



# MINIMAL WATER EXCHANGE TECHNOLOGIES TO DEVELOP AQUACULTURE ENTREPRENEURSHIP

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# MINIMAL WATER EXCHANGE TECHNOLOGIES TO DEVELOP AQUACULTURE ENTREPRENEURSHIP

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This e-book is a compilation of resource text obtained from various subject experts of AQUAFIN, Chennai & MANAGE, Hyderabad, on “Minimal Water Exchange Technologies to develop Aquaculture Entrepreneurship”. This e-book is designed to educate extension workers, students, research scholars, academicians related to fisheries science and aquaculture about the entrepreneurship opportunities in aquaculture systems and technologies. Neither the publisher nor the contributors, authors and editors assume any liability for any damage or injury to persons or property from any use of methods, instructions, or ideas contained in the e-book. No part of this publication may be reproduced or transmitted without prior permission of the publisher/editors/authors. Publisher and editors do not give warranty for any error or omissions regarding the materials in this e-book.

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## MESSAGE

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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 collaboration between MANAGE and AQUAFIN has been critical in driving the aquaculture industry forward, promoting knowledge sharing, and fostering innovation. The online training program organised from 20-22<sup>nd</sup> December 2022 on "Minimal Water Exchange Technologies to Develop Aquaculture Entrepreneurship" is a prime example of this collaboration in action. The program provides participants with the necessary skills and knowledge to adopt minimal water exchange technologies in aquaculture, thereby promoting sustainable entrepreneurship in the sector.

As the world grapples with the existential crisis of climate change, the need for innovation and adaptation has never been more crucial. The aquaculture industry, in particular, is poised to play a pivotal role in this change. It presents immense opportunities for creating self-sufficient communities that can thrive through resourceful conservation practices.

This e-book covers an array of subjects, from market research to innovative technologies and techniques, offering practical insights that are relevant to a broad range of stakeholders, including farmers, entrepreneurs, policymakers, and students. We are confident that this compilation of cutting-edge knowledge and industry insights will be a valuable resource for those looking to optimize their operations and contribute to a more sustainable future. I would like to extend my appreciation to Prof. S. Felix, Founder President of AQUAFIN, Dr. Shahaji Phand and Dr. Sushirekha Das for the tremendous effort in compiling this e-book. I also thank the authors, editors, and designers who have contributed to this ebook creation. Their dedication and commitment towards sustainable aquaculture practices have been instrumental in driving the industry forward.

**Dr. P. Chandra Shekara**  
Director General, MANAGE



## FOREWARD

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It is my utmost privilege to introduce the Collaborative Online Training Program on "Minimal Water Exchange Technologies to Promote Aquaculture Entrepreneurship," an illustrious joint initiative between MANAGE, Hyderabad, and AQUAFIN, Chennai from 20-22<sup>nd</sup> December, 2022.

As the global population burgeons, the demand for food is poised to escalate significantly in the years to come. This pressing demand presents a formidable challenge to conventional agriculture, which already grapples with resource constraints, especially in water-scarce regions. In sharp contrast, aquaculture offers a sustainable alternative, leveraging resource-efficient methods and producing protein-rich food with considerably reduced environmental footprints. However, for the aquaculture sector to fulfil its promise, it is essential to foster sustainable practices that are resource-efficient and economically viable. One of the most efficacious means of achieving this goal is by adopting minimal water exchange technologies, which have been proven to curtail water consumption, enhance profitability, and promote sustainable entrepreneurship.

The Collaborative Online Training Program offered by MANAGE and AQUAFIN is a critical step towards empowering entrepreneurs with the knowledge and skills requisite to adopt these technologies. The program encompasses theoretical knowledge and pragmatic insights, delving into topics such as water quality management, biofloc technology, and integrated multitrophic aquaculture.

The training program is designed to cater to a broad spectrum of stakeholders, including farmers, aquaculture entrepreneurs, researchers, and policymakers. The modular format enables participants to learn at their own pace, while the online platform fosters knowledge-sharing and interaction between participants and trainers.

The Collaborative Online Training Program on Minimal Water Exchange Technologies to Promote Aquaculture Entrepreneurship is a splendid manifestation of the potential for collaborative efforts between organizations to drive innovation and promote sustainability. I commend the efforts of MANAGE and AQUAFIN in conceiving and executing this program and anticipate its prodigious success in promoting sustainable entrepreneurship in the aquaculture sector.

A handwritten signature in black ink, appearing to read 'S. Felix'.

**Prof. S. Felix**  
Founder President, AQUAFIN

## **PREFACE**

It is with great pleasure that we present an E booklet, "Minimal Water Exchange Technologies to Promote Aquaculture Entrepreneurship," which stands as a testament to the groundbreaking partnership between MANAGE, Hyderabad, and AQUAFIN, Chennai. The booklet represents a collective effort to proffer sustainable practices that ensure resource efficiency, promote profitability, and reduce environmental degradation in the aquaculture sector. It serves as a repository of knowledge that brings together innovative concepts, best practices, and practical solutions to facilitate the transition towards sustainable entrepreneurship.

As the global population burgeons, the demand for food is poised to escalate significantly. Aquaculture offers a sustainable alternative, leveraging resource-efficient methods to produce protein-rich food with minimal environmental footprints. However, realizing the full potential of the aquaculture sector requires a paradigm shift in the way we approach production and consumption. The booklet is meticulously crafted to cater to a wide range of stakeholders, including aquaculture entrepreneurs, farmers, researchers, and policymakers. It covers various topics, including the management of water quality, biofloc technology, and integrated multitrophic aquaculture. It presents readers with a wealth of theoretical knowledge, case studies, and practical advice, enabling them to adopt minimal water exchange technologies and implement sustainable practices effectively.

The collaborative effort between MANAGE and AQUAFIN represents a beacon of hope, demonstrating the power of collaboration and the potential for innovative solutions. By coming together to promote sustainable entrepreneurship in the aquaculture sector, we have forged a path towards a brighter, more sustainable future.

We are indebted to all the contributors who have made this booklet possible and hope that it will serve as a valuable resource for all those invested in promoting sustainable entrepreneurship in the aquaculture sector.

### **Editors**

Felix Sugantham  
Shahaji Phand  
Sushirekha Das  
Menaga Meenakshisundaram

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## Chapter-1

# Circular Economy in Indian Aquaculture Industry- A MWET Perspective

S. Felix<sup>1</sup> and Sushirekha Das<sup>2</sup>

<sup>1</sup>Founder President, AQUAFIN

<sup>2</sup>MANAGE, Hyderabad

### Introduction:

Aquaculture is predicted to play a critical role in supplying nutritious food to a growing human population, which is expected to exceed 9 billion by 2050. To meet increasing global demand for seafood and omega-3 fatty acids (particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)), aquaculture, which today contributes to 47% of global seafood production (171 MT in 2016, is expected to intensify practices. This raises significant concerns regarding limiting resources (e.g. water, space, feed) and the environmental impacts (e.g. wastewater, solid waste) that higher stocking densities and feed supplementation can cause. For example, mismanagement in the release of nutrients (e.g. N Nitrogen, P Phosphorous) and solid organic matter into the environment can drive algal blooms, eutrophication, hypoxic events and water acidification. Organic material discharge can also increase concentrations of pathogenic bacteria and viruses in water systems. Furthermore, extensive antibiotic usage in farm systems can accelerate the spread of disease resistant pathogens in receiving waters, with detrimental impacts on aquaculture production.

In order to sustainably intensify aquaculture and maintain a continuous seafood supply, without causing catastrophic ecosystem damage, there is a need to implement a more resource-efficient approach and minimize aquaculture waste. Consequently, there is growing global awareness and interest in the valorization of available resources, specifically recycling of nutrients and by-products, to support a circular economy within aquaculture. In 2012, the European Commission promoted “Blue Growth”, a green economy applied to maritime and coastal sectors. There is potential for by-products and wastewater effluents to be diverted back into aquaculture systems and account for high percentages of aquaculture production.

Nowadays, in order to accomplish industrial requirements while satisfying environmental protection actions, many different approaches of sustainable production have been designed. Currently, one of the most applied models is ‘circular economy’ which has been defined as “an economic system that replaces the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/ distribution and consumption processes, with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers”. This concept has been recently updated by the incorporation of the

term ‘bio-economy’ which itself does not embed circularity and efficiency. The European Commission defined it as follows: “bio-economy covers all, primary production, economic and industrial sectors that use, produce or process biological resources (agriculture, forestry, fisheries, and aquaculture) to produce food, feed, bio-based products, energy, and services”. Circular economy and bio-economy converge in several points, especially, in the use of biological resources, and particularly when this biomass is a by-product that represents an input for another industrial sector. Hence, these two strategies tend to overlap since they are both based on the use of biological resources and show a strong synergy. In fact, in the very last years, the European Commission and several industrial associations apply the term ‘circular bio-economy’ and support their integration.

For fish grown in aquaculture facilities it has been estimated that 45% is directly transformed while the remaining 55% is considered subproduct. When considering a finfish, this percentage of sub-products can be mostly explained by the sum of the percentage of head and frames, which include bone skeleton and its associated flesh, that account for 20%; viscera for 12.5% (mostly formed by gut); skin and belly flaps sum 5% while trimmings and blood represent 4%. Similar efficiencies have been determined for crustaceans, where the shell, including the head, represents 60% of the total body weight while the portion directly destined to consumption is about 40%. Molluscs are the most efficient organisms since flesh constitutes 70% and shell 30% of total body weight. Among these amounts of sub-products, it has to be added the fraction of died animals along the growing process which has been considered to be a 4% for each production system. Regarding waste classifications, aquaculture wastes can be divided into four groups: solid wastes as particles in suspension (mostly derived from non-consumed animal food); dissolved organic substances (mainly phosphorus and nitrogen); dissolved chemical compounds (from pharmacological treatments) and pathogens.

Therefore, the approaches presented in next sections pretend to provide alternative uses of wastes and their further innovative application in order to provide solutions that may revalue waste and maximise the economical throughput of aquaculture systems.

## **IMTA**

In order to magnify the productivity of aquaculture systems and reduce their environmental impact, derived wastes, such as metabolic products or uneaten food, have to be considered potential source of minerals, vitamins, proteins and lipids, for their further use. Integrated multi-trophic aquaculture (IMTA) is considered a model to fulfil all these requirements. In the last years, has gained several countries attention, among them, Spain . This production design implies the culture of few species from different trophic levels, so wastes produced by those from higher levels are inputs for species from lower levels, similar as occurs in natural ecosystems. First level usually includes fish, crustacean and cephalopods. The second one involves filtering and suspensivore invertebrates (e.g. filter molluscs, anemones, sea cucumbers, etc.), which feed on organic matter generated by first level, such as feed remains or sub-products. In the third level, marine macroalgae use inorganic compounds, like those from excretory products released by previous levels Numerous authors defend that the presence of macroalgae is one of the most important factors in IMTA. Monoculture farms discharge great amounts of effluents with solid waste (uneaten food, faeces) and dissolved nutrients that



can induce water eutrophication and affect surrounding ecosystems. Seaweeds used in the IMTA remove the excess of dissolved nutrients and CO<sub>2</sub>, avoiding the eutrophication process. IMTA systems allow the production of different valuable species with less amount of consumables and reduce the negative environmental impact. Therefore, production systems based on IMTA model favour the responsible use of natural resources and a sustainable productivity.

IMTA developed in open waters also improves water quality by reducing its ammonium charge while enhancing the efficiency of the production system. In fact, it provides two valuable sources of natural ingredients, mussels and *S. latissima*. Both can be exploited for human consumption or for more innovative applications in cosmetics or food industry, used as alternative additive. Finally, another beneficial effect of the combined use of seaweeds in aquaculture involves them in the control of pathogenic organisms. In a recent study conducted on an IMTA-RAS farm, *Ulva* species have been demonstrated to provide an optimal niche for forming biofilms of beneficial bacteria. Their presence has been related with the capacity of reducing fish larvae mortality and controlling populations of pathogenic *Vibrios spp.*

### **Innovative application of aquaculture sub-products**

Primary aquaculture products are those obtained as part of the main production process while sub-products are those secondarily obtained and can be directly utilised if they comply legal requirements. An example of sub-products obtained after processing primary products are fish bone, skin, belly flaps or trimmings. These sub-products are considered to have great potential since they can be re-introduced into the food chain as ingredients destined to human consumption, which will render the maximum benefit. Even though this is the most efficient model, when their re-utilisation for human consumption it is not possible, they may be re-introduced at any of the next levels of the waste hierarchy.

There are three categories of animal-derived materials not intended for human consumption contemplated in EU Regulation. Category 1 mainly includes: body parts of sick animals, those used for experimental purposes, and those containing an excessive level of residues, illegal or contaminated substances. Category 2 includes manure, non-mineralised guano and digestive tract content; animal by-products containing authorized residues above permitted levels; animal products with foreign bodies; imported animals not complying with veterinary legislation; died animals; foetuses, oocytes, embryos and semen not destined for breeding purposes. Finally, category 3 compiles carcasses, products and sub-products of animal origin, foodstuffs or parts of animals slaughtered that fit for human or animal consumption but not intended for this aim for legal or commercial reasons. Animal-derived materials belonging to the category 1 are the ones aimed to be reduced since their re-utilisation becomes tough. They can be applied to last steps of the waste hierarchy, it means for industrial or technical uses, such as for cosmetic purposes or energy production, before they get dumped or incinerated. Similarly, by-products from category 2 can be applied for industrial or technical applications, such as for agriculture aims such as compost or silage. Finally, animal-derived materials from category 3 are the most relevant ones in terms of re-utilisation since, in addition to the uses allowed for the previous categories, these materials can be also employed for manufacturing animal feed. Numerous studies have evaluated the valorisation of aquaculture

sub-products by their composition in terms of biomolecules. The reutilisation of aquaculture sub-products permits to recover ingredients with high economical value for other industries. The potential applications of aquaculture animal-derived products to different sectors are detailed in the following sub-sections.

### **Human food ingredients**

Aquaculture sub-products obtained from processing fresh and transformed products are the most interesting source for re-utilizing them as human food. Animal-derived by-products from category 3 have been also demonstrated to be an interesting source for animal alimentary industry. Aquaculture sub-products represent a sustainable source to recover non consumed compounds such as proteins, lipids and pigments that are mostly re-utilised for producing broths, aromas, fish protein concentrates, etc. Several compounds widely used in food industry can be obtained from sub-products, for example, fish flour, chitosan (a biopolymer derived from chitin, present in the exoskeleton of crustaceans), proteins concentrated, collagen (obtained mainly from fish skins), gelatine (produced by partial hydrolysis of collagen), and astaxanthin.

Chitosan and astaxanthin are both used also as nutritional supplements in humans. One of the most common ways to extract these valuable compounds is by thermal-based maceration of previously powdered fractions that are then boiled in agitation using a small volume of water. After filtrating and decanting, the supernatant is collected to apply an ultra-heat treatment or dehydration process that allows their storage for long periods.

Proteins, including collagen, and lipids are main components of fishes. However, the selection of the sub-product is fundamental for reaching optimal recovery rates. For example, protein and lipid content of whole turbot (*Scophthalmus maximus*) exemplars is pretty low (17 and 1%, respectively), whereas high relative amounts of protein (82%), including 20% of soluble-collagen, and lipids (13%) were found in turbot skin. Interestingly, it also possesses a high calcium content ( $2069.0 \text{ mg kg}^{-1}$ ), and low concentrations of mercury and lead ( $>5 \text{ } \mu\text{g kg}^{-1}$ ) which reveals turbot as a safe source of collagen. Proteins obtained from turbot submitted to enzymatic or fermentation hydrolysis were described to possess a remarkable amino acids profile and high digestibility accompanied of scarce fish odour. Besides, they were demonstrated to have antioxidant and antihypertensive activities. All these features point to their potential use as natural additives for marine products ingredient, formulations of protein concentrates for human consumption, pet food diets, and supplements for aquaculture feeds.

For instance, proteins from salmon and cod, after their alkaline treatment, were demonstrated to be capable of forming gels with good water hold capacity and breaking force. Lipids from marine organisms are also highly valuable for their associated health benefits and can be used for fortify food matrices or as nutritional supplements. Apart from above cited discards, fish canning industry represents another potential source of recovery of  $\omega 3$  lipids from their sub-products with rates that can reach 3 g per liter of effluent.

Regarding freshwater production, rainbow trout (*Oncorhynchus mykiss*) frames have been treated with a separation technology named electro-dialysis with filtration membrane. This technique allowed fractionating active peptides from complex hydrolysates yielding enriched fractions with peptides that showed antioxidant properties. Similarly, viscera from the

common carp (*Cyprinus carpio*) and other additional by-products (muscle and head) of the fresh water fish tilapia (*Oreochromis niloticus*) have been submitted to different extraction procedures and chemically characterize. Their major bioactive compounds in the oil recovered from *C. carpio* included PUFAs (34 g/100g) and monounsaturated fatty acids (MUFAs, 45 g/100g), while saturated fatty acids (SFAs) were less abundant, accounting for 19 g/100 g. Although these concentrations were lower in the viscera of *O. niloticus* (3.3 g/100g for SFAs, 1.4 g/100g for MUFAs and 2.1 g/100g for PUFAs) they showed low n-6/n-3 PUFA ratio, and low atherogenic and thrombogenic indexes. These values indicate the great suitability of these extracts to be included as food ingredient destined for human consumption as a nutritive source and as tool for preventing coronary diseases.

Astaxanthin is the most common carotenoid obtained from aquaculture sub-products, particularly, salmon, trout, krill, shrimps, fresh water crabs and crustacean shells are the main sources for recovery. Carotenoids and other colorants are useful food ingredients which are present in many products destined to human consume since they enhance their organoleptic characteristics by providing colour but also additional properties (i.e. antioxidant). Currently, the culture of macro and microalgae has gained importance in this area since both kind of algae have been demonstrated to represent a vary source of pigments. Pigments may be recovered from sub-products remaining after their processing. Beta-carotene is a yellow pigment known to be also a precursor to vitamin A with free radical scavenger and antioxidant properties. Together with beta-carotene few other carotenoids, including astaxanthin, have been extracted from brown macroalgae, such as *Laminaria* spp. and *Undaria pinnatifida* or green macroalgae, such as *Ulva lactuca*. The main species of microalgae that respectively produce beta-carotene and astaxanthin are *Dunaliella salina* and *Haematococcus pluvialis*. Phycoerythrin is another molecule of interest, a red pigment that can be mostly extracted from red macroalgae (Rhodophyta), as for example, *Mastocarpus stellatus*, *Gelidium pusillum*, *Gracilaria vermiculophylla* and from the microalga *Porphyridium cruentum*. R-phycoerythrin has been demonstrated to possess diverse biological activities such as hypertensive and antioxidant. Therefore, discards from algae production may represent a source of pigments that can further be applied as natural colorants or exploited for their bioactivities.

## **Animal feeding**

Aquaculture sub-products and animal-derived material from categories 2 and 3 have been suggested to be a potential source of nutrients for animal feeding. Besides, if an IMTA model is not applied fish waste can be also reutilised for recovering the non-consumed content of minerals, proteins and fatty acids. Sub-products, mainly heads, bones, skin, and viscera, were described to possess an ash content of 22% which indicates the high mineral concentration. The amount of protein can achieve up to a 58% of the dry matter. The most abundant monounsaturated fatty acids, reaching values of 19% of the dry matter, are palmitic and oleic acids. For instance, they represent a good source of nutrients. A drawback of this type of fish waste and sub-product is the low concentration of heavy metals such as arsenic, lead, mercury and cadmium which hinders their detection and can cause issues when bio-accumulated. In the same way, it is necessary to avoid the presence of phycotoxins when macro and microalgae sub-products are used for feeding purposes.

Crushed shells represent an important calcium supplementation ( $\text{CaCO}_3$ ) which results very useful when introduced in hen feeding. The replacement of the calcium present in limestone with that from oyster shells has been proved to enhance egg production, strength weight and thickness. Chickens fed using oyster shells also showed a quicker increase of weight. Shells from other edible mussels, such as *Chamelea gallina* or those from invasive species such as *Dreissena polymorpha* have also been showed as promising sources of calcium for feeding poultry animals.

Aquaculture systems can also recycle wastes from other sectors. For instance, *Chlorella* has been satisfactorily grown by adding pre-treated pig slurry. The chemical characterization of this manure after its use for culturing the microalgae showed a reduction of the chemical oxygen demand up to 55%, the nitrogen content up to 46% and the amount of phosphorus (TP) to nearly 75%. Besides, this treatment also provides high removal ratios of heavy metals, especially copper (94%), chromium (90%), lead (72%) and zinc (70%). Therefore, this synergic model prevented the release of heavy metals; phosphorus and ammonia contaminated water and achieved great rates of biomass production.

## **Agriculture**

Historically, shells from mussel (*Mytilus galloprovincialis*) have been used as a liming agent or as mulches for soil amendment in farming. In fact, the agricultural application of shells represents the second major shell market. Shells are crushed after their thermal treatment. The main component of shell, calcium carbonate ( $\text{CaCO}_3$ ), neutralises acidic and metal contaminated soils while improving its fertility and increasing oxygen levels. The use of this natural product allows their application in ecological agriculture and represents a replacement for mined- $\text{CaCO}_3$ .

## **Industrial uses: food packaging, cosmetic and pharmaceutical**

For food packaging, cosmetic and pharmaceutical industries, marine protein-based products such as collagen or gelatine, lipids and pigments result very useful. Besides, many marine compounds such as phlorotannins or PUFAs have been investigated over the last years as biomolecules with potential applications, especially in the field of cosmetics and medicine. Collagen represents the base for the treatment of osteoporosis and arthritis, but it is also a cosmetic ingredient due to its anti-aging properties. Its derivate, the gelatine, can also be found in cosmetics and drugs. Moreover, food industry is boosting the development of biodegradable active packaging to reduce single-use plastics and improve shelf-life products. Chitosan and/or gelatine have been widely chosen for creating biodegradable packages, but also carrageenans are increasingly used, while algae extracts, squid or *Litopenaeus vannamei* by-products, have been included as active ingredients to improve their preservation properties. As well, freshwater cultured species, such as rainbow trout (*Oncorhynchus mykiss*), are a valuable source of active peptidic hydrolysates and oils rich in PUFAs. Both kinds of compounds have been demonstrated to have antioxidant properties and even antibacterial and antifungal

properties. These features convert them in potential ingredients to prevent spoilage in a huge range of products, including food and cosmetics.

Apart from pigments, macroalgae represents a sustainable source of biodegradable and non-toxic natural bioactive compounds. Many compounds obtained from different algae have been described as photo-protective. Several compounds with UV protection capacity have been found in algae species such as *Ascophyllum nodosum*, *Bifurcaria bifurcata* and *Fucus vesiculosus* were identified to contain phlorotannins, *Sargassum muticum*, an invasive algae, contains sargachromenol, and *Gracilaria sp.* and *Gelidium corneum* possess mycosporine-like amino acids (MAAs), a group of secondary metabolites produced which are able of absorbing UV radiation in the harmful range from 309 to 362 nm (Lourenço-Lopes et al., 2020). Algae are also a well-known source of polysaccharides (alginates, agar, carrageenans or fucoidans) that possess moisturizing properties. Brown algae such as *Laminaria sp.* and *Saccharina sp.*, are recognized by their capability of synthesizing high quality alginates that showed better moisturizer capacity than the hyaluronic acid. Many micro- and macroalgae molecules have moisturizing, anti-aging, lightning and/or photoprotective properties and then have been applied for sunscreen creams, peeling, slimming, hair and dental care products.

### **Biodiesel and other uses**

Wastes capable of yielding oil, such as skin, fishbone or liver, are the most suitable ones for obtaining biodiesel. In order to extract oil from aquaculture wastes or sub-products different approaches can be used, like the reactive extrusion. The lipid content obtained is then subdued to different kinds of trans-esterification reactions to produce biodiesel. Additionally, currently microalgae cultures are growing and they represent a profitable source for obtaining biodiesel.

### **Future trends and conclusions**

Aquaculture continues to grow faster than other major food production sectors, and with most fishery stocks expected to remain unsustainably fished or overfished for at least the next decade, aquaculture must bridge the growing gap between supplies of aquatic food and demand from a growing and wealthier global population that demands high amounts of animal protein.

The global relevance of Indian aquaculture productivity is recognized world-wide and expected to continue growing. Nevertheless, this increasing production trend has a drawback: whether it keeps growing following the current model, it will promote the generation of huge amounts of wastes. In this scenario, a circular bio-economy model should be adopted to re-utilise wastes and sub-products and maximise their throughput while reducing their negative environmental impact. Nevertheless, the recent implementation of ‘circular economy’, ‘bio-economy’ or ‘circular bio-economy’ strategies present few drawbacks as the time and cost-consuming processes that delay the approval of new products derived from these production systems. In fact, it has addressed the little effort that some industrial sectors have carried out to establish a tailored policy framework and to promote environmental, social and economic changes based on the application of circular bio-economy models. Therefore, even though these innovative and sustainable models have been demonstrated to be efficient, they still require visibility and stronger support. Indeed, the development of circular bio-economy

production systems represents an innovative approach which can increase the creation of new job positions, so necessary in rural areas but also in industrial ones to minimize their environmental impact.

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## Chapter-2

# Cage Farming of Improved Tilapia Species in Indian Reservoirs

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### Introduction

Cage farming has emerged as a promising aquaculture technique in India, particularly for rearing improved tilapia species. Tilapia is a popular freshwater fish known for its fast growth rate, high reproductive capacity, and excellent adaptability to various environmental conditions. In recent years, the adoption of cage farming systems in Indian reservoirs has gained momentum due to its potential for sustainable fish production, economic viability, and minimal environmental impact. This article explores the benefits, challenges, and future prospects of cage farming of improved tilapia species in Indian reservoirs.

### Improved Tilapia Species

Tilapia is an exceptional choice as an affordable source of protein, essential nutrients, and fatty acids crucial for maintaining good health. Due to its unique characteristics, tilapia is well-suited for genetic improvement through selective breeding, allowing for the development of improved strains. This adaptable fish species can be cultivated in various farming systems and exhibits omnivorous behaviour, thus requiring minimal fish meal in its diet. Additionally, tilapia possesses a remarkable ability to tolerate varying water qualities, making it suitable for both freshwater and marine environments. Its hardiness and strong disease resistance make it a cost-effective and manageable option for small-scale farmers seeking to produce food, enhance nutrition, and generate income. Moreover, the early onset of breeding at four to six months allows for rapid genetic advancements to be achieved within a short timeframe. The selection of suitable tilapia species plays a vital role in successful cage farming. India has seen the introduction and cultivation of genetically improved tilapia strains that exhibit enhanced growth rates, disease resistance, and better meat quality. Species such as Nile tilapia (*Oreochromis niloticus*) and Mozambique tilapia (*Oreochromis mossambicus*) have been widely used due to their adaptability to local conditions and high market demand.

### Cage Farming Systems

Cage farming involves the cultivation of fish within a floating enclosure, which allows for controlled feeding, monitoring, and harvesting. The cages are typically constructed using a combination of nets and frames, ensuring sufficient water exchange while confining the fish.

In Indian reservoirs, cages are often anchored to the reservoir floor or secured to the banks, utilizing the ample water resources available.

### **Advantages of Cage Farming**

*Increased Production:* Cage farming allows for higher stocking densities compared to traditional pond-based aquaculture. This leads to increased production per unit area, maximizing the utilization of reservoir resources and meeting the growing demand for fish.

*Water Quality Management:* The cage structure facilitates better control over water quality parameters such as dissolved oxygen levels, temperature, and nutrient concentrations. This control minimizes the risk of oxygen depletion, disease outbreaks, and eutrophication.

*Reduced Environmental Impact:* Compared to open-water fishing, cage farming has a lower impact on the surrounding ecosystem. Waste and excess feed can be effectively managed within the cages, minimizing pollution and maintaining water quality.

*Efficient Feed Conversion:* Tilapia are known for their efficient feed conversion ratios, making them suitable for cage farming. This means that they can convert feed into body mass more efficiently, reducing the overall feed requirements and operational costs.

### **Challenges and Mitigation Strategies**

*Disease Management:* Disease outbreaks can pose a significant risk to cage-farmed tilapia. Regular health monitoring, vaccination, and biosecurity measures are crucial to mitigate disease risks. Isolation and proper disposal of diseased fish are also essential to prevent the spread of pathogens.

*Predation:* Predatory fish and birds can cause losses in cage farming systems. Employing appropriate predator deterrents and installing netting or mesh covers can help minimize predation risks.

*Environmental Considerations:* Careful site selection, environmental impact assessments, and regular monitoring are necessary to ensure that cage farming operations do not adversely affect the reservoir's ecosystem. Compliance with relevant environmental regulations is vital for sustainable aquaculture practices.

*Market Demand and Infrastructure:* Establishing efficient market linkages, processing facilities, and cold chains is crucial to ensure a ready market for cage-farmed tilapia. Strengthening the existing infrastructure and establishing robust value chains can enhance the profitability of cage farming operations.

## **Cage Farming in Reservoirs:**

Genetic improvement in tilapia involves a selective breeding program that combines various strains of Nile tilapia to produce genetically improved farmed tilapia. Through selective breeding, broodstock with desirable traits are carefully chosen to breed and produce offspring with enhanced characteristics. This process allows for the development of tilapia strains that exhibit improved growth rates, disease resistance, meat quality, and other desirable traits. For example, male tilapia tend to grow faster than females since all their food is utilized for growth alone.

Cage farming in reservoirs presents a new opportunity for optimizing fish production in India's inland aquaculture sector. While cage aquaculture is relatively new to the country's reservoirs and lakes, it holds potential for increasing fish yields and maximizing the utilization of these water bodies. India has a vast expanse of reservoirs, covering approximately 3.15 million hectares. However, the average fish production from these reservoirs remains low. Therefore, exploring alternative production techniques, such as cage culture, becomes crucial in augmenting fish production from inland open waters, particularly reservoirs.

Cage culture involves the use of enclosed spaces, referred to as cages, to rear organisms in water while maintaining a free exchange of water with the surrounding environment. These cages are designed to confine the fish while allowing for water circulation and exchange, ensuring adequate oxygen supply and waste removal. By utilizing cage culture techniques in reservoirs, fish farmers can overcome the limitations of traditional open-water fishing and enhance production in a controlled and sustainable manner.

Also, genetic improvement through selective breeding plays a significant role in developing genetically improved farmed tilapia strains. Cage farming in reservoirs offers a viable solution for increasing fish production in India's inland open waters, including reservoirs, and presents opportunities for sustainable aquaculture practices. By harnessing the potential of genetic improvement and cage culture, India can boost its fish production, meet the growing demand for affordable protein, and contribute to the socio-economic development of rural communities.

## **Shape of Cages and Cage Materials to be Used:**

- The cages are generally enclosed on all sides, except for leaving an opening at the top for feeding and handling the stock.
- Size of a cage for fish culture in reservoirs can vary, but often multiple units are installed as a battery of cages with catwalks for easy access to the fish stock and floating huts.
- From operational and planning purposes, a cage with the dimensions: 6m x 4m x 4m is considered as a standard unit and a battery comprises 6, 12 or 24 such cages, as per requirement.

- The cages in a battery are arranged in caterpillar design for better exchange of water thereby facilitating relatively high dissolved oxygen.
- Durable and stable cage materials are essential for achieving better results.
- A cage comprises hard frames as support and nylon nettings as cage body. It is desirable to have environment friendly, rust-free materials for cage fabrication.
- Commonly used materials for cage frames are bamboos, mild steel (MS), galvanized iron (GI), poly-vinyl chloride (PVC) and virgin-grade HDPE (High Density 5 Polyethylene) (for runner-based & pontoon-based frames).
- The bamboo-based frames are not recommended for commercial cage fish farming due to their poor longevity and strength to withstand turbulence.
- Knotless nylon nets are recommended for cage fabrication.
- The net mesh size recommended for rearing fry of Tilapia is 8 to 10 mm and that for fingerling to marketable size is 20 to 30 mm.
- Protective net may be put above the cage to avoid crop loss due to predation by birds
- Separate cages are needed for nursery rearing and grow-outs. Normally, 30% of the cages in a battery are earmarked for in situ rearing of fingerlings; the rest being grow-out cages.
- Special care is needed on mooring/anchoring of the cage structure to avoid displacement or damage to the structure.
- Anchoring needs to be done diagonally opposite at the four corners of the cage structure by providing heavy sinkers such as anchors or black stones having a dimension of 0.5 m x 1.0 m (not less than 40 kg in weight) tied with strong nylon rope.

### **Selection of Water Body:**

- Due to ecological reasons, cage culture in rivers is discouraged world over.
- Large, deep reservoirs and lakes need to be chosen for cage culture, leaving aside small and shallow water bodies for the following reasons:
  - Small and shallow water bodies are very productive and usually suited for free-ranching as there is no constraint in harvesting the fishes.
  - Predators are not a big problem.
  - Such water bodies are suitable for practicing culture-based capture fisheries, managed on the basis of annual stocking and harvesting.
  - Small and shallow waters are generally rich in nutrients and the sunlight penetrates down to the bottom resulting in high rate of primary production.
  - Small reservoirs do not have sufficient depths for the cages to remain afloat during the lean season. If water level recedes and goes beneath the critical level, the crop will be destroyed. Therefore:
- The cage site at the reservoir should have at least 10 m depth round the year
- Site Selection Criteria for site selection are based on safety of the location and smooth culture operations avoiding or minimizing user conflicts. Thus, the sites to be avoided are:
  1. places with turbulence and excessive wave/wind action,

2. bad water quality
  3. water bodies with obstructions and heavy weed infestation
  4. low depth
  5. difficult to access the site and logistic considerations
  6. nearness to dense human habitation, dams, tourist spots, industries and polluting industries.
  7. Areas of fish nursery and breeding grounds, sensitive areas like wildlife habitat including birds nesting, socio-culturally important areas like pilgrimage centers, water bodies for public use like drinking water, cleaning, navigation, etc, and protected aquatic reserves, sanctuaries, etc. are also to be avoided.
- The ideal locations for siting cages in large and medium reservoirs are the protected bays/coves to avoid damage due to strong wind action. However, some mild turbulence always helps exchange of metabolites and nutrients between the cage and outside environment.
  - A minimum clearance of 6 to 8 meters will be always needed from the cage bottom to the floor of the water body. As the cage culture operations will tend to increase nutrient load, BOD and COD in the water bodies, care must be taken to pre-assess the water quality of the location. Excessive nutrient load from cage culture inputs, especially feeds can create eutrophic conditions with disastrous consequences to the ecosystem.
  - It needs to be ensured that the water body is either oligotrophic (low nutrient content) or mesotrophic (moderate nutrient content) before starting the cage culture.
  - Cage Maintenance Anti-corrosive paint should be applied to GI/MS cages to prevent rusting and to increase the durability.
  - Cage should be cleaned at 15-days interval to avoid net clogging.
  - After shifting the stock to another cage, each cage is taken out, sun-dried and cleaned thoroughly by scrubbing/ water-jet wash to remove debris and fouling organisms.
  - Additional hapas/nets may be maintained for this purpose or to meet another emergency situation.
  - The physio-chemical parameters of water should be recorded regularly as a part of water quality monitoring.

### **Stock Management:**

In cage fish farming, the sourcing of fish seed from authentic and reliable agencies is crucial for successful operations. It is essential to maintain proper records regarding the source of the seed, ensuring traceability and accountability. The acquired seed should undergo quarantine and acclimatization procedures to minimize the risk of introducing diseases to the farming system. The size at which fish are stocked and the optimal stocking density should be determined based on specific requirements, taking into account factors such as growth rates and survival rates. Since cage fish farming relies heavily on supplementary feeding, selecting high-quality fish feed and applying it in the appropriate quantity is vital to achieve desirable results. It is important to avoid sinking feed in cage fish farming as it tends to accumulate at the bottom of the cages or reservoirs, leading to environmental degradation and water quality

issues. Therefore, the use of floating or slow-sinking feeds is recommended to ensure efficient consumption by the fish and maintain a clean and healthy cage or reservoir environment. By adhering to these practices, cage fish farmers can optimize the overall productivity and sustainability of their farming operations.

**Table-1: Net Cage Dimensions for Tilapia Culture**

<b>Net Cage Specifications</b>	<b>Fish Weight</b>
Fish net cage without top cover made of HDPE 0.75/16mm mesh size webbings with rope (Cage size: 6m x 4m x 4m)	50 - 150 grams
Fish net cage without top cover made of HDPE 1.25/20mm mesh size webbing with rope (Cage size: 6m x 4m x 4m)	150 – 250 grams
Fish net cage without top cover made of HDPE 1.25/24mm mesh size webbing with rope (Cage size: 6m x 4m x 4m)	250 – 500 grams, till harvest

**Table-2: Specifications of Net Cage for Tilapia Culture**

<b>Items</b>	<b>Details</b>
Cage Size	6m x 4m x 4m
Mesh Sizes	16 mm, 20 mm, 24 mm
Body weight, Feed Pellet Size & Protein Content	50-150 grams – 2 mm (28% protein)
	150-500 grams – 3 mm (28% protein)
	500-600 grams – 4 mm (25% protein)
	600 grams and above – 5 mm (22% protein)
Stocking Density	40/m <sup>3</sup>
Cage Changing	Fortnightly

**Table-3: Feeding Chart for Tilapia**

S. No.	ABW (g)	Feeding rate (% of Body Weight)	Culture Phase
1	1-5	8%	Nursery Rearing
2	6-10	6%	
3	10-15	5.5%	
4	15-20	4%	
5	20-50	4.0 - 2.5%	
6	50-100	2.5 -1.7%	Growout Rearing
7	100-200	1.7 - 1.3%	
8	200-300	1.3 - 1.0%	
9	300-500	1.0 - 0.9%	
10	500-700	0.9 - 0.8%	
11	>700	1.8 - 0.6%	

### **Fish Health Monitoring**

Fish health monitoring plays a crucial role in maintaining a hygienic and healthy culture environment in cage fish farming. It is essential to source seed and feed from authorized and genuine agencies that adhere to high-quality standards. Using suitable quality feed, maintaining optimal stocking densities, and implementing preventive measures such as prophylactic treatment before stocking are key to preventing disease outbreaks and minimizing stock losses. Whenever possible, the use of antibiotics and chemicals should be avoided to promote environmentally friendly practices.

To ensure the safety of workers and minimize risks, an adequate number of lifebuoys and other life-saving equipment should be provided at the cages and vessels used for managing them. Workers should wear life jackets at all times while working in water and cages. Emergency life-saving kits and first-aid boxes should be easily accessible at the cages, boats, floating huts, or field camps to address any unforeseen incidents.

During the harvesting process, feeding should be stopped at least two days prior to harvesting to facilitate proper evacuation of the digestive system. It is advisable to harvest the larger fish first, conducting phased harvesting to optimize efficiency. Maintaining accurate records of the harvest at the site is crucial for traceability and quality control purposes. It is

also essential to develop a post-harvest and marketing strategy before scaling up cage culture ventures on a large scale.

Furthermore, the social relevance of cage fish farming lies in the pursuit of increased fish production through environmentally sustainable and socially inclusive means. By adopting responsible farming practices and considering the impact on the environment and local communities, cage fish farming can contribute to both economic growth and social well-being.

Overall, fish health monitoring, safety measures, effective harvesting practices, and a focus on social relevance are vital components of successful cage fish farming operations. By implementing these measures, fish farmers can ensure the well-being of their stocks, minimize risks, and maximize the benefits of sustainable aquaculture practices.

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## Chapter-3

# Profitable Mud Crab Farming & Fattening for the Coastal Fisherfolk

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### Introduction:

The coastal waters have a wealth of crustaceans that play a vital role in the food chain and food web of the ecosystem. The distribution and abundance of the crustacean population is dependent on the tidal influence and tidal amplitude, the presence of seaweeds and seagrasses, the proximity to the lake mouth and the soil texture. Crustacean diversity ranges from tiny amphipods to large mud crabs, from a few milligrams to a few kilos. Some of the crustaceans seen in Pulicat lake are the Amphipods, Isopods, Tanaids, Squilla, mole crabs, fiddler crabs, hermit crabs, ghost crabs, mud crabs, lagoon crabs and ocydops. The habit and habitat of these crabs are so varied yet they contribute to the lake energetics are detritus feeders or scavengers. There are a few commercially important crabs like the mud crabs, *Scylla serrata*, *Scylla olivacea*, and marine crabs like *Portunus pelagicus* and *Portunus sanguinolentus*.

Most of the shore crabs live in burrows. Species of *S. serrata* and *S. olivacea* burrow in the shallow intertidal area primarily for the purpose of moulting



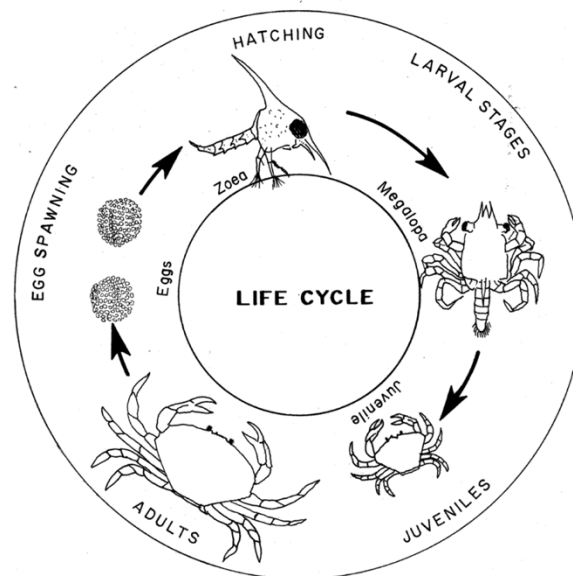
*Scylla olivacea*



*Scylla serrata*

## Life Cycle of a Mud Crab:

- **Zoea** – A mud crab begins life as a larva called a ‘zoea’, which hatches from an egg. It is about one millimetre long, has undeveloped limbs, and floats with the plankton.
- **Megalopa** – A zoea grows by ‘moulting’ (shedding its shell) four times over 12 to 15 days. During the fifth moult, it transforms into a ‘megalopa’, which has functional claws. After a week or so, it moves inshore and settles to the seabed. After a few days, it moults into a stage one juvenile crab.
- **Juvenile crab** – A miniature version of the adult, it is about 4 mm wide. About a month after hatching, when 10 – 20 mm wide, it moves to an estuary and settles in a sheltered area. Young adult – The crab reaches sexual maturity at 18 to 24 months.
- **Spawning and hatching** - The female migrates offshore to spawn. The fertilised eggs are released in batches of two to five million. After digging a hole in the sand or mud with her abdominal flap, the female releases her eggs into it. Using her swimming legs, she gathers the eggs up to carry them under her abdomen. The eggs hatch in two to four weeks. The lifecycle then begins again.



Life cycle of crab

## Crab Fattening Technology:

Mud crab aquaculture involves the capture and fattening of juvenile crabs from the wild. The mud crab, *Scylla serrata*, is abundant in the Pacific and Indian oceans. It is available in brackish coastal waters and estuaries and has great potential for aquaculture. Mud crab of genus *Scylla*, also known as green crab or mangrove crab, constitutes an important secondary crop in the traditional shrimp or fish culture systems of Asian countries. Due to its export potential, there is a rise in the popularity of crab farming among the coastal communities. Crab fattening requires low investment and can be carried out in small water bodies. The soft-shell crabs are caught and reared for around 15 days in saline water. Once these crabs become hard shelled, their market value increases. They are then marketed and exported. For fattening, the technology involves the construct of small cages with individual cells which are then stocked

with lean crabs, weighing at least 100 g (if female native crabs) or 300 g (if female giant crab). Males weighing 200 g (if native) or 350 g (giant crab) may also be stocked individually in the cage cells. Fattening can take 15-30 days. Feeds, usually trashfish, are bought in from the local market. Mud crab (*Scylla serrata*) is actually an ecologically important species of crab which is also called as mangrove crab and as well as black crab. And the mud crab is mainly found in the estuaries and mangroves of Asia, Africa and Australia. Mud crabs as food have become popular since the early 80's with the commencement of live crab export to the American and European countries.

The live mud crabs as an export product have opened up huge opportunities for mud crab farming business in some poor South Asian countries. Mud crabs have both high price and demand in both local and the international market.

### **Mud Crab Farming Methods:**

Starting mud crab farming is easy and simple, even beginners can start this business. Mud crabs are raised in many different methods depending upon the available facilities in your area. Mud crabs can be reared in two systems. Grow out farming and fattening systems. The systems of mud crab farming in these two methods are described below.

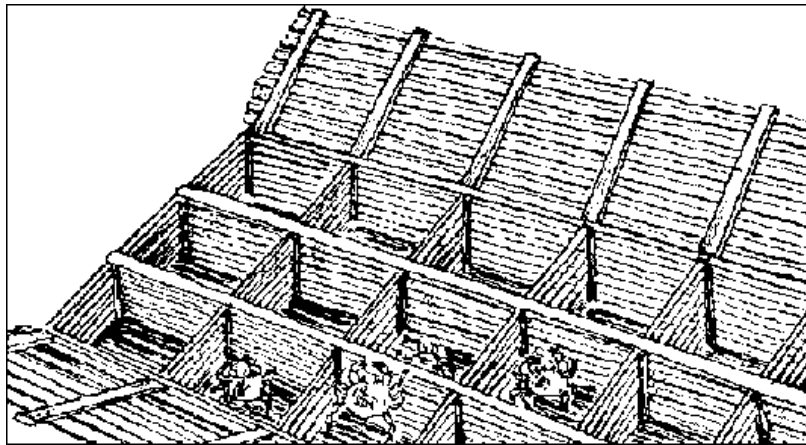
#### **Grow Out System:**

In the grow-out farming system, young crabs are raised and grown for a certain period of 5 to 6 months till they reach marketing size and weight. This type of crab farming system is generally pond-based. The pond size depends on the product type. Generally, ponds for crab farming sized between 0.5 to 2 hectares. Proper bunds and tidal water exchange are a must. Small-sized ponds are very suitable for crab farming because they are easily maintained. Make a suitable fence if the size of the pond becomes small. In larger-sized ponds where natural conditions are prevailing, strengthening is necessary along the outlet area. Wild-collected juvenile crabs that weigh around 10 to 100 grams are stocked. Depending on the size of crabs and available facilities the duration of production may vary between 3 to 6 months.

In commercial production with supplementary feeding, one can stock 1-3 crabs per square meter. Crabs are fed with low-cost fish, shrimps, small-sized crabs, etc. Nearest local market can be visited and rotted fish and innards of birds and animals from slaughterhouses are collected. The crabs are provided with 5% feed daily of their total body weight. For example, if there are 100 kg crabs in the pond then feed with 5 kg food daily. Collect some crabs and try to determine an average weight. Regular sampling is very necessary for monitoring the growth and general health, and to adjust the feeding rate. Within 3 to 5 months they will reach marketing weight and become suitable for selling.

### Crab Fattening In Cages and Ponds:

There are two methods that are commonly used in fattening crabs. One method is the use of bamboo cages 1.83 m long 92 cm wide and 23 cm high. The top cover is provided with holes used in feeding trash fish or mussels. One unit is composed of 18 cubicles or compartments that can hold one thin mature crab each. The cages are anchored to the muddy bottom by a post (813 cm in diameter and 1.221.83 m long) at 1 to 2 m below the tide level.



The cubicle or compartment-type method.

The other method is the fishpond method. The pond may be constructed in varying sizes ranging from 10 to 20 m wide, 20 to 40 m long and 1 to 2 m deep dikes. It is placed in brackish water areas. The fishpond dikes are provided with bamboo slat fences of 2.54 cm wide and 0.91-1.52 m long. The bamboo slat fence is anchored to a 8-13 cm post at a 45-degree angle towards the inside pond. This is done because gravid crabs have the tendency to escape during their spawning period to go to deeper seas. During heavy rains that cause stratification or reduction of oxygen level in the water, the crabs are forced to come out to breathe. Also, mud crabs have the instinct to go out at night from their burrows to look for food. At a 45-degree slant of the bamboo slat fence the crabs cannot escape clue to their weight. The bamboo slat is also hard and slippery to cling on. They will only fall back into the fishpond. Fattening ponds can accommodate four to six nieces per square meter.



The mud crabs are fed with fresh trash fish, roughly five percent of the crabs' body weight, in the early morning and late afternoon. Mud crabs increase their weight at an average of 10 grams

per day. Feeding three to five kg of fresh trash fish (brown mussels, fishes, shells, etc.) can give one kg added weight to the mud crabs.

### **Indoor Mud Crab Farming:**

Raising soft-shelled crabs for a certain period until their exoskeleton gets hardened is known as the crab fattening system. Hard-shelled crabs have four to five times more value in the market than soft-shelled crabs. Farming crabs in this system take less time and the process is very profitable.



Juveniles are introduced into the boxes (one per box) and are maintained till reach the marketing weight (300-500g). Water levels in the boxes are maintained by having elevated outlets. Water quality is important. Recirculating Aquaculture System (RAS) is adopted to maintain water quality and supply.

Mud crabs are fed with feeds weighing 5-8% of the total body weight. They are fed twice a day and major feeding is during the evening hours. Presence of fecal matter is a good sign of feeding which will often pollute the culture water. Flush valves are provided so that solids can be drained with ease.

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## Chapter-4

### Government Initiatives on Sustainable Aquaculture

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The fishing industry is a large one that encompasses a variety of industries. It is a very well-known fact that many people benefit from the fishing industry's value chain because fish and fish-based goods are consumed all over the world. With the advancement in technology (using organic juice, mud pot techniques, integrated diversified aquaculture etc) now anyone can start a fish farm in the desert as well. This demonstrates that if you want to create a fishing-related business, your location should not be a barrier. If you want to make a lot of money by leveraging the fishing sector, you'll have to pick one of the many fish-related business options available.

Pradhan Mantri Matsya Sampada Yojana. (PMMSY) is designed to address critical gaps in fish production and productivity, quality, technology, post-harvest infrastructure and management, modernisation and strengthening of value chain, traceability, establishing robust fisheries management framework and fishers' welfare.

The PMMSY is an umbrella scheme with two separate Components namely (a) Central Sector Scheme (CS) and (b) Centrally Sponsored Scheme (CSS). The Centrally Sponsored Scheme (CSS) Component is further segregated into Non-beneficiary oriented and beneficiary orientated subcomponents/activities under the following three broad heads:

The intended beneficiaries under the Pradhan Mantri Matsya Sampada Yojana (PMMSY) amongst the others include the following:

The intended beneficiaries under the Pradhan Mantri Matsya Sampada Yojana are:

- (i) Fishers
- (ii) Fish farmers
- (iii) Fish workers and Fish vendors
- (iv) Fisheries Development corporations
- (v) Self Help Groups (SHGs)/Joint Liability Groups (JLGs) in fisheries sector
- (vi) Fisheries cooperatives
- (vii) Fisheries Federations
- (viii) Entrepreneurs and private firms
- (ix) Fish Farmers Producer Organisations/Companies (FFPOs/Cs)
- (x) SCs/STs/Women/Differently abled persons

## List of Activities

Beneficiary Oriented Sub-Components and activities proposed under Centrally Sponsored Components of Pradhan Mantri Matsya Sampada Yojana

### **A Enhancement of Production and Productivity**

- 1 Development of Inland Fisheries And Aquaculture
  - 1.1 Establishment of New Freshwater Finfish Hatcheries
  - 1.2 Establishment of New Freshwater Scampi Hatcheries
  - 1.3 Construction of New Rearing ponds
  - 1.4 Construction of New Grow-out ponds
  - 1.5 Inputs for fresh water Aquaculture including Composite fish culture, Scampi,Pangasius, Tilapia etc.
  - 1.6 Establishment of need based New Brackish Hatcheries (shell fish and fin fish)
  - 1.7 Construction of New ponds for Brackish Water Aquaculture
  - 1.8 Construction of New ponds for Saline /Alkaline areas
  - 1.9 Inputs for Brackish Water Aquaculture
    - 1.1 Inputs for Saline /Alkaline Water Aquaculture
    - 1.11 Stocking of Fingerling (FL) in Wetlands @2000FL/ha
    - 1.12 Stocking of Fingerlings in Reservoirs @1000FL/ha
- 2 Development of marine fisheries including mariculture and seaweed cultivation
  - 2.1 Establishment of Small Marine Finfish Hatcheries
  - 2.2 Construction of large Marine Finfish Hatcheries
  - 2.3 Marine Finfish Nurseries
  - 2.4 Establishment of Open Sea cages (100-120 cubic meter volume)
  - 2.5 Establishment of Seaweed culture rafts including inputs
  - 2.6 Establishment of Seaweed culture with Monoline/tubenet Method including inputs (oneunit is approximately equal to 25 ropes of 25m length)
  - 2.7 Bivalve cultivation (mussels, clams, pearl etc.)
- 3 Development of fisheries in North-eastern and Himalayan States/UTs (besides the below activities, the North-eastern and Himalayan States/UTs will also be assisted under other sub-components/activities envisaged under PMMSY that are common to all states/UTs).
  - 3.1 Establishment of Trout Fish Hatcheries
  - 3.2 Construction of Raceways
  - 3.3 Inputs for Trout Rearing Units
  - 3.4 Construction of New Ponds in Himalayan Region.
  - 3.5 Establishment of Mini RAS for Cold water Fisheries
  - 3.6 Establishment of Medium RAS for cold water fisheries
  - 3.7 Input support for Integrated fish farming (paddy cum fish cultivation,livestock cum



fish, etc)

- 3.8 Establishment of Cages in cold water regions
- 4 Development of ornamental and recreational fisheries
  - 4.1 Backyard Ornamental fish Rearing unit (both Marine and Fresh water)
  - 4.2 Medium Scale Ornamental fish Rearing Unit (Marine and Freshwater Fish)
  - 4.3 Integrated Ornamental fish unit (breeding and rearing for fresh water fish )
  - 4.4 Integrated Ornamental fish unit (breeding and rearing for marine fish )
  - 4.5 Establishment of Fresh water Ornamental Fish Brood Bank
  - 4.6 Promotion of Recreational Fisheries
- 5 Technology infusion and adaptation
  - 5.1 Establishment of large RAS (with 8 tanks of minimum 90 m<sup>3</sup>/tank capacity 40 ton/crop)/Biofloc (50 tanks of 4m dia and 1.5 high) culture system.
  - 5.2 Establishment of Medium RAS (with 6 tank of minimum 30m<sup>3</sup>/tank capacity 10 ton/crop)/Biofloc culture system (25 tanks of 4m dia and 1.5 high)
  - 5.3 Establishment of small RAS (with 1 tank with 100m<sup>3</sup> capacity/Biofloc (7 tanks of 4m dia and 1.5 high) culture system
  - 5.4 Establishment of Backyard mini-RAS units
  - 5.5 Installation of Cages in Reservoirs
  - 5.6 Pen culture in open water bodies

## **B Infrastructure and post-harvest management**

- 6 Post-harvest and cold chain infrastructure
  - 6.1 Construction of Cold Storages/Ice Plants
  - 6.2 Modernization of Cold storage /Ice Plant
  - 6.3 Refrigerated vehicles
  - 6.4 Insulated vehicles
  - 6.5 Live fish vending Centres
  - 6.6 Motor cycle with Ice Box
  - 6.7 Cycle with Ice Boxes
  - 6.8 Three wheeler with Ice Box including e-rickshaws for fish vending
  - 6.9 Fish Feed Mills(mini)
  - 6.1 Fish Feed Plants
- 7 Markets and marketing infrastructure
  - 7.1 Construction of fish retail markets including ornamental fish/aquarium markets.
  - 7.2 Construction of fish kiosks including kiosks of aquarium/ornamental fish
  - 7.3 Fish Value Add Enterprises Units
  - 7.4 E-platform for e-trading and e-marketing of fish and fisheries products
- 8 Development of deep-sea fishing
  - 8.1 Support for acquisition of Deep Sea fishing vessels for traditional fishermen
  - 8.2 Up gradation of existing fishing vessels for export Competency

- 8.3 Establishment of Bio-toilets in mechanized fishing vessels
- 9 Aquatic health management
  - 9.1 Establishment of Disease diagnostic and quality testing labs
  - 9.2 Disease diagnostic and quality testing Mobile labs/clinics
- C Fisheries management and regulatory framework**
  - 10 Monitoring, Control and Surveillance (MCS)
    - 10.1 Communication and /or Tracking Devices for traditional and motorized vessels like VHF/DAT/NAVIC/Transponders etc.
  - 11 Strengthening of safety and security of fishermen
    - 11.1 Support for providing safety kits for fishermen of Traditional and motorized fishing vessels (other than Communication and/or Tracking Device mentioned at 10.1 above)
    - 11.2 Providing boats (replacement) and nets for traditional fishermen
    - 11.3 Support to Fishermen for PFZ devices and network including the cost of installation and maintenance etc.
  - 12 Fisheries extension and support services
    - 12.1 Extension and support Services
  - 13 Livelihood and nutritional support for fishers for conservation of fisheries resources
    - 13.1 Livelihood and nutritional support for socio-economically backward active traditional fishers' families for conservation of fisheries resources during fishing ban/lean period.
  - 14 Insurance of Fishing Vessels and Fishermen
    - 14.1 Insurance premium subvention for fishing vessels and Insurance premium for fishers

**Non-Beneficiary Oriented Activities Proposed Under the Centrally Sponsored Components of Pradhan Mantri Matsya Sampada Yojana**

<b>A</b>	<b>Enhancement of fish production and productivity</b>
1	Development of inland fisheries and aquaculture
1.1	Establishment of Brood Banks (including seed banks for seaweeds)
1.2	Integrated Development of Reservoirs
1.3	Integrated Aqua Parks
2	Development of fisheries in the Himalayan and North-Eastern States/UTs
2.1	Support to states for import of germplasm
<b>B</b>	<b>Infrastructure and post-harvest management</b>
3	Development of fishing harbours and fish landing centres
3.1	Construction/Expansion of Fishing Harbours.

3.2	Modernization/Up-gradation of existing Fishing Harbours
3.3	Modern Integrated Fish Landing Centres
3.4	Maintenance of Dredging of existing FHs
<b>4</b>	<b>Markets and marketing infrastructure</b>
4.1	Construction of state of art whole sale fish market.
4.2	Organic Aquaculture Promotion and Certification
4.3	Promotion of Domestic fish consumption, branding, Fish mark, GI in fish, Himalayan Trout-Tuna branding, Ornamental fishes promotion and brandingetc.
5	Development of deep sea fishing
5.1	Promotion of technologically advanced vessels to marine fishermen/fishermen groups through State/UT Governments
6	Integrated modern coastal fishing villages
6.1	Integrated modern coastal fishing villages
7	Aquatic health management
7.1	Aquatic Referral Labs for Quality testing and Disease Diagnostics
<b>C</b>	<b>Fisheries management and regulatory framework</b>
8	Monitoring, Control and Surveillance (MCS)
8.1	Common Infrastructure for MCS including Hub stations, towers, IT based software, peripherals, networks and operations etc.
9	Fisheries extension and support services
9.1	Multipurpose Support Services – Sagar Mitra (performance-based incentives along with requisite IT/Communication support like Tablet/mobile telephony etc. would be provided to Sagar Mitras)

**D Central Sector Scheme Sub-Components/ Activities With 100% Central Funding Proposed Under PMMSY**

1	Genetic improvement programmes and Nucleus Breeding Centers (NBC)
2	Innovations and Innovative projects/activities, Technology demonstration including startups, incubators and pilot projects
3	Training, Awareness, Exposure and Capacity Building
4	Aquatic Quarantine Facilities
5	Modernization of Fishing Harbours of central government and its entities
6	Support to National Fisheries Development Board (NFDB), Fisheries Institutionsand Regulatory Authorities of Department of Fisheries, Government of India and need based assistance to State Fisheries Development Boards.
7	Support for survey and training vessels for Fisheries Institutes including dredger TSD Sindhuraj owned by the DoF and GoI.
8	Disease Monitoring and Surveillance Network
9	Fish data collection, fishers' survey and strengthening of fisheries database

10	Support to security agencies to ensure safety and security of marine fishermen atsea
11	Fish Farmer Producer Organizations/Companies (FFPOs/Cs)
12	Certification, Accreditation, Traceability and Labeling

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## Chapter-5

### Case studies on Sustainable Fishery Resource Management & Development In Haldia, West Bengal

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#### **Introduction:**

The present paper is based on the field survey in different villages of Haldia Block of Purba Medinipur District of West Bengal. The survey investigation indicated that integrated fishery management practices related to proper resource utilization, species diversification with endangered indigenous & new fish species introduction i.e. Amur Common Carp, Pengba, Milk fish, Pabda , GIFT Tilapia rearing as per scientific recommendations has helped in long-term rural livelihood improvement for the fish farmers. This paper entails several success stories and interesting livelihood opportunities with respect to Haldia region of West Bengal.

#### **Case Study- I**

Mrs. Arati Barman, with her four family members resides in Dwariberia village (Haldia block) of Purba Medinipur district in West Bengal. She owns 3.5 hectare land most which is in the own village and villages of Tamluk Block. She generally used to cultivate Indian Major Carps. Initially in her young age she was shelling 'ghugni muri' at local melas to run their family. She has a pond of 0.13 (1 bigha) hectare besides her residence where she cultivated fish in extensive way of without any scientific management. Because of an erratic and insufficient household income, their nutritional requirements were barely met prior to 2008. After that Mrs. Arati Barman got Govt. assistant with bank loan for renovation of her pond in the year 20015-2016. as well as she participated in Fish culture training programme conducted under Dept. of Fisheries, Govt. of WB. From this intervention she has got profit. After getting good profit she decided converted her rice field for fish cultivation. Even though she invest a huge amount of money she got a net profit from fish farming which she expected to increase in the next year. It has significantly changed her standard of living. She received state level "Meen Mitra" award from dept. of fisheries, Govt. of West Bengal. It is a one of the best example of family fish farming. This farmer is associated with family farming and kept close contact with fisheries department of the Haldia block. This farmer joins the government fisheries training camp and enhances the efficiency of his work, and has also improved the integrated fish cultivation by

implementing various government projects. This is one of the best examples which encourage other fish farmers. This topic has been published in the newspaper.



"Ei samay" News Paper :: Dated 25/03/2018 apge 10

Photo: Mrs. Arati Barman

### Case Study- II

Mr. Sudip Bikash Khatua, who believes that fisheries are one of the major components of development, is one of the beneficiaries under family farming farm school, Haldia. He is from Barbasudevpur village of Haldia Block. His family consists of his wife & widow sister-in-law. He is very much enthusiastic & energetic farmer of age 55. His family's main source of livelihood is only fish farming. He is being supported by RKVY Scheme. His construction of fish farming in 4 hectare of his own land. He has a backyard small scale ornamental fish breeding & rearing unit. Now he became self sufficient and continues culturing of fish in integration of horticulture. He received National Best Fish Farmer award from Central Inland Fisheries Research Institute. This farmer is associated with family farming and kept close contact with fisheries department of the Haldia block. This farmer joins the government fisheries training camp and enhances the efficiency of his work, and has also improved the integrated fish cultivation by implementing various government projects. This is one of the best examples which encourage other fish farmers. This topic has been published in the newspaper.



### Case Study- III

Mr. Sarat Chandra Bhawmik is a energetic & optimistic farmer from Basanchak village of Haldia block. He is an under metric & his family consist of his wife, daughter, son & himself. The main source of their livelihood is pisciculture only. His total water area holding is 60 bighas . He has duck cum fishery, horticulture. He is also being provided training on Integrated Farming System & improved cultivation practices under department of Fishries.

He has cultivated vegetables in two bighas of land. Vegetables grown are mostly used in household consumption .Moreover, some of the quantities are sold in market from where he earned. He successfully cultured Pabda Fish, Pengba Fish. This farmer is associated with family farming and kept close contact with fisheries department of the Haldia block. This farmer joins the government fisheries training camp and enhances the efficiency of his work, and has also improved the integrated fish cultivation by implementing various government projects. This is one of the best examples which encourage other fish farmers. This topic has been published in the newspaper.



Pengba Fish

Photo: Mr. Sarat Chandra Bhowmik with his wife

#### Case Study- IV

Fish is one of the favorite items of the diet of Bengalis people. Integration of livestock, fish and horticulture in a one plot of 10 bigha land can bring a new hope for the small and marginal farmers. Mr. Rangalal Samanta (age 42 years) is a H.S. passed farmer of village Dwariberia of Haldia Block. Successfully implemented Genetically Improved Farm Tilapia (GIFT Tilapia) experimental trail run by dept. of fisheries, West Bengal. This farmer is associated with family farming and kept close contact with fisheries department of the Haldia block. This farmer joins the government fisheries training camp and enhances the efficiency of his work, and has also improved the integrated fish cultivation by implementing various government projects. This is one of the best examples which encourage other fish farmers.



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### Case Study- V

Mr. Mrinmoy Samanta is a young energetic farmer from Dwariberia village of Haldia block. He is an under Madhyamik & his family consist of mother, father, his wife & himself. The main source of their livelihood is pisciculture only. His total water area land around 30 bigha. He has cultivated Indian major Carp. He is also being provided training on Integrated Farming System & family fish farming Practices under fisheries department. Implemented DC (Demonstration Center) scheme on MSMH( Multiple Stocking Multiple Harvesting) . He has total 30 Bigha land including lease. He is a successful fish farmer for the culture of Amur Carp, Jayanti Rohu along with Indian Major Carp. He received Kriti Krishak award in Mati Utsav for successful culture of Amur Carp. This farmer is associated with family farming and kept close contact with fisheries department of the Haldia block. This farmer joins the government fisheries training camp and enhances the efficiency of his work, and has also improved the integrated fish cultivation by implementing various government projects. This is one of the best examples which encourage other fish farmers. This topic has been published in the newspaper.



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### Case Study VI

Mr. Subrata Maity is an energetic & optimistic farmer from Basanchak village of Haldia block. He is an under metric & his family consist of mother, his wife, two daughter & himself. The main source of their livelihood is pisciculture only. His total water area holding is 10 bighas. He has backyard small hatchery. Hatchery runs by husband & wife together. They attend various training. Now he gets an IMC Hatchery scheme under blue revolution. It is a one of the best example of family fish farming. This farmer is associated with family farming and kept close contact with fisheries department of the Haldia block. This farmer joins the government fisheries training camp and enhances the efficiency of his work, and has also improved the integrated fish cultivation by implementing various government projects. This is one of the best examples which encourage other fish farmers. This topic has been published in the newspaper.





'Bartaman' News paper Dated-0 08/02/2018 Page 8

Mr. Subrata Maity & his Wife

### Case Study- VII

Mr. Narayan Barman & his family totally involve in various type of fish culture. Total 40 Bigha fisheries situated at Dwariberia Village of Haldia Block. Narayan Barman received 'Meen Mitra' award from state fishery department. He successfully implemented Rastriya Krishi Vikash Yojona schemes in intensive-fish farming. He utilized pond dyche as ornaments trees. This farmer is associated with family farming and kept close contact with fisheries department of the Haldia block. This farmer joins the government fisheries training camp and enhances the efficiency of his work, and has also improved the integrated fish cultivation by implementing various government projects. This is one of the best examples which encourage other fish farmers. This topic has been published in the newspaper.



Photo: Mr. Narayan Barman

### Case Study- VIII

Mr. Krishnaprasad Samanta is versatile progressive fish farmer. He attends various type of fishery training under dept of fisheries. Successfully cultivate a new fish species i.e. Milk Fish along with other fresh water culturable species & integrated fishery management practices. Successfully implemented Demonstration Center on MSMH concept. This farmer is associated with family farming and kept close contact with fisheries department of the Haldia block. This farmer joins the government fisheries training camp and enhances the efficiency of his work, and has also improved the integrated fish cultivation by implementing various government projects. This is one of the best examples which encourage other fish farmers. This topic has been published in the newspaper.



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## Chapter-6

# Entrepreneurial Opportunities in Fisheries Fabrication Industry

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In the fisheries industry, there are several types of fabrication businesses that entrepreneurs can consider. These businesses focus on various aspects of the fabrication and processing of fish products. Here are some of the different kinds of fabrication businesses in the fisheries industry:

### **Net Fabrication:**

Fishing nets are integral part in almost all fishery activities such as culture and capture of shellfishes, finfishes as well as other aquatic organisms. Nets or fishing gears are evolved from being simple pointed wooden projectile to advanced and complex nets over past centuries. The fabrication and manufacture of these nets and gear is carried out by small artisan to large scale industrial ventures. There is continuous demand for different types, shapes and amount of nets and gears used in fishery activities. Many of the Indian net fabricating industry are exporting quality of fishing nets, traps, cages and other fishing gears to majority of the countries of the world. Some of the industry have gained expertise in design and manufacture of culture cages and other units which has huge worldwide demand. This sector can assure huge employment and revenues.

### **Craft fabrication:**

Fishing boats and crafts are essential mainly in capture fishery. There is huge demand for different types of fishing crafts ranging from simple dugout canoe to large industrial fishing ships. The fabrication, construction and maintenance of fishing crafts provides huge employments. Some of the fishing ships requires hundreds of workers for its regular operations. Moreover, regular maintenance, repair, navigation, harbouring, etc, generates substantial employment opportunities.

### **Fish Processing Plants:**

Fish processing plants specialize in receiving, sorting, and processing raw fish into various forms such as fillets, steaks, and portions. These plants often employ advanced machinery and techniques to handle large volumes of fish efficiently. They may also have specialized facilities for tasks like smoking, canning, freezing, or drying fish.

### **Value-Added Seafood Products:**

Entrepreneurs can establish businesses that focus on creating value-added seafood products. These products involve processing or modifying raw fish to enhance their appeal or convenience. Examples include pre-marinated fish cuts, ready-to-cook seafood meals, fish

burgers, fish sausages, fish-based spreads, and gourmet seafood snacks. Value-added products often target niche markets and cater to specific consumer preferences.

### **Fish Packaging and Distribution:**

Fish packaging and distribution businesses are involved in the packaging, labeling, and distribution of fish products. They ensure that the fish is properly packaged to maintain freshness, quality, and safety during transportation and storage. These businesses may also provide services like custom packaging, private labeling, and distribution logistics for fish products.

### **Fishery Equipment and Machinery Manufacturing:**

Entrepreneurs can venture into the fabrication of specialized equipment and machinery used in fisheries. This includes manufacturing fish processing equipment like filleting machines, scaling machines, skinning machines, fish drying equipment, and packaging machinery. Additionally, they can produce equipment for fishing vessels, fish farms, and aquaculture operations.

### **Fish Feed Manufacturing:**

Fish feed manufacturing businesses produce formulated feeds for various species of fish, including both freshwater and marine fish. These feeds are designed to provide optimal nutrition for fish growth and health. Entrepreneurs in this sector need knowledge of feed formulation, ingredient sourcing, and manufacturing processes.

### **Fish Farm Infrastructure and Aquaculture Systems:**

Entrepreneurs can establish fabrication businesses that focus on designing, manufacturing, and installing infrastructure and systems for fish farms and aquaculture operations. This includes the fabrication of fish cages, nets, fish farm equipment, aeration systems, water filtration systems, and recirculating aquaculture systems (RAS).

### **Seafood Processing Equipment Maintenance and Repair:**

Entrepreneurs can provide maintenance, repair, and servicing for seafood processing equipment. This includes offering on-site repairs, equipment calibration, spare parts supply, and preventive maintenance services for fish processing plants and related facilities.

### **Fish Waste Utilization and Byproduct Processing:**

Entrepreneurs can explore businesses that specialize in the utilization and processing of fish waste and byproducts. This can involve converting fish waste into fishmeal, fish oil, or other value-added products. By maximizing the use of fish resources, these businesses contribute to sustainability and waste reduction in the fisheries industry.

It's important for entrepreneurs to conduct thorough market research and assess the local demand and competition before starting a fabrication business in the fisheries industry. Additionally, staying updated with market trends, technological advancements, and regulatory requirements is crucial for success in this dynamic sector.

## Infrastructure development

The PMMSY has a major focus on infrastructural development. 42% of the PMSSY funds are set aside for the creation and upgradation of infrastructural facilities. The need to develop marine infrastructure has been recognised to ensure safe fishing, including upgrade of vessels and technology adoption.

## Promotion of fisher community institutions and FFPOs

The fisheries sector requires a multi-pronged approach to streamline the existing issues and encourage improved participation of stakeholders. Strong participation from aqua farmers and fishers is the primary requisite to advance the fisheries ecosystem. A key intervention will be aggregating them into aqua farmer or fisher-based institutions. Collectivisation of producers, especially small and marginal producers, into producer organisations can be one of the most effective ways to address the many challenges. More importantly, it will lead to improved access to investments, infrastructure, technology, inputs and markets. In this context, the two most important areas of intervention would be – (a) aggregating aqua farmers and fishers into FFPOs and (b) supporting and strengthening farmers’ interests through FFPOs.

The Government has taken initiatives to promote fish farmers and fishers’ institutions and the Department of Fisheries, GoI, has published a framework to promote FFPOs and provide necessary support for the growth of such institutions. Guidelines on the ‘Formation and Promotion of Fish Farmer Producer Organizations (FFPOs)’ were launched under the PMMSY in 2021 to empower fishers and fish farmers economically and enhance their bargaining power. Along with a conducive policy environment, a structured approach is needed to ground this vision and ensure the sustainability of these institutions.

An FFPO is an association or group of fishers or fish farmers or fisheries stakeholders, organised with the primary objective of carrying out sustainable fisheries value chain business activities and registered under any law for the time being in force, or promoted under a scheme or programme supported by the Central or state government.

With the objective of improving returns for fish farmers and fishers, FFPOs can promote several socio- economic activities for their members and other value chain actors. Some broad activities of FFPOs are listed below:

<b>FFPO initiatives</b>	<b>Key activities</b>
Capacity building and ecosystem development	<ul style="list-style-type: none"><li>• Capacity building of members</li><li>• Dissemination of best practices and cross learning among members</li><li>• Water and resource management in production clusters</li><li>• Technology-driven tools and equipment delivery</li></ul>

	<ul style="list-style-type: none"> <li>• Promotion of new aquaculture techniques</li> </ul>
Market linkages	<ul style="list-style-type: none"> <li>• Linkage with market intermediaries and processors to sell produce</li> <li>• Direct market linkage in other states</li> <li>• Establishing wholesale or retail outlets</li> </ul>
Infrastructure development	<ul style="list-style-type: none"> <li>• Cold storage units, various types of chiller boxes, storage units, ice factory</li> <li>• Pre-processing, processing units, food parks</li> <li>• Logistics and transport</li> </ul>
One-stop shop for fisheries: Owned and run by FFPOs	<ul style="list-style-type: none"> <li>• Supply of inputs and equipment to members at affordable prices</li> <li>• Aggregation of fish from members and trade</li> <li>• Leasing machinery and tools</li> <li>• Extension services</li> <li>• Information centre: Technical know-how, market information, information on Government schemes, SMS-based service delivery</li> </ul>

To make a fabrication business successful in the fisheries industry, there are several key features that entrepreneurs should focus on. These features encompass various aspects of the business, including market positioning, operations, sustainability, and customer satisfaction. Here are some key features to consider:

*a. Quality and Product Differentiation:*

Emphasize the importance of producing high-quality fish products that meet or exceed customer expectations. Differentiate your products by offering unique characteristics, such as superior freshness, taste, texture, or value-added features. Invest in quality control measures, traceability systems, and certifications to build trust and ensure consistent product excellence.

*b. Market Research and Customer Understanding:*

Conduct thorough market research to identify consumer preferences, market trends, and demand patterns. Understand the needs, behaviors, and expectations of your target customers. This knowledge will help you tailor your products, pricing, packaging, and marketing strategies to effectively address customer needs and stand out from competitors.

*c. Efficient Operations and Technology Adoption:*

Streamline your fabrication processes by embracing automation, technology, and efficient operational practices. Invest in state-of-the-art machinery and equipment that improve productivity, enhance product quality, and reduce labor costs. Leverage technologies such as robotics, artificial intelligence, and computer vision systems to optimize various stages of the fabrication process.

*d. Sustainability and Responsible Practices:*

Incorporate sustainable practices throughout your fabrication business. Focus on responsible sourcing of fish, adhering to sustainable fishing methods, reducing waste and energy consumption, and adopting eco-friendly packaging options. Customers increasingly value businesses that prioritize sustainability, and adopting such practices can also help you comply with regulations and gain a competitive edge.

*e. Strong Supply Chain Management:*

Establish reliable and efficient supply chain management to ensure a steady and consistent supply of raw materials. Forge strong relationships with fishermen, fish farmers, and suppliers to secure a consistent supply of high-quality fish. Implement effective inventory management systems to minimize waste, optimize stock levels, and ensure timely delivery of products to customers.

*f. Branding, Marketing, and Distribution:*

Develop a strong brand identity that resonates with your target customers. Invest in effective marketing strategies, including online and offline channels, to create awareness and generate demand for your fish products. Establish distribution networks that enable you to reach your target markets efficiently, considering factors such as transportation, storage, and delivery logistics.

*g. Customer Relationship Management:*

Prioritize customer satisfaction by offering excellent customer service and building long-term relationships. Listen to customer feedback, address concerns promptly, and continuously improve your products and services based on customer preferences. Implement loyalty programs and engage with customers through various channels to foster loyalty and repeat business.

*h. Continuous Learning and Adaptability:*

Stay informed about industry trends, market dynamics, and technological advancements. Attend industry events, participate in conferences, and engage in professional development activities to stay ahead of the curve. Be adaptable and willing to embrace change as the fisheries industry evolves, ensuring your business remains relevant and competitive.

By focusing on these key features, entrepreneurs can increase their chances of building a successful fabrication business in the fisheries industry. Flexibility, innovation, and a

customer-centric approach are essential for sustained growth and profitability in this dynamic sector.

Starting a fabrication business in the fisheries industry requires careful planning, research, and execution. Here are the steps to consider when launching your fabrication business:

*i. Market Research:*

Conduct thorough market research to understand the dynamics of the fisheries industry in your target location. Identify the demand for fish products, market trends, competition, and potential customer segments. Evaluate the viability of your business idea and determine the specific niche or segment you want to focus on.

*ii. Business Plan:*

Develop a comprehensive business plan that outlines your goals, target market, products and services, operational strategies, marketing approach, and financial projections. This plan will serve as a roadmap for your business and will be useful when seeking financing or partnerships.

*iii. Legal and Regulatory Compliance:*

Research and comply with the legal and regulatory requirements of operating a fabrication business in the fisheries industry. Obtain the necessary licenses, permits, and certifications. Familiarize yourself with food safety regulations, environmental regulations, and any specific industry standards.

*iv. Financing:*

Assess your financial needs and explore funding options. This may include personal savings, bank loans, venture capital, grants, or partnerships. Prepare a detailed financial plan, including start-up costs, operating expenses, and revenue projections. Consider seeking advice from financial professionals or business development organizations.

*v. Location and Infrastructure:*

Choose a suitable location for your fabrication business, considering factors such as proximity to fish sources, accessibility, utilities, and transportation infrastructure. Ensure that the facility meets health and safety requirements, with adequate space for processing, storage, and equipment installation.

*vi. Equipment and Machinery:*

Identify the necessary equipment and machinery for your fabrication operations. This may include processing equipment like filleting machines, scaling machines, packaging machinery, cold storage facilities, and other specialized tools. Research suppliers, compare prices, and consider both new and used equipment options.

*vii. Supply Chain Management:*

Establish relationships with reliable suppliers, including fishermen, fish farmers, and seafood distributors. Ensure a consistent supply of high-quality fish products. Negotiate favorable terms and conditions, and consider establishing long-term contracts to secure a reliable supply chain.

*viii. Human Resources:*



Determine the human resources needed for your fabrication business, including skilled labor for processing, quality control, maintenance, and administration. Recruit and train employees with relevant experience in fish processing techniques, food safety practices, and equipment operation. Develop a strong company culture focused on teamwork, quality, and continuous improvement.

*ix. Marketing and Branding:*

Develop a strong brand identity and create a marketing strategy to promote your fabrication business. Build a professional website, utilize social media platforms, and consider participating in industry events and trade shows. Highlight your unique selling points, such as product quality, sustainability practices, or value-added offerings. Engage with potential customers through targeted marketing campaigns.

*x. Operational Efficiency and Quality Control:*

Establish efficient operational processes to ensure consistent product quality and minimize waste. Implement quality control measures throughout the fabrication process to maintain high standards. Monitor and optimize processes, regularly review product quality, and continuously improve your operations.

*xi. Distribution and Sales Channels:*

Identify appropriate distribution channels to reach your target market. This may include selling directly to restaurants, retailers, wholesalers, or even establishing your own retail outlets. Explore online sales platforms and consider partnerships with distributors or seafood-focused businesses.

*xii. Continuous Learning and Adaptation:*

Stay updated with industry trends, technological advancements, and changing customer preferences. Attend industry conferences, join professional networks, and seek opportunities for continuous learning. Be adaptable and willing to evolve your business strategies based on market demands. Starting a fabrication business in the fisheries industry requires careful planning, attention to quality, and a customer-focused approach. By following these steps and leveraging industry knowledge, you can lay a solid foundation for a successful venture in this dynamic sector.

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## Chapter-7

# BMP's in Shrimp Farming with Technology Interventions

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### Introduction:

Fisheries and aquaculture is one of the most popular sources of protein worldwide. It is the fastest growing food production system in the world and almost half of this that we eat comes from farms. 85% of the world's marine stocks are either fully exploited or overfished, driving accelerated growth in the farmed seafood industry. With an anticipated 10 billion people expected to inhabit the planet by 2050, the demand for animal protein will increase by 52 %. In order to sustainably feed the world's growing population with a healthy, lean protein, aquaculture's role is of the utmost importance. Farmed seafood provides an answer as the world's population becomes more affluent, urbanized and approaches 9 billion before 2050. Global fish production is estimated to have reached about 179 million tonnes in 2018 but only 156 million tonnes ended up on our plates of which 51.3 million tonnes coming from inland aquaculture. World aquaculture production of farmed aquatic animals has been dominated by Asia, with 89 % share in the last two decades. India is the second largest aqua producer and 4th largest seafood exporter in the world claiming its share as 7.73% of global fish production. It is the country's single-largest agriculture export, with a growth rate of 6 to 10 % in the past five years. The average annual growth rate of fisheries sector recorded 10.88% during the period 2014-15 to 2018-19. Across the world, fisheries and aquaculture sector is also a major source of employment. In 2018, an estimated 59.5 million people were engaged in the primary sector of fisheries and aquaculture. India provides employment to about 15 lakhs which is targeted to increase to 5.5 million by 2025 in the PMMSY. India has contributed roughly Rs. 45,106.89 crores (0.91%) to India's GDP.

India being the second largest country in the world fish production, there are huge opportunities for expanding the export basket by including finfish varieties like carps, tilapia, seabass, catfish *etc* which are produced in huge quantities. With thrust being given for Gift tilapia by the Ministry of Fisheries for increasing fish production, this can be seen as a second major commodity in the export basket either in fresh form or better in value addition after shrimp if right interventions are made by various stake holders. Aquaculture in India has evolved as a viable commercial farming practice and has been showing an impressive annual growth rate of 10-15 per cent every year. "India's seafood exports are valued at around US\$ 7 billion in 2018. India stands top on shrimp production and it contributes 70 per cent of Indian aquaculture export value. The International Market Analysis Research and Consulting (IMARC) Group has predicted that the Indian shrimp farming market would reach a volume of 1.13 Mn tonnes by 2024, undergoing a CAGR of around 9% between 2019-2024, reminding

that though it is a multibillion-dollar industry, it still lacks the technology adoption and efficiency it is expected to have. India's agricultural workforce will be smaller, younger, and more feminized in future, which will shape how it is retained in higher productivity jobs of the future. It's projected that skilling is a major area in need of growth.

### **Pre-requisites of a successful crop:**

A successful farm is largely dependent on a farmer's ability to make the right decision at the right time. More than any other business, farming is hugely dependent on the timing of each process, be it stocking, feeding, water quality management, harvesting. Even the slightest delay can hamper farm output and result in losses. Irrespective of the type of production, farmers have been depending on their experience and learning from older farmers in their vicinity to make decisions on when to start each process, which is not always accurate and can lead to significant loss or zero profit or damage to produce.

Nearly 30-40% of farms do not follow recommended GMP, becoming one of the reasons of low productivity of 3tons/HA. Fear of disease outbreak in shrimp has been reported as one of the prime reasons for a 10%-15% drop in production in India, this year. From 2006-08, Indian shrimp farmers were estimated to have undergone a production loss of one thousand Crore rupees due to disease outbreak in shrimp farms.

Majority of the aquafarmers may not be even aware that international markets rely more on certified products and there is a niche market who are willing to pay a premium price for the certified products. The rejections of shipments because of presence of antibiotic raises doubt on the religious adoption of BMP by some farmers and their unhealthy product makes the industry responsible. In the face of such challenges, it becomes inevitable to make the industry antibiotic free. Retailers, regulators, and consumers have become much more attuned to the negative environmental and social impact aspects of unregulated shrimp production, including use of banned chemicals, environmental degradation, human and labor rights violations. To defend its current strong competitive position and to maintain exceptional growth, India needs to produce sustainable products.

### **Adoption of BMP among shrimp farmers in India:**

BMPs involve legal compliance, social responsibility, good site selection, farm construction, good practices in farm management harvest and post-harvest management activities. Adoption of BMPs would result in better production, productivity and returns on the one hand and environmental and social responsibilities on the other where Crop planning, preparation of Crop calendar, Pond preparation practices to be followed, water holding capacity of ponds, Complete drainage of water from pond, removal of organic waste from pond bottom, drying and ploughing the pond bottom, Fertilization and liming of the pond bottom, Water screening, Water Fertilization, Stabilization of the plankton bloom, Biosecurity practices, Shrimp Seed selection & testing, acclimation and stocking, adoption of Feed Management Practices, Water quality management practices, Aeration, Pond bottom management practices, Health Management, harvest and post-harvest practices, Record Keeping.

Suzuki and Hoang Nam (2017) realized that despite the growth of aquaculture exports from developing countries in recent years, a high percentage of these products are rejected because of non-compliance with international standards. So, they attempted case studies of shrimp aquaculture sector in Vietnam to examine the factors behind the persistence of such port rejections. In particular, they focused on why the so-called Better Management Practices (BMPs) are not appropriately adopted by many farmers and examined whether the number and types of information sources matter in farmers' decisions on BMP adoption and whether BMP adoption actually leads to better performances. On the basis of their estimation using primary data collected in Southern Vietnam, they confirmed that information sources and training experiences indeed matter in the adoption of a higher number of BMPs and that BMP adoption indeed reduces the possibility of disease outbreaks. Such studies proved the effectiveness of BMPs and suggest the importance of disseminating knowledge to farmers through experts. The findings of Sahu et al., (2014) revealed the adoption level of Better Management Practices (BMPs) by shrimp farmers in Balasore and Puri districts of Odisha between 46% and 63% only. Price fluctuation, High cost of input materials, Lack of electricity, Lack of credit facilities, High cost of input materials, Lack of technology guidance, Lack of credit facilities, Labour scarcity, Poor cooperation, Disease occurrence, Natural disaster, Poor quality seed, Poor water quality, weed infestation and Poaching etc. were identified constraints faced by farmers in adopting the BMPs. Gowde (2006) attempted to study the adoption of improved shrimp farming practices by shrimp farmers along the south Konkan region of Maharashtra through personal interview and questionnaire. The adoption quotient obtained by the shrimp farmers ranged from 50 to 96.88 at a mean of 76.18. It was observed that there was quite high extent of adoption for use of check trays and adjustment of feed accordingly (95.0%) checking of water parameters (82.5%) and checking of healthiness of seed before packing (72.5%). Other aspects were below 40% level. Charles Jeeva (2009) conducted GMP study among the aquafarmers in four selected districts viz., Trichur, Alleppey, Ernakulam and Kannur in Kerala. Out of the 10 practices evaluated, the adoption scores were higher for six practices viz., preparation of ponds (93.15%), eradication of predators and weeds (85.39%), use of PGR tested seeds (84.47%), use of recommended feeding schedule (77.63%), water exchange and quality monitoring (71.69%) and harvesting after prescribed days of culture (70.32%). The extent of adoption of each practice varied significantly among aquafarmers with the overall mean adoption score of 70.09%. The variables viz., number of training programmes undergone, number of information sources utilized and expert services availed were found to have positive relationship with the extent of adoption. According to Kumaran et. al., (2008) adoption is a mental process through which an individual eventually make a decision to follow an innovation after carefully evaluating its relative advantage, compatibility, complexity, visibility and adoptability vis-à-vis his biophysical and socioeconomic environment. An investigation carried out among the shrimp farmers of Andhra Pradesh (AP) and Tamil Nadu (TN) to assess the 'adoption-gap' in Good Management Practices (GMPs) of shrimp culture revealed that 68% and 72% of the GMPs of shrimp farming were adopted and an adoption gap of 32% and 28% was noticed. They opined that adoption of aquaculture guidelines like Effluent Treatment System (ETS) needs mass education, voluntary cooperation and maximum motivation among farmers. A strong extension support to facilitate the above is absolutely essential. Further, educational status, occupation,

farm size, training, farm experience and social participation of farmers aid significantly in minimizing their adoption gap. Ponnusamy and Pillai (2014) conducted studies to identify the factors contributing to +productivity and net income of shrimp farming in four districts of south Gujarat by randomly interviewing 129 shrimp farmers. The variables were identified hypothetically to arrive at the relationship between factors affecting the adoption of management practices, productivity and net income in shrimp farming. The data after analysis revealed adoption and productivity level at 32% and 42%, respectively and indicated the possibilities of higher productivity through infusing large credit flow and motivation to adopt better management practices.

### **WHY BMP's?**

Aquaculture is the controlled process of cultivating aquatic organisms, especially for human consumption. It is an economic human activity that uses and transforms natural aquatic resources into commodities like fish and shrimp. While doing so it may impact on biodiversity due to the consumption and transformation process of resources and production of wastes. The adverse effects on the environment vary with the intensity of practices followed. Bacteria present in the aqueous environment quickly colonize animals and plants. This microflora leads to either disease epizootics or commensal relationships. The interactions between the cultured organisms and bacterial communities is complex and critical. In the 1990s, there was pressing concern among the international public that the growing aquaculture sector is also deteriorating the environment. FAO issued the Code of Conduct for Responsible Fisheries in 1995. Then, to provide a specific code of conduct for the shrimp sector, an international consortium was established in 1999, involving organizations such as the World Bank, the Network of Aquaculture Centres in Asia-Pacific (NACA), the World Wildlife Fund, and FAO that led to formulation of International Principles for Responsible Shrimp Farming considering it as BMP. A number of international standards and certification are present, such as GLOBALGAP, Safe Quality Food, a series of ISO standards, and Aquaculture Stewardship Council certifications, which assure the quality of seafood products. However, the data on the rejection at international ports indicate that the BMPs are not being fully followed. Thus, there is an urgent need to examine the extent to which these practices are actually being implemented in the field.

### **Technology, Internet and Digitalization:**

The digitization of the farm sector which was expected to play out over 15-18 months, took just a few months in the backdrop of the coronavirus pandemic and the ensuing lockdown. Precision agriculture and automation creating a “farm of one”; Farms & farmers need to be connected, digitized, and smart. Farmer-consumer intimacy will improve value for diversity, quality and sustainability of food sources to an extent where food will replace medicine scientifically. The world’s largest consumer base will be Richer, Urbanized, and more Digitalized and Internet Savvy.

By 2030, one billion Indians will have access to internet; 50% of them will be Digital “enthusiasts” conducting a bulk of search and shopping online. Technology and infrastructure in the future will bring considerable changes to the operating context of tomorrow’s consumer

and farmer. We need an intuitive, intelligent, self-evolving system capable of delivering future-ready farming solutions to the entire aquaculture sector. The smarter aqua solutions that is powered in real-time for farmers to archive patterns, predict trends and to make a blueprint for their aqua business.

The major challenge is overcoming the technological divide between the urban and rural India. Even though the entry of Reliance Jio has led to lower data prices and has increased smartphone adoption in India, internet use-cases are yet to go beyond WhatsApp and Facebook in rural areas. Reiterating this challenge of tech literacy, “Promoting technology awareness among farmers, reaching out to farmers and proposing a new technology solution will be a challenge for us.

Our objective should be to ‘maximise per acre value’ and to promote traceable and storied seafood. It can be achieved via an intelligent data powered platform that can provide digital solutions for the key stakeholders of the agri value chain to create a healthy, empowered and committed ecosystem from pond to plate, in a manner that increases efficiency, scales productivity, strengthens sustainability and is socially fair.

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## Chapter-8

# Fish Farmer Producer Organizations (FFPO) and its role in Increasing Productivity

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### Introduction

Fish farming plays a significant role in meeting the growing demand for seafood and addressing food security concerns worldwide. In order to enhance productivity, sustainability, and the socio-economic well-being of fish farmers, various organizational models have emerged. One such model is the Fish Farmer Producer Organization (FFPO), which focuses on empowering small-scale fish farmers by providing them with collective bargaining power, access to resources, and improved market opportunities. This article explores the concept of FFPOs and examines their role in increasing productivity in the fish farming sector.

### Understanding Fish Farmer Producer Organizations (FFPOs)

#### *Definition and Objectives:*

Fish Farmer Producer Organizations (FFPOs) are collective entities formed by fish farmers to address common challenges, promote collaboration, and achieve mutual benefits. The primary objective of FFPOs is to empower small-scale fish farmers by strengthening their capacities, enhancing their livelihoods, and improving their access to markets, technologies, and resources.

#### *Key Functions and Activities:*

FFPOs perform a range of functions and activities to support their members. These include: Collective marketing and negotiation with buyers to obtain better prices for their products. Pooling of resources, such as feed, equipment, and infrastructure, to reduce costs and improve efficiency.

- Facilitating access to credit, insurance, and government support schemes.
- Promoting knowledge sharing, capacity building, and training among members.



- Advocating for favorable policies and regulations that benefit fish farmers.
- Undertaking research and development initiatives to improve production techniques and sustainability.

### **Broad Services and Activities to be undertaken by FPOs**

- Supply quality production inputs at reasonable rates (Feed, Fry, Fingerling, Yearling, Medicine, Net, small equipment etc)
- Make available need based production and post-production machinery and equipment on custom hiring basis for members to reduce the per unit production cost
- Undertake aggregation of smaller lots of farmer-members produce
- Make available value addition like cleaning, assaying, sorting, grading, packing
- Farm level processing facilities at user charge basis
- Storage and transportation facilities
- Facilitate market information about the produce for judicious decision in production and marketing
- Market the aggregated produce with better negotiation strength to the buyers and in the marketing channels offering better and remunerative prices
- Undertake Pond Culture, Pen Culture, Cage culture, RAS, Raceways, Bio-floc etc. related fish culture activities

### **Key Deliverables for FFPOs**

<b>Timeline</b>	<b>Stages</b>	<b>Key Activities</b>
1 Month	Stage one: Pre-project Implementation	<ul style="list-style-type: none"> <li>• The selection of blocks, villages and clusterization of the Produce</li> <li>• Baseline Survey</li> <li>• DPR</li> </ul>
2 Months	Stage two: Incorporation of Farmer Producer Organization	<ul style="list-style-type: none"> <li>• Statutory process required for formation of FPO like attainment of PAN, DIN of Directors etc.</li> <li>• Framing of FPO Memorandum of Association (MOA), Article of Association (AOA) and incorporation of FPO.</li> <li>• Women participation in Board of Management of FPO.</li> <li>• Mobilization of farmers</li> <li>• Refer MCA guideline / State Cooperative guideline</li> </ul>

6 months	Stage three:- FPO Establishment	<ul style="list-style-type: none"> <li>• Physical establishment of FPO office.</li> <li>• Opening of Bank Account in the name of FPO.</li> <li>• Membership drive continues for Mobilization of new farmers.</li> <li>• Formation Farmers Interest Groups (FIG).</li> <li>• Share money collection from new FIG members.</li> <li>• Training of FIG members/promoters of FPO.</li> <li>• Demonstration conducted on improved agriculture practices.</li> <li>• Formulation of business plan including financing plan Proposal for release of FPO Management Cost</li> </ul>
12 months	Stage four: - Implementation of Business Plan	<ul style="list-style-type: none"> <li>• Implementation of Business Plan</li> <li>• Minimum 100-500 farmers members in plain area and minimum 35-200 member farmers in hilly areas for FFPOs</li> <li>• Statutory Clearance required to carry out business activities.</li> <li>• Proposal for release of FPO Management Cost</li> <li>• Institutional Training of CEO/BODs</li> </ul>
18 Months	Stage Four: FPO Strengthening	<ul style="list-style-type: none"> <li>• Implementation of Business Plan.</li> <li>• Exposure visit and Awareness Programme for FPO members undertaken.</li> <li>• First tranche of Equity Grant scheme to strengthen equity base of FPO.</li> <li>• Membership drive continues for Mobilization of new farmers.</li> <li>• Share money collection from new FIG members.</li> <li>• Proposal for release of FPO Management Cost.</li> </ul>

24 Months	Stage Five:- Convergence with Central/State Government Schemes	<ul style="list-style-type: none"> <li>• ·Convergence with various central and state government schemes</li> <li>• Registration of FPOs on e-NAM and other electronic platforms.</li> <li>• First tranche of Credit Guarantee Scheme to establish credit linkages for FPO, if any.</li> <li>• Membership drive continues for Mobilization of new farmers Share money collection from new FIG members..</li> <li>• Proposal for release of FPO Management Cost</li> </ul>
36 Months	Stage Six:- FPO Sustainability	<ul style="list-style-type: none"> <li>• Issuing of Share Certificates to FPO member.</li> <li>• Auditing as required.</li> <li>• MoU and vendor registration as per Business Plan with Marketing Agencies/ Institutional Buyers..</li> <li>• Trading/uploading of produce in e-NAM/other sources.</li> <li>• Creation of Infrastructure for carrying of business activities.</li> <li>• Membership drive continues for Mobilization of new farmers.</li> <li>• Share money collection from new FIG members.</li> <li>• Second tranche equity grant to FPOs.</li> <li>• Second tranche of credit guarantee facility, if any</li> </ul>
48 Months	Stage Seven: Strategy for scale up the business activities and financial performance	<ul style="list-style-type: none"> <li>• Implementation of Business Plan</li> <li>• Optimal Utilization of infrastructure.</li> <li>• Auditing as required.</li> <li>• Third tranche of credit guarantee facility, if any.</li> <li>• Proposal for release of FPO Management Cost</li> </ul>

60 Months	Stage Eight: Phase-out and Exit Plan	<ul style="list-style-type: none"> <li>• Agreement to be signed between CBBO &amp; FPO for long-term handholding support.</li> <li>• Revenue model showing financial growth in last 3 consecutive years.</li> <li>• FPO rating as per Rating Tool developed by NPMA.</li> <li>• Third tranche of credit guarantee facility, if any .</li> </ul>
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### **The Role of FFPOs in Increasing Productivity:**

#### *Enhanced Bargaining Power*

One of the key advantages of FFPOs is the collective bargaining power they provide to small-scale fish farmers. By organizing themselves into a unified entity, farmers can negotiate better prices with buyers and secure more favorable terms for their produce. This results in increased income and improved profitability for individual farmers, thus incentivizing them to invest in improving productivity.

#### *Access to Resources and Technology*

FFPOs play a crucial role in providing their members with enhanced access to resources and technology. By pooling their resources, farmers can collectively invest in critical inputs such as high-quality fish seed, feed, equipment, and infrastructure. Additionally, FFPOs can facilitate access to advanced technologies, innovative production methods, and best practices through partnerships with research institutions, government agencies, and private sector stakeholders. These resources and technologies help farmers optimize their production processes, improve fish health, and enhance overall productivity.

#### *Knowledge Sharing and Capacity Building*

FFPOs promote knowledge sharing and capacity building among their members, facilitating the dissemination of information on the latest advancements in fish farming techniques, disease management, and sustainable practices. By organizing workshops, training programs, and study tours, FFPOs empower farmers with the skills and knowledge necessary to improve productivity and adapt to changing market demands. Additionally, FFPOs serve as platforms for farmers to exchange experiences, learn from each other's successes and challenges, and collectively address common issues.

#### *Market Access and Value Chain Integration*

One of the significant contributions of FFPOs is their role in improving market access for small-scale fish farmers. By consolidating their produce and negotiating with buyers on behalf of the members, FFPOs can secure larger contracts, access higher-value markets, and develop direct linkages with processors, exporters, and retailers. This not only improves farmers' profitability but also enables them to capture a greater share of the value chain. Furthermore,

FFPOs can assist their members in meeting quality standards, certifications, and traceability requirements, thus enhancing market competitiveness and export potential.

### *Strengthened Resilience and Risk Mitigation*

FFPOs can enhance the resilience of fish farmers by collectively addressing production risks and external challenges. Through risk-sharing mechanisms, such as collective insurance schemes or contingency funds, FFPOs help farmers manage the impact of natural disasters, disease outbreaks, or market fluctuations. By providing a support system and facilitating collaboration, FFPOs enable farmers to respond more effectively to crises and recover more quickly, thereby minimizing productivity losses.

### **Success Stories and Case Studies**

Several success stories highlight the positive impact of FFPOs in increasing productivity and improving the socio-economic conditions of fish farmers. For instance, in India, the National Fisheries Development Board has supported the establishment of FFPOs, resulting in improved market linkages, higher profits, and enhanced access to credit and government schemes for thousands of fish farmers. Similarly, the Lake Victoria Fisheries Organization (LVFO) has facilitated the formation of FFPOs in East Africa, leading to increased productivity, improved compliance with fisheries regulations, and better bargaining power for small-scale fishers.

### **Challenges and the Way Forward**

While FFPOs offer significant potential for increasing productivity in fish farming, several challenges need to be addressed. These include:

- Limited awareness and understanding of FFPOs among fish farmers.
- Insufficient financial and technical resources to establish and sustain FFPOs.
- Capacity gaps in governance, management, and leadership skills within FFPOs.
- Lack of supportive policies, regulations, and institutional frameworks for FFPOs.

To overcome these challenges, it is essential to prioritize capacity building initiatives, provide technical and financial support to FFPOs, and foster an enabling environment through favorable policies and regulations. Collaboration among government agencies, research institutions, development organizations, and the private sector is crucial to ensure the long-term success and sustainability of FFPOs.

### **Conclusion**

Fish Farmer Producer Organizations (FFPOs) play a vital role in increasing productivity, improving market access, and enhancing the socio-economic well-being of small-scale fish farmers. By empowering farmers through collective action, FFPOs enable them to overcome individual limitations, access resources and technology, strengthen market linkages,

and mitigate risks. The success stories of FFPOs worldwide demonstrate their potential to transform the fish farming sector and contribute to sustainable and inclusive growth. To harness the full benefits of FFPOs, concerted efforts from various stakeholders are necessary to address challenges, provide support, and create an enabling environment for their establishment and growth. Through continued investment and collaboration, FFPOs can drive increased productivity, profitability, and resilience in the fish farming sector, benefiting both farmers and the broader community.

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## Chapter-9

# Percolation Tank Based Aquaculture: Entrepreneurship Opportunity for Rural Tribal Youth

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### Introduction

Freshwater aquaculture in underutilized and untapped water bodies have vast potential. One such underutilized water body which has not caught the attention of many is percolation tanks. With reference to the percolation tanks, it is known that it is one of the effective methods of refilling groundwater table and the most traditional and popular method. It is known that Government Organizations (GO), Non-Governmental Organizations (NGO) and Corporates are working to design effective solutions for groundwater recharge in arid zones and rainwater harvesting is being taken as a national level project. Percolation tanks are found in state like Tamil Nadu, Maharashtra, Andhra Pradesh, Karnataka and Gujarat.

### Entrepreneurship Opportunity of Aquaculture in Percolation tanks

Utilization of percolation tanks for fish culture has not yet been popularized in India even though these water bodies are large in numbers. These can serve as an important contributor in livelihood security of people.

There are very few examples of utilization of percolation tanks for fish culture. Like it is reported Development of Humane Action (DHAN) Foundation they have utilized such water bodies for additional income generation for rice farmer through fish culture in Tamil Nadu. Fish culture is also reported in percolation tanks in Gondia district. DHAN (2017)

There are no reports of usage of percolation tanks for aquaculture in Maharashtra. It is reported that one third area of Maharashtra is drought prone and Government of Maharashtra is trying to maximise the use of available water. Maharashtra has 9,384 percolation tanks and Nashik district has 868 percolation tanks. (Zila Parishad Report, 2018). The existing percolation tanks and village ponds need to be rejuvenated to act both as water conservation and artificial recharge structure. Ground Water Information Nashik District Maharashtra, Govt. of India, (2019)

In Master Plan for Artificial Recharge to Groundwater in India (2021) – A CGWB Compilation it is reported that Maharashtra has 7188 Percolation tanks and in this plan 141810 are proposed and the estimated cost is to the tune of 10210.41 crores. In Nashik 650 are proposed with a cost estimate of 86014.50 lakhs. Government of India (2020)

Considering this untapped resource in Maharashtra state, a research project was undertaken by ICAR-CIFE, Mumbai team with the objective of initiating percolation tank based aquaculture for livelihood generation for tribals in Nashik district, Maharashtra with convergence of Corporate Social Responsibility (CSR).

*A brief about Corporate Social Responsibility (CSR) is presented for understanding.*

With reference to CSR, it is important to note that India is the first country in the world to make CSR mandatory, following an amendment to the Companies Act, 2013 in April 2014. Businesses have to invest 2% of their profits in areas such as education, poverty, gender equality, and hunger as part of any CSR compliance. Companies with a net worth of INR 500 crore or more, or an annual turnover of INR 1000 crore or more, or net profit of INR 5 crore or more, to spend 2% of their average net profits of three years on CSR. As per the National CSR Portal of Ministry of Corporate Affairs GoI, January 2022 data 1,619 companies have spent Rs. 8,828 crores on CSR, total No. of CSR Projects were 8,009 in 29 development sectors. Looking at the statistics the CSR initiatives are appreciable. With the Covid 19 pandemic the spending of CSR funds was changed and focus was given on that.

*About Lakshmanpada Percolation Tank and CSR activities of BOSCH*

Lakshmanpada Percolation Tank where this work was undertaken has an area of 18 acres and is situated about 25-30 feet above ground level and has a depth of 40 feet. Under the CSR, BOSCH, India has taken up holistic village development programme here. As reported by CSR team of BOSCH it was found that in the beginning, the percolation rate from the tank was very high which resulted in water logging in the agriculture fields of farmers and the tank was also emptied in very short span of time. Due to this, the villagers were unable to sow any kind of agricultural seed on their land. In the area near to percolation tank the land has become barren.

In order to find a solution, BOSCH approached Maharashtra Engineering Research Institute (MERI), Aurangabad. The scientists from MERI advised to lay a geotextile membrane along the inner wall from bottom to highest water level of percolation tank. In this regard, BOSCH India Ltd., under guidance of MERI could resolve the issue of high percolation rate. Renovation of percolation tank was therefore done in consultation with MERI. It has been reported that renovation activity has improved agriculture through availability of water and they grow millets, rice (of Indrayani variety) and oil seed. More than half of local farmers can now plant a second cereal crop each year.

This renovation also improved availability of water and now they have water in this tank for 10 months. After renovation, the tank could store around 400 million litres of water. Now it



provides drinking water to about 200 households from nearby five villages thus they have increased access to clean water. With rise in groundwater levels, eight drinking water wells and four hand pumps now have a stable water supply. The water which gets percolated gets filtered due to natural process as it is coming from height to ground level and is collected in dug wells. This water is further treated so as to make it safe for drinking purpose. Every household contributes Rs. 50 per month towards this so as to have a sense of ownership towards this. The tank water was being used for drinking purposes through natural filtration process and also for ground water recharge. This solution converted a barren land into productive agriculture field and also provided the tank with water for about 10 months. This led the community and the CSR officials to explore the opportunity with ICAR-CIFE, Mumbai to tap the water in the percolation tank for fish culture. Field visits, community meetings, transect walk were done in Laxmanpada village and in the village meetings, the youth of Laxmanpada hamlet were encouraged to get engaged in undertaking scientific aquaculture in percolation tank. The water level in monsoon was recorded up to 40 ft in monsoon and till 10 ft in June. After the water analysis it was found that water was found suitable for aquaculture, possible challenges which would occur in future were discussed in detail with the expert group.

### **Challenges**

The challenges which occur in undertaking aquaculture in percolation tanks are reducing level of water due to percolation process as well as evaporation. Water has multiple usage like drinking purpose so inputs like feed/cow dung etc. will have to be less. In this project, the percolation tank was at a height and there are no direct water pipelines. The percolated water gets collected in dug/ground wells. As the tank is at a height the water which gets collected in the dug wells goes through natural filtration process. For drinking water it was reported that in this tank the collected water was treated, lifted to the overhead tanks and supplied to different tap points in the village. The ground wells are 70-75 meters away from the percolation tank.

### **Formation of Youth Group for undertaking aquaculture in percolation tank**

During the community meeting concept of initiating aquaculture in this percolation tank was mooted. A group of 15 village youth came forward to take up aquaculture and they were encouraged to form a youth group. A group was formed and later named as 'Laksh Yuva Purush Bachat Gat'. In subsequent meetings, the group elected Chairman and Secretary of the 'Laksh Yuva Purush Bachat Gat'. As per NABARD guidelines all members were encouraged to do a fixed saving every month and deposit in the name of 'Laksh Yuva Purush Bachat Gat'. Opening of bank account was facilitated for the group.

The Department of Fisheries (DoF) was consulted for leasing of this water body but they reported that this water body was in the purview of DoF. Further study was done and it came to the knowledge that the water body is with the Gram Sabha under the Provisions of the Panchayats (Extension to the Scheduled Areas) (PESA) Act, 1996. As per this act, the Gram Sabha has the power of planning and management of minor water bodies.

Expert group facilitated in helping them to apply to the Gram Panchayat for undertaking aquaculture activity in percolation tank. So 'Laksh Yuva Purush Bachat Gat' approached the Gram Pradhan to allow them to undertake aquaculture in this tank. The gram panchayat agreed for the same and charged fixed leased amount. After thorough discussion 'Laksh Yuva Purush Bachat Gat' was allowed to undertake scientific aquaculture in this percolation tank under the PESA Act. Following the guidelines of Government regulations (GR) of Maharashtra aquaculture was undertaken in this percolation tank under the guidance of expert group which is explained in latter section in detail.

In addition to this, a whatsapp group was formed which consisted of 'Laksh Yuva Purush Bachat Gat' members and the Expert Group. Advisories were regularly provided on the group via text/video/audio in Marathi. Visual Confirmation through technology of mobile phone was regularly done taking the advantage of whatsapp where text/photo/video messages are posted on group. 'Laksh Yuva Purush Bachat Gat' members, BOSCH CSR and ICAR-CIFE had the ability to share visual confirmation that they had meetings, they completed task in real life, growth of fish, feeding, growth monitoring by uploading video/audio/photo/visual proof/screen shots via smartphone. In the group, all had access to these. In the age of social media visual confirmation and social ownership was recorded through use of mobile phone (whatsapp: photo/video messages on group). This also increased social ownership where all are engaged to learn from each other. This emerged as an efficient advisory tool for all specially during Covid-19 pandemic.

### **Training Need Assessment**

Youth's Knowledge, Skill, Attitude and Aspirations (KASA) was recorded with reference to aquaculture. Knowledge and skill in aquaculture of all 'Laksh Yuva Purush Bachat Gat' members were found to be very low as they did not have exposure to any training on aquaculture. But the scores for attitude towards learning of aquaculture were high. Aspiration scores to achieve success in aquaculture were also high. To conduct the Training Need Assessment (TNA) list of training areas was prepared through discussions with ICAR-CIFE team who suggested 7 training areas viz. Candidate species for aquaculture, Seed stocking, Water and soil quality management, Feed and feeding management, Harvest and post-harvest management, integrated agri-fish farming, project formulation and economics. Training Need Assessment (TNA) was conducted using the Borich Need Assessment Model where 'importance' and 'competency' scores of youth were recorded. Competency of the 'Laksh Yuva Purush Bachat Gat' members on these training areas was reported and found to be very low with score 0 as they had never attended any training nor had any knowledge on fisheries or aquaculture. But perceived importance for different training areas was given high scores by them. As per this information Mean Weighted Discrepancy Scores (MWDS) were calculated and training areas were prioritised.

## **Conduct of training programme**

Based on the TNA, training programmes were designed in Hindi/Marathi for 'LakshYuva Purush Bachat Gat' members which included imparting knowledge and skill on Candidate species for aquaculture (Godyapanyatil matsya sanvardhanakarita upyukta jati), Seed stocking (Bij Sanchayan), Water and soil quality management (Pani aani mati gunvatta vyavasthapan), Feed and feeding management (Khadya vyavasthapan), Harvest and post harvest (Mase kadhni paschyat prakriya) and agri fish farming, project formulation and economics. Presentations were prepared along with pictures, videos and literature in Marathi. A booklet on 'Scientific Aquaculture' and a video was made in Marathi for distribution. Onsite trainings were held at primary school and anganwadi of the Pahine hamlet near the percolation tank. Basic questions related to the above mentioned training areas were prepared to be administered before and after the training programme to have pre and post training scores so as to test the improvement in the learning. A Marathi booklet on Scientific Aquaculture and video on Percolation Tanks Based Aquaculture was also disseminated.

## **Aquaculture in Percolation Tank**

Following the guidelines of Government regulations (GR) of Maharashtra aquaculture was undertaken in this percolation tank under the guidance of expert group and the steps are explained as follows.

### **Seed procurement, Stocking**

Initiation of aquaculture was done as per the Government regulations of Maharashtra. As the size of percolation tank is about 18 acres (7.5 ha approximately), it is considered as a small reservoir (0 to 20 ha category) according to classification of State Fisheries Department, Government of Maharashtra (India). According to the Government Resolution (GR) of Government of Maharashtra the stocking density in the small reservoirs of 0 to 20 ha size is suggested to be 5000 numbers per hectare. Therefore, guidelines of government were followed for stocking density in the percolation tank. The species stocked were Catla catla (Catla), Labeo Rohita (Rohu) and Cyprinus carpio (Common carp). Indian Major carps and exotic carps are widely stocked in Indian reservoirs. These species are in great demand for local consumption and sturdy enough to tackle tropical weather conditions.

### **Species Justification**

The construction of percolation tank is explained in detail so as to justify the species selection for aquaculture. The area of the Lakshmanpada percolation tank is 18 acres and three sides of the tank are surrounded by hills and embankment wall is constructed to store the water at one side. The length of the embankment wall is 200 ft. During construction work, at the bottom of wall slope, a trench of 6 ft width and 3 m deep was excavated (excavation was done till got hard substrate at the bottom) parallel to the wall. Then this trench was filled with impervious soil layer up to 1 meter and the embankment wall is also covered with 1 m layer of soil. Then

soil compaction was carried out. The Geo-Textile membrane sheet was spread over the compacted soil layer at the bottom and extended up to mid-section of the embankment wall slope. The entire sheet is spread on trench and slope of the wall was cover by soil layer of 2 meter. This soil was thoroughly compacted, and stone pitching was carried out on slope of the wall. Through common carp is bottom dwelling fish with borrowing behavior it would not be possible to harm the bottom or slope of the wall which is protected with the geotextile sheet at the bottom side and stone pitching at the upper side. Hence common carp culture in was recommended. A survey was carried out in local markets of Nashik district for gathering information about consumer demand on consumption of fish species. It was observed that maximum demand was for *Cyprinus carpio* followed by *Labeo Rohita* and *Catla catla*. Among the Indian Major carps, *Cirrhinus mrigala* (Mrigal) was least demanded in Nashik Market. Therefore, Catla, Rohu and Common carp were stocked in percolation tank. Fish seed of advanced fry to semi fingerling size were stocked according to the guidelines of State Fisheries Department, Government of Maharashtra. Telephonic advisories were provided by ICAR-CIFE to CSR team of BOSCH India for seed procurement. Fish seed of catla, rohu and common carp was procured through local seed supplier and provided to the youth group by BOSCH India. Thus advanced fish fry were stocked in the tank.

### Feeding

Feeding advice of Ground Oil Cake (GOC) and rice bran was provided by ICAR-CIFE team. The fishes were fed with supplementary feed of combination of de-oiled groundnut oil cake and de-oiled rice bran. There was also influx of natural water from one side of percolation tank. This influx would bring organic nutrients in the tank. This helped in production of phytoplankton and zoo plankton in the tank. Therefore, the daily feeding rate was dropped to 50% of the total supplementary feed. All group members took ownership in looking after the culture activities including feeding which was done by two members in morning and two in the evening on rotation basis. Discussions were done from time to time to assess the progress of aquaculture, growth of fish, water level, ‘Laksh Yuva Purush Bachat Gat’ community information, training requirements and constraints faced. Fish was harvested from time to time as per demand and community could earn as well use the fish for domestic consumption. Due to Covid-19 pandemic, the fish harvest and selling had lot of challenges. During that time the harvested fish was also used for domestic consumption.

Constraints faced by the youth group in undertaking aquaculture were

S. No.	Constraints
	Financial
1.	Less funds, Lack of CSR funds due to Covid 19 disruption
2.	Other livelihood works
	Extension
1.	Organisations at distant places
2.	Consensus for timings of Youth Group Meetings and unity on group

3.	Paper work for formation of FPO/SHG
4.	Discussion that tank is owned by community so profits should be shared with all not just with the group
	Covid-19 and aquaculture
1.	Fish feed
2.	Fish sale/price
3.	Transport
4.	Harvest
5.	Lockdown

When the project was taken the unprecedented challenges which came due to Covid 19 were not perceived at all. However, due to the Covid 1-19 pandemic the project faced a number of disruptions. Under the Covid -19 pandemic additional challenge emerged. Fish feed which was stocked got over and the same was not available in market. As an emergency response, home made fish feed was suggested. As fish feed changed it must have had an effect on fish growth. But due to lockdown the fish growth could not be regularly monitored. Partial harvesting was done from time to time but due to lack of market some fish was used for personal consumption. This provided them food and nutrition at the time of pandemic. However, they were unable to fetch good price of the fish. The main challenges were that CSR fundings were contributed to the PM Cares fund, in addition to the marketing, feeding challenges faced due to the lock down and partial halt/disruption of the markets.

The youth group was new and to maintain unity in the group was another challenge by the project team. To keep the youth mobilised and motivated on phone calls was challenging. Due to Covid-19 tours were not possible so to keep the group united by virtual meetings was a big challenge. Network issues emerged every now and then.

But telephonic advisories were regularly provided on the group via text/video/audio in Marathi. Visual Confirmation though technology of mobile phone is being done regularly taking the advantage of whatsapp where text/photo/video messages are posted on group. This gave visual confirmation that they had meetings, they completed task in real life, growth of fish, feeding, growth monitoring by uploading video/audio/photo/visual proof/screen shots via smartphone. This has also increased social ownership where all are engaged to learn from each other. This has emerged as an efficient advisory tool for all.

The enthusiasm of members is clear from the following narration. “When we stocked fish we had no idea what is going to happen in future. We used to wonder what is happening to the fish and if we will get any fish. We had never done such an activity so we had many doubts. When we did netting for the first time we could not believe that we could do fish culture. It was one of the happiest moments of our lives. We would like to thank team BOSCH and Team ICAR-CIFE for teaching us how to do aquaculture.”

In addition, efforts were done to overcome the challenges and constraints with converging efforts of CIFE-BOSCH-Community and based on this convergence model was developed.

### **Convergence of CSR, ICAR-CIFE, Mumbai and Tribal youth community**

However, some of these challenges were envisioned as an opportunity because community youth was keen to take up a new activity, CSR officials were supportive, ICAR-CIFE team were ready to experiment and water was suitable and available in percolation tank. A convergence model Convergence of Corporate Social Responsibility in Aquaculture (CCSRA) was thus developed based on the learnings.

In the present study convergence research was inspired by the need to address a specific challenge of using an untapped water body for aquaculture for livelihood generation of tribal youth and this was turned into an opportunity. It required deep integration across disciplines. As experts from different disciplines pursued common research challenges, their knowledge, theories, methods, data became increasingly intermingled or integrated.

Lee et.al (2014) have reported about the strategies for invigorating the convergence business models. Conceptual convergence of pluralistic extension has been mentioned by Mukherjee (2012). GOI (2018) prepared a report of the high level committee on CSR but due to Covid-19 pandemic the priorities were revised. Parekh (2020) has presented the views of what nonprofits think of CSR. There are 3 models of CSR reported in literature CSR Pyramid, Intersecting Circles, and Concentric Circles (Geva, 2008). The 5 dimensions of CSR are philanthropic, environmental, social, stakeholder and voluntariness dimensions (Dahlsrud, 2008). But the challenge was that there was no existing convergence model in fisheries/aquaculture so a new convergence model had to be developed. The Model of Convergence of Corporate Social Responsibility in Aquaculture (CCSRA) is presented in figure 1.



Fig 1: Model of Convergence of Corporate Social Responsibility in Aquaculture (CCSRA)

## **Learnings from the study:**

It is clear from the study that there are challenges and opportunities in percolation tank based aquaculture. Literature on fish culture in percolation tanks is lacking. It has challenges like multiple usage of water, receding of water level due to percolation nature of the tank and natural process of evaporation. Reduction in water level in summers was initially thought as a serious concern for aquaculture. Since the tank was deep, harvesting of fish was also thought to be more difficult in the beginning. But later it was realized that when water level reduced to 7-10 ft., fish could be harvested easily.

Leasing rights of the percolation tanks is not with Department of Fisheries. Due to this, DoF may not make aquaculture in percolation tanks a priority. Discussions with few officials of DoF revealed that they are engaged in other works and this is not in their mandate at present. As the tank under study is in tribal area, the rights are given to Gram panchayat under Panchayat Extension for Scheduled Area (PESA) act. PESA sought to enable the Panchayats at appropriate levels and Gram Sabhas to implement a system of self-governance with respect to a number of issues such as customary resources, minor forest produce, minor minerals, minor water bodies, selection of beneficiaries, sanction of projects, and control over local institutions. So a new extension model like Convergence of Corporate Social Responsibility in Aquaculture (CCSRA) model as explained in figure 1 which has been successful in this project will be more beneficial to be adopted. The CCSRA model is unique in nature and will help the community for livelihood opportunity and utilization of underutilized water bodies for aquaculture.

Fertilization with cow dung was not done in the tank as the water is used for drinking purpose. However, it was revealed from the visit that no direct water pipeline is laid. The percolated water gets collected in dug/ground wells. As the tank is at a height the water which gets collected in the dug wells goes through natural filtration process. The collected water is treated, lifted to the overhead tanks and supplied to different tap points in the village. The ground wells are 70-75 meters away from the percolation tank. In the current scenario, use of cow dung can be done for fertilization, this will enhance the primary productivity and provide natural food (Phyto and Zoo plankton) for fishes in the tank.

Advisory services through WhatsApp groups using text/audio/video messages has proved to be very efficient. It has also been beneficial in visual confirmation and bringing social ownerships.

Following are the learnings

- Aquaculture can be done in percolation tanks successfully if guidelines are followed
- Innovative Extension Model Convergence of CSR in Aquaculture (CCSRA) model has a lot of scope and was proven to be successful in percolation tank based aquaculture
- Community ownerships of percolation tanks is necessary

- Small focused Whatsapp groups of community, CSR and Government with clear objectives are very useful in providing advisories, visual confirmations and social ownerships
- In times of crisis it is very necessary to provide special advisories and keep the group engaged using social media platforms in order to instill confidence and motivation
- Through this project it is recommended that water bodies which are not under the purview of DoF but under the PESA act have a potential of entrepreneurship, livelihood generation and providing food and nutritional security to the rural/tribal youth.
- This percolation tank can become a model for utilizing this untapped/underutilized water body for aquaculture
- Difference of opinions can emerge among the community, that percolation tank is owned by community and thus profits should be shared with all not just with the group. However, if these kind of differences arise this can be solved with discussions as this shows the success of aquaculture. In this case it can be suggested that Gram Panchayat takes the ownership and forms a working committee group for undertaking aquaculture where ownership and responsibility go hand in hand.
- Convergence and integration of aquaculture while construction and engineering design of the percolation tanks is recommended. Through this model of CCSRA i.e., convergence of GO (ICAR-CIFE, Mumbai)-Community (Lakshmanpada tribal youth, Nashik)-Private (CSR-BOSCH, Nashik) has provided additional livelihood opportunity and food and nutritional security to the tribal youth.

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## 10.SWOT Analysis of Aquaculture & Aquapreneurship in India

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### Introduction

Constituting about 7.73% of the global fish production and export earnings of Rs.46,589 Crores (2018-19), India today has attained the status of the second largest aquaculture and 4th largest fish exporting nation in the world. SWOT analysis addresses the strengths, weakness, opportunities and threats is a valuable tool used for analyzing internal and external factors to attain a systemic approach for decision making. The Fisheries sector has shown an impressive growth in terms of fish production and export earnings during the past five years. The sector recorded an Average Annual Growth Rate of 10.88% during 2014-15 to 2018-19, 7.53% average annual growth in fish production and 9.71% average annual growth in export earnings, with 18% share in agricultural exports. Gross Value Added (GVA) of Fisheries sector in the national economy during 2018-19 stood at Rs 2,12,915 crores which constituted 1.24% of the total National GVA and 7.28% share of Agricultural GVA. India is the second largest shrimp producer after China producing 9% of the world output and the demand for Indian quality is increasing day by day. India has a strong demand for its shrimp products in the international market which is making it the top exporter of shrimp.. India has exported 1289651 MT of seafood worth the US \$ 6.68 billion to more than 100 countries in the financial year 2019 as per MPEDA. India has a vast coastline which benefits the production of shrimps at the industrial level. The west coast contributed 62% whereas the east coast contributed 38% of the output. As per the CMFRI, India has 3.56 million tonnes of marine fish landing in the year 2019 which is a great advantage.

Aquaculture production of freshwater species has increased steadily over the period 2020-2022. The increase in freshwater fish production to two main factors:

- (i) A shift from low intensity 'traditional' culture methods towards monoculture production systems and increasing intensification through the use of pelleted feeds, and
- (ii) Introduction of other species such as *Pangasius* sp and intensive cage culture systems across the reservoirs and other inland bodies has boosted the production

Besides the above, various farming methods are used by Indian farmers, including static water ponds, running water ponds, cages in reservoirs and rice fish culture ponds, depending

on the space and capital available to the farmers. While the bulk of freshwater aquaculture production in India is still from small scale farms, there is a trend to increasing ‘modernization’. Many traditional integrated practices, such as some forms of rice fish culture, have declined considerably, while others, such as the use of terrestrial animal manure as a fish pond fertilizer to produce natural food, have been discouraged by the government on food safety grounds. Compared with brackishwater or marine aquaculture, freshwater aquaculture is practiced intensively in relatively small areas. However, the limited profitability of traditional ‘low value’ freshwater fish species is forcing farmers to specialize in specific parts of the production cycle, such as nursing. Growout to market size requires more areal resources, more water and a longer period of time, and thus higher levels of investment, than nursing. In addition, nursing cycles are relatively short (typically around 21 days in segmented carp nursing), reducing the risk of crop losses and providing a regular income to farmers through faster cash flow.

**SWOT Table of Indian Aquaculture :**

Strengths	Weakness
Site Availability	Limited farmer capability
High biodiversity	Limited enforcement of policies and regulation
Good environment and climate	Limited extension capability
Good R & D capability	High cost and variable quality of feeds
Good government support	Processing and marketing limitations
Available and cheap labour	Limited technology
High market demand	Poor transport infrastructure
Available ingredients for feeds	Restricted access to finance
High potential for seed production	Limited R & D capability Variable product quality Disease impacts on production Environmental degradation High production costs
Opportunities	Threats
Increasing market demand	Markets -prices and competition
Product/Species opportunities	International trade issues
Farmer training & extension	Environment
Increasing employment and incomes	Increasing cost of production
Planning and siting	Land use conflicts
Improve product quality	Disease introductions
Increase the use of local ingredients in feeds	Use of new technologies by overseas competitors
Improve outcomes from R & D	
Increased support for Aquaculture	
Product Promotion	

## 1. PMMSY

The Pradhan Mantri Matsya Sampada Yojana (PMMSY) aims to enhance fish production to 220 lakh metric tons by 2024-25 from 137.58 lakh metric tons in 2018-19 at an average annual growth rate of about 9%. Overall, the programme to increase Indian aquaculture production that would cover the development of hatchery, nursery and grow out production systems, Infrastructure, entrepreneurship and business, health and environmental issues, technology implementation assistance and management support.

## 2. Entrepreneurship

The government plans to stimulate the entrepreneurship spirit of farmers through the provision of technical training in aquaculture production, processing and marketing. Following the training, it is expected that young farmers would have the ability to generate proposals for funding to banking institutions for aquaculture business development

## 3. Networking

Improved networking amongst other stakeholders (intra- and inter- sector) will also be strengthened to provide mutual benefits

## 4. Technology and innovation

Government agencies are supporting the development and adoption of new and innovative aquaculture technologies for dissemination and uptake by farmers to improve the sustainability of aquaculture production

## 5. Empowerment

Government policy is to improve the empowerment of the community both at the individual and group levels to enable them to manage the resources for their own resilience, social security and welfare.

## 6. Strengthening and empowering community groups

7. Providing superior broodstock and high-quality seed in adequate quantity to support aquaculture production

## **Research, development and extension**

Local implementation of these strategies is largely undertaken through the aquaculture research institutes and technical implementation units operated by ICAR, SAUs to support the widespread adoption of aquaculture technologies. The role of the research institutes and the SAUs is to develop and implement technologies for hatchery, nursery and grow out production systems, environmental monitoring and management, and fish health management. Since 2000, aquaculture extension has been primarily the responsibility of

district level. This was one result of major government responsibility reforms that were intended to increase the autonomy of district level governance. It was envisioned that these reforms would change the approach of extension services from the traditional 'top-down approach' with its one way linear research extension client farmer relationship to a 'bottom-up', participatory approach responsive to farmers needs.

### **Market development**

The Indian government is also looking at the expansion of markets and an improvement of trading promotion. These activities are linked to economic transformation and selling of diversified products. Special priorities are put toward promotion of international markets and strengthening human capacity for people working on trading and export of aquaculture products.

### **Aquaculture industry development issues**

#### **Site availability and potential for expansion**

It was generally felt that India has considerable potential for aquaculture expansion. Improvement of cold chain facilities, broodstock multiplication centres & nauplii production centres. Conflicts of land use and zoning were also alluded to as potential limitations for industry expansion.

### **Biodiversity**

The high level of biodiversity of the India's fauna and flora was regarded as a particular strength, providing opportunities for diversification of production. This provides opportunities for a wide range of species to be produced in aquaculture.

### **Capacity of farmers**

A major feature of Indian aquaculture production is that all sectors tend to be dominated by smallholder farmers, at least in terms of number of farms, although this is unlikely of farmers to adopt new technologies and approaches was consistently identified as a significant constraint to aquaculture development generally, and more specifically to the uptake of new and improved technologies. In general, small scale farmers have a relatively limited capacity to make significant technological changes due to educational and attitudinal constraints, as well as resource constraints such as access to finance.

### **Technological capability**

The SWOT analysis demonstrated that farmers from India aspire being perceived as a technologically advanced aquaculture producer. The SWOT analysis provide insight into the aquaculture development environment in India. Furthermore, they highlight the complex nature of the potential interventions required to increase aquaculture production in line with government objectives. Interestingly, many of the industry development issues, particularly the large number of smallholder farmers and the resultant limitations on adoption of new, and implicitly more complex, farming technologies, the potential for expansion of production and the lack of infrastructure restricts production

expansion. Clearly, these factors are not limited to aquaculture, but are key developmental issues across both terrestrial as well as aquatic agriculture in India.

There are effectively three strategies to achieve the scale of increase targeted for Indian Aquaculture production within the current 5 year time frame.

1. Intensification of existing production systems and commodities
2. Areal increase of existing production systems and commodities
3. Increased diversity of production through adoption of new commodities

These three strategies are not mutually exclusive. Indeed, a combination of two or more may provide an optimal aquaculture development strategy, depending on local context. In the SWOT analysis, a significant feature of Indian aquaculture is the large number of smallholder farmers. Despite the predominance of smallholder farmers, their contribution to national aquaculture production of many commodities (notably shrimp) is low. However, the continued participation of smallholder farmers is critical from social and economic perspectives as aquaculture is an important livelihood for many parts of India.

### **Intensification**

Intensification and production segmentation are options to increase production from freshwater and brackishwater aquaculture. A combination of intensification and segmentation of production may support increased production. Under such situations, increasing intensity of production coupled with increasing segmentation—small holder farmers can potentially contribute to increased national aquaculture production.

### **Areal expansion**

The potential for areal expansion is largely limited to mariculture, since areas deemed suitable for freshwater and brackishwater aquaculture are already largely exploited. However, the SWOT analysis recognized that there are severe infrastructure limitations in many parts of India that are likely to limit aquaculture development.

### **Increased diversity of production**

The SWOT analysis identified India's high biodiversity as a strength for aquaculture development. However, this high biodiversity also dilutes research and development efforts. The situation is exacerbated by the tendency of the industry to shift quickly between species, particularly in response to disease problems. e.g. the shift from *P. monodon* to *L. vannamei* production due to whitespot disease and the shift from common carp to other freshwater species.

### **Market potential**

The dominance of small-scale farmers may restrict India's ability to access many of these developing international markets. High value and niche export markets typically require

consistent, year round, high quality product which is often difficult to source from geographically dispersed and often low skilled small scale farmers. Increasingly, the seafood trade in developed countries is being influenced by the demands of environmental non-governmental organizations for increased 'sustainability' of production, from both wild fisheries and aquaculture.

### **Conclusion**

Improved coordination of aquaculture industry development is a complex issue with a number of dimensions such as coordination across levels of government, consistent implementation of regulations and the linking of research, development, extension and training activities. Regardless of the analysis, it is clear that India is positioned to remain a major global aquaculture producer. The need to promote large scale aquaculture to achieve the India's government's objective of increasing national aquaculture production, and the limited capacity of small-scale farmers to support this objective, leaves small scale farmers relatively vulnerable to a stronger focus on large scale commercial aquaculture and its associated issues. To some extent this is mitigated by the government's focus on the creation of job opportunities (pro-job) and the reduction of poverty (pro-poor), as well as economic growth and sustainability.

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