the pipe. The central chamber is connected to all the drainage pipes of the tanks.



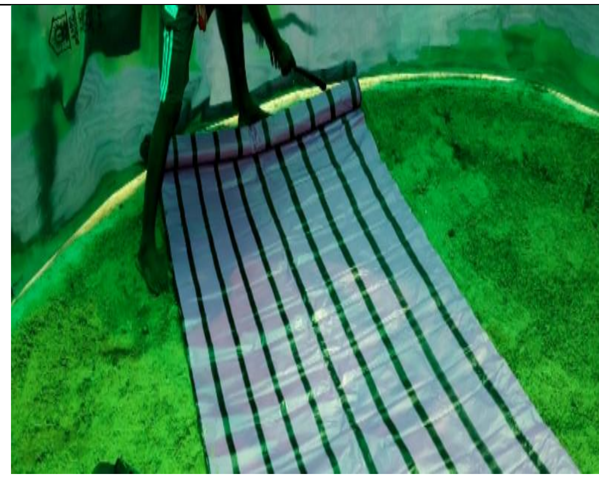

Step 4: Make sure that mesh circumference is of 12.56 meter so that the tarpaulin cover is sufficient to go inside it. Join the mesh in round manner. Carefully check to see the bottom and the top size of the mesh is 4 diameters. Paint the wire mesh to make it rust proof.

Step 5: Fill the tank seat area with sand. The tank ground area should have a 1.5ft slope towards the center (inwards) for proper drainage.

Step 6: Place the mesh on the top of the brick and cover the bottom of the mesh with cement to protect it from rust.

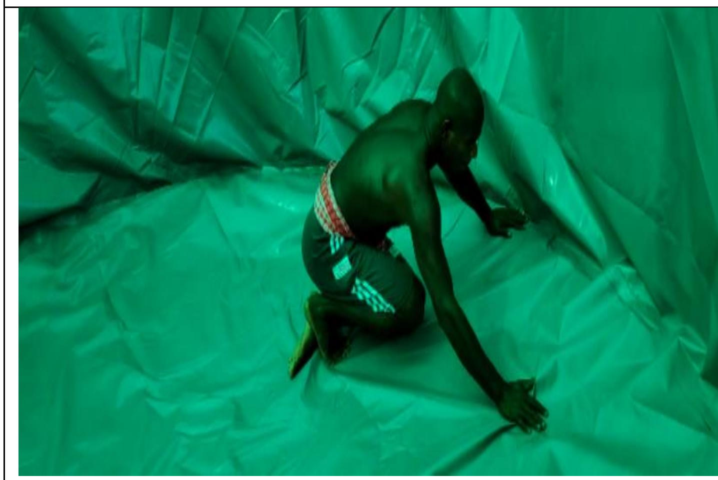
Step 7: Place a protective plastic liner /aluminum sheet between the tarpaulin and the mesh to insulate the tank from external damages.

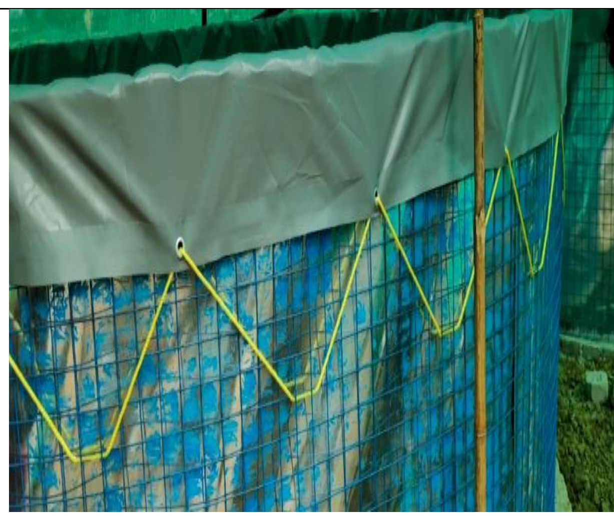
Step 8: An additional layer of polythene sheet may be added at the bottom to provide extra protection. This activity is purely optional.



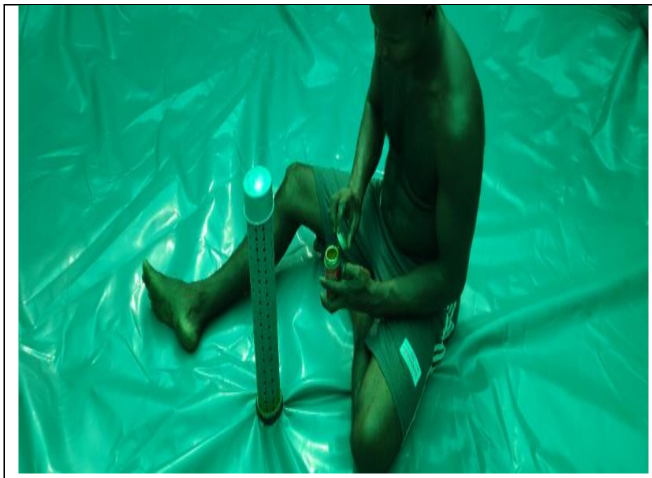
Step 9: Iron mesh contains sharp spikes that can damage the tarpaulin. Some use cycle tyres to cover the sharp edges or fix an 8” iron rod (sariya) around the top edge to further strengthen the structure.

Step 10: Unfold the tarpaulin sheet to spread it uniformly inside the tank. Make sure that there are no wrinkles. The tarpaulin sheet is placed on the wire mesh and firmly tied with a strong nylon cord.

After the tarpaulin tank is properly placed, install the central drainage pipe. Ensure there is no leakage from the central drainage pipe.



This is the final step in the tank set up. The tank is now ready to hold water.

Annexure 3.1: Water Preparation

Water analysis in a scientific manner is essential to success in biofloc farming. For commercial scale operations, it is better to test key water parameters in a recognized laboratory. Good quality water fit for Biofloc has zero pathogens and iron, chlorine, lead, mercury, zinc, iron etc. within the permissible levels. Each biofloc farmer must perform a routine check for pH, salinity of water, TDS, and DO level. These basic tests can be performed by amateurs using low cost ready to use kits available online.

pH Level: It is a proxy parameter to check if the water is no too acidic or too alkaline. Measure the pH level after 24 hours of first aeration in water. If the pH value is lower than 7, add $CaCO_3$ 0.05gm/L i.e. 500 gm in 10,000 liter tank. $CaCO_3$ helps to steady the pH Level. Repeat the process every 4 hours till Ph level is at desired level. Do not put probiotics before pH level has stabilized.

Dissolved Oxygen (DO) level: Leave the tank water on aeration for 48 hours, it helps to oxidise and evaporate harmful chemicals from the water body. The DO level should be within the range of 4 mg/l (for warm-water fish) and 6 mg/l (for cold-water fish). DO level below 4 or above 7 causes stress to the fishes. DO is monitored using DO Test strips or a digital DO Meter.

The salinity of Water: Plays an important part in regulating the biofloc system. The tolerance level for salinity varies according to the species. It does vary from 0 to 50 ppt. The salinity level has to match with the requirements of the concerned specie. Strips and Salinity Meter (Refractometer) are available to the salt content in the water.

Total Dissolved Solids (TDS) in Water: TDS is a measurement of all negative (anions) and positively charged ions (cations) that are present in water. Among the citations magnesium (Mg), sodium (Na), potassium (K), calcium (Ca); and among the anions are sulphate (SO_4), chloride (Cl), and bicarbonate (HCO_3) are abundantly present in water. Many chemicals and pesticides, sewage and industrial wastes pollute the water source; a high TDS reading may give an early warning to deterioration of the water quality. TDS Strips and Meter both helps to measure the TDS Levels. Care should be taken to not to damage the electrodes by repeated touching. The electrodes can be cleaned with diluted vinegar, and properly rinsed. Use only clean collection vessel for collecting water for testing. Tiny specks of detergent can give wrong results.

Annexure 4.1: Useful Resources

Government

Joint Secretary
Department of Animal Husbandry, Dairying & Fisheries
Ministry of Agriculture & Farmers Welfare, Government of India Krishi Bhavan,
New Delhi 110 001
Website: www.dadf.gov.in &http://dahd.nic.in
KISAAN PORTAL Website: www.farmer.gov.in / www.mkisan.gov.in
Tel: 1800-180-1551
SMS to 51969 Subject "KISAAN GOV HELP"

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Ph**:** +91 22 2636 1446
Dr. C. N. Ravishankar, Director, Central Institute of Fisheries Technology, CIFT Junction, CIFT Road Matsyapuri, Willingdon Island, Kochi, Kerala 682029. Phone: 0484 241 2300
Chief Executive
National Fisheries Development Board,Department of Fisheries,
Ministry of Fisheries, Animal Husbandry and Dairying, Govt of India,
"Fish Building" Pillar No:235, PVNR Expressway, SVPNPA Post,Hyderabad-500052.
E-Mail: ce.nfdb-dadf@gov.in, info.nfdb@nic.in;
Web: nfdb.gov.in
Toll Free Helpline Number: 1800-425-1660

Director
Central Soil & Water Conservation Research & Training Institute,
218, Kaulagarh Road, Dehradun-248 195, Uttarakhand
Phone: 0135-2758564. Email: director@cswcrtiddn.org

Useful Links

Fishery Survey of India
Central Institute of Fisheries Nautical and Engineering Training
National Institute of Fisheries Post Harvest Technology and Training
Coastal Aquaculture Authority
National Fisheries Development Board
Indian Council of Agricultural Research (ICAR)
Central Institute of Fisheries Education
Central Marine Fisheries Research Institute
Central Inland Fisheries Research Institute
Central Institute of Freshwater Aquaculture
Central Institute of Brackishwater Aquaculture
Central Institute of Fisheries Technology
National Bureau of Fish Genetic Resources
National Research Centre on Coldwater Fisheries
The Marine Products Export Development Authority
FAO FishStatJ – Universal software for fishery statistical time series