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Edition

Promoting Aquapreneurship through Potential Aquaculture Systems

Edited by

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MANAGE, Hyderabad

Promoting Aquapreneurship through Potential Aquaculture Systems

Programme Coordination

Madras Christian College, East Tambaram, Chennai - 600059

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MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

The nation's fisheries and aquaculture sector has developed from a traditional source of income into a business sector that is heavily reliant on technology. Fisheries and aquaculture is witnessing a changed scenario from its traditional role as a supplementary subsistence activity in most of the States to viable and sustainable economic activity. The sector is now gaining importance as an attractive investment destination and a lucrative business activity. With the changing consumption pattern, emerging market forces and recent technological developments, the sector has assumed increased importance with farmers and other stakeholders in the country. Fish consumption has recently increased worldwide with high demands in the developing countries. Fish contains protein source because it is less expensive than other meats including bush meat, hog, chicken, and cattle. Fish is anticipated to be the most major source of protein in the human diet on a global scale, and it is believed that more than 30% of all fish consumed by humans comes from aquaculture.

It is a pleasure to note that, Madaras Christian College, Chennai & MANAGE, Hyderabad is organizing a collaborative training program on "*Promoting Aquapreneurship through Potential Aquaculture Systems*" from 17-19 August, 2022 and coming up with a joint publication as e-book on "Promoting Aquapreneurship through Potential Aquaculture Systems" as immediate outcome of the training program.

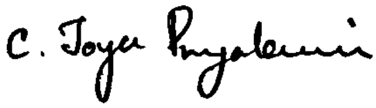
I wish the program be very purposeful and meaningful to the participants and also the e-book will be useful for stakeholders across the country. I extend my best wishes for success of the program and also Madaras Christian College, Chennai & MANAGE, Hyderabad, many more glorious years in service of Indian agriculture and allied sector ultimately benefitting the farmers. I would like to compliment the efforts of Dr. ShahajiPhand, Centre Head-EAAS, MANAGE, Hyderabad Dr. C. Joyce Priyakumari for this valuable publication.

Dr. P. Chandra Shekara
Director General, MANAGE

MESSAGE

MCC Pulicat Estuarine Biological Research Centre (MCC PEBRC) formerly known as Estuarine Biological Laboratory, an Off-Campus Facility of the Department of Zoology, Madras Christian College, Chennai was established at Pulicat (Pazhaverkadu), Thiruvallur district in 1968. Pulicat Lake is a biodiversity hotspot in Southern India. This Centre has been working on the environmental and fisheries aspects of the lake and the livelihood of fisher men folk of the the number of coastal villages juxtapose to the lake and generated a lot of data apart from publishing many research reports and articles. By the virtue of the long period of experience of the faculty and the scholars on the Pulicatlake and its fisheries, a number of fisheries and aquaculture opportunities were identified and technologies and entrepreneurial skills have been developed for the benefit of stakeholders. This Centre has been availing a number of R & D schemes from the funding agencies viz. DBT, DST, UGC, etc. The Centre has now upgraded its facilities to focus also on the applied research and technology development in areas such as aquaculture, aquaponics, lake- ranching, Coral rocks, etc. focusing on biodiversity richness of the Pulicat Lake.

It is a pleasure to collaborate with MANAGE, Hyderabad in organizing a collaborative training program on "*Promoting Aquapreneurship through Potential Aquaculture Systems*" from 17-19 August, 2022. I whole heartedly wish the program to be a grand success.



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PREFACE

In India population increasing every day with increase in the demand for the food. Aquaculture is the main source of food, income and employment. Even though aquaculture is rapidly growing profitable industry, the diseases caused by various pathogens, feed cost, water availability and suitable culture methods are the main problems faced by the aqua farmers. Owing to the great diversity of aquaculture operations, the description of types ofaquaculture systems may be complex and sometimes confusing. Broadly, aquaculture structures includeponds, tanks, raceways, cages and pens. Economics of the different culture systems and its applicability in the small and medium scale fish production is required for existing as well as new entrepreneur in the sector. The use of these culture systems and its economics in the installation and maintenance has to be nurtured to the aquapreneurs for formulating their budget and adopting the right systems for the right species.This book was made possible by the sincere efforts of the contributing authors.

This e-book is an outcome of collaborative online training program on "Promoting Aquapreneurship through Potential Aquaculture Systems" conducted from 17th–19thAugust, 2022. This book will be highly useful to the young aquapreneurs and field workers who are working at the ground level. Various important topics on different culture systems which are practised in aquaculture have been covered for the benefit of the readers.

The editors express sincere thanks to Dr. P. Wilson, Principal, Madras Christian College, Chennai for the encouragement in publishing this e-book. The financial aid provided by MANAGE, Hyderabad for this training program is duly acknowledged. We hope and believe that the suggestions made in this e-book will help to improve the knowledge on the different culture systems in upcoming aquapreneurs.

Editors

Dr. C. Joyce Priyakumari
Dr. Shahaji Phand
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Chapter 1

BEFITTING AQUACULTURE SYSTEMS FOR THE BENEFIT OF AQUAPRENEURS IN INDIA

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Introduction

From traditional to modern aquaculture aquaculture was entirely 'traditional' up to less than 30 years ago as locally available resources were the only sources of nutritional inputs available to farmer before the relatively recent agro-industrial manufacture of pelleted feed (Edwards, 2009a). Traditional aquaculture is mainly integrated with other human activity systems. Major types of traditional aquaculture are integrated agriculture-aquaculture systems (IAAS) with on-farm or local agricultural by-products, manures and/or vegetation; integrated peri-urban aquaculture systems (IPAS) using domestic sewage and local agro-industry; and integrated fisheries-aquaculture systems (IFAS) with carnivorous fish fed with trash and low-value fish. The farming of molluscs and seaweeds, so-called 'extractive species', because they depend for nutrition on usually naturally occurring organic detritus, plankton and dissolved nutrients in the water column may also be considered as traditional aquaculture systems. There has been a relatively recent rapid increase in aquaculture production based on the development of 'modern' aquaculture through the application of science and technology, with the delinking of aquaculture from agriculture (IAAS) and sanitation (IPAS).

The selection of the aquaculture system or approach to adopt in a particular development is determined by several factors including the following:

- development goals/objectives and target beneficiaries
- acceptability/marketability of culture species
- availability and level of technology
- availability of production inputs and support facilities and services
- investment requirements
- environmental considerations

Main aquaculture production systems used in India

Aquaculture in India is currently developed using the following production systems: i) Land-based ponds (Carrera, 2019), ii) Floating cages (Moreno et al., 2013b), iii) Recirculating Aquaculture Systems (RAS) circulation system (Criollo and Ortiz, 2015), iv) Biofloc (Hernández Mancipe et al., 2019), and v) Intensive Pond Aquaculture (IPA). Table-1 defines each production system also highlighting the limitations within their application in India.

Table.1: Production systems used in India for aquaculture: definition, applications and limitations.

Production system	Definition and Application	Limitations
Land-based pond: semi-intensive and intensive	It consists in controlled ponds or water reservoirs stocked with fish. It is the most widely used semi-intensive system and represents ~66% of production. For the shrimp production, it is the main farming system used by companies (Aldridge et al., 2008). The intensive technology increases fish production by using aerated flowing water and the elimination of fish metabolic waste. This technology allows to increased fish survival, cost reduction per unit of weight gained, energy savings per unit produced, and reduction of labour and waste products (Cremer et al., 2014).	Over time, they have generated environmental impacts on water tributaries due to the addition of feed waste, medicines for disease control and the accumulation of organic matter, mainly derived from phosphorus, potassium and nitrogen, affecting water quality and causing eutrophication processes (Hernández Mancipe et al., 2019). Regarding the intensive system, the country presents a shortage of knowledge workers and skilled workforces, that is needed to implement this technology.
Floating cage system	It can be suspended in free-flowing water, i.e. large reservoirs, lakes, lagoons, dams, rivers or oceans, to contain and protect fish until they can be harvested (Mancera-Rodriguez and Plutarco, 1997). It presents low investment in infrastructure and the use of simple technology, its management is not complex as well as the use of high planting densities (Botero and	After long periods of production, there is an increase in sedimentation, not only of uneaten food particles, but mainly of organic waste or excrement that adds to the sediment from the tributaries that reach the water resources where the cages are installed (Mancera-Rodriguez and Plutarco, 1997).

Production system	Definition and Application	Limitations
	Fernando Ospina, 2003) (Carrera and Villarreal, 2015).	
Recirculating Aquaculture System	It is a closed system that involves housed fish in tanks where water is continuously recirculated and treated by a filtration system to guarantee optimum growing conditions is. It occupies small area and allow the grower to stock fish at high densities and produce high yields per unit area.	It presents high implementation cost making it suitable only for certain production stages. There is also a significantly production of sludge with high organic matter content. Additionally, not all water is 100% recirculated however as it is difficult to ensure that all waste products are converted or removed by the treatment process (Maigual-Enriquez et al., 2019).
Biofloc	It is based on the use of aggregates of bacteria, algae, or protozoa, combined with particulate organic matter to improve water quality, waste treatment and disease prevention in intensive aquaculture systems. It has a lower set-up cost, requiring less equipment and water treatment units. It is friendly with the generation of abundant variety of microorganisms that can provide nutritional benefits to the fish (Brú-Cordero et al., 2017). This system does not exceed the 10% of national production	Microbiota can be developed in the water or in the gut of the species, leading water quality control in ponds difficult and unpredictable. This makes risky the implementation biofloc at farm level (Cienfuegos-Martínez et al., 2020; Crab et al., 2012).

Linking Traditional and Modern Practice

There are promising technologies that link traditional and modern aquaculture practice to reduce the adverse environmental impact of modern pellet-fed aquaculture and/or to lower the cost of production.

Modern Polyculture

Chinese farmers returned in part to traditional polyculture practice by stocking filter feeding species such as bighead and silver carp in an attempt to reduce excessive growth of phytoplankton induced by residual fertilization of fish faeces and uneaten feed in the intensive pond culture. Such a modern polyculture system, the '80:20 system' is being promoted in China (Manomaitis and Cremer, 2007; Ye, 2002). About 80% of the harvest weight is high-value 'target species' and the other 20 % comprises low-value 'service species', mainly filterfeeding silver carp to reduce the biomass of phytoplankton. High physical quality extruded and nutritionally complete feed are promoted in the aerated, closed water ponds and their use is reported to lead to faster growth, higher production and better feed conversion with higher profits than traditional polyculture technology and less adverse environmental impact.

Cage-in-pond culture system

Considerable experimentation has developed an integrated cage-in-pond system with fish grow-out in cages installed in a pond in which nursing takes place simultaneously. Intensive pellet-fed cage grow-out is integrated with semi-intensive pond nursing with fingerlings nursed in the same pond on spilled feed and 'green water' from fish faeces from the caged fish. A major environmental benefit of the system is protection from external agricultural, industrial and urban water pollution which increasingly threaten aquaculture in public water bodies.

Raceway-in-pond culture

Two promising technologies that minimize or even eliminate the adverse impact of pond effluents on the environment are raceways-in-pond systems, closed aerated systems with zero water discharge.

A partitioned aquaculture system (PAS) incorporated high-rate micro-algal culture with fish culture (Brune et al. 2003; Hargreaves, 2006). Pellet-fed channel catfish (*Ictalurus punctatus*) were stocked at high density in a rearing tank with the water circulated through a shallow high-rate phytoplankton pond by a low-energy paddle to treat the fish wastes. Low speed paddle wheels moved large volumes of water at low velocities uniformly throughout the pond with filter-feeding tilapia reducing phytoplankton biomass in water produced by residual fertilization from the pellet-fed catfish raised in adjacent raceways. The PAS was reported to also have the potential to reduce total water usage per unit of fish produced by 90%.

A new intensive pond aquaculture technology with zero-discharge developed in the USA, has been demonstrated in China (Cremer et al. 2014). An in-pond concrete raceway system comprising three cells stocked with pellet-fed grass carp within an earthen fish pond yielded 42 tonnes from the 2.1 ha combined system, an extrapolated yields of 20 tonnes/ha, almost three times the average Chinese pond yield of 7.2 tonnes/ha. A high volume air blower supplied air to diffuser mats to promote circulation of water through the raceways, with solid wastes collected two or three times daily by vacuuming from the quiescent zone located in each concrete cell.

Seaweed farming

Seaweed farming is environmentally friendly as it is extensive, depending on naturally occurring nutrients in the water column. While it has a long tradition in East Asia, especially in Japan, it has been developed more recently in tropical Asia, initially in the Philippines which has recently been overtaken by Indonesia as the largest producer of the red seaweeds Kappaphycus and Eucheuma. These species are farmed for carrageenan, a polysaccharide widely used in processed foods and cosmetics (Rimmer et al. 2013). It is mainly carried out by small-scale fisher families with considerable benefits for household income and has considerable potential for sustainable expansion.

Alternative Use of Water

Community or culture-based fisheries (CBF), usually extensive aquaculture in small water bodies, has been described as an 'under ultilized opportunity in aquaculture development' (De Silva, 2003). Production of more fish from existing waters with minimal external feed inputs provides an important means to augment conventional aquaculture practices. While aquaculture-based fisheries enhancements have been successfully implemented in more than 27 countries with an estimated production of 2 million tonnes of fisheries products (Bostock et al. 2010), it has been estimated that there are 67 million ha of small water bodies, constructed mainly for irrigation, in Asia (De Silva, 2003). The promotion of CBF is likely to deliver more immediate yield increases than investment in technology as it is technically simpler than conventional aquaculture although there are usually complex technical, social and institutional issues regarding biodiversity, access to water bodies, social equity arrangements, and competition of water use to be addressed (De Silva et al. 2006). There is considerable potential to expand cage culture in under-utilized reservoirs, lakes and rivers. However, fluctuating water levels in reservoirs used for irrigation and hydropower generation can adversely affect aquaculture due to draw downs (Finlayson et al. 2013). The culture of fish in cages in irrigation canals also requires coordination between the water authorities that manage the system and fish farmers.

Open ocean aquaculture

There is another mantra in the popular and scientific literature, dating back more than half a century, that the future of aquaculture is in the oceans because of perceived constraints of land and freshwater. The open ocean does offer tremendous potential to increase global aquaculture production with almost unlimited space and diffusion of wastes in contrast to coastal aquaculture. Significant expansion of coastal aquaculture for the adoption of integrated multitrophic aquaculture (IMTA). In IMTA, multiple aquatic species from different trophic levels are farmed in an integrated fashion to improve efficiency, reduce waste, and provide ecosystem services, such as bio-remediation. Species at the lower trophic level (usually plants or invertebrates) use waste products such as feces and uneaten feed from the higher trophic species (typically finfish), as nutrients. The lower trophic species can then be harvested in addition to the fish to give the farmer more revenue, or even to be fed back to the fish. The composition of production would also have to change for open ocean aquaculture to contribute significantly to global food supplies. Mariculture is currently dominated by seaweeds (46%) and bivalve molluscs (43%) at 89% of total production, which do not provide major sources of human food, with crustaceans (2%) and finfish (9%) providing only a total of 11% of total mariculture production .

The way forward

Aquaculture has great potential to expand and intensify sustainably to meet the demand for fish in 2050 as the human population is predicted to continue to grow for the next 30 years before stabilizing at a minimum of 9 billion people (Godfray et al. 2010). The major trend towards intensification and use of formulated pelleted feed in aquaculture will continue because the main driver for intensification is farm profit; once there is an available market and seed and feed become readily available, farm income is greater from intensive aquaculture even though the cost of production as well as the adverse environmental impacts are both larger than in traditional semi-intensive aquaculture which characterizes most integration. While production from traditional systems has declined considerably in well-endowed aquaculture areas, integrated systems still have a role to play in densely populated rural areas, especially those in remote areas and with limited livelihood opportunities.

Chapter II

SCOPE AND OPPORTIUNITES IN SHRIMP CULTURE

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Introduction

Aquaculture is one of the fastest growing industries around the world. Coastal aquaculture plays an important role in livelihoods, employment and local economic development among coastal communities in many developing countries. It is practised in completely or partially artificial structures in areas adjacent to the sea, such as coastal ponds and gated lagoons. In coastal aquaculture with saline water, the salinity is less stable than in mariculture because of rainfall or evaporation, depending on the season and location. Although coastal ponds for aquaculture, modern or traditional, are found in almost all regions in the world, they are far more concentrated in South, Southeast and East Asia and Latin America for raising crustaceans, finfish, molluscs and, to a lesser extent, seaweeds (FAO 2020).

World aquaculture production of farmed aquatic animals has been dominated by Asia, with an 89 % share in the last two decades. Over the same period, Africa and the America have improved their respective shares in world production of farmed aquatic animals, while those of Europe and Oceania have dropped slightly. Among major producing countries, Egypt, Chile, India, Indonesia, Viet Nam, Bangladesh and Norway have consolidated their share in regional or world production to varying degree over the past two decades. In addition to Egypt, Nigeria has increased its aquaculture production significantly to become the second major producer in Africa, although the share of Africa is still low at about 2.7 percent of world aquaculture production (FAO. 2020).Farmed shrimp production in India touched 7.0 lakh tonnes in 2019, of which 87% is exported to USA, China, Japan, EU and South East Asia, earning a robust foreign exchange to the tune of Rs.35,000 crores (MPEDA, 2019).

History

Shrimp aquaculture in India has an extensive history of successes and challenges reflecting both the potential and the problems of developing this industry. In India, shrimp farming was first conducted only on an experimental scale. A major step toward large scale shrimp aquaculture took place soon after the first use of brackish water fish farming was demonstrated in West Bengal by the Central Inland Fisheries Research Institute under the Indian Council of Agricultural Research (ICAR) in 1973. Subsequently, an ICAR coordinated research project on brackish water aquaculture was sanctioned in all of India in 1975 through centres in West Bengal, Andhra Pradesh, Odisha, Tamil Nadu, Goa and Kerala (Sinha 1999).

Simultaneously, Central Marine Fisheries Research Institute of ICAR successfully demonstrated theproduction of shrimp seed in Narakkal, Kerala (Silas 2003).Thereafter, Marine Products Export Development Authority (MPEDA)established the commercial shrimp hatcheries. Semi-intensive culture technology was also demonstrated on a pilot-scale project by the MPEDA (Muralidharan 2010).These technologies, along with further experimental efforts by farmers, worked well and led to large scale development of this sector as shrimp aquaculture took root in India.

The total farming area devoted to shrimp farming increased almost by 50% from 65,100 Ha in 1990-1991 to over 121,208 Ha in 2011-12 (SEAI 2012). This created job opportunities in remote coastal villages and helped to ensure income security for poor people and valuable foreign exchange to the country.

In India, a strong emphasis was also placed on improving shrimp farming techniques to minimize their environmental impact, as well as to extend sustainability through the use of technology. In contrast, countries like China, Thailand, Indonesia, and Vietnam have emphasized practices intended to reduce production losses (Ponniah *et al*. 2011).The species of shrimp commonly used during the early period of aquaculture development in India are *P. monodon* and *F. indicus* were initially the most popular. Currently, another species *L. vannamei* is widely used.

Current scenario of shrimp culture

Since 2010, exotic Pacific white shrimp (*Penaeus vannamei*) is the candidate species farmed in the country, which accounts for the 90% of the farmed shrimp production. Indian hatcheries imports Specific Pathogen Free (SPF) brood stock mainly from USA, Madagascar, Mexico and Hawaii after due quarantine clearance by Govt. of India through the Aquatic Quarantine Facility (MPEDA-RGCAAQF) located at Chennai. During 2019-20, 1,24,957 pairs of brood shrimp were imported from the 14 authorized suppliers from abroad to cater the needs of 311 hatcheries and 90 nauplii rearing centres. During the first three months of 2020, the country has imported about 63,430 pairs of vannamei brood stock which was 32% higher compared to the same period in the previous year 2019 (CAA, 2020)

Shrimp Culturetechniques

In shrimp culture pond preparation, water quality parameter, selection of seed, feed management and farm management are playing major role for successful culture (Gunalan *et al* ., 2011). Initially the ponds are allowed to dry and crack to increase the capacity of oxidation of hydrogen sulphide and to eliminate the fish eggs, crab larvae and other predators. Then pond bottom has been scrapped 2 to 4 cm by using a tractor blade to avoid topsoil. Then the pond bottom should be ploughed horizontally and vertically at depth of 30 cm to remove the obnoxious gases, oxygenate the bottom soil, discoloration of the black soil to remove the hydrogen sulphide odour and to increase the fertility. The soil pH is recorded in the ponds with the help of cone type pH meter. The average pH calculated from the collected data and required amount of lime has been applied to neutralize the acid soil condition and increases the availability of nutrient.

The initial water levels in ponds should be maintained at 120 cm level. Required amount of organic fertilizers such as rice bran; groundnut oil cake, dry cow dung and yeast have been soaked overnight and applied the extract to all the ponds. The same procedure has to be continued for three days. After three days the water colour turned to light green. Then water level has to rise up to 100 cm and urea and super phosphate has to be added to improve the primary production. Fertilization enhanced the optimal algal bloom in the ponds and the transparency in the ponds ranged from 33 to 36 cm. During the culture period lime has been used to maintain the pH and algal bloom and chain dragging should be done dailybefore stocking of seeds (Gunalan *et al* 2011; Soundarapandian and Gunalan 2008). PCR negative specific pathogen free seeds are stocked after proper acclimation temperature, salinity and pH. The shrimp will noticed by after 30 days of culture through cast net (sampling). The shrimps are fed with protein rich feed. Once the shrimps rich the size of 25 to 30 grms the harvest will be takes place.

Scope and opportunity

Since its look like small industry but there is lot of scope and opportunity in shrimp culture industry. For eg; brood stock supply, hatchery, feed companies, chemical companies, aerator manufacture, pumping motor manufactures, research field, laboratories etc., were involved in this industry which in turn provide job opportunities to many of the many people. India is now become a largest shrimp producer in world.

Conclusion

Shrimp culture industry indirectly control the nutrition deficiency (more than two billion people),control the over exploitation or conserve the wild stock, no need to depend on the capture fishery, providing employment opportunity and supporting the Blue economy.

Chapter III

Fish Nutrition, Feeds and Feeding -An Aquapreneur's Perspective

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Introduction

Over the years, the annual growth rates in the Indian inland Aquaculture sector (4.35%) and Marine (-3.2%) have been fantastic, presenting an opportunity for investors to invest and grow with the sector. India earned around Rs. 56,000 crore during 2021-22 by exporting various aquaculture, mainly shrimp. Traditionally India has been a carp cultivating country. However, the pressure to increase productivity from the ever-reducing land holdings has pushed the sector to go for input-intensive culture systems. World over the share of unfed aquaculture has reduced to 30.5%, increasing feed-based aquaculture by 10% in 2016.

On the other hand, sustainability is a critical issue in achieving optimum production year after year. This has to be done by meeting consumers' demand, achieving food safety standards, environmental concerns, legislation, and regulations and still generating profitin the end. It means that the people involved in this sector must have knowledge and skill set other than the production technology to succeed.

The basics of fish farming and feed

The success of farming largely depends on the right soil and water quality, pond environment and adequate feed. The primary effort to increase productivity is high stocking density with a high degree of management. In this scenario, the natural fish food is not enough to support the biomass of the stocked fish. Thus, exogenous feeding is necessary to meet nutritional requirements, achieve optimum growth, and enhance reproductive efficiencies with minimum mortality. In the case of ornamental fish production, feeding is the key element for colouration in fish.

Reportedly, about 30 high-tech feed mills are currently operating for fish feed production, providing employment opportunities for skilled /non-skilled workers in Indiawith a collective installed capacity of 2 MMT per annum. About 1 MMT of fish feed was sold in 2018, indicating a feed mill utilization capacity of 50 percent.It is estimated that only 10 to 15 percent of Indian freshwater fish have been brought under feed-based farming. During 2015-2020, 30 feed mills with 6-10 ton/hr capacity were sanctioned by the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, covering 11 states under the Blue revolution Scheme. This shows the intent and drive of the government agencies to ramp up aquaculture production in a big way in the near future. This presents an opportunity for entrepreneurs rather aquapreneurs to be part of the revolution to increase productivity providing employment opportunities, thereby boosting the rural economy.

Role of Entrepreneurship development in Aquaculture:

The success story of aquaculture in Andhra Pradesh can be primarily attributed to the farmers' entrepreneurship spirit. Many of these farmers have previous experience of serving in different industry sectors. Thus, they bring in lots of those of entrepreneurship skill set to the sector. Entrepreneurship development in rural farming activities like fish farming is the best possible alternative to find employment avenues for the rural population, especially for small-scale farmers and farm youths in rural development.

Entrepreneur & Entrepreneurship

The word ***Entrepreneur*** is derived from French word “entrepreneur” which means “to do something”. Joseph Schumpter regarded the entrepreneur as an innovator with potentialities of doing things in a new way. According to McClelland, an entrepreneur is “someone who exercises some control over the means of production and produces more than what he/she can consume to sell it for profit”. Entrepreneur is essentially an innovator who introduces new combinations, creating business despite risk for achieving profit and growth by availing opportunities and assembling the necessary resources to capitalize on them. ***Entrepreneurship*** is the process of identifying and utilizing available opportunities and resources to convert an idea into the form of a product or service to market.

Entrepreneurship Development

The primary objective of entrepreneurship development is to develop the man and competencies required to initiate, manage, and expand the entrepreneurial activity. It involves applying focused strategies to mould new ideas to create a product or service that satisfies customers’ needs or solves their problems. It is the name given to the factor of production which performs the function of “Enterprise”. Out of the five factors of production i.e. land, labour, capital, organization and enterprise, organization does the work of coordination between different factors and makes the production possible by taking upon itself the risk or, more appropriately, the uncertainty of output. In light of the cooperative approach, details of entrepreneurship development process are discussed below-

Managerial Practices in a Feed based Enterprise

The following managerial activities are essential for managing an aquaculture feed manufacturing enterprise-

Planning: Involves selecting objectives and strategies, policies, programmes and procedures for achieving them. It also requires a market survey to identify feed demand, type, and the competing players in the market. Determination of a competitive affordable price at which a farmer is ready to buy your feed is essential to gain foot hall in the market.

Organizing: Involves establishing different roles through determining activities required to achieve the goals, grouping activities, delegating authority and coordination, etc.

Staffing: It assures the optimum utilization workforce and manpower and its associated activities. Proper identification and hiring of skilled manpower from the various fisheries colleges and other institutions is necessary.

Leading: It acts in terms of addressing the desire, attitude, and behaviour of individual and groups amidst challenges towards opportunities.

Controlling: It measures and correct staff activities to ensure that events are in consonance with the growth plan of the enterprise.

Finance: It is the main sustenance of initiating an entrepreneurial venture. An entrepreneur can get credit for the enterprise by ensuring the required faith, credibility, and strength. Funding opportunities from various funding agencies like NABARD, nationalised banks, NFDB etc should be explored.

Quality Control: It determines the future of one's aspirational climb up. For example, good quality feed creates a good market and the concerned enterprise gets long-term profit.

Market Linkage: Should be diligently built up by making the produced feed cost competitive, unique and indispensable before the farmers.

Alternate Opportunity: It is a second plan or parallel enterprise contrary to the actual enterprise.

Distinguish consumer trends in advertising-Differentiate types of social media platforms for marketing to develop a strategic social media plan and create content for social media engagement.

Basics of fish nutrition and feed manufacturing

Feed formulation is the process of selecting and blending the appropriate feed ingredients to produce a diet with essential nutrients. No single ingredient can meet all nutrient requirements of cultured organisms. By selecting various ingredients in correct amounts, a compounded ration, which is nutritionally balanced, pelletable, and easy to store, can be prepared. Providing adequate nutrition for various aquaculture species involves the formulation of diets containing all essential nutrients and the proper management of multitude of factors relating to diet quality and intake. Therefore, various information is required for formulating an ideal diet.

Pre-Requisite Information for Feed Formulation

1) Nutrient requirements of the species to cultivate 2) Feeding habit of the species 3) Locally available feed ingredients, costs and nutrient compositions 4) Digestibility of feed ingredients 5) Inclusion levels of ingredients in the formula 6) Feed additives needed 7) Type of feed processing desired or type of diet 8) pellet stability.

1. Nutrient Requirement

Before feed formulation, information of nutrient requirement of fish and prawn as per their life stages should be ready in hand. Protein and amino acids, lipid and fatty acids, carbohydrates, minerals, and vitamins are different nutrients required for fish and prawn.

The optimum dietary crude protein level ranges from 30-45%. Although no clear differences between the species have been reported, protein requirements decrease with increasing fish size. While young fish (below 1g) appear to require 40 to 45% protein in their diets, older fish (>5g) appears to need 30 to 35% protein. Depending on the quality and quantity of dietary protein, the requirement of dietary lipid, which contain the appropriate levels of essential fatty acids, should range from 5-8% and 3-8% for carps and freshwater prawn, respectively. Lipid requirement for carnivores may ranges from 6-12%. Generally, fish has a limited capacity to utilize dietary carbohydrates. However, carbohydrate utilization is more in herbivores and omnivores than the carnivores. In general, carnivores cannot utilize more than 20 % of dietary carbohydrates, including crude fibre, up to 25% carbohydrate can be incorporated in the carnivore diet. Herbivores and omnivores can utilize about 25-40% carbohydrate including crude fibre (CF). Protein, lipid and carbohydrate are the energy source of animals. Fish diet should have optimum protein: energy ratio (P: E). P:E is higher in small fishes. Commercial grade vitamin premix is generally used in feed preparation, which ranges between 1-2 % for carp and prawn diet. Commercial grade mineral premix is generally used to prepare feed, which should not exceed the inclusion level of 2% for carp and prawn diet.

2. Feeding Habit of Fish and Prawn

In general, some fishes feed on mainly plant ingredients with a very few part of animal ingredients (herbivorous fish), some on mainly animal ingredients with a very few part of plant ingredients (carnivorous fish), some both on plant and animal ingredients equally (omnivorous fish) and some solely on plankton throughout life (planktonivorous). Generally, prawns are “omnivorous scavengers” or “detritus feeders”.

3. Feed Ingredients (Availability, Cost, Chemical Compositions)

Broadly the feed ingredients can be classified as energy (<20% protein) and protein-rich (>20% protein) ingredients. As per the origin, it is categorized as plant ingredients and animal ingredients. As per the quality is concerned animal protein is better than plant protein. Ingredients should be selected in a formulation on the basis of local or regular availability and cost without much more deviation of quality of feed. These information should be gathered on the basis of regular survey. The feedstuff composition varies regionally, seasonally and with soil fertility and the type of processing and storage method adopted. Therefore, each batch of feed ingredients should be analysed for actual nutrient content before feed formulation.

4. Digestibility of Ingredients

Determination of digestibility is a tedious and time-consuming process. General digestibility values for most of the ingredients are presently available in public domain and are often used in feed formulation.

5. Inclusion Levels of Ingredients

In all fish feed formulations, limits are placed on the levels of certain ingredients, irrespective of cost. These limits may be upper limits, lower limits or fixed limits, meaning that the level of an ingredient is set at a fixed percentage. Upper limits are often placed on ingredients which may contain antinutritional factors or toxicants on ingredients which affect the palatability or pelletability. Lower limits are placed on ingredients which are desirable in the formulation despite their cost. For example fish meal may be an expensive source of protein in feed formulations, and replacing fish meal with rendered animal proteins may reduce the feed cost. In general carp diet should contain 40 to 45% protein rich ingredients, 45 to 50% carbohydrates rich ingredients and the rest fulfilled with lipid-rich and other ingredients.

6. Feed Additives

The increasing diversity of additives is being used in animal feedstuffs, including synthetic amino acids, vitamins, binders, antioxidants, preservatives, prophylactic medicines, hormones and growth promoters. The major synthetic amino acids such as L-lysine and DL-methionine may be supplemented at the rate of 0.05% level. Vitamin and mineral premix available for poultry feed can also be used for fish feed and is added at levels ranging from 0.5 – 4% and 1% of the diet, respectively. Binders such as carboxymethylcellulose (CMC), hemicellulose, bentonites, agar, carrageenin, collagen, guargum etc. may be added at 1-2% level in the diet. Starch as binder can be added at 20% level in the diet. The commercially available antioxidants such as BHT (butylated hydroxytoluene), BHA (butylated hydroxyanisole) and ethoxyquin at 0.5% level can be added in the diet to prevent rancidity of lipid in the diet.

7. Pellet Stability

In practical fish farming, pellet stability influences the success of aquaculture. The formulation can improve pellet stability by including certain binders mentioned above. In contrast to the carps, pellets produced for slow-eating crustaceans must remain in water for hours without disintegrating. This requires special formulations and/or manufacturing processes.

Flow diagram of Preparation of Diet

Selection of feed ingredients ⇒ Feed formulation ⇒ Grinding

⇓

Mixing

⇓

Mixing of vitamin mineral premix and additives ⇐ Cooling ⇐ Cooking ⇐ Dough Preparation

⇓

Pelleting ⇒ Pellet Drying ⇒ Storage

Manufacturing

The broad categories of feed are –

Micropellets- Very small, accurately cut, floating or sinking pellets starting at 0.8 mm, for feeding ornamental fishes and larvae.

Floating feeds- Pellets with moderate protein and fat contents for feeding warm-water species such as tilapia, catfish etc

Sinking feeds- Pellets with high protein and fat contents, high water absorption rate, and high water stability sink slowly in saline water.

Shrimp pellets- Fast-sinking pellets retain their elastic structure even after hours in the water

Raw material

The capacity for raw material intake in an aquafeed mill shall be 2~3 times its production capacity. For materials of different properties, a special cleaning operation should be carried out where it is received.

Grinding

As the pretreatment of fine-grinding in feed production, primary grinding (or coarse grinding) is designed to diminish the difference and the variation of ingredient particle size, to improve the operational performance and efficiency of the pulverizer and to ensure constant quality of finished products. Several grinding equipment for fish feed grinding include hammer mill, vertical hammer mill, water-drop crushing machine, micro-grinding machine and ultrafine grinder. Hammer mill has high efficiency when using the 2, 4mm sieve pore to process feed materials into particles with a size of 1200 µm; its 1 mm sieve pore can process materials into particles with a size of 500-600 µm which is the right particle size for the adult freshwater fish. Vertical hammer mill has a higher working efficiency than hammer mill because it has a rotor working as a fan, but it is not good at fine grinding. Water-drop crushing machine has a crushing chamber employing double-grinding design. It can complete coarse, fine and micro grinding with 15% rise in capacity and particle size of 100-500μm. It is the first-choice machine for general fish feed crushing.

Proportioning and batch mixing

The major ingredients in aquafeed formulation, are batched by an electronically controlled proportioning system, and then sent for primary mixing. Primary proportioning and batch mixing is done to limit the variation of material particle size before ultra-fine grinding, to further ensure thequality.Horizontal-type helical blade mixer and double-shaft paddle mixer are used for this purpose.

Extrusion and drying

Conditioning

Preconditioning is used to condition the material before the follow-up extruder cooking stage so as to supply the extruder with homogenous and hydrated material by mechanical stirring and adding steam. With the blending movement of conditioner paddles, the moisture content of mash is uniform, and the temperature is steady eventually.Fish feed conditioning also gelatinize starch, denature the protein, soften the raw material by heat-moisture treatment to fish feed pellet with high stability and digestibility.

Extrusion

Extrusion process is mainly performed by an extruder having a stationary barrel housing in which as segmented screws and shearlocks rotates, fulfilling extrusion operation together with a disc and knife assembly. Two kinds of extruders might be used in aquafeed production: the single-screw extruder and the twin-screw extruder.

Single-screw extruder: A single-screw extruder has only one extruding screw and is of simple structure, so its price is relatively lower. The single-screw extruding technology has become mature, and the operational performance is relatively stable and reliable. Generally, single-screw extruders are widely used for producing feeds for low-protein adult fishes such as tilapia, catfish fish, grass carp, etc.

Twin-screw extruder: The twin- screw extruder has wide adaptability, sliding conveying in the barrel, self-cleaning function, etc. However, it is relatively expensive. Therefore, the twin-screw extruder is usually used in the production of feed for high-value fish. For other special feed production like the production of micro feed (pellet size: Φ0.8~1.5mm), oil-rich feed and the feeds with changeable formulas, the twin screw extruder is of immense utility.

Drying

Drying step is required to remove the excess water and return the product back to a shelf-stable moisture condition. A crossflow dryer is used for drying wet extrudates, in which moisture and heat of product is exchanged with a perpendicular airflow.

Coating and cooling

Lipids, flavours, and vitamins is added to extruded feeds after drying. After liquid application by coating will not only avoid the risk of damaging heat-sensitive ingredients, but also improve the palatability and reduce crumbling of the finished product.

Bagging

The amount of air entrapped in the bag should be controlled to a minimum to prevent feed from oxidation and deterioration. Therefore, the bag is closed with sewing plus heat sealing (plastic film lining), which can prolong the shelf life of feed by 50-100%.

Conclusion

The time for entrepreneurs to participate in aquaculture activities has come with the Government promoting the sector in a big way. With the ever-increasing demand for fish due to changes in food habits, increasing purchasing power, and the designation of fish as healthy food, the future looks good for the Indian aquaculture sector.

Chapter IV

GOVERNMENT SCHEMES AND INVESTMENTS FOR AQUAPRENEURS IN INDIA

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Pradhan Mantri MatsyaSampada Yojana - A scheme to bring about BlueRevolution through sustainable and responsible development of fisheries sector inIndia

1. Background

1) Fisheries and aquaculture are an important source of food, nutrition, employment andincome in India.The sector provides livelihood to about 16 million fishers and fishfarmers at the primary level and almost twice the number along the value chain. Fishbeing an affordable and rich source of animal protein, is one of the healthiest optionstomitigatehungerandmalnutrition.

2) The Gross Value Added (GVA) of fisheries sector in the national economy during2018-19 stood at Rs 2,12,915 crores (current basic prices) which constituted 1.24% ofthe total National GVA and 7.28% share of Agricultural GVA. The sector has immensepotential to double the fishers and fish farmers' incomes as envisioned by governmentandusherineconomicprosperity.

3) Fisheries sector in India has shown impressive growth with an average annual growthrate of 10.88% during the year from 2014-15 to 2018-19. The fish production in Indiahas registered an average annual growth of 7.53% during last 5 years and stood at anall-time high of 137.58 lakh metric tons during 2018-19. The export of marine productsstood at 13.93 lakh metric tons and valued at Rs.46,589 crores (USD 6.73 billion)during2018-19.

4) Foreseeing the immense potential for development of fisheries and for providingfocused attention to the sector, the Government in its Union Budget, 2019-20 has announced a new scheme, the Pradhan Mantri Matsya Sampada Yojana(PMMSY).

2. PMMSYSCHEME

1) **Pradhan Mantri MatsyaSampada has been approved at a total estimatedinvestment of Rs. 20,050 crores to be implemented over a period of 5 yearsfromFY2020-21 toFY2024-25.**

2) The schemeintends to address critical gaps in fish production and productivity,quality, technology, post-harvest infrastructure and management, modernisation andstrengthening of value chain, traceability, establishing a robust fisheries managementframeworkandfishers' welfare.

3) The PMMSY is an umbrella scheme with two separate Components namely (a)Central Sector Scheme (CS)and(b)CentrallySponsoredScheme(CSS).TheCentrallySponsoredScheme(CSS)ComponentisfurthersegregatedintoNon-beneficiaryorientedandbeneficiaryorientatedsub-components/activitiesunderthefollowingthreebroadheads:

   (i) EnhancementofProductionandProductivity
   (ii) InfrastructureandPost-harvestManagement
   (iii) FisheriesManagementandRegulatoryFramework

3. AIMSANDOBJECTIVES

TheAimsandObjectivesofthePradhanMantriMatsyaSampadaYojana(PMMSY)are:

(a) Harnessingoffisheriespotentialinasustainable,responsible,inclusiveandequitablemanner
(b) Enhancing of fish production and productivity through expansion,intensification,diversificationandproductiveutilization oflandand water
(c) Modernizing andstrengtheningofvaluechain- post-harvestmanagementandqualityimprovement
(d) Doublingfishersandfishfarmersincomesand generationof employment
(e) EnhancingcontributiontoAgricultureGVAandexports
(f) Social,physicaland economicsecurityforfishersandfishfarmers
(g) Robustfisheriesmanagementandregulatoryframework

4. IMPLEMENTATIONSTRATEGYAND ACTIVITIES

PMMSY will be implemented as an umbrella scheme having both Centrally

SectorComponents and Centrally Sponsored Scheme Components. It would focus on allround development ofFisheriessector through a bunch ofdiverseinterventionsalongthefisheriesvaluechainrightfromproductiontoconsumption.

5. FUNDINGPATTERN:

PMMSYwillbeimplementedwiththefollowingfundingpattern.

CentralSector Scheme(CS)

(a) Theentireproject/unitcostwillbebornebytheCentralgovernment(i.e.100%c entralfunding).

(b) Whereverdirectbeneficiaryorientedi.e.individual/groupactivitiesareundert aken by the entities of central government including NFDB, the centralassistance will be up to 40% of the unit/project cost for General category and60%forSC/ST/Womencategory.

CentrallySponsoredScheme(CSS)

CSScomponentandsub-componentsimplementedbytheStates/UTs(**Non-beneficiary orientated**):The entire project/unit cost will be shared between CentreandStateasdetailedbelow:

a) NorthEastern&HimalayanStates:90%Centralshareand10%Stateshare.
b) OtherStates:60%Centralshareand40%Stateshare.
c) UnionTerritories(withlegislatureandwithoutlegislature):100%Centrals hare.

CSS component and sub-components implemented by the States/UTs (**Beneficiaryorientated i.e. individual/group activities**). The Government financial assistance ofbothCentreandState/UTsgovernmentstogetherwillbelimitedto40%oftheproject/ unitcostforGeneralcategoryand60%oftheproject/unitcostforSC/ST/Women. This governmental assistance will in turn be shared between CentreandState/UTs inthefollowingratio:

a) TheNorthEastern&theHimalayanStates:90%Centralshareand10%Stat eshare.
b) OtherStates:60%Centralshareand 40%Stateshare.

6. UnionTerritories(withlegislatureandwithoutlegislature):100%Centralshare.MAJ ORIMPACT,INCLUDINGEMPLOYMENTGENERATIONPOTENTIAL

An investment of Rs 20050 Crore under PMMSY is the highest ever in Fisheries andAquacultureSector.Therefore,theschemesetsanambitioustargets.Theanticipatedoutcomesonaccountofimplementationof PradhanMantriMatsyaSampadaYojana(PMMSY)inquantifiabletermsareas below:

(a) Thefishproductionislikelytobeenhancedfrom13.75millionmetrictons(2018-19)to22millionmetrictonsby2024-25.
(b) Asustainedaverageannualgrowthofabout9%infishproductionisexpected.
(c) Anincreaseinthecontribution of GVA of fisheries sector to theAgricultureGVAfrom7.28%in2018-19toabout9%by2024-25.
(d) DoubleexportearningsfromthepresentRs.46,589crore(2018-19)toaboutRs.1,00,000croreby2024-25.
(e) Enhancement of productivity in aquaculture from the present national averageof3tonnestoabout5tonnesperhectare.
(f) Reduction of post-harvest lossesfromthereported 20-25% toabout10%.
(g) Doublingofincomesof fishersandfishfarmers.
(h) Generation of about 15 lakhs direct gainful employment opportunities andthrice the number as indirect employment opportunities along the supply andvaluechain.
(i) Enhancement of the domestic fish consumption from about 5 kg to about 12kgpercapita.
(j) Encouragementofprivateinvestmentandfacilitationofgrowthofentrepreneurshipinthefisheriessector.

7. BENEFICIARIES

The intended beneficiaries under the Pradhan Mantri Matsya SampadaYojana(PMMSY)amongsttheothersincludethefollowing:

TheintendedbeneficiariesunderthePradhanMantriMatsyaSampadaYojanaare:

(i) Fishers
(ii) Fishfarmers
(iii) FishworkersandFish vendors
(iv) FisheriesDevelopmentcorporations
(v) SelfHelpGroups(SHGs)/JointLiabilityGroups(JLGs)infisheriessector
(vi) Fisheriescooperatives
(vii) FisheriesFederations
(viii) Entrepreneursandprivatefirms

(ix) FishFarmersProducerOrganisations/Companies(FFPOs/Cs)
(x) SCs/STs/Women/Differentlyabledpersons

8. ENDIMPLEMENTINGAGENCIES(EIAS)

(i) Central Government and its entities including National FisheriesDevelopmentBoard
(ii) State/UTGovernmentsandtheirentities
(iii) StateFisheriesDevelopmentBoards
(iv) Any other End Implementing Agencies as notified by DepartmentofFisheries

BENEFICIARYORIENTEDSUB- COMPONENTS AND ACTIVITIES PROPOSED UNDER THE CENTRALLY SPONSORED COMPONENTS OF PRADHAN MANTRI MATSYASAMPADA YOJANA

A **ENHANCEMENTOFPRODUCTIONANDPRODUCTIVITY**

1 DevelopmentofInlandFisheriesAnd Aquaculture

1.1 EstablishmentofNewFreshwaterFinfishHatcheries
1.2 EstablishmentofNewFreshwaterScampiHatcheries
1.3 ConstructionofNewRearingponds
1.4 ConstructionofNewGrow-outponds
1.5 InputsforfreshwaterAquacultureincludingCompositefishculture,Scampi,Pangasius,Tilapi aetc.
1.6 Establishmentofneedbased NewBrackishHatcheries(shellfishandfinfish)
1.7 ConstructionofNewpondsforBrackishWaterAquaculture
1.8 ConstructionofNewpondsforSaline/Alkalineareas
1.9 InputsforBrackishWater Aquaculture
1.1 InputsforSaline/AlkalineWaterAquaculture
1.11 Stockingof Fingerling(FL)inWetlands@2000FL/ha
1.12 StockingofFingerlingsinReservoirs@1000FL/ha

2 Developmentofmarinefisheriesincludingmaricultureandseaweedcultivation

2.1 EstablishmentofSmallMarineFinfishHatcheries
2.2 Constructionof largeMarineFinfishHatcheries
2.3 MarineFinfishNurseries
2.4 Establishmentof OpenSea cages(100-120 cubicmetervolume)
2.5 EstablishmentofSeaweedcultureraftsincludinginputs
2.6 Establishment of Seaweed culture with Monoline/tubenet Method including inputs(oneunitisapproximatelyequalto25ropesof25mlength)
2.7 Bivalvecultivation(mussels,clams,pearletc.)

3	**Development of fisheries inNorth-eastern and Himalayan States/UTs(besidesthe below activities, the North-eastern and Himalayan States/UTs will also beassistedunder other sub-components/activities envisagedunder PMMSY thatarecommon to allstates/UTs).**
3.1	EstablishmentofTrout FishHatcheries
3.2	ConstructionofRaceways
3.3	InputsforTroutRearing Units
3.4	ConstructionofNewPondsinHimalayanRegion.
3.5	EstablishmentofMiniRASforColdwaterFisheries
3.6	EstablishmentofMediumRASforcoldwaterfisheries
3.7	InputsupportforIntegratedfishfarming(paddycumfishcultivation, livestockcumfish,etc)
3.8	EstablishmentofCagesincoldwaterregions
4	**Developmentofornamentalandrecreationalfisheries**
4.1	BackyardOrnamentalfishRearingunit(bothMarineandFreshwater)
4.2	MediumScaleOrnamentalfishRearingUnit(MarineandFreshwaterFish)
4.3	Integrated Ornamentalfish unit(breedingand rearingforfreshwaterfish)
4.4	Integrated Ornamentalfishunit(breedingandrearingformarinefish)
4.5	Establishmentof FreshwaterOrnamentalFishBroodBank
4.6	Promotionof RecreationalFisheries
5	**Technologyinfusionandadaptation**
5.1	Establishmen to flarge RAS (with8tanksofminimum90m3/tankcapacity40ton/crop)/Biofloc (50tanks of4mdiaand1.5high)culturesystem.
5 .2	EstablishmentofMedium RAS(with6tankofminimum30m3/tankcapacity10ton/crop)/Bioflocculturesystem(25tank s of4mdiaand1.5high)
5.3	Establishmentofsmall RAS(with1tankwith100m3capacity/Biofloc(7tanksof4mdiaand1.5high) culturesystem
5.4	Establishmentof BackyardminiRASunits
5.5	InstallationofCagesinReservoirs
5.6	Penculture inopen waterbodies
B	**INFRASTRUCTUREANDPOST-HARVESTMANAGEMENT**
6	**Postharvestandcoldchaininfrastructure**
6.1	ConstructionofColdStorages/IcePlants
6.2	ModernizationofColdstorage /IcePlant
6.3	Refrigeratedvehicles
6.4	Insulatedvehicles
6.5	Livefishvending Centres
6.6	MotorcyclewithIceBox
6.7	Cycle with IceBoxes
6.8	ThreewheelerwithIceBoxincludinge-rickshawsforfishvending

6.9 FishFeedMills(mini)
6.1 FishFeedPlants
7 Marketsandmarketinginfrastructure
7.1 Constructionoffishretailmarketsincludingornamentalfish/aquariummarkets.
7.2 Constructionoffishkiosksincludingkiosksofaquarium/ornamentalfish
7.3 FishValueAddEnterprisesUnits
7.4 E-platformfore-tradingand e-marketingof fishandfisheriesproducts
8 Developmentofdeepseafishing
8.1 Supportforacquisitionof Deep seafishingvesselsfortraditionalfishermen
8.2 Upgradationof existingfishingvesselsforexportCompetency
8.3 Establishmentof Bio-toiletsinmechanisedfishingvessels

9 Aquatichealthmanagement
9.1 EstablishmentofDiseasediagnosticandqualitytestinglabs
9.2 DiseasediagnosticandqualitytestingMobilelabs/clinics

C FISHERIESMANAGEMENTANDREGULATORYFRAMEWORK

10 **Monitoring,ControlandSurveillance(MCS)**
10.1 Communicationand/orTrackingDevices fortraditional andmotorisedvesselslikeVHF/DAT/NAVIC/Transponders etc.

11 **Strengtheningofsafetyandsecurityoffishermen**
11.1 SupportforprovidingsafetykitsforfishermenofTraditionalandmotorizedfishingvessels(other thanCommunicationand/orTrackingDevicementionedat10.1above)
11.2 Providingboats(replacement)andnetsfortraditionalfishermen
11.3 SupporttoFishermenforPFZdevicesandnetworkincludingthecostofinstallationandmaintenanceetc.

12 **Fisheriesextensionandsupportservices**
12.1 Extensionand supportServices
13 **Livelihoodandnutritionalsupportforfishersforconservationoffisheriesresources**

13.1 Livelihoodandnutritionalsupportforsocio-economicallybackwardactivetraditionalfishers'familiesforconservationof fisheriesresourcesduringfishingban/lean period.
14 **InsuranceofFishingVesselsandFishermen**
14.1 Insurancepremiumsubventionforfishingvesselsand Insurancepremiumforfishers

Entrepreneur development scheme is operated by NFDB with the financial assistance of 25% limited to Rs. 1.25 lakh (general category) and 30% limited to Rs. 1.50 lakh (SC/ST/Women) for the entrepreneurs.

Fisheries and Aquaculture Infrastructure Development Fund (FIDF).

Fisheries and Aquaculture Infrastructure Development Fund (FIDF). FIDF envisages creation of fisheries infrastructure facilities both in marine and inland fisheries sectors and augment the fish production to achieve the targeted production. Besides, the FIDF aims to achieve a sustainable growth of 8-9 per cent, in a move to augment the country's fish production to the level of about 20 million tonnes.

The details of the unit cost for each component are given in the PMMSY guidelines. The guidelines can be downloaded from dof.gov.in and nfdb.gov.in

Apart from PMMSY and FIDF, MPEDA is having the financial assistance scheme for the establishment of nurseries, shrimp handling facilities, GIFT/Crab/Seabass farming and hatcheries for diversified species (Seabass/Mud Crab/GIFT)

Fishers and fish farmers can also avail the facility of Kisan Credit card.

Chapter V

Digitalised Business Intelligence in Management of Aquaculture Systems

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Introduction

There is increasing depletion of wild fish stocks globally, where fish is an important source of high protein products and omega 3 (FAO, 2020). Aquaculture has been one of the fastest growing food sectors in agriculture globally (Tahar, Kennedy, et al., 2018; 2018b; FAO, 2020). Xia et al. (2022) noted that aquaculture has produced more fish for human consumption than wild-caught fish. The sustaining increase in aquaculture has been positively influenced by new technological developments where there is a pressing need to find appropriate solutions to meet growing world population that will reach approximately 10 billion by 2050 (FAO, 2020). Xia et al. (2022) highlighted potential disruptive solutions in the fishery and aquaculture in number of areas including alternative proteins and oils for fish meal, offshore farming, recirculating aquaculture systems, oral vaccination, genome editing, solar emerging and novel marketing strategies, disease mitigation technologies monitoring tools, artificial intelligence and blockchain for business model development including cybersecurity.

Table 1. Summary of some recent literature on usage and effects of ICTs in agriculture.

Reference	Country /findings	ICT tools
Chikuni and Kilima (2019)	In Lilongwe, Malawi, existing mobile phone-based MIS which entail users subscribing to SMS price alerts had insignificant effect on promoting smallholder farmers' participation in maize markets	Radio, mobile phone
Fafchamps and Minten (2012)	Market and weather information delivered by Reuters Market Light (RML) to farmers in India did not have significant effect on prices received, crop value added, crop losses resulting from rainstorms, or the likelihood of changing crop varieties and cultivation practices.	Mobile phone

Reference	Country /findings	ICT tools
Fu and Akter (2016)	The usage of the video-enabled mobile phone technology by small and marginal farmers in India improved their awareness and agricultural knowledge, as well as access to credit. The experience of using the services has made farmers feel more at ease with new technology and adapting to new things for life in the future.	Mobile phone
Khan et al. (2020)	Smallholder farmers of Muzafargarh district of Pakistan have benefited from mobile-based farm advisory services (mFAS) in terms of reduction in transportation cost, better decision making, and increased farm income.	Mobile phone
Mwombe et al. (2014)	In the Gatanga district of Kenya, the use of ICTs by small-scale banana farmers influenced the adoption of tissue culture (TC) bananas, while socioeconomic factors such as age, gender, income and acreage of bananas planted also influenced the intensity of use of ICT tools as a source of agricultural information.	Radio, Television, Video, Print Media
Okello et al. (2020)	In Tanzania, the use of ICT tools was interrelated, whereas several factors such as extension contacts, access to electricity, level of buyer trust, and availability of market information were associated with the likelihood of ICT use.	Mobile phone, television [TV], and radio
Quandt et al. (2020)	The use of mobile phone by maize farmers in Iringa Rural District of Iringa Region in southern Tanzania for agricultural activities significantly influenced maize yield.	Mobile phone
Tata and McNamara (2018)	In Kenya, extension officers using the Catholic Relief Services SMART skills and Farmbook (CSSF) technology were able to reach more farmers compared to extension officers not using the service. Also, extension workers trained in CSSF were likely to have spent more days in the field compared to extension officers not trained in CSSF.	Tablet computer

Reference	Country /findings	ICT tools
van Campenhout et al. (2017)	Watching agricultural extension videos significantly increased farmers' knowledge in Southwestern Uganda. In addition, video-based extension is most effective in contexts where farmers already have some idea about the techniques explained in the video.	Tablet computer
van Campenhout et al. (2020)	Providing information to farmers in eastern Uganda through a short video significantly increased farmers' knowledge about improved agricultural input use and recommended management practices, while the incremental effects of IVR and SMS were insignificant.	Mobile phone, tablet computer
Voss et al. (2021)	An ICT-enabled extension project (TICmbay) in Senegal did not have significant impact on farmers' adoption of the seed and fertilizer promoted in the project study area. The findings further showed that uptake of technology was skewed in favor of men, signaling a red flag on equity and effectiveness of ICT-enabled extension in promoting agricultural inputs in contexts like Senegal.	Radio, mobile phone
Zoundji et al. (2018)	In Mali, integrating video in extension services enhanced acquisition of knowledge and adoption of climate-smart agricultural practices among farmers	Television, DVD player

The main digital technologies relevant to food safety include

(a) IoT, cloud computing, bid data, machine to machine communication and remote sensing that enables rapid communication from across the global value chain (Misra et al., 2020; UK Food Standards Agency, 2021);

(b) AI, machine learning, digital twins that offer sophisticated analytics, diagnostics and predictive capabilities, self-monitoring capabilities, and smart machines that evaluate and diagnose issues without need for human intervention (Defraeye et al., 2021; UK Food Standards Agency, 2021); and distributed ledge technology (DTL) such as blockchain that facilitates the decentralization of databases across several location to provide secure, verifiable and auditable history of all information stored in the dataset (Rejeb et al., 2020; UK Foods Standards Agency, 2021).

Digital technologies used in fisheries and aquaculture

Health, nutrition and convenience are significant factors influencing the sustainable direction of the food industry globally (Nagarajarao 2016). Fish products have attracted considerable attention as a important source of protein, vitamins, minerals, and fats. However, as fish are very perishable, appropriate processing and packing is required to maintain their quality. Worldwide, a diversity of preservation methods are been applied and developed ranging from simple chill storage to more complex advances in high pressure and electromagnetic field application (Nagarajarao 2016). Food Standards Agency UK (2021) noted that agri-food industry is experience strong technology push, potentially bringing products and services to the market for the sake of the technology, rather than satisfying a consumer need. This organization considers that modern heavily processed foods and processes may remove the opportunity of immune-priming by making everything unnaturally clean, which is something to be mindful in terms of health for the long term. Digital technologies can transform food processing by enabling end-to-end monitoring that can inform standardization of approaches including incremental innovative steps.

Marvin et al. (2017) noted the relevance of consumer-facing apps that support access to food data and information for decision making that has a nexus to social media, education and early warning systems. Rejeb et al. (2020) reported that their remains challenges with implementation, validation and regulation of digital technologies. Technical integration and interoperability across the worldwide supply chains is complex and be impeded by lack of infrastructure, lack of standardization and harmonization, and data integrity and data security risks (Agency, 2021; Feng et al., 2020; UK Food Standards; Galanakis et al., 2021).

Rowan (2019) had reviewed the disruptive potential of pulsed UV with particular emphasis on contact surface disinfection for foods and for packaging where there is a lack of international consensus on defined parameters and disinfection performance for this technology that could be informed by cloud-edge computing, AI and machine learning. Emergence of new studies on the use of novel bioactive in edible and non-edible packaging films such as use of plant antioxidants and antimicrobials for seafood is becoming increasingly popular (Oreopoulou and Tsironi, 2022).

The UK Food Safety Authority (2021) intimated that emerging disruptive technologies may arise in active packaging, intelligent and smart packaging, novel nanotechnology packaging films, biodegradable and edible films, and reusable and zero packaging. Masterson et al. (2021) also reported on the use of a mild-temperature extrusion process suitable for combining and treating heat-sensitive bioactives that can have potential applications in fish and seafood packaging. The develop of algorithms and machine learning for the future real-time assessment and modelling of shelf life of processed fish will advanced the field of sustainable food processing (Tsironi et al., 2021).

Relative to other sectors, the food industry has been relatively slow to adopt digital technologies that includes discrete applications at the field, farm and factory level including automation, robotics and performance monitoring where the emphasis has been placed on process optimization (Food Standards Agency UK, 2021). Innovate new internet-embedded food distribution and services have been developed at the consumer level. Digital technologies have been applied at an integrated systems level to connect stakeholders at all stages of the value chain and to secure the gap-less digital traceability of food items for farm to fork, such as use of blockchain (UK Food Standards Agency, 2021).

The UK Food Standards Agency (2021) stated that digital technologies that impact on consumers and food safety can be grouped as:
(a)Digital technologies that are applied directly to food production processes (such as sensor-based agriculture, traceability, scanning technologies for contaminant detection, monitoring of producing and delivery, smart packaging), where resulting flow of information is based on input of data collected from the actual food item.

(b)Digital technologies generating information relevant for food from input data not directly collected form that actual food item – such as that used for supporting decision making and influencing consumer choices (such as genomics or bioinformatics data).

(c)The platforms used for aggregating data, transmitting data securely, record keeping, and decision making either autonomously or with human input.
Among the background of developments in automation and intelligence, machine learning technology has been extensively applied in aquaculture in recent years, providing a new opportunity for the realization of digital fishery farming.The AM Resilience Project recently developed a comprehensive theoretical framework for the design, implementation, assessment and evaluation of effective AMR interventions in socioecological systems, and further proposed a One Health platform to systematically gather evidence of interventions.

Table-2.Digital technologies used in fisheries and aquaculture.

Digital Technology	Application	Supporting Reference
Robotics	➢ Address complicated tasks and laborious work, such as cleaning ponds and repair damaged nets ➢ monitoring behaviours, removing diseased fish, feeding ➢ injecting vaccines, ➢ unwater inspections of nets, evaluating fish health and escapes	Lucas et al. (2019) Kruusmaa et al. (2020) Sun et al. (2020)
Drones	➢ Monitor fish farms above and below water ➢ Check holes in damaged cages ➢ Data collection combining AI and cloud computing to improve	Sousa et al. (2019) Yoo et al. (2020) Weiss et al. (2020)

Digital Technology	Application	Supporting Reference
	aquaculture operations	
Sensors/Remote Sensing	➢ Collecting water parameters in real time ➢ Underwater sensors to monitor hunger levels of fish in ponds and cages ➢ Fish metabolism and heart rates ➢ Reduced wastage and improved feed rates	Antononucci& Costa, 2020 Xing et al. (2019)
AI	➢ Makes better and faster decisions ➢ Less labor intensive, ➢ Improved efficacy of feeders, water quality monitoring and control, harvesting and processing	Razman et al. (2020) Josthiswaran et al., 2020
Augmented Reality (AR)	➢ Teaching, training and education ➢ Improved production efficiencies, decreased costs ➢ Facilitates under water drones and robots ➢ Monitors fish behaviour, net holes and fish mortality ➢ Risk mitigation ➢ Measure water parameters	Jung (2019) Xi et al. (2019) Rowan et al. (2022)
Virtual Reality (VR)	➢ Real time simulation of environmental situations using digital interface (head sets) ➢ Teaching, training and education ➢ Used for high risk environments (remote) using human computer and multimedia platforms	Ferreira et al., 2012 Prasolova-Førland et al. (2019)
3D printing	➢ Printing hydroponic systems ➢ 3D verification devices ➢ 3D printed water sensors for monitoring water parameters	Clark, Moore, Wang, Tan, and McKinley (2012)

Digital Technology	Application	Supporting Reference
	➢ Reduced equipment and production costs	
IoT	➢ Connect big data across aquaculture industry ➢ Combined use of social media	Kamaruidzaman and Rahmat (2020)
Blockchain	➢ Cypersecurity, safe data sharing, ➢ Payment processing ➢ Industry protection ➢ Full traceability across value chain ➢ Reduce food wastage, improve food safety	Bodkhe et al., 2020 Altoukhov, 2020 Feng et al. (2020)

Way Forward

Digital technologies include cloud-edge computing, AI enabled drones, sensors and robotics, immersive technologies and blockchain. However, increasing converging efforts need to be made to create a greater awareness of the practical applications of digital technologies in order to advance the industry that is slow to adopt new innovation. While it is appreciated that the short to medium term deployment of digital technologies will improve efficiencies and speed of production for improved profitability and sustainability, there is also significant potential for use of AI, machine learning and robotics to unlock a wealth of innovation when one aligns these digital technologies with bioinformatics and next generation sequencing. Digital technologies can also inform novel processing of fish and seafood that includes potential for future automation, training and improved standardization. Thus, digitalization will support and enable our ability to make -informed decisions on the use and protection of our natural resources.

Chapter VI

INTEGRATED AQUAPONICS SYSTEM - COMMUNITY SUPPORTED AGRICULTURE

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When our ancestors tossed a few dead fish into the ground with their vegetable seeds, they were providing a great source of fertilizers. Since fish decay rapidly, their proteins and amino acids quickly turn into nitrogen which can be used by the plants. A 21st-century version of the plants/fish combination, Integrated Aquaponics System, uses live fish to supply the nutrients. This not only smells a whole lot better, it makes a lot of sense. You get three high value crops from the same space and the same amount of water - fish, vegetables and fruits. From small-scale hobby systems to subsistence scale domestic projects in protective shelters such as rain shelters and/or small polyhouses, integrating aquaculture with vegetable and fruit production has turned out to be a good way to increase commercial agricultural profits and improve food supplies in developing nations.

Integrated vegetable and fruits growing and fish farming polyculture systems have long been used in Far-Eastern countries such as China and Thailand. Farm wastes are commonly added as feed to fish ponds and fish are often cultured in flooded rice paddies. Horticulturists of North Carolina State University had demonstrated that fish and crops can be raised concurrently in an interconnected system to produce significantly higher yields than either system alone. There were several other studies done by other researchers on this subject. This presentation presents the basic definitions and a brief history of aquaponics food production technology, the establishment of Integrated Aquaponics Systems of various scales since its adoption in 2012 by NARDC (Nanniode Aquaponics Research and Development Center) at Nanniode, Palakkad, Kerala in India using a combination of different fish species namely Nile Tilapia, Giant Gourami, Asian Seabass, Anabas Cobojius, Macrobrachiumrosenbergii, Common Carp, Grass Carp, etc. as fed species and several types of vegetables and fruits as extractive species. Integrated Aquaponics System is the cultivation of fish, plants and fruiting trees together in a constructed, re-circulating ecosystem utilizing natural bacterial cycles to convert fish wastes to plant nutrients. This is an environmentally-friendly, natural food growing method that harnesses the best attributes of aquaculture, hydroponics, and organic agriculture without the need to discard any water or filtrate or add chemical fertilizers in solid/liquid form or the pesticides.

The advantages of linking crop production and the culture of fish are shared startup, operating, and infrastructure costs for recirculating tank waste nutrient and water removal by plants, thus reducing water usage and waste discharge to the environment; and increased profit potential by simultaneously producing two cash crops (McMurtry, 1984; Rakocy, 1999;

Timmons et al., 2002; Diver and Rinehart, 2010). The sand media surface used in Integrated Aquaponics System unlike in other aquaponics variants physically removes the suspended solid waste fraction from the aquaculture water. The soil ecosystem biologically transforms the fish 'waste' products (both the solids and solutes) into nutrient forms that vascular plants will assimilate. The plants perform the function of filter cleaners by extracting their nutrient from the soil and thereby limiting/preventing toxic accumulations. (McMurtry). Properly designed and well-managed integrated aquaculture systems may be considered environmentally responsible alternatives to field-grown vegetable production and wild-caught fisheries (Lim and Webster, 2006; Smither-Kopperl and Cantliffe, 2004; Timmons et al., 2002.) When these systems are combined, Aquaponics closely fits the definition of sustainable agriculture because it combines the production of plants and animals, integrates nutrient flow by natural biological cycles (nitrification), and makes the most efficient use of nonrenewable resources (Gold, 1999). Challenges to sustainability center around balancing the Integrated Aquaponic System environment for the optimum growth of three organisms, maximizing production outputs and minimizing effluent discharges to the environment.

Two principal applications of the integrated aquaponics system technology are readily apparent. One is as a small-holder activity using local inputs, providing food self-sufficiency plus a surplus for the cash market. A second application is as large-scale, commercial enterprise/s sited near population centers. Either approach could be combined with ongoing water conservation/harvesting, gardening, local-food or commercial greenhouse projects, planned or already in place. IAS technology is eminently applicable to the requirements of regions where water and/or land resource availability are dominantly limiting to food production. The shortage of fresh water and loss of prime agricultural lands to accommodate growing human populations will require the development of new crops and new agricultural systems to meet the demands for food, fiber, and fuel while reducing the environmental impacts of their production. The objectives of this presentation are also to identify the Community Supported Agriculture (CSA) opportunities and challenges affecting commercial Integrated Aquaponic System sustainability and to suggest avenues for research and demonstrations that will increase mass-scale adoption of this futuristic farming system by the agriculture community.

Chapter VII

BIOFLOC SYSTEMS AND ITS ROLE IN NUTRIENT CYCLING

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Aquaculture, is the rearing and cultivation of fishes or other aquatic organisms especially for human consumption. It is mainly the farming of aquatic organisms, including fishes, molluscs, crustaceans and aquatic plants. The farming also implies some form of intervention in rearing process to enhance production such as regular stocking, feeding and protection from predators (John, *et. al.,* 2019). Among rearing of different aquatic organisms, culturing of shrimps is the most important and profitable among all other cultivable aquatic organisms. For the past few decades, the culturing of shrimp was greatly affected by the disease out breaks. To solve this,different strategies can be brought up through different techniques, one of which is Biofloc Technology. It is a promising ecofriendly technique which promotes the retention of waste and its subsequently converts to biofloc as a natural food in the aquaculture system. Biofloc is the aggregation of microorganisms such as algae, heterotrophic bacteria, fungi, ciliates, flagellates, rotifers, nematodes and metazoans. These organisms uses up the nitrogen and convert to microbial proteins.

Biofloc Technology is considered as “Blue Revolution” in aquaculture. This technique is based on in situ microorganism production which plays the major roles such as maintenance of water quality (by up taking the nitrogen compounds), increasing nutrition, and also providing competition with pathogens. The technology in which the aggregates of microorganisms i.e., biofloc inoculum is used for the purpose of improving water availability, quality, prevention against disease and waste treatment is Biofloc technology. The basis of Biofloc technology are the bioflocs that are used, which is nothing but conglomerates if microbes, algae, protozoa and others together with detritus, dead organic particles. Bioflocs are porous, light and usually have a diameter of 0.1 to few mm (Avnimelech*et al.,* 2009). Biofloc technology is an eco-friendly process. In recent years, the biofloc technology has gained attention as it is known for high stocking densities with little to no water exchange (Avnimelech, 1999).In aquaculture, to maintain optimum water quality biofloc technology has become a sustainable technique and this can be achieved with presence of dense heterotrophic bacterial groups with the supplementation of carbon source to the water (Avnimelech*et al.,*1999; Crab *et al.,*2007).The biofloc present in the Culture tanks, though it contains more amount of microbes and other aggregates, it makes the culture or pond water clear by removing waste particles. The total suspended/ dissolved particles in the Biofloc tanks will be at normal levels usually. Increase in water turbidity and decreasing light penetration, may affect the growth of microalgae (Baloi*et al.*, 2012). Biofloc have dual function because they absorb accumulated dissolved nutrients that are inorganic, and thus it helps to maintain water quality, and are a food source for reared organisms (Avnimelech,1999,2007; Hari *et al.*, 2004; Ballester*et al.*, 2010).

The microorganisms present in the fish or shrimp ponds assimilate the inorganic nitrogen added through the feed and convert into microbial protein through adjustment of C:N ratio. The principle of biofloc technology involves removal of nutrients from the water and produces the microbial biomass, which can be used by the culture species which could be the additional source of food. The optimum C:N ratio (12-15:1) in an aquaculture system can be maintained by adding different carbon sources or reducing the protein percentage in the feed. Under the optimum C:N ratio, the inorganic nitrogen is immobilized into bacterial cell while organic substrates are metabolized. In a typical brackishwater pond, 20-25% of the fed protein is utilized by the fish or shrimp, rest of which goes for waste and contributes to the formation of ammonia and other metabolites, organic nitrogen in feces and feed residue.

Microbes plays an important role in biofloc treated culture tank waters by maintaining the water quality parameters, some microbes take part in nitrogen cycle since they have the ability of nitrogen fixation, and some take part in ammonification i.e., decomposing. The microbes present in culture tanks or ponds indirectly/directly influences the growth rate, food consumption rate, survival rate of fishes in culture. Sometimes presence of some pathogenic microbes leads to infections and mortality of fishes. Common microbes associated with the flocs are basically photoautotrophic microbes such as algae and heterotrophic microbes like bacteria, rotifers, ciliates, protozoans and nematodes (De Schryver*et al,*2008). Bacteria are responsible for the most of the uptake of Nitrogen and Phosphorus, and since bacteria assimilate more nutrients due to their higher surface -to -volume ratio they have an advantage over phytoplankton (Kirchman, 2000).

The maintenance of water quality in culture tanks is mainly by control of bacterial community (Wasave*et al.,* 2020). The microbial diversity associated with biofloc depends on the carbon sources and the cultured species (Ray *et al.,* 2009). Then different microbial community can be seen in different culture species. Then if there is a mixed culture of *Oreochromis niloticus*and *Pampus argenteus,* different kinds microbes can be observed when compared to microbes present in microbes present in culture tanks that has only *Oreochromis niloticus.* And also, the role of microbes in the culture tanks can be identified. In Biofloc technology, since the biofloc helps in clearing the wastes in Cultured tanks, the larger light penetration occurs. Sometimes, the larger light penetration in Biofloc treated culture tanks may improve the performance of the rearing organisms, but sometimes it may also result in the presence of potentially harmful organisms, such as filamentous bacteria (Ray *et al.*, 2009). Bacterial metabolization of carbohydrates removes inorganic nitrogen and produces protein, forming bioflocs of different sizes.

Advantages of biofloc system

1. Biosecurity of the culture system can be maintained with zero or minimal water exchange system.
2. Toxic metabolites like NH_3 and NO_2can be reduced by the heterotrophic bacteria.
3. Ecofriendly and easier to manage.
4. Protein usage is doubled as the shrimps eat feed and then harvest flocs.
5. Probiotic action.
6. Microbes in bioflloc stimulates the cellular and humoral immune components.
7. Reduces the cost of production by 15 – 20%

Disadvantages of biofloc system

1. Aeration and energy cost increases
2. Involves more technical expertise and better understanding of the system
3. Limited progress due to lack of proper facities.

REFERENCES

1. Avnimelech, Y.1999.Carbon/nitrogen ratio as a control element in aquaculture systems**.** **Aquaculture176**: 227–235.
2. Avnimelech, Y.2007.Feeding with microbial flocs by tilapia in minimal discharge bio-flocs technology ponds. **Aquaculture 264:**140–147.
3. Avnimelech,Y .2009. Biofloc technology-A practical guide book. The World AquacultureSociety. **Aquaculture 176:** 227-235.
4. Ballester, E.L.C., Abreu, P.C., Cavalli, R.O., Emerenciano, M., Abreu L. &Wasielesky. W. 2010. Effect of practical diets with different protein levels on the performance of Farfantepenaeuspaulensis juveniles nursed in a zero-exchange suspended microbial flocs intensive system. **Aquacult. Nutr., 16:** 163-172.
5. Baloi, M., Arantes, Schveitzer R. R., Magnotti C. &Vinatea L.2012. Performance of Pacific white shrimp Litopenaeusvannamei raised in biofloc systems with varying levels of light exposure. **Aquaculture Eng., 52:** 39-44.
6. Crab, R., Avnimelech, Y., Defoirdt, T., Bossier, P. and Verstraete, W. 2007. Nitrogen removal techniques in aquaculture for a sustainable production. **Aquaculture 270**:1-14.
7. De Schryver P, Crab R, Defoirdt T, Boon N and Verstraete W.2008.The basics of bio-flocs technology: the added value for aquaculture. **Aquaculture 277:** 125–137.
8. Hari, B., Madhusoodana K. J.T., Scchama, J.W. and Verdegem, M.C.J. 2004. Effects of carbohydrate addition on production in extensive shrimp culture systems. **Aquaculture 241:**179-194.
9. John, S.L., Paul C.S. and Craig S.T.2019. Aquaculture Farming Aquatics Animals and Plants. **Wiley Blackwell**
10. Kirchman, D.L.2000. Uptake and regeneration of inorganic nutrients by marine heterotrophic bacteria. In: D.L. Kirchman (ed.). Microbial ecology of the oceans, **Wiley-Liss, New York, 9**: 261-288.
11. Wasave, S.S., Chavan, B.R., Naik, S.D., Wsave, S.M., Pawase, A.S., Tibile, R.M., Ghode, G.S., Meshram, S.J. and Shivalkar, V.S.2020.Role of Microbes In Biofloc System: A Review.J. **Exp.Zool.India 23(1):**pp 903-906.

Chapter VIII

MICRO, SMALL AND MEDIUM ENTERPRISES APPROACH IN ORNAMENTAL AQUACULTURE

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Ornamental fish is a relatively small but active component of the international fish trade, which has seen unimaginable changes in the last decade, especially in terms of the changing pattern of entrepreneurship development and associated consequences in terms of marketing of ornamental livestock and accessories, especially during and after the COVID-19 pandemic. In India, collection of ornamental livestock for trade is entirely open access and unregulated. Most wild caught ornamental fish originating from India come from the Eastern Himalaya and Western Ghats, hotspots known for their remarkable freshwater biodiversity and endemism. In spite of all its merits, the sector has still been subject to indirect impacts of the pandemic through changing consumer demands, market access or logistic problems related to transportation and border restrictions. These have impacted the export competitiveness of this sector, directly affecting livelihoods of its stakeholders. Even though the present value of the domestic market for the ornamental fishery is estimated at about Rs.500 crores and its global trade estimated at $18-20 billion per year, the activity is still limited to some specific areas in West Bengal, Tamil Nadu, Kerala, Maharashtra, North-eastern States and the Islands. Therefore, it is the need of the hour is to assess the existing ground for implementation of the new policy initiatives under the present National Fisheries Policy, encouraging setting up of domestic ornamental units in every corner of the country to enhance the production, marketing, conservation of live gene pool and promoting microenterprises for livelihood security in the country as a whole. Effective “microfinance-based models” can be thereafter formulated to attract resource poor stakeholders into becoming entrepreneurs, as an effective initiative towards promoting awareness not only about production and conservation of ornamental livestock, but also about the aquarium servicing industry, which has tremendous potential in mitigating challenges in the post pandemic era.

India still remains a sleeping giant with a meagre contribution of 0.4% (1.4 million) to the global ornamental fish trade,wherein,if world trade of ornamental fish is estimated to be about Rs. 2000 crores, India's share is only an insignificant Rs. 15 crores. Export performance of Indian ornamental fish trade based on the data pertaining from 1991 to 2009 shows that the increasing trend of ornamental fish exports. Indian ornamental fish export registered a higher positive compound growth rate of 14.4% in terms of export value, 12.1% in terms of quantity exported and 2.1% in terms of unit value. Considering the existing potential, India can be considered as one of the gold mines. There are three major hubs of ornamental fish marketing and export, contributing substantially to the overall trading and marketing in ornamental fishes. About 90% of India’s exports are handled by the major hub in Kolkata followed by Tamil Nadu, Kerala and Mumbai, of which, the marketing hub in Chennai is gaining importance due to several public and private sector undertakings promoting marketing and trade in the region in recent years. Boost from agencies providing financial support such as Marine Products Export Development Agency(MPEDA),National Bank for Agriculture and Rural Development (NABARD), National Fisheries Development Board (NFDB) and research support can soon make India a major player in international ornamental fish trade. Increasing demand for ornamental fishes gradually paved the way towards its increasing global trade.

The Indian Microfinance Sector

Indian economy is growing strongly with the growth rate of 8.5% - 9% annually. India is emerging as one of the strongest developing economies in the world. On the other hand, 26% of Indian population lives below poverty line (BPL), and don't have proper source of income or employment to earn their daily bread. Govt. of India has been taking initiatives for development of Indians BPL by providing credit for their farming & small-scale industries, notable among which is the ornamental fish industry. The process of providing loans to small and marginal farmers in various denominations is called 'Microfinance'. Indian microfinance industry is emerging as one of the fastest growing industries in India due to the huge demand & supply mismatch. This demand & supply mismatch creates lots of opportunity for banks & financial institutions to come forward with their kitty of providing financial assistance in the form of small loans. According to a survey, there are about 75 million poor people in India who require credit support to meet their daily requirements; of this 60 million are rural & 15 million are urban. The annual demand for credit by the 75 million poor people is about $ 11billion; of this 64% is for consumption and 36% is for production.

In the pandemic era (2020), the government of India the Department of Fisheries, Government of India has launched a new flagship scheme of microfinance named as the Pradhan Mantri Matsya Sampada Yojana (PMMSY) at an estimated investment of Rs. 20,050 with an array of diverse interventions along the fisheries value chain from production to consumption. Out of this, the PMMSY reserves a whopping Rs.576 crores for development of the ornamental and recreational fisheries, under which, various types of backyard, medium scale and integrated ornamental fish breeding and rearing units are being promoted for both freshwater and marine ornamental fish species. Thereafter, revival of macro, small and micro enterprises (MSME Act of 2006 and revival in 2020 under Ministry of micro, small and medium enterprises), through promotion of corresponding scales of entrepreneurship in the manufacturing and services sector in India, saw the advent of revised microfinance criteria (for streamlining options for credit disbursement) through re-classification of micro, small and medium enterprises wherein, a micro enterprise was classified as an enterprise where the capital investment does not exceed one crore rupees and turnover does not exceed five crore rupees, a small enterprise, where the capital does not exceed ten crore rupees and turnover does not exceed fifty crore rupees and a medium enterprise, where capital does not exceed fifty crore rupees and turnover does not exceed two hundred and fifty crore rupees. An additional Rs.500 crore additional investment proposed under World Bank Scheme of PMMSY would catalyze about Rs.2500 crore microfinance additionally. Besides these, marketing infrastructure under FIDF and public sector investments would be catalyzing the growth of the private sector on its own to about Rs.10,000 crores. Therefore, this innovative vehicle called PMMSY is here to stay for promotion of microfinance in the fisheries sector and create a dent especially in ornamental fisheries sector, even though fisheries is a state subject.

There has been a breakthrough in promotion of various schemes implemented by the Ministry of MSME (Medium Small and Micro enterprises) & its organizations for mobilizing and channelizing human resources through effective "microfinance-based models" helping resource poor stakeholders towards becoming small entrepreneurs. Details may be referred at (FlipbookEnglishSchemeBooklet.pdf (msme.gov.in) with a snapshot provided below :

1. Prime Minister's Employment Generation Programme (PMEGP)

The scheme aims to provide financial assistance to set up self-employment ventures and generate sustainable employment opportunities in rural as well as urban areas. To generate sustainable and continuous employment opportunities to rural and unemployed youth as well as prospective traditional artisans and thereby halt occupational migration. This is a scheme suitable for skilled breeders or aquarium fabricators/ accessory dealers who are eager to set up micro or small enterprises just after acquiring skill development training.

2. 2nd Loan for up-gradation of the existing PMEGP/MUDRA units

With an objective to assist exiting units for expansion and up gradation, the scheme provides financial assistance to successful/ well performing units. • The scheme also caters to the need of the entrepreneurs for bringing new technology/ automation so as to modernize the existing unit.

3. Credit Guarantee Scheme for Micro & Small Enterprises (CGTMSE)

To encourage first generation entrepreneurs to venture into self-employment opportunities by facilitating credit guarantee support for collateral free / third-party guarantee-free loans to the Micro and Small enterprises (MSEs), especially in the absence of collateral.

4. Credit Linked Capital Subsidy Component (CLCS & TU Scheme)

The objective is to facilitate technology up-gradation in MSEs with state-of-the-art technology, with or without expansion and also for new MSEs which have set up their facilities by providing an upfront capital subsidy of 15 per cent (on institutional finance of upto Rs 1 crore availed by them).

5. Procurement and Marketing Support (PMS) scheme

To enhance the marketability of products and services in the MSME sector. To promote new market access initiatives, create awareness and educate the MSMEs about various marketing relevant topics. To create more awareness about trade fairs, digital advertising, e-marketing, GST, GeM portal, public procurement policy and other related topics etc.

6. International Cooperation (IC) Scheme

To enhance the competency of MSMEs, capture new markets for their products, and explore new technologies for improving manufacturing capacity, etc. • The scheme supports MSMEs by way of participation in international events for exploring export opportunities, access to international business networks, technology up gradation/modernization, improved competitiveness, awareness of better manufacturing practices etc.

7. Micro & Small Enterprises Cluster Development Programme (MSE – CDP)

To support the sustainability and growth of MSEs by addressing common issues such as improvement of technology, skills & quality, market access, etc. • To create/upgrade infrastructural facilities in the new / existing Industrial Areas / Clusters of MSEs. • To setup Common Facility Centres (for testing, training, raw material depot, effluent treatment, complementing production processes, etc). • Promotion of green & sustainable manufacturing technology for the clusters.

8. A Scheme for Promotion of Innovation, Rural Industries and Entrepreneurship (ASPIRE)

To set up a network of technology centres and incubation centres to accelerate entrepreneurship and promote innovation to further strengthen the competitiveness of MSME sector.

9. Digital MSME

To promote Information and Communication Technology (ICT) in MSME Sector by adopting ICT tools and applications in their production and business process. • The scheme is also aimed at creating awareness, supporting developments and e-platforms, creating literacy, training and promoting digital marketing in MSME sectors.

The MSME sector has been a major propellor for channelizing microfinance through the public sector to stakeholders and therefore can be predicted to be a major determinant of successful entrepreneurship development in fisheries and allied sectors in the country. Since ornamental fisheries is all about value addition, this industry needs certain innovative cues for it to benefit from microfinance, which have been elaborated in the talk.

Conclusion

All said and done, the post COVID era has seen lots of unemployment for daily wage and skilled personnel, which again can be a blessing in disguise for the ornamental fish industry. The National Fisheries Policy (NFP) emphasizes significant interventions that are imperative to bring about a consolidation in activities encompassing the sustainable harvest of ornamental resources from the wild coupled with necessary controls that are needed to be exercised for sustainable harvest and culture for this highly unorganized sector. Sectorial conflicts are needed to be resolved with uniform registration of all potential MSME based farms/units so as to help upscaling of the same for enhancing export competitiveness for the sector as a whole. The government initiative to promote MSMEs through public sector schemes such as PMMSY will pave the way for the sector towards gaining long term prominence and definitely prove beneficial for increasing the probability of shareholding of this sector manifold in the export basket in the post COVID arena.

Finally, drawing inspiration from the fact that the Government has created a separate Ministry for the fisheries sector, fisheries should become an equal partner with the other developmental sectors in making India a USD 5.0 trillion economy by the year 2025 and options/interventions should ideally focus towards effective trade promotion (by attracting new and fresh entrepreneurs into the market) and enhancing the export competitiveness of this sector so as to make its presence felt in the global ornamental fish trade scenario.

Chapter IX

MARKETING INDIAN SHRIMP

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Aquaculture is an underwater agriculture involving propagation and cultivation of economically important aquatic organisms under a set of controlled culture conditions. These culture organisms includes fish, shell fishes and aquatic plants. Next to fish culture, crustacean aquaculture is a major industry in most of the tropical and subtropical developing countries. Intensive cultivation of shrimp culture began in 1970 and production has been developed gradually raising thereafter.

Among the cultivation of various crustaceans, the shrimp cultivation plays a significant role in national economic development for many Asian countries, especially the penaeid shrimp cultivation has become one of the most profitable aquaculture practice in India.

The culture techniques of shrimp vary among and within particular geographic regions even though cultivation of shrimp is practiced in many parts of the world. Different culture methods of shrimps include intensive, semi-intensive, and extensive categories based upon the area of land, water quality and stocking density of larvae.

Shrimp culture is assigned to a variety of categories depending on pond size, stocking density, water system and feeding methods. Intensive culture of shrimps is the most sophisticated and it requires high financial and technical inputs. Earthen pond or concrete tanks are used for the intensive culture. This system includes high density stock, use of formulated diets, application of aeration to increase dissolved oxygen level in ponds and intensive management.

In semi-intensive system, the improvement over traditional method is the systematic layout of ponds. The ponds are generally rectangular in shape with size about 13 hectares and depth of 0.80 m to 1.20 m. Each pond has separate inlet and outlet gates to facilitate exchange of water, pond preparation and harvesting. Current practices vary from country; the normal stock density in semi-intensive system varies from 28,000 - 50,000 fry per hectare. This system also requires the use of water pump to maintain good water quality.

Extensive culture has been considered as the simplest culture approach, unlike in the intensive culture system; this system is characterized by irregular shape and sized ponds, which range from 3-20 hectares. Usually, each pond is a peripheral ditch 10-20 m wide and 30-60 cm deep. In this system seed stock normally comes from the wild and hence supply is seasonally dependent.

Farmed shrimp production in India has increased by 82% from 1984 to 1994, followed by a sharp decline during 1995 to till date, despite the increase in the hector age as well as the intensity of aquaculture and per hectare production leading to huge economic losses to farmers. Such a decline is due to combined effect of incidence and spread of shrimp diseases. In a global scale, marine shrimp continue to dominate in the crustacean aquaculture production, with three major species namely *Penaeus monodon*, *Penaeus chinensis* and *Litopenaeus vannamei* with over 75 percent of total shrimp aquaculture production in 2002. FAO statistics show that the total production of cultured *Litopenaeus vannamei* increased steadily from 8 000 tonnes in 1980 to 194000 tonnes in 1998. There was a decline in 1999 and but in 2000 there was a more significant decline because of WSSV in Latin America. FAO data shows a rapid increase in production to over 1 386 000 tonnes in 2004, due to the spread of this species to Asia. The main producers in 2004 were: China (700,000 tonnes), Thailand (400,000 tonnes), Indonesia (300,000 tonnes) and Vietnam (50,000 tonnes).India was top shrimp producer from 2015 -21. There was slight decrease in the production by 5% from January to April 2022. These losses were attributed to diseases caused by various pathogens.

The first spawning of this species was achieved in Florida in 1973. In 1976, commercial culture of *Litopenaeus vannamei* began in South and Central America. Subsequent development of intensive breeding and rearing techniques led to its culture in Hawaii, mainland United States of America, and much of Central and South America by the early 1980s. From this time, the commercial culture of this species in Latin America showed a rapidly increasing trend. Despite these problems, production of *Litopenaeus vannamei* from the Americas has been increasing – after declining from its earlier peak production of 193 000 tonnes in 1998 to 143 000 tonnes in 2000 it had grown to over 270 000 tonnes by 2004. Asia has seen a phenomenal increase in the production of *Litopenaeus vannamei*. Although no production was reported to FAO in 1999, it was nearly 1 116 000 tonnes by 2004 and had overtaken the production of *P. monodon* in China, Taiwan Province of China and Thailand, due to a number of favourable factors. However, due to fears over importation of exotic diseases, many Asian countries have been reluctant to promote farming of *Litopenaeus vannamei*, so that its culture remains officially confined to experimental testing only in Cambodia, India, Malaysia, Myanmar and the Philippines. Thailand and Indonesia both freely permit its commercial culture but have official restrictions, so that only SPF/SPR brood stock may be imported. Similarly, most Latin American countries have strict quarantine laws or bans to prevent importation of exotic pathogens with new stocks.

The main producer countries of *Litopenaeus vannamei* include: China, Thailand, Indonesia, Brazil, Ecuador, Mexico, Venezuela, Honduras, Guatemala, Nicaragua, Belize, Viet Nam, Malaysia, Tawian P.C., Pacific Islands, Peru, Colombia, Costa Rica, Panama, El Salvador, the United States of America, India, Philippines, Cambodia, Suriname, Saint Kitts, Jamaica, Cuba, Dominican Republic, Bahamas. The white leg shrimp is native to the Eastern Pacific coast from Sonora, Mexico in the North, through Central and South America as far South as Tumbes in Peru, in areas where water temperatures are normally >20 °C throughout the year. *Litopenaeus vannamei* live in tropical marine habitats. Adults live and spawn in the open ocean, while postlarvae migrate inshore to spend their juvenile, adolescent and sub-adult stages in coastal estuaries, lagoons or mangrove areas. Males become mature from 20 g and females from 28 g onwards at the age of 6–7 months. *Litopenaeus vannamei* weighing 30–45 g will spawn 100 000–250 000 eggs of approximately 0.22 mm in diameter. Hatching occurs about 16 hours after spawning and fertilization. The first stage larvae, termed nauplii, swim intermittently and are positively phototactic. Nauplii do not feed, but live on their yolk reserves. The next larval stages (protozoea, mysis and early postlarvae respectively) remain planktonic for some time, eat phytoplankton and zooplankton, and are carried towards the shore by tidal currents. The postlarvae (PL) change their planktonic habit about 5 days after moulting into PL, move inshore and begin feeding on benthic detritus, worms, bivalves and crustaceans.

Diseases of shrimps

Shrimp diseases are mainly caused by biological and non-biological agents. Viruses, bacteria, fungi, epibiotic protozoans and helminthic parasites are biological agents and the non-biological agents include nutritional and environmental factors.

Bacteria, in particular *Vibrio sp.*, are known to cause some of the most serious diseases found in penaeid shrimp. Other than bacteria, the viruses are known to cause various devastating diseases. In Thailand, Taiwan and Indonesia, viruses such as Monodon Baculo Virus (MBV), Yellow Head Virus (YHV), Taura Syndrome Virus (TSV) and Systemic Ectodermal and Mesodermal Baculovirus (SEMBV) are considered as main cause of the mass mortalities of shrimps.

White Spot Syndrome Virus (WSSV) has been reported to cause severe damage to penaeid shrimp culture in several parts of Asia including India. Several million dollars loss has been caused by this virus in different parts of India (Anonymous, 1996). The WSSV has been isolated and its morphology has been studied by Sahul Hameed *et al* (1998). The WSSV is a double stranded virus, enveloped and elliptical in shape with measurement of 266×112nm and is cylindrical in shape (420×68nm) with one end flat and other pointed and having a pattern of opaque and transparent striations arranged perpendicular to the axis nucleocapsid (Sahul Hameed *et al.,* 1998). The WSSV was been found to be highly pathogenic to *P.indicus* and *P.monodon* (SahulHameed *et al.*, 1998).

Wang *et al.,* (1998) classified the white spot viral infection into two types. Type 1 is an acute infection that causes high mortality within two weeks in species such as *P.monodon, P.indicus* and *P.penicillatus* (Chou *et al.,* 1995; Nakano et al, 1994). Type 2 is latent and the individuals harbouring this specific virus remains alive as in the case of *Macrobrachium sp.*, wild crabs and wild lobsters without any external manifestation of symptoms as described by Peng *et al.* (1998)

Challenges in Shrimp trading in India

India Shrimp exports now are facing high competition in world market, although shrimp exports have been growing at ~30% per annum since 2010. Few suggestions for handling trade risk and uncertainty of markets are given below. Registrations of brackish water aquaculture farms are being done by the CAA. But the procedure needs to be speed up. Trade risk could be reduced by easy traceability by proper registration. In shrimp farms certified inputs are to be used necessarily in shrimp farms which could reduce the high trade risk caused by output contamination due to usage of of uncertified and unethically produced and marketed inputs. If they are tested for contamination, these consignments which involves the uncertified inputs have high chances of getting rejected. SPF certified shrimp seed (post larvae), brood stocks and other inputs must be made available within affordable price to farmers. This will help the farmers to practice honest shrimp farming without malpractices to reduce the risk in production and trade.

Capacity building is needed for shrimp farming, processing and hatchery operation. Shrimp and shrimp products need to be promoted more vigorously. Exclusively the Indian shrimp as unique product needs to be promoted. MPEDA and other agencies related to seafood exports need to actively create new markets as well as develop existing ones. India may lead in total shrimp production and exports. Volumes need to be converted to value. India need to develop a more competitive domestic value chain by providing a better shrimp chain from input supply of production until the product received by the final user or customer. It should minimize the role of middlemen, since they cause the chain longer and more expensive. As price of shrimp export are very sensitive to India's shrimp export, government intervention related to this matter is needed. Demand for shrimp is considered to be quite price elastic. It means that a change in shrimp product will highly affect to demand for shrimp.

Chapter X

GOOD STOCK MANAGEMENT PRACTICES OF AQUAPRENEURSHIP

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Introduction

Fish stock assessment is an evaluation of the state of the stock as relating to change in the abundance or composition of the stock to changes in the amount of fishing. It involves the use of theories, laws, models and methods propagated by various scientists. Fisheries tend to collapse because of fleet over-capacity, leading to harvesting the stocks of fish beyond their ability to recover. Fishery collapses have been very common, creating economic, social and ecological problems of great complexity. One of the major aims of fisheries management is to avoid fleet overcapacity by directly controlling the fishing effort (input control) or by setting limits to the total catch per season/year and its biological characteristics (output control). On the other hand, fish stocks may also be under-utilized because of fleet under-capacity. This is particularly the case when fleets are artisanal, in initial stages of development, or with poor infrastructure facilities. When fish stocks are under-utilized because of fleet under capacity there is loss of economic diversification, revenue, employment and food security.

In this situation, the prices of sea food are usually higher because domestic supply may not meet the demand. Due to the reasons mentioned above, fisheries management must strike a balance between over-exploitation and under-exploitation (Restrepo et al., 1992). The risk of over-exploitation is the risk of management inaction, letting fishermen take too many fish from the sea thereby negatively impacting the sustainability of the stock and the fishing industry. The risk of under-exploitation is the risk of excessive management interference, setting too many obstacles to the fishermen to take fish. The fishery manager has to strike a balance by directly controlling the fishing capacity (input control) and/or by setting restrictions on the catch (output control)

Changing Role of Assessment in Fisheries Management

Commercial fisheries usually develop initially through a dynamic process that involves several distinct stages.

i. First, there is discovery of a valuable stock. This is the predevelopment of the fishery.

ii. Second, there is a period of rapid growth of fishing effort.

iii. Next, the fishery reaches full development, where yields are near or perhaps a little above a long-term sustainable level.

iv. The rapid development results in fish stock reduction and more fishermen compete for the remaining fish.

v. The fishery often then enters an overexploitation stage, which is followed by a collapse. The stock may or may not recover on its own during this period.

vi. The fishery often then enters an overexploitation stage, which is followed by a collapse. The stock may or may not recover on its own during this period.

Fisheries management should consider quantification of these different phases of fisheries for taking decisions.

- The most important management as well as assessment question is what level of fishing pressure should be permitted at an initial stage of fisheries development. On a sustainable basis, is the stock likely to support 10 boats or 100 or 1000? In the early development phase, an order of magnitude of assessment, even if it is a rough estimate, will be of considerable value. This will permit precise estimates of assessment later in the development.

- A key role of stock assessment during fisheries development is to provide regular updating and feedback of population parameters and estimated potential into the decision making process. Systematic and regular assessments will provide good early warnings of overfishing and help avoid overcapitalisation. A simple method of assessment as the fishery develops is to monitor the relationship between the fishing effort and catch and plot a graph as shown in Figure 2. As the catch reaches the top of the curve and starts to drop, it shows that the MSY has been reached and it is time to reduce the fishing effort.

- When the fish stocks are overexploited, the key role of stock assessment is to quantify the choices as precisely as possible. How to rebuild the stocks? Should it be through reducing fishing effort, if so how much? How long it will take for the fisheries to rebuild? In this situation, it is important to predict how the stocks will respond to new management initiatives. A classic role of stock assessment would be to provide, based on available information, reasonable prediction about such circumstances.

Breadth of Stock Assessment

Stock assessment is sometimes viewed as a rather narrow biological discipline that might be summarized as “the interpretation of commercial catch to estimate potential yields”. However, stock assessment is much more than this. First and foremost, stock assessment involves understanding the dynamics of fisheries. This recognizes that fisheries are dynamicentities that will respond over time to management regulations, and to extrinsic factors. Modern stock assessment is not just the task of making static predictions about sustainable yields. It should also involve making predictions about how policies should be structured in order to deal with the unpredictable changes that will inevitably occur.

Fisheries are also much more than fish catch. Fishermen are an important component of fisheries, and stock assessment must take into account how fishermen will respond, and also make predictions about things important to fishermen such as catch per unit effort. Processing and marketing are also very important components of the fishery system.

Importance of Stock Assessment to Fisheries Management

Scientists strive to increase the types and amounts of data collected from fisheries and research projects in order to improve the accuracy of stock assessments. Fisheries managers then consider results of the stock assessment when taking management action, which in turn may affect stock abundance or productivity. If a stock is overfished, actions need to be taken to reduce fishing pressure. This allows the stock to rebuild to an acceptable level and promotes a healthy fishery in the future.

On the other hand, if a stock is healthy, managers take steps to ensure the stock is harvested at a level allowing for long-term sustainability. Because stock assessments are directly linked to management actions, it is important to understand appropriate uses of data, different options for analyses, and how to apply assessment results.

The results of stock assessments serve as the basis for long-term and short-term fishery management decisions. First, the assessment provides the basis for status determinations, which entails the following:

(1) Determining whether underfishing or overfishing is occurring and determine the level that would produce maximum sustainable yield; and

(2) Comparison of current reproductive potential (usually measured as spawning biomass) to a limit level (usually set to approximately half the level that would produce maximum sustainable yield) as a measure of stock depletion and a trigger for development of a rebuilding plan.

Second, assessments provide forecasts of the expected future catch and stock abundance associated with proposed harvest policies. Thus they provide scientific information for implementation of the harvest policy that will produce optimum yield from the fishery. Finally, the time series of abundance, mortality, and productivity produced by single-species stock assessments provide input to ecosystem food web models.

Principles of Fisheries Management

Arising from the considerations discussed above, a number of key principles can be identified which may serve to focus attention on effective fisheries management:

1. Fish resources are a common property resource
2. Sustainability is paramount and ecological impacts must be considered
3. Decisions must be made on best available information but absence of, or any uncertainty in, information should not be used as a reason for delaying or failing to make a decision.

4. A harvest level for each fishery should be determined.

6. The total harvest across all sectors should not exceed the allowable harvest level.

7. If this occurs, steps consistent with the impacts of each sector should be taken to reduce the removal.

8. Management decisions should aim to achieve the optimal benefit to the community and take account of economic, social, cultural and environmental factors.

In keeping with the integrated nature of fisheries ecosystems, these principles cannot be considered in isolation in considering how best to manage fisheries: their implications and consequences overlap, complement and confound each other which is what makes fisheries management so demanding and challenging.

Different Types of Management

Wider examination of fisheries management framework currently existing in different countries shows that the following three approaches are being adopted:

(i) Rights-based approach

(ii) Ecosystem approach

(iii) Precautionary approach

(i) **Rights-based approach**

In well managed fisheries, Maximum Sustainable Yield (MSY) or Maximum Economic Yield (MEY) or yield-per Recruit (Y/R) is used as biological reference points (BRPs) to derive thresholds and targets to arrive at sound fisheries management decisions (FAO, 2006). Spawning-recruitment relationship (S-R) is used as a key element for formulating fisheries management advice. A few other empirical reference points such as long-term mean size at capture also can be used as BRPs. By using the MSY approach and BRPs, countries like the USA, Canada, New Zealand, and a few countries in the Europe are

following advanced rights-based management approach to limit the catch equal to or within the total allowable catch by following catch quotas. In these countries, Total Allowable Catch (TAC) is set with reference to maintaining the biomass at or above a level that can produce maximum sustainable yield (MSY).

(ii) Ecosystem approach

In the last ten years, it has been recognized that effective fisheries management could be achieved by following ecosystem approach, in which multiple regulatory measures and management actions could be applied in full consideration of aquatic species, the ecosystems in which they live and the developmental systems that degrade the ecosystems.

Applying an ecosystem approach to fisheries management (EAFM) is considered the preferred option and the best practice for long-term sustainability of fisheries and the services that fisheries ecosystems provide to the society.

(iii) Precautionary approach

Although MSY is an appropriate basis for reference points, there are limitations of applying MSY approach in fisheries management in the absence of key BRPs like the S-R. However, non-availability of a whole range of scientific information should not deter taking management decisions. In this situation, precautionary approach should be the backbone of fisheries management.

Definition of Fisheries Management

Fisheries management has been defined as “The integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and the accomplishment of other fisheries objectives” (Cochrane, 2002).

The Technical Guidelines on Fisheries Management (FAO, 1997) describe a management plan as “a formal or informal arrangement between a fisheries management authority and interested parties which identifies the partners in the fishery and their respective roles, details the agreed objectives for the fishery and specifies the management rules and regulations which apply to it and provides other details about the fishery which are relevant to the task of the management authority.” It is a process of considering the following components to make decisions and implement actions to achieve goals:

- Biological considerations
- Ecological and Environmental considerations
- Technological considerations
- Social and Cultural considerations
- Economic considerations
- Considerations imposed by other parties