Aquaculture Technologies Implemented by NFDB






NFDB

National Fisheries Development Board

Department of Fisheries

Ministry of Fisheries, Animal Husbandry & Dairying, Govt. of India

Hyderabad - 500 052

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PREFACE

Fisheries and Aquaculture Sector in the country has evolved from the traditional livelihood activity to a technology driven commercial industry. Through sustained scientific research and experimental studies under the aegis of the ICAR, Govt. of India, the various Fisheries Research Institutes and Universities have over the years developed several new and innovative technologies that are adaptable, scalable and sustainable.

Since inception in the year 2006, the National Fisheries Development Board (NFDB) has been striving to enhance fish production and productivity and to coordinate fisheries development in the country in an integrated and holistic manner. NFDB works closely with all the Central Fisheries Organizations and Institutes, Universities, States' Department of Fisheries, besides various stakeholders thus contributing to the development and management of Fisheries Sector.

To enhance fish production by sustainably utilizing the existing and potential resources, Govt. of India launched the '*Centrally Sponsored Scheme (CSS) on Blue Revolution: Integrated Development and Management of Fisheries*'. NFDB as the implementing arm of the Department of Fisheries, Govt. of India, is mandated to realize the untapped potential of fisheries sector that includes inland and marine capture and culture, processing and marketing besides accelerating the growth of the sector.

Keeping the above said objectives in view, NFDB has taken up itself to directly implement across the country some of the key projects based on available technologies by facilitating their transfer from '*Lab to Land*' so as to fast track the overall fish production and productivity as envisaged in the Blue Revolution Scheme.

With a view to bring about a higher growth rate in the sector and contribute to the economy, generate employment and livelihood opportunities, it is felt desirable to assist the stakeholders by disseminating information on the said technologies for implementing various fisheries projects under the Blue Revolution Scheme. Towards this end the present handbook on '*Aquaculture Technologies Implemented by NFDB*' is being brought out for the benefit of stakeholders.

The efforts of Dr. K. Ravindranath, Senior Consultant (Tech), NFDB, in compiling and editing this Handbook are appreciated and acknowledged.

Hyderabad
16 November 2019

Smt. I. Rani Kumudini, IAS
Chief Executive, NFDB

Wetland Fisheries Development

1. Introduction

Floodplain Wetlands are water bodies associated with major rivers systems, connected to them by some means or the other, accommodating the swelling waters and playing a great role in mitigating floods and irrigating croplands. They are also the habitat for a large number of small indigenous fish species (SIFS) which support subsistence fisheries and provide livelihood to fisher communities, besides meeting nutritional requirements of the local population.

2. Resources

India has about 8.0 lakh ha of floodplain wetlands (*beels, jheels, mauns, chaurs, pats,* etc.) spread across the numerous river basins in the country. Major wetland areas are in the States comprise – Assam: 1.10 lakh ha, West Bengal: 0.42 lakh ha, Bihar: 0.05 lakh ha, Uttar Pradesh: 1.33 lakh ha, Odisha: 1.80 lakh ha, Arunachal Pradesh: 0.42 lakh ha, Kerala: 2.43 lakh ha, Manipur: 0.04 lakh ha, J&K: 0.06 lakh ha, Gujarat: 0.12 lakh ha, Haryana: 0.10 lakh ha (Total: 7.98 lakh ha). Wetlands of Assam, West Bengal, Bihar, Uttar Pradesh, Odisha, Arunachal Pradesh and Manipur States are amongst the most important from fisheries point of view and account for 7.50 lakh ha of wetland water spread area (WSA).

3. Status and Potential

Fish yield from floodplain wetlands has been estimated at 400-800 kg/ha/yr, against the production potential of 1,500-2,500 kg/ha. Harvesting is a major problem in most of them as they are usually weed-choked, obstructing use of fishing gear. Presence of predators often results in high natural mortality of stocked fishes causing low productivity. Therefore, enclosure culture systems are adopted to augment fish production from floodplain wetlands, wherein a captive seed stock is grown to fingerlings (*in-situ* or *ex-situ*) on formulated feeds, protected from predators, stocked in the main water body or in cages and harvested in due course of time. This is referred to as *Culture Based Capture Fisheries* (CBCF).

Selecting the right combination of fish species, based on trophic structure and potential of such wetlands, stocking seed of appropriate size (80-100 mm) and releasing them at the right time are essential to fully utilize all ecological niches and optimize fish yield from wetlands. Species most suitable for stocking in wetlands/*beels* include: Indian Major Carps (improved varieties), Indigenous Minor Carps, Exotic/Chinese Carps, etc.

4. Project Location and Implementation

A. Beneficiaries: Beneficiaries include fishermen and their cooperative societies/ SHGs/ fish farmers. The overall increase in wetland fish production would in turn improve the livelihoods of fishers and fish vendors, and provide nutritional security to the surrounding rural population.

B. Criteria for Selection of Wetlands: A committee comprising of representatives from State Fisheries Department/ Fisheries Development Corporation, ICAR-CIFRI, SAU-COF/ KVK, ATMA, would identify and select wetlands/*beels* for development. NFDB would provide financial assistance to the States having wetland resources for enabling an institutional setup and development in a project-mode.

Wetlands would be selected based on the following criteria:

- Wetlands/*beels* having water spread area (WSA) 10 ha and above.
- Wetlands that are not within restricted or prohibited area.
- Both registered and unregistered perennial wetlands.
- Community-based Combination Strategy shall be adopted.
- Wetlands leased out to a Cooperative Society would be selected.
- Where wetlands/*beels* are leased out to individuals, the State Fisheries Department/ Corporation shall organize the stakeholder's community into a Cooperative Society.

5. Project Components

(i) Construction/Renovation of Wetland Embankment.
(ii) De-weeding.
(iii) Stock Enhancement.
(iv) Procuring Stocking Material:
  a) Rearing Fry in Pens
  b) Rearing Fry in Cages
  c) Rearing Fry in Ponds

(i) **Construction/Renovation of Embankment:** Most of the natural wetlands were developed 10-20 years ago and require strengthening of embankments to facilitate stock enhancement and increase fish production. Need-based renovation/construction of embankment to appropriate width and height is required to hold flood-water and prevent escape of fish stock.

(ii) **De-weeding:** Aquatic weeds, especially the floating weeds such as Water Hyacinth, build up a huge biomass on the water surface and choke the water body. Further, there is: (a) enormous water loss through transpiration; (b) impediment to water flow, causing sedimentation, flooding and soil erosion; (c) obstruction to light penetration required for photosynthesis by primary producers; (d) drastic change in the physical and chemical properties of water with detrimental effects on the biota; (e) hindrance to navigation; and (f) fishing is hampered, reducing the catch, source of food and income of local population. Weeds also cause environmental as well as public health problems, as they may create a microhabitat suitable for the breeding of many vectors of human diseases and for harbouring poisonous snakes. Therefore, removal of floating weeds is necessary to make wetlands/*beels* productive.

(iii) **Stock Enhancement:** Wetlands/ *beels* were initially connected with rivers and there was free flow of water and auto-stocking of fish during rainy season. Now, the connecting channels of most of them are either silted up or encroached upon or blocked for constructing water control devices by the Flood Control Department, all of which have prevented auto-stocking. Therefore, stock enhancement is of paramount importance in wetlands to increase fish production.

Further, wetlands/*beels* have a large number of carnivorous and uneconomical weed fishes which either eat bulk of the stocked small-sized fish or compete with them for food and space. It is practically impossible to remove all the carnivorous species. Thus, all these factors are responsible for poor growth and survival of fish and low fish production in wetlands. To overcome this problem, large-sized fingerlings (at least 100 mm) need to be stocked in these water bodies so that they can escape from carnivores and fish production and productivity can be increased significantly to attain the potential of 2,500 kg/ha/year.

(iv) **Procuring Stocking Material:** Most of the States having Wetlands are self-sufficient in fish seed (spawn/fry) production for stocking in aquaculture ponds, but there is scarcity of grownup seed (advanced fingerlings) required for stocking in wetlands/*beels*. Advanced fingerlings are not readily available at the *beel* site, and bringing them from a distant farm is uneconomical due to high mortality and transportation cost. The problem can be overcome by raising fingerlings *in-situ* in cage and pen enclosures or *ex-situ* in rearing ponds constructed in the peripheral areas of wetlands. Fish fry of 2-4 cm size are to be procured from Govt. Registered Farms only.

(a) **Rearing Fry in Pens:** Shallow peripheral area of wetlands is suitable for installing pens. Pen culture, especially for raising stocking material, offers a great scope for effective utilization of available wetland water resources for fisheries enhancement that will lead to significant improvement in the socio-economic status of poor *beel*-fishers. Different sizes of pens can be installed in *beels*, but a 0.2 ha area pen is found to be ideal. Pens may be constructed using HDPE mesh/netting or bamboo-split fence. HDPE pens last longer than bamboo pens.

(b) **Rearing Fry in Cages:** Wetlands also offer good scope for installing cages to rear fish seed to stocking size or for further culture to table fish. At least one battery consisting of six cages (each 6 x 6 x 3 m or 6 x 4 x 2 m, depending on size and depth of *beel*) can be installed at selected locations. Cages may be free floating or fixed. Floating HDPE cages with GI pipe-frame are preferred as they last longer than bamboo framed floating cages.

(c) **Rearing Fry in Ponds:** Low-lying areas of wetlands/*beel* are suitable for constructing rearing/stock ponds at a low cost. These low-lying areas are vulnerable to encroachment and it is one of the biggest threats to *beel* fisheries. Construction of rearing/ stock ponds at the low-lying peripheral areas will help to prevent encroachment as well as enhance production. Rearing pond area may be 0.20-0.50 ha with a depth of 1.0-1.5 m, so that after rearing fish fry to fingerlings, the same pond can be used for grow-out to table size fish.

6. Technical Details

Sl. No.	Component	Salient Feature
1	Construction/ Renovation of Embankments	i. Wetland embankment height 2-3 m ii. Wetland embankment top width 2 m iii. Wetland embankment slope 1:1.5
2	De-weeding	i. Floating weeds like Water Hyacinth and other dense floating and rooted weeds forming mats are removed
3	Stock Enhancement	i. Fry of freshwater fish (IMC & other permissible species) are reared to fingerling size (8-10 cm) and stocked in the Wetland @ 2,000/ha.
4	Rearing Pen	i. Rectangular Pen. ii. Area minimum 0.20 ha. iii. Pen made of either split-bamboo mats or HDPE mesh. iv. Stocking: Fry of 3-4 cm @ 6,000 nos/pen (30,000/ha); survival 40% v. Supplementary Feed: Oil Cake (ground nut/mustard) & Rice Bran in 1:1 ratio @ 7% of body weight.
5	Rearing Cage	i. GI-framed HDPE mesh Cage. ii. A battery consists of 6 Cages; minimum one battery.

Sl. No.	Component	Salient Feature
		iii. Size of each Cage 6 x 6 x 3 m (108 m^3) or 6 x 4 x 2 m (48 m^3) iv. PVC drum floats (12 nos). v. RCC sinkers/ boulders at each corner (4 nos). vi. Stocking rate of fry @ 150/m^3; survival 40%. vii. Supplementary Feed: Oil Cake & Rice Bran in 1:1 ratio @ 7% of body weight. viii. Ramp/Catwalk optional. Instead, country-boat/raft can be used for feeding & harvesting.
6	Rearing Pond	i. Construction in low-lying peripheral areas. ii. Pond size 0.2-0.5 ha. iii. Pond depth 1.0-1.5 m. iv. Pond bed slope at least 1000:1 v. Pond dyke top width 1.5-2.0 m depending on soil type. ix. Stocking rate of fry @ 30,000/ha; survival 40%. vi. Supplementary Feed: Oil Cake & Rice Bran in 1:1 ratio @ 5-7% of body weight.

7. Production Economics

Item	Amount/ Quantity
Setup Cost: Strengthening Wetland Embankment, De-weeding, Construction of Rearing Ponds (up to 0.5 ha), etc.	Rs. 6.0 lakh
Inputs Cost: Pen (0.2 ha)/ Cages (6x6x3 m); fish fry/ fingerlings; manures/fertilizers, supplementary feed; etc.	Rs. 3.0 lakh
Estimated fish Production from Wetland/ha/Cycle	2,500 kg
Estimated Returns/ha/Cycle (Rs. 100/kg fish)	Rs. 2.5 lakh
Estimated Returns/ha/Year (2 Cycles)	Rs. 5.0 lakh
Net Returns/ha/Year	Rs. 2.0 lakh
Net Returns from a 10 ha Wetland/Year	Rs. 20.0 lakh

8. Project Monitoring Unit (PMU)

The Technology Partner ICAR-CIFRI would constitute a PMU, and a PERT (Programme Evaluation Review Technique) Chart would be prepared for all the major components of the project, in terms of activities and events.

The Project Monitoring Indicators would broadly include:

- Fish escape prevention structure to be in place
- Wetland being free from floating weeds except those used as fish aggregators
- Enhancement of fish yield
- Increase in fishing days for stocked fishes
- Creation of Sustainability Fund Account
- Emergence of local level people-institutions (Cooperatives, SHGs, etc.).

- Increase in employment opportunities pertaining to fisheries
- Increase in awareness level among fishers and their capacity
- Improvement in livelihoods

9. Aqua One Center (AOC)

An 'Aqua One Center' would be established to provide technical services.

- The AOC would register fishers holding lease or fishing rights of Wetland.
- Where the beneficiaries choose to avail AOC advisory services, a sum of Rs. 1200/- will be charged per crop towards registration, monitoring water quality, growth, health, etc. If not, this amount will be released to beneficiaries as part of the input cost.
- The AOC will carry out inspection/ field visit and submit report to the Project Monitoring Unit (PMU), in the prescribed format.
- The PMU will compile and submit reports to NFDB, crop-wise separately for each Wetland.

10. Governance and Socio-Economics

Wetlands are generally under the ownership of Dept. of Fisheries of the State Govt. They are usually leased out to Fishermen Cooperative Society (FCS) for a period of 7 years. The routine activity of an FCS is managed through an executive committee under the command of the President and Secretary. Fishing is mainly carried out by means of cast net, drag net and gill net using a traditional dingy boat. Harvesting is scheduled twice a year spreading over summer and winter seasons. Summer fishing lasts for 60 days whereas in winter it is for 70 days.

Functional linkages among Fisher/Fish Farmer Interest Groups (FIGs)/ Self Help Groups (SHGs), line departments, technology partner, ATMA, KVKs, input suppliers and marketing agencies will be established for the sustainability of the Group as well as for the Project Development. Further, a Sustainability Fund for each Wetland would be created to provide financial back-up that will ultimately help the Post-Project Sustainability. Workshops, capacity building, forward & backward linkages (fish seed hatcheries, feed mill, post-harvest handling and marketing) and Sustainability Fund will ensure continuity and adoption of the technological intervention.

11. Further Reading

Bhaumik. U. 2015. Aquaculture and Culture-based Inland Fisheries Extension in the Country through PPP Mode. *In*: V.R.P. Sinha, P. Keshavanath, A.P. Sharma and B. P. Mohnaty (eds.), *Public Private Partnership in Aquaculture*. Narendra Publishing House, Delhi. 2015, pages 291-308.

Mohanty, B.P. and P.K. Parida, 2017. Need for Culture-based Capture Fisheries Development Agency (CFDA) for Accelerated Development of the Indian Reservoir Fisheries. *In*: V.R.P. Sinha, Gopal Krishna, P. Keshavanath and N.R. Kumar (eds.), *Social Entrepreneurship in Aquaculture.* Narendra Publishing House, Delhi, 2017, pages 415-426.

Cage Culture in Inland Open Water Bodies

1. Introduction

Cage aquaculture, though relatively new to the inland aquaculture scenario of the country, brings in new opportunities for optimizing fish production from the reservoirs, lakes, floodplain wetlands and for developing new skills among fishers and entrepreneurs to enhance their incomes. A cage is enclosed on all sides with mesh netting made from synthetic material that can resist decomposition under water for a long period of time and is generally small ranging from 1 m^2 to 500 m^2.

Various types of cages are used in Cage Aquaculture: Fixed Cage is the simplest and used in 1-3 m deep waters; it consists of a net bag fitted to posts such that it does not touch the bottom and is normally placed in the flow of streams, canals, rivers, rivulets, shallow lakes and reservoirs. Floating Cage is used in water bodies deeper than 5 m; it is supported by a floating frame such that the net bag hangs in water without touching the bottom. There is wide range in shape, size and design to suit the requirement and conditions of fish culture in inland open waters.

NFDB is promoting cage culture with an integrated approach in the inland open water bodies of the country as an alternative livelihood and income generation programme under Blue Revolution Scheme of Government of India with ICAR-CIFRI as the technology partner.

2. Resources

India has 3.15 million ha of Reservoirs and about 8.0 lakh ha of Floodplain Wetlands (*beels, jheels, mauns, chaurs, pats,* etc.) spread across the major river basins in the country. The present fish yield from reservoirs is low, to the tune of about 82 kg/ha (Jha, et al., 2013), in spite of their high production potential (500 kg/ha, 250 kg/ha and 100 kg/ha in small, medium and large reservoirs, respectively). Similar is the case with floodplain wetlands, where the present yield has been estimated at 400-800 kg/ha, against the production potential of 1500-2500 kg/ha (Sugunan and Sinha, 2001). Enclosure culture systems have a definite role to play in augmenting fish production from inland open waters in India especially the Reservoirs and Floodplain Lakes.

3. Status and Potential

Inland aquaculture in the country presently contributes 5.6 million tonnes of fish annually; with the three Indian major carps *viz.*, Catla (*Catla catla)*, Rohu (*Labeo rohita)* and Mrigal (*Cirrhinus mrigala)* constituting 87% of the production. Several variants of carp culture such as poly-culture, mixed culture, composite culture, wastewater-recycled culture, integrated agriculture aquaculture (IAA) and many short-term culture practices are also available. However, freshwater aquaculture in India is largely a pond-based system.

Culture of fish in enclosures such as cages and pens installed in open water bodies offer scope for increasing production obviating the need for more land-based fish farms. Considering India's rich and varied open water resources like reservoirs, lakes and floodplain wetlands, enormous scope exists to increase production through enclosure aquaculture. Utilizing a modest fraction of their surface area, large and medium reservoirs can contribute a substantial quantity of fish to the total inland fish production basket.

Small and shallow reservoirs and lakes are managed on the principle of culture-based capture fisheries (CBCF) and therefore need to be stocked with advance fingerlings in appropriate numbers in order to get the desired production level. According to one estimate, >3,000 million fingerlings of size 80-100 mm are required annually to stock reservoirs alone in India.

4. Project Module, Location and Implementation

A. Project Module: NFDB proposes to implement Inland Cage Culture Project in selected Reservoirs across the country in an integrated approach in collaboration with Dept. of Fisheries/ Fisheries Corporations or Federations of States/UTs. Up to 100 Cages are proposed to be installed in selected Reservoirs (> 1000 ha) and ancillary activities such as Seed Rearing, Feed Manufacturing, Post-Harvest Processing, Marketing, etc. are to be developed in the vicinity of the Reservoir.

B. Site Selection: Cage Culture shall be allowed in water bodies having a surface area 1,000 ha or more at FRL. (Exception to this can be made only in case of 'very deep abandoned mines', which are less than 1000 ha in area, but too deep for practicing culture-based fisheries, subject to all other conditions prescribed in this document). Cage culture shall be allowed in reservoirs with an average depth of 10 m (Average depth is calculated as: Area in hectares divided by water holding capacity in m^3).The cage site at the reservoir should have at least 10 m depth round the year.

Water bodies or specific locations within a water body can be chosen for Cage Culture. A committee comprising of representatives from State Fisheries Department/ Fisheries Development Corporation, ICAR-CIFRI and NFDB would identify and select suitable sites for project location and development in reservoirs, lakes and floodplain wetlands.

C. Beneficiaries: Interested and eligible Entrepreneurs/Agency/Firm/Company will be selected through Expression of Interest (EoI) to undertake the Project on '***Lease-Develop-Operate Basis***'. Further, local fishermen, members of Coop-Society/ Federation/SHGs will be trained and engaged in Cage Culture operations and in the ancillary activities/industries for smooth operation of the Project as well as for providing them livelihood opportunities.

D. Project Implementation: Management of cages will be under the technical guidance of State Fisheries Department/Federation/Corporation, ICAR-Central Inland Fisheries Research Institute and National Fisheries Development Board. Periodic evaluation of progress would be done by a Project Monitoring Unit (PMU) to be constituted for the successful operation of the project.

E. Financial Assistance: NFDB would provide financial assistance in accordance with the norms laid down in the Central Sector Scheme on Blue Revolution: Integrated Development and Management of Fisheries, 2016 for enabling an institutional setup and development in a project-mode. The cage culture unit shall be kept operational at all times to its full capacity for a minimum period of 5 years. Training cost will be borne wholly by NFDB. Rest of the project cost shall be borne by the successful applicant.

Project Components

A. Cage Setup: The Cage comprises of rigid floating frame (usually made of HDPE/PVC) as support and submerged knotless nylon netting as cage body. Size of a cage for fish culture in reservoirs can vary. However, for ease of operation and management, a cage with the dimensions 6 m (length) x 4 m (width) x 4 m (height) is considered a standard unit. Multiple cage units are installed as a battery comprising 6, 12 or 24 such cages, as per requirement, with catwalks for easy access to the fish stock, and a floating hut/store room. The cages in a battery are arranged in caterpillar design for better exchange of water thereby facilitating relatively high dissolved oxygen. To prevent drifting anchors are tied to the four corners of a Cage/ Set of Cages or at more points for a Battery of Cages and dropped to the floor. Solar-Wind Power Generators are being installed on the cages for lighting purpose. An FRP boat or a coracle is used for transporting men and material.

HDPE Floating Pontoon Cubes used for suspending Nylon Net Cages for fish culture

PVC Barrels used as floats for suspending Nylon Net Cages for fish culture

B. Targeted Fish Species: Cage Culture in Reservoirs is being promoted as a commercial activity. Therefore, fast-growing and economically important exotic species such as Pangasius (*Pangasiandon hypopthalmus*) and GIFT Tilapia (*Oreochromis niloticus*) are being widely farmed in cages.

	
Pangasius (*Pangasiandon hypophthalmus*)	GIFT Tilapia (*Oreochromis niloticus*)

C. Stocking, Feeding and Yield: Although stocking densities should be determined by species requirements and operational considerations, the influence of stocking densities on growth and production has been determined empirically. The indicative stocking, feeding and harvest details for Pangasius Culture in 6 x 4 x 4 m (96 m^3) Cages are as follows:

- Rearing Cage Stocking: Fry (20 mm) 500 - 700 nos./m^3
- Grow-out Cage Stocking: Fingerlings (50 - 60 mm) 60 - 100 nos./m^3
- Feeding Rate (% Av. Body Wt.): Rearing: up to 10%, 4-5 times/day; Grow-out: 5% (first 2 months), 3% (3^{rd} to 5^{th} month), and 2% (from 6^{th} month onwards), twice a day.
- Survival Rate: 80% (7680 nos.)
- Average Body Weight: 600 g in 7-8 months
- Total Biomass per Cage: 7680 nos. x 0.6 kg = 4.608 tonne/ 8 months/ Cage (96 m^3).

D. Cage Management: Maintenance of cages, feeding, harvesting, etc., would be done by the trained local fishermen, members of Coop-Society/ Federation/ SHGs.

E. Harvesting: Harvest of fish in cages is less labour intensive compared to that in ponds. Cages can be towed to a convenient place and harvested by lifting the cage net. Also based on demand, partial or full harvest can be done. Crop could be harvested and marketed fresh to get higher returns.

5. Technical Details

<table>
<tr><th>Sl. No</th><th>Component</th><th colspan="3">Salient Feature</th></tr>
<tr><td>1</td><td>Cage Specifi-cations</td><td colspan="3">Rectangular Cage measuring 6 x 4 x 4 m (96 m^3) is considered as a Standard Unit and a Battery comprises 6, 12 or 24 cages.
Cage Frames are made of any of the following:
• Bamboos
• Mild Steel (MS)
• Galvanized Iron (GI)
• Poly Vinyl Chloride (PVC)
• Virgin Grade HDPE - for runner based & pontoon based frames</td></tr>
<tr><td rowspan="5">2</td><td rowspan="5">Net Cages</td><td colspan="3">Knotless nylon nets are recommended for cage fabrication. The net mesh size recommended for culture of fish in inland cage culture is as follows:</td></tr>
<tr><td>Type of Net Cage</td><td>Specification (Ply)</td><td>*Mesh Size (mm)</td></tr>
<tr><td>Rearing Net (Knotless)</td><td>10-12</td><td>10-15</td></tr>
<tr><td>Grow-out Net (Knotless)</td><td>20-30</td><td>30-40</td></tr>
<tr><td>Predator or Outer Net</td><td>25-30</td><td>35-40</td></tr>
</table>

Sl. No	Component	Salient Feature		
		Bird Protection Net	18-20	60-80
		* Mesh Bar (knot to knot) is half the length of Mesh Size (stretched mesh)		
3	Carrying Capacity & Limit of Cages in Reservoir	**Reservoir Area (ha)**	**Maximum No. of Cages Allowed#**	
		< 1000	Not allowed	
		1001 to 2000	500	
		2001 to 3000	1000	
		3001 to 4000	1500	
		4001 to 5000	1900	
		5001 to 10000	3000	
		>10000	5000	
		#Stand-alone Cages or in Batteries (of 4, 6, 12 or 24 Units), as required		

6. Integrated Project Components and Unit Costs

Sl. No.	Component	Unit Cost (Rs. in Lakh)
1	Cage Unit (6 x 4 x 4 m = $96m^3$) @ Rs.1.0 lakh/ Cage, for 100 Cages, in 25 Batteries of 4 Cages each, including all Accessories, Solar-Wind Energy System, etc	100.0
2	Inputs Cost @ Rs.2.0 lakh/Cage, for 100 Cages	200.0
3	Hatchery (10 million fry / year)	25.0
4	Feed Mill (10 tonne / day)	200.0
5	Ice Plant (40 tonne)	2.5 lakh/tonne
6	Cold Storage (40 tonne)	2.5 lakh/tonne
7	Transportation Facility (Refrigerated Vehicle 10-tonne capacity)	25.0
8	Construction of Fish Landing Centre (Platforms for landing, berthing, auctioning, net mending shed, etc)	4.0
9	FRP Boat (up to 10 m OAL) Insulated Fish & Ice Boxes,	4.5
10	Other Costs (Awareness, Promotion, Consultancy, etc.)	3.5

7. Estimated Project Costs & Returns Per Cage

Item	Amount/Quantity
Setup Cost: GI Cage Unit (6 x 4 x 4 m), and *Inputs Cost*: Fish Seed, Feed, etc.	Rs. 3,00,000
Culture/ Grow-out Duration	7-8 months
Weight of Fish at Harvest (average)	600 g
Expected Yield/Cage/8 months	4.608 tonne
Estimated Returns/Cage/8 months (Sale Price Pangasius @ Rs. 90/kg)	Rs. 4,14,720
Estimated Total Costs/Cage/8 months	Rs. 3,00,000
Net Returns/Cage/8 months	Rs. 1,14,720

8. Governance and Socio-Economics

Unlike the land-based aquaculture undertaken on private land, cage culture is practiced in common property resources. Therefore, the question – who owns the cages installed in reservoirs needs an important consideration. While answering the question, the following facts need to be considered:

(a) Almost all large and medium reservoirs in the country are owned by the Government or Government Agencies and fishers do fishing these water bodies as common property resource with free or almost free access.
(b) Fish produced from the reservoirs is essentially a natural resource and the traditional and local fishing communities have the 'natural primary rights' to this resource.
(c) Livelihoods of many poor people depend on catching fish from reservoirs.
(d) Reservoir fishing is sometimes allowed as a means to rehabilitate the people ousted from the dam project site.

Considering the above facts, it is essential to ensure that expansion of cage culture does not impair the livelihoods and income of fishers. Cage culture can adversely impact the interests of local fishers by denying access to fishing grounds, obstructing their pathways, and a decline in fish catch if cage culture affects the natural productivity of the water body. At the same time, it is equally important to utilize the additional fish production potential through cage culture. Considering the need to avoid conflicts, the best way to achieve the goal is to empower the fishers to take up this activity collectively without conflicts. Following a purely revenue approach by allowing individual investors and corporate houses to undertake cage culture will be against the spirit of inclusive growth and can create social tension. Thus, the community (or a group of members of the community) should own the cages as a common property and they should be the beneficiaries of this technology, even in a PPP mode.

A strong Governance platform based on co-management principles is essential for responsible cage culture operations to be undertaken by the community. But the existing fishermen cooperative societies have poor track record of functioning as a responsible entity to work as a group. This throws a big challenge on the Government to organize and empower the fisher communities and develop capacity among them to enable them to take up cage culture. SHGs, Cooperative Societies or other such groups should be given licenses to undertake cage culture. When a private entrepreneur or investor is allowed to undertake Cage Culture, the Government through strong policies should protect the interest of the local fishers and fisher communities, who have the primary rights to the natural resource. A Conflict Management Cell should be established to address complaints.

9. Further Reading

Das, A.K., K.K. Vass, N.P. Shrivastava, P.K. Katiha. 2009. *Cage Culture in Reservoirs in India (A Handbook).* WorldFish Center Technical Manual No. 1948. The WorldFish Center, Penang, Malaysia, pp. 24.

NFDB, 2015. *Guidelines for Responsible Farming of Tilapia in India*. DAHD&F, GoI. Published by NFDB, November 2015, pp. 16.

NFDB, 2016. *Guidelines for Cage Culture in Inland Open Water Bodies of India*. Published by NFDB, September 2016, pp. 20. [http://nfdb.gov.in/guidelines.htm]

Brackishwater Cage Culture

1. Introduction

Brackishwater is water having salt content more than that of freshwater but less than that of seawater. It results from mixing of freshwater discharged by the rivers and canals with seawater. Typically, salinity of brackishwater ranges from 0.5 to 30.0 parts per thousand (‰), and this water is highly productive. Fishes adapted to such salinity range are known as euryhaline fishes and often occur in coastal waters, estuaries, backwaters, coastal lagoons/ lakes, etc. Most of the fishes adapted to brackishwaters are tasty and have a high market value. It is estimated that there are 12.40 lakh ha of brackishwater resources in India, some of which could be beneficially put to use for aquaculture of highvalue fish and shellfish.

NFDB is promoting brackishwater cage culture with an integrated approach in the backwaters and estuarine regions of the country as an alternative livelihood and income generation programme for the coastal population under Blue Revolution Scheme of Government of India with ICAR-CMFRI as the technology partner.

2. Resources

The estimated 12.40 lakh ha of brackishwater areas comprise of estuaries (deltaic river mouths), coastal lagoons, lakes, backwaters, tidal creeks, canals, mudflats, mangrove plants, etc. These water bodies lying between the freshwater and marine regimes have certain characteristics: (i) fluctuating water level synchronizing with the tides, (ii) wide salinity range of 0-35 ppt, (iii) higher nutrient content and productivity, (iv) serve as nursery grounds for numerous marine organisms, (v) harbour a rich diversity of flora and fauna, and (vi) support artisanal capture fisheries and provide livelihood to the coastal fishers.

3. Status and Potential

The tidal currents carrying with them the juvenile fish and shrimp, and the rising and falling water level formed the basis of traditional brackishwater fish and shrimp farming practices in the Bheries of West Bengal and Pokalli paddy fields of Kerala. Scientific brackishwater aquaculture started around 1980s, wherein shrimp were cultured in well-designed and managed ponds, as there was high demand for them in the export market. At present about 1.60lakh ha are under shrimp culture.

Andhra Pradesh and West Bengal States are the chief producers of shrimp accounting for about 80% of the total country's production. However, of late, culture of high-value euryhaline marine fish species is being undertaken in brackishwater ponds and cages to meet the demand in domestic market. The most commonly cultured fish are Mullets, Milkfish, Seabass, Pompano, Grouper, etc.

4. Project Location and Implementation

A. Site Selection:A committee comprising of representatives from State Fisheries Department/ Fisheries Development Corporation, ICAR-CMFRI and NFDB would identify and select suitable sites for project location and development in the estuarine/ backwaters/ lagoons of coastal States.

B. Beneficiaries: Beneficiaries include SHGs/fishers/ fisherman societies/ farmers/ entrepreneurs; selection would be based on their interest and awareness. Fishers living in hamlets along the backwaterareas, farmers involved in aquaculture and owning homestead near backwater resources,fisherman societies or entrepreneurs of coastal region could directly benefited from this project.Fisherwomen would be encouraged to earn their income and become independent by doing cage culture activities as it requires less capital investment but gives more financial returns.

C. Project Implementation:

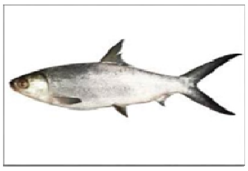
- Management of cages will be under the technical guidance of ICAR-Central Marine Fisheries Research Institute (CMFRI).
- The '*Aqua One Centre*' would provide training on cage farming of fish and shellfish in brackishwater besides technical services to thebeneficiaries.
- Periodic evaluation of progress would be done by CMFRI Project Monitoring Unit (PMU) for the successful operation of the project.
- NFDB would provide financial assistance to the States having brackishwater resources for enabling an institutional setup and development in a project-mode.

5. Project Components

A. Cage Setup: Each cage measures a minimum of 2 x 2 x 1.5 m (6 m^3); 3 such cages constitute a Unit and are encircled by abigger outer net (predator net) measuring 8 x 3 x 2 m; 5 cages constitute a Battery that can be installed at the selected location. Cages may be free floating or fixed. Floating HDPE cages with GI pipe-frame are preferred as they last longer than bamboo framed floating cages.These cages can be used to rear fish fry to fingerlings or for grow-out to table fish. Cages measuring 4 x 4 x 3 m (48 m^3) are also used for brackishwater culture.

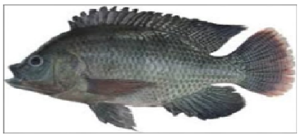
Each SHG/ Society will be provided a maximum of 5 Cages (1 Battery), while individual farmer/ entrepreneur will be provided a maximum of 3 Cages (1 Unit).

B. Targeted Fish Species: Milk Fish (*Chanos chanos*), Asian Seabass (*Lates calcarifer*), Grey Mullet (*Mugil cephalus*), Pearlspot (*Etroplus suratensis*) and Nile Tilapia (*Oreochromis niloticus*), Silver Pompano (*Trachinotus blochii*).




Milk Fish Asian Seabass


Grey Mullet Pearlspot




Nile Tilapia Silver Pompano

C. Stocking and Yield: Although stocking densities should be determined by species requirements and operational considerations, the influence of stocking densities on growth and production has been determined empirically.The indicative stocking and harvest details are as follows:

- Advanced Fingerlings (10-12 cm) Stocked: 240 nos./cage
- Fingerlings Stocked per Unit: 240 x 3 = 720 nos./ 3 cages
- Survival (80%): 576 nos.
- Average Body Weight at Harvest: 1.25 kg
- Total Biomass per Unit:576 nos. x 1.25 kg = 720 kg/ 9 months/ 3 cages (18 m^3)

D. Cage Management: Maintenance of cages, feeding, harvesting, etc., would be done by the beneficiaries themselves, i.e. SHGs/ Fisherman Society, fish farmers.

E. Harvesting: Harvest of fish in cages is less labour intensive compared to that in ponds. Cages can be towed to a convenient place and harvested by lifting the cage net. Also based on demand, partial or full harvest can be done.

Crop could be harvested during the marine fishing ban period and marketed fresh to get higher returns.

6. Integrated Project Components and Unit Costs

Component	Unit Cost (Rs)
Cost of GI Cage (4 x 4 x 3 m = 48 m^3) and Inputs	2.50 lakh
Small Feed Mill (1- 5 quintals/day)	10.00 lakh
‘*Aqua One Center*’	20.00 lakh

7. Estimated Project Costs & Returns

Item	Amount/ Quantity
Setup Cost: GI Cage (4 x 4 x 3 m = 48 m^3) and *Inputs Costs*: Fish Seed, Feed, etc.	Rs. 2,50,000
Fingerling Stocked/Cage (survival 80%)	2,500 nos.
Culture/ Grow-out Duration	6-9 months
Weight of Fish at Harvest (average)	1.0 kg
Expected Yield/Cage/8 months	2,000 kg
Estimated Returns/Cage/8 months (Sale Price Seabass @ Rs. 300/kg)	Rs. 6,00,000
Estimated Total Costs/Cage/8 months	Rs. 2,50,000
Net Returns/Cage/8 months	Rs. 3,50,000

8. Project Monitoring Unit (PMU)

The Technology Partner ICAR-CMFRI would constitute a PMU, and the Project Monitoring Indicators would broadly include:

- Installing and Stocking Cages in timeso as to synchronize harvesting with marine fishing ban period.
- Fish-escape prevention structure to be in place.
- Ensuring predator net is secured and in place.
- Formation of local level people-institutions (Cooperatives, SHGs, etc.).
- Creation of Sustainability Fund Account.

9. Aqua One Centre (AOC)

An ‘*Aqua One Center*’ would be established to provide technical services:

- The AOC would register fishers holding lease of brackishwater areas.
- Where the beneficiaries choose to avail AOC advisory services, a sum of Rs. 1200/- will be charged per crop towards registration, monitoring water quality, growth, health, etc. If not, this amount will be released to beneficiaries as part of the input cost.

- The AOC will carry out inspection/field visit and submit report to the Project Monitoring Unit (PMU), in the prescribed format.
- The PMU will compile and submit reports to NFDB.

10. Governance and Socio-Economics

Brackishwaters are generally under the ownership of Dept. of Fisheries of the State Govt. They are usually leased out to Fishermen Cooperative Society (FCS)/Self Help Groups (SHGs)/Entrepreneurs for a period of 7 years. The routine activity of an FCS/SHGs is managed through an executive committee under the command of the President and Secretary.

Functional linkages among Fishers/Fish Farmer Interest Groups (FIGs)/ Self Help Groups (SHGs), line departments, technology partner, input suppliers and marketing agencies will be established for the sustainability of the Group as well as for the Project Development. Workshops, capacity building, forward & backward linkages (fish seed hatcheries, feed mill, post-harvest handling and marketing) and sustainability fund will ensure continuity and adoption of the technological intervention.

11. Outcomes

- Availability of high-value fish to local/ domestic markets will prevent the supply of low-quality fish to theconsumers.
- It will increase the income and generate alternative employment opportunities to coastalpopulation.
- Efficient use of water bodies in a production perspective will reduce pollution of coastalwaters.
- Empowerment of fishermen, women, unemployed youth, etc. by providing self-employment, income and entrepreneurshipopportunities.
- There would be overall development of backwater fisheries and this in turn will improve the standard of living of rural population in the coastal districts of the State.
- An additional 1000 tonnes of high-value fish is expected to be produced by each maritimeState.

12. Further Reading

CMFRI, 2015. Training Programme on Brackishwater Farming. 16-22 December 2015. Training Manual, Mangalore Research Centre of Central Marine Fisheries Research Institute, Mangalore, Karnataka, pages 1-106.

NFDB, 2016. Economically Very Important Marine Fish with Wide Salinity Tolerance [Asian Seabass or Barramundi, *Lates calcarifer*]. NFDB Newsletter *Matsya Bharat*, Volume 8, Issue 2 and 3 June - September 2016, pages 13-17.

Farming Silver Pompano (*Trachynotus blochii*) in Brackishwater Ponds

1. Introduction

India with an annual production of about 11.41 million tonne stands second among the leading fishing nations of the world. Quite significantly, nearly 50% of this production is from Aquaculture. However, our production or the number of species we farm or export, as compared to many other countries in the region is very low for various reasons. While we have done comparatively well in the case of freshwater fish farming and brackishwater shrimp farming, we have still a long way to go in the development of marine fish farming.

Development of seed production and culture technologies for a large number of commercially important and high value marine fish species is needed. In the case of species for which seed production technologies have been developed, such as Sea Bass (*Lates calcarifer*), Milk Fish (*Chanos chanos*), Cobia (*Rachycentron canadum*), Pompano (*Trachynotus blochii*), Grouper (*Epinepheles* sp.) etc., there is need to upscale the seed production technology and raising fingerlings to promote their farming on a large-scale.

2. Resources

In India an estimated 3.9 million ha open brackishwaters, comprising of estuaries, creeks, backwaters and lagoons exist, but vast estuarine areas remain unutilized for fish production. An estimated 1.2 million hectares of coastal saline lands have been identified to be potentially suitable for brackishwater farming. Also, about 9 million hectares of salt-affected inland soils in the hot semi-arid and arid eco-region of northern plains and central highlands in the States of Haryana, Rajasthan, Punjab, Uttar Pradesh, Maharashtra and Gujarat are found suitable. Estimates show that only 11% of the potential coastal area available is utilized for fish farming. Therefore, development of suitable technologies for the utilisation of coastal saline soil/ saline ground water has become a national priority in the past few years. In addition to food production, coastal aquaculture can generate substantial employment opportunities in diversified fields in maritime States of the country.

3. Status and Potential

Understanding the importance of available resources, seed production technologies for high value marine finfish have been developed in the country and their culture possibilities have been studied in different culture systems.

Aquaculture of Silver Pompano (*Trachynotus blochii*) is being successfully undertaken in many Asia Pacific countries like Taiwan and Indonesia. It can be farmed in coastal earthen ponds, low-cost cages installed in brackishwater canals/backwaters and in sea cages. The species can be acclimatized and grown even in low saline water of 10 ppt.

Among the many high-value marine tropical finfish that could be farmed in India, the Silver Pompano is one of the most promising species as its growth rate is high, meat quality is good and it fetches high price in the market. Body shape, colouration and meat quality of this fish is similar to that of highly priced Silver Pomfret (*Pampus argenteus*). In the international market, the dockside price of Florida Pompano averaged $ 8 per kg; in India the price of Silver Pompano is about Rs. 300/- per kg. It has since been proven that Silver Pompano can be cultured in the brackishwater shrimp ponds as an alternative species achieving high survival rate, appreciable FCR and desired meat quality.

4. Project Location and Implementation

A. Site Selection: A committee comprising of representatives from State Fisheries Department/ Fisheries Development Corporation, ICAR-CMFRI and NFDB would identify and select suitable sites for project location and development in the estuarine/ backwater areas of coastal States and saline inland areas.

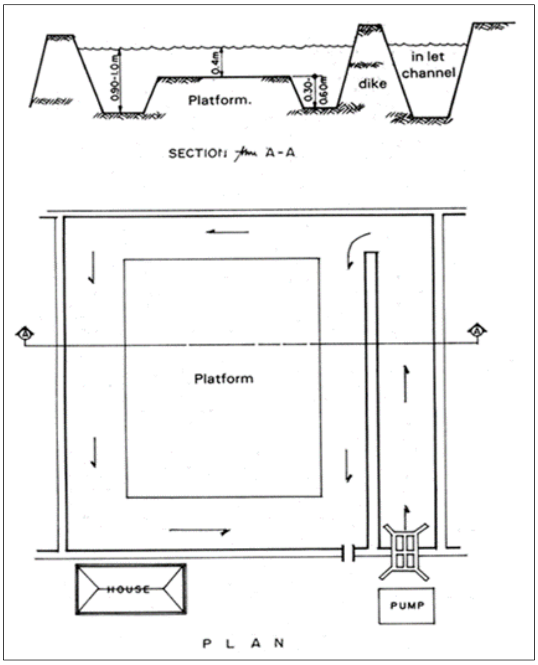
B. Beneficiaries: Beneficiaries include SHGs/ fishers/ fisherman societies/ farmers/ entrepreneurs; selection would be based on their interest and awareness. Fishers living in hamlets along the backwater areas, farmers involved in aquaculture and owning homestead near backwater resources, fisherman societies or entrepreneurs of coastal region could directly benefited from this project. Fisherwomen would be encouraged to earn their income and become independent by doing fish farming activities as it requires less capital investment but gives more financial returns.

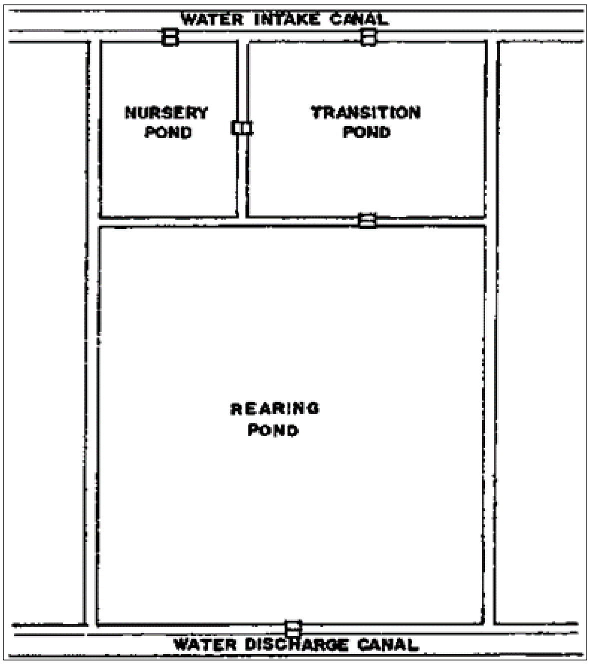
C. Project Implementation:

- Management of Silver Pompano farming will be under the technical guidance of the ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala.
- NFDB would provide financial assistance to beneficiaries through State Govt. for farming Silver Pompano in brackishwater ponds as a sustainable aquaculture project.

5. Project Components

A. Pond Preparation: The pond bed has to be dried until cracks appear on the soil surface. Top layer of the soil containing accumulated waste matter from previous crop of fish or shrimp has to be removed. Ploughing is done to overturn the soil to a depth of 30 cm. Feeding areas, corners and side ditches in the pond have to be properly tilled, leveled and dried to avoid formation of black soil. Water pH of 7.5-8.5 would be ideal for farming Silver Pompano. Quantity of lime applied during pond preparation depends on pH of the soil; dose has to be calculated accordingly. Filling the pond with water has to be done only after firmly tying the inlet pipe opening with two layers of fine (100 microns) mesh to prevent entry of unwanted fishes and predators. A week before stocking, the pond must be fertilized with either organic manure or inorganic fertilizers to stimulate plankton production.





Different layouts of Brackishwater Ponds for farming Silver Pompano

B. Salinity: Silver Pompano can tolerate vide range of salinities from 5–40 ppt. However, ideal salinity for farming would be between 15–25 ppt. The pond has to be filled to a minimum depth of 100 cm prior to stocking of fish seed. During the entire culture period, a minimum of 1.5 m water depth has to be maintained.

C. Nursery, Rearing and Seed Stocking: Hatchery produced Silver Pompano fry/fingerlings of 1–2 inch size are released into fine-mesh *hapas*/ cages/ pens of 2 m length, 2.0 m width and 1.5 m depth, installed in the pond. While stocking, care should be taken not to disturb the pond bottom by the persons getting into the pond as it may increase the suspended solid load in the water and choke the gill of fingerlings leading to mortality. Initially, 4 mm mesh *hapas*/ enclosures are used and after 30 days the fish seed are shifted into 8 mm mesh *hapas*/ enclosures. The stocking density during rearing phase could be up to 200 nos./ *hapa*. The fish seed have to be reared in *hapas*/ enclosures for 60 days or until they grow to at least 10 - 15 gram fingerlings, after which they can be released into the pond. Ideally, 5,000 nos. of 30 gram fingerlings can be stocked in a one acre (4,000 sq m) pond.

Nursery & Rearing Hapas in Culture Pond

D. Nutritional Requirement and Feeding: Silver Pompano is a fast swimming marine fish with darting movements and it requires highly nutritive feed to meet its energy requirements. During nursery rearing Pompano can be weaned to any type of feed, *viz*., extruded floating pellet, sinking pellet feed and chopped trash fish. Ideally, Pompano can be weaned to extruded floating pellet feed to avoid feed wastage and spoilage of pond bottom.

During rearing phase, in the *hapas*/enclosures, feeding has to be done 4 times a day and during grow-out phase in culture ponds it could be 3 times a day. Feeding zones demarcated by 3-inch diameter PVC-pipe floating frames of 2 x 2 m square have to be installed in the ponds. Feed has to be dispensed inside the feeding zone to avoid dispersal of floating feeds by wind/waves. At least 4 - 6 nos. of feeding zones have to be demarcated in one acre (4,000 sq m) pond. The feed pellet size should be less than the mouth size of the fish and hence, suitable size feed has to be selected for feeding the fish.

Details of feed and feeding schedule for Silver Pompano are as follows:

Fish Weight	**Feed Pellet Size**	**Crude Protein (%)**	**Crude Fat (%)**	**Feed Ration as (%) Biomass**	**Feedings per Day**
> 1 gram	800 -1000 µ	50	10	30	4
1-10 gram	1.0 -1.5 mm	40	8	20	4
10-100 gram	1.8 mm	35	8	8	3
100-250 gram	3.5 mm	30	6	5	3
250-500 gram	4.5 mm	30	6	3	3

A mix of two sizes of extruded feed pellet can be used if any size variation is found among fish during regular sampling. If sinking pellet feed is used, at least 4 – 8 feed trays (80 x 80 cm) per pond could be placed. Regular sampling of fish once in 15 days has to be carried out to determine growth rate and to calculate the FCR. In the demonstration of Silver Pompano farming, an FCR of 1:1.8 was obtained using feed having the above given formulation.

E. **Water Quality Management:** Plankton bloom is essential during early stages (up to 100 gram) of Silver Pompano culture. If the pond water is clear without any colour, a mixture of organic manure (10-30 kg/ha) and inorganic fertilizers (1-3 kg/ha) can be applied to obtain the algal bloom. Sufficient water depth must be maintained in the ponds to prevent growth of algae/vegetation on the pond bottom. Water depth in the shallowest part of the pond should be at least 100 cm. Water quality can be maintained by exchanging 10% of the water once in a week, 20% per week after 3 months and 30% per week after 6 months. If water colour is too dark, the quantum of water exchange can be proportionately increased. To maintain water pH within an optimum range of 7.5 - 8.5, agriculture-lime has to be applied regularly. Dissolved oxygen (D.O.) level should be maintained above 5 ppm at all times. Paddle wheel aerators can be placed in the pond to circulate the water and maintain the DO level. Aeration is a must during late evening to early morning period once the fish attain 200 gram size, and above.

F. Health Management: Silver Pompano is a hardy species and disease problems are not much. When reared in high salinities infestation with parasitic copepods may occur. Periodical application of commercially available pond water sanitizers/chemicals like Iodine solution would help to keep the fish healthy. Feed supplements such as LIV-52 syrup can be given by mixing with the feed to improve the immunity levels.

G. Growth Pattern: During the entire culture period, growth pattern of Silver Pompano is monitored by sampling the fish at fortnightly intervals. Estimated length and weight measurements against days of culture (DOC) are as follows:

DOC	Length (mm)	Weight (g)
1	30.59 ± 0.24	2.00 ± 0.04
30	73.42 ± 0.53	15.08 ± 0.16
60	102.88 ± 1.91	34.60 ± 0.41
90	158.39 ± 2.42	72.54 ± 1.95
120	182.30 ± 2.03	101.82 ± 3.11
150	203.71 ± 3.73	172.39 ± 4.55
180	226.51 ± 2.90	258.31 ± 5.76
210	273.07 ± 3.62	375.32 ± 8.07
240	296.88 ± 6.27	464.65 ± 10.25

H. Harvesting: Harvesting of Silver Pompano could be carried out by using drag net as in the case of freshwater fish ponds. To maintain the freshness and quality of harvested fish, washing in clean water and chill-killing can be done. Harvested fishes can be stocked in plastic crates by adding layers of ice in equal quantities at the bottom and top of the fish. It is suggested that harvesting of fish can be carried out during the off season period of April to June to get a better price.

Harvested Silver Pompano, *Trachynotus blochii*

6. Probable Unit Costs

The Probable unit cost for farming Silver Pompano in brackishwater ponds is given below:

Sl. No.	Particulars	Units	Quantum	Rate (Rs.)	Total Amount (Rs.)
A	**Capital Cost**				
1	Construction of Pond	1 ha	40 hrs	2000	80,000
3	Water inlet structures for pond	LS	1	10000	10,000
4	Water outlet structure for pond	LS	1	10000	10,000
5	Main outlet sluices	LS	1	20000	20,000
6	Pump-house	sq ft	100	200	20,000
7	Watchman shed	sq ft	100	200	20,000
8	Pumps	5 HP	1	40000	40,000
				Total A	**2,00,000**
B	**Operational Cost for One Crop (8 months)**				
1	Manures for pond preparation	kg/ha	1	10000	10,000
2	Cost of fingerling incl. transport	Rs.	12500	8	1,10,000
3	Feed including transport	Kg	7000	70	5,00,000
4	Harvesting charges	LS	-	10000	10,000
5	Miscellaneous expenses	LS	-	20000	20,000
				Total B	6,50,000
				Total A+B	**8,50,000**

7. Estimated Project Costs & Returns

Sl.No.	Particulars	Amount/ Quantity
1	Culture Period	1 year
2	Fingerlings Stocked (nos./ha)	12,500 per ha
3	Expected Survival (%)	75%
4	Total Fish Survived (nos.)	9,375 nos.
5	Average Harvest Size (g)	450 g
6	Total Production (kg/ha/year)	4218.75 kg
7	Sale Price (Rs/kg)	Rs. 250/-
8	Gross Income per year (Rs)	Rs.10,54,687/-
9	Net Benefit	Rs.2,04,687/-

8. Socio-Economics

To achieving sustainable aquaculture production, species diversification is vital. High-value marine fishes are in good demand in the domestic market and often are in short supply. Silver Pompano is in demand from 250 gram size onwards and therefore its farming could be quite lucrative and emerge as a major aquaculture enterprise in the coming years financially benefiting a large number of coastal fishers and fish farmers.

9. Further Reading

Jayakumar, R., Nazar, A K A., Tamilmani, G., Sakthivel, M., Kalidas, C., Ramesh Kumar, P., Rao, G Hanumanta, Gopakumar, G., 2014. Evaluation of growth and production performance of hatchery produced silver pompano *Trachinotus blochii* (Lacépède, 1801) fingerlings under brackishwater pond farming in India. *Indian Journal of Fisheries*, 61(3), pages 58-62.

Sea Cage Farming

1. Introduction

The global mariculture production including the seaweeds is about 54.0 million tonne, which constituted 53.4% of the aquaculture production. In the recent past marine fish catch in the country is stagnating around 3.5 million tonne annually, indicating that increasing the fish catch from the existing fishing grounds is not sustainable economically and ecologically. Added to this dwindling catch in capture fisheries, rampant unemployment in the coastal region and demand for additional seafood necessitates the development of mariculture as a substantial seafood production sector. It has been projected that in India we need to produce about 18 million tonne of fishes by 2030 as compared to about 13 million tonne we produce today. It implies that our aquaculture production has to increase from about 5 million tonne to about 12 million tonne. Enhancing fish production from inland sector has limited scope and the major portion of the additional demand has to come from mariculture.

2. Resources

India is endowed with vast marine fisheries resources such as 8,118 km long Coast Line, 193,834 km^2 of Territorial Sea (12 nautical miles/ 22.2 km from shoreline), about 4 million Marine Fishermen living in 3432 Marine Fishing Villages in 66 Coastal Districts of 9 Maritime States and 2 Union Territories, besides 2 Island Territories of Andaman & Nicobar and Lakshadweep. Infrastructure available includes 6 Major Fishing Harbours, 40 Minor Fishing Harbours and 1537 Marine Fish Landing Centres.

The relatively shallow inshore water along the vast coast line of mainland and island territories offer scope for Sea Cage Farming. However, sheltered areas such as bays, lagoons, semi-exposed and exposed coasts having less wave action are preferable. The existing marine infrastructure and marine fisher population would be serving as complementary resources.

3. Status and Potential

Sea cage farming is viewed as a major option for increasing the seafood production and has been expanding rapidly in recent years at global level. When compared to many maritime countries, India is still in its infancy in cage culture. Recently, it has been estimated that total number of cages of varying sizes installed in the inshore and brackishwater areas number around 1500 with a total estimated production of around 1500 tonne. Hence, there is tremendous scope for the further expansion of cage farming in India. The ICAR-Central Marine Fisheries Research Institute (CMFRI) has projected that even if 1% of the inshore waters is used for cage farming, we can deploy 8,20,000 cages with a production potential of 3.2 million tonne. Thus, there is an urgent need to expand sea cage farming in India.

Sea cage farming in India was initiated by CMFRI with support from Ministry of Agriculture, Govt. of India and National Fisheries Development Board (NFDB) and is gaining momentum as a commercial seafood production system. Several R&D programmes in cage culture, demonstrations and participatory mode of cage farming have led to the emergence of an economically viable farming method which resulted in popularization of the technology. The necessity of seed for farming has led to the development of hatchery technology for high valued finfish like Cobia, Pompano and Grouper. Consequently, seeds of these species also were made available for cage farming along with the already available seeds of Asian Seabass. As a result, cage farming of Cobia, Pompano, Asian Seabass and Grouper became popular among fishermen-groups and entrepreneurs along the Indian coast.

4. Project Location and Implementation

A. Site Selection: A committee comprising of representatives from State Fisheries Department/ Fisheries Development Corporation, ICAR-CMFRI and NFDB would identify and select suitable sites for project location and development in the sheltered bays/ lagoons/ open seas of coastal States and Island Territories. A minimum of 10 m seawater depth even during low-tide should be ensured.

B. Beneficiaries: Beneficiaries include SHGs/ fishers/ fisherman societies/ farmers/ entrepreneurs; selection would be based on their interest and awareness. Fishers living in hamlets along the coast could directly benefit from this project.

C. Project Implementation:

- Management of cages will be under the technical guidance of ICAR-Central Marine Fisheries Research Institute (CMFRI).
- The '*Aqua One Centre*' would provide training on fish and shellfish farming in cages besides technical services to the beneficiaries.
- Periodic evaluation of progress would be done by CMFRI Project Monitoring Unit (PMU) for the successful operation of the project.
- NFDB would provide financial assistance to the States having marine resources for enabling an institutional setup and development in a project-mode.

5. Project Components

A. Cage Setup: Circular Cage having minimum diameter of 6 m and depth of 4 m (113 m^3 volume) or Rectangular Cage measuring 6 x 4 x 4 m (96 m^3 volume) can be installed at the selected location. They are encircled by a bigger outer net (predator net) with one metre gap all around, and a bird net is overlaid on the cage frame. Cages may be free floating or fixed. Mooring system/

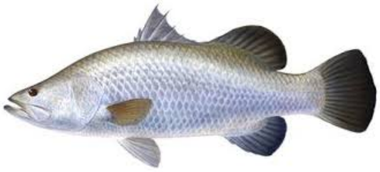
assembly holds the cage in desired position and at desired depth using mooring lines, chains and anchors. Cages with appropriate mesh size can be used to rear fish fry to fingerlings (nursery cage) &/or to grow table fish.

Each sea cages is considered a Unit, and in a given location a maximum of 20 cages will be installed by a group of fishers/ society/ entrepreneur to form a cluster. Sea Cage Units usually form part of an Integrated Project comprising of Marine Fish Hatchery, Feed Plant, Ice Plant, Cold Storage, Refrigerated Truck, etc

B. Targeted Fish Species: Cobia (*Rachycentron canadum*), Silver Pompano (*Trachinotus blochii*), Seabass (*Lates calcarifer*), Snappers (*Lutjanus sp.*), Groupers (*Epinephelus sp.*) and Spiny Lobster (*Panulirus sp.*) are highly suitable for sea cage farming

Cobia (*Rachycentron canadum*)

Silver Pompano (*Trachinotus blochii*)



Seabass (*Lates calcarifer*)

Snappers (*Lutjanus sp.*)

Groupers (*Epinephelus sp.*)

Spiny Lobster (*Panulirus sp.*)

C. Stocking and Yield: Stocking density influences growth and production; it has been determined empirically; stocking and estimated harvest quantities are as follows:

Species	Stocking Size (Length/ Weight)	Stocking Density (Nos./ m^3)	Production per Cage (kg)
Cobia	15 cm/ 35 g	8-10	2400 kg/ 7 months
Pompano	10 cm/ 35 g	30-40	1800 kg/ 8 months
Seabass	10 cm/ 30 g	30-40	2000 kg/ 8 months
Grouper	15 cm/ 40 g	15-20	2000 kg/ 7 months

D. Cage Management: Sea Cage management involves optimizing production at minimum cost. Efficient management largely depends on the competence and efficiency of farm operator with regards to feeding rate, stocking density, minimizing loss due to diseases and predators, monitoring environmental parameters and maintaining efficiency in all other technical aspects.

The entire structure including cage frame and mooring must be routinely inspected and necessary maintenance and repairs should be carried out. Bio-fouling clogs the mesh of net cages and thereby reduces rate of water exchange causing stress due to low oxygen and accumulated wastes leading to mortality of fish. Therefore, regular brushing of the net cages mesh is essential.

E. Harvesting: Harvesting can be done as per the market demand to ensure maximum returns. Partial harvesting of stock may be practiced, by harvesting the larger fish first, to avoid glut in the market and consequent fall in sale price. Records of harvest should be maintained at the site. It is necessary to have a post-harvest and marketing strategy while undertaking large-scale sea cage farming activity. The production centres should have facilities such as proper craft and gear to harvest fish, facilities for icing, holding and storage of fish, live-fish transport, linkages to post-harvest processing centres and market chains.

6. Technical Details

Sl. No	Component	Salient Feature
1	Cage Specifi-cations	Circular Cage having minimum diameter of 6 m and depth of 4 m ($113 m^3$) or Rectangular Cage measuring 6 x 4 x 4 m ($96 m^3$) **i. Base Collar** • Inner Ring - 6m ø • Outer Ring – 7 m ø • Middle Ring (Catwalk ring) – 6.5 m ø • Base Supports - 8 nos. • Vertical supports – 8 nos. (to connects the base supports to the circular top handrail) • Diagonal Supports – 8 nos. (to connect the catwalk ring to the circular top handrail with T-joints) **ii. Handrail** • 6 m ø (HDPE, 90 mm ø pipe), fitted about 1 m above the inner Collar Ring and connected by vertical as well as diagonal supports with the Base Collar Rings.

<table>
<tr><th>Sl. No</th><th>Component</th><th colspan="5">Salient Feature</th></tr>
<tr><td></td><td></td><td colspan="5">iii. Mooring System
• Anchors/ Gabion Boxes
• D-Shackles
• Mooring Chains
• Buoys
• Anchor Marker Line
• Mooring Rope</td></tr>
<tr><td>2</td><td>Outer Predator Net Cage</td><td colspan="5">i. Braided UV treated HDPE netting of 3 mm thickness and 80 mm mesh size is very effective and recommended.
ii. Dimensions of Predator Net Cage – 7 m diameter and 5 m depth (entirely submerged).</td></tr>
<tr><td>3</td><td>Inner Fish Rearing / Grow-out Net Cage</td><td colspan="5">i. Twisted HDPE netting of 0.75-1.5 mm thickness and 16 – 40 mm mesh size is selected depending on the size of cultivable species.
ii. Dimensions of Fish Rearing Net Cage – 6 m diameter and 5 m depth (4.0 m submerged and 1.0 m up to the handrail; volume 113 cubic metres)</td></tr>
<tr><td rowspan="5">4</td><td rowspan="5">3-4 Sets of Inner Fish Rearing / Grow-out Net Cages Required as Culture Progresses</td><td>Species</td><td>18 mm Mesh
For Fish Size (mm/ g)</td><td>25 mm Mesh
For Fish Size (mm/ g)</td><td>40 mm Mesh
Fish Fish Size (mm/ g)</td><td>60 mm Mesh
For Fish Size (cm/ kg)</td></tr>
<tr><td>Cobia</td><td>100-200 / 10-70</td><td>200-450 / 70-1100</td><td>460-750 / 1100-4000</td><td>75-100 / 4-7</td></tr>
<tr><td>Pompano</td><td>20-30/ 2</td><td>40-100/ 35</td><td>100-200/ 500</td><td>--</td></tr>
<tr><td>Seabass</td><td>20-100/ 15</td><td>40-200/ 300</td><td>200-400/ 1500</td><td>--</td></tr>
<tr><td>Grouper</td><td>20-100/ 15</td><td>40-200/ 300</td><td>300-400/ 1000</td><td>--</td></tr>
<tr><td>5</td><td>Bird Net</td><td colspan="5">i Twisted HDPE and UV treated 1.25 mm twine and 60 – 80 mm mesh size will be ideal.</td></tr>
<tr><td>6</td><td>Ballast</td><td colspan="5">i. To maintain the cylindrical shape of the net cages, concrete blocks of appropriate weight are tied at suitable intervals.
ii. Alternately, HDPE pipe of 1.5 inch (38 mm) diameter, with MS chain or wire rope of 10 mm thickness inserted in it, can be used as ballast.</td></tr>
</table>

7. Integrated Project Components and Unit Costs

Sl. No.	Component	Unit Cost (Rs. in Lakh)
1	Sea Cage Unit - Circular (6 m ø x 4 m depth = 113 m^3) or Rectangular (6 x 4 x 4 m = 96 m^3) and Inputs	5.0
2	Hatchery (10 million fry / year)	25.0
3	Feed Mill (10 tonne / day)	200.00
4	Ice Plant (40 tonne)	2.5 lakh/tonne
5	Cold Storage (40 tonne)	2.5 lakh/tonne
6	Transportation Facility (Refrigerated Vehicle 10-tonne capacity)	25.00
7	Aqua One Center	20.00

8. Estimated Project Costs & Returns

Sl. No.	Item	Amount / Quantity
1	*Setup Cost*: Circular Cage Unit (6 m ø x 4 m depth = 113 m^3); Rectangular Cage Unit (6 x 4 x 4 m = 96 m^3); *Inputs Cost*: Fish Seed, Feed, etc.	Rs. 5,00,000
2	Stocking Density/ Cage	1000 nos.
3	Culture/ Grow-out Duration	7 months
4	Weight of Fish at Harvest (Cobia, average)	3.0 kg
5	Expected Yield/Cage/7 months	2,400 kg
6	Estimated Returns/Cage/7 months (Sale Price Cobia @ Rs. 300/kg)	Rs. 7,20,000
7	Estimated Total Costs/Cage/7 months	Rs. 5,00,000
8	Net Returns/Cage/7 months	Rs. 2,20,000

9. Project Monitoring Unit (PMU)

The Technology Partner ICAR-CMFRI would constitute a PMU, and the Project Monitoring Indicators would broadly include:

- Installing & Stocking Cages in time so as to synchronize harvesting with marine fishing ban period and thereby realize higher market price.
- Fish-escape prevention structure to be in place.
- Ensuring predator and bird nets are secured and in place.
- Formation of local level people-institutions (Cooperatives, SHGs, etc.).
- Creation of Sustainability Fund Account.

10. Governance and Socio-Economics

The routine activity of an FCS/ SHGs is managed through an executive committee under the command of the President and Secretary. Functional linkages among Fishers/ Fish Farmer Interest Groups (FIGs)/ Self Help Groups (SHGs), line departments, technology partner, input suppliers and marketing agencies will be established for the sustainability of the Group as well as for the Project Development. Workshops, capacity building, forward & backward linkages (fish seed hatcheries, feed mill, post-harvest handling and marketing) and sustainability fund will ensure continuity and adoption of the technological intervention.

11. Further Reading

Philipose, K.K., 2013. *Development of innovative low cost cages for promoting open sea cage culture along the Indian coast*. pp. 127-132. Customized Training in Mariculture. Course Manuel, CMFRI, Kochi, Kerala.

NFDB, 2018. *Guidelines for Sea Cage Farming in India*. Published by NFDB, January 2018, pp. 32. [http://nfdb.gov.in/guidelines.htm]

Seaweed Cultivation

1. Introduction

Seaweeds are macroscopic algae growing in the marine and shallow coastal waters and on rocky shores. Seaweeds are wonder plants of the sea, the new renewable source of food, energy, chemicals and medicines with manifold nutritional, industrial, biomedical, agriculture and personal care applications. Seaweeds are also termed as the ‘Medical Food of the 21st Century’ as they are being used as laxatives, for making pharmaceutical capsules, in treatment of goiter, cancer, bone-replacement therapy and in cardiovascular surgeries.

The major industrial applications of seaweeds are as a source of agar, agarose and carrageenan used in laboratories, pharmaceuticals, cosmetics, cardboard, paper, paint and processed foods. In India there are 46 seaweed-based industries, 21 for Agar and 25 for Alginate production, but they are not functioning up to their rated capacity, due to short-supply of raw materials.

2. Resources

Seaweeds are abundant along the Tamil Nadu and Gujarat coasts and around Lakshadweep and Andaman & Nicobar Islands. Rich seaweed beds occur around Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhinjam and Pulicat in Tamil Nadu, Andhra Pradesh and Chilka in Orissa.

3. Status and Potential

Around 844 species of seaweeds have been reported from Indian seas, their standing stock is estimated to be about 58,715 tonne (wet weight). Out of the 844 seaweed species, India possesses around 434 species of Red Algae, 194 species of Brown Algae, and 216 species of Green Algae. The Red Algae *Gelidiella acerosa, Gracilaria edulis, G. crassa, G. foliifera and G. verrucosa* are farmed for manufacturing Agar and Brown Algae *Sargassum* spp., *Turbinaria* spp. and *Cystoseira trinodis* for the production of alginates and liquid seaweed fertilizer. The quantity of seaweeds available currently is inadequate to meet the raw material requirement of Indian seaweed industries.

Seed stock of seaweeds is traditionally collected from sea bed in shallow waters along the southeastern coast of Tamil Nadu. Further, continuous, indiscriminate, and unorganized harvesting has resulted in depletion of natural resources. Seaweed cultivation is a highly remunerative activity involving simple, low cost, low maintenance technology with short grow-out cycle.

4. Project Location and Implementation

A. Beneficiaries: Coastal fisher-families, especially fisher-women, their societies/ SHGs, and farmers/ entrepreneurs. The project is to be implemented in a cluster model with each cluster consisting of a minimum of three beneficiaries. Project will be implemented by the beneficiary with technical support from Department of Fisheries of the State Govt.

B. Selection of Site for Seaweed Cultivation: Seaweed cultivation would be undertaken in shallow coastal waters of maritime States, wherein Bamboo-Rafts or Tube-Nets would be held in clusters. A committee comprising of representatives from State Fisheries Department and CSIR-Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar, Gujarat, would identify and select the area for development of seaweed cultivation. CSIR-CSMCRI would be the technology partner, Department of Fisheries of Coastal States would be the Implementing Agency and NFDB would provide financial assistance.

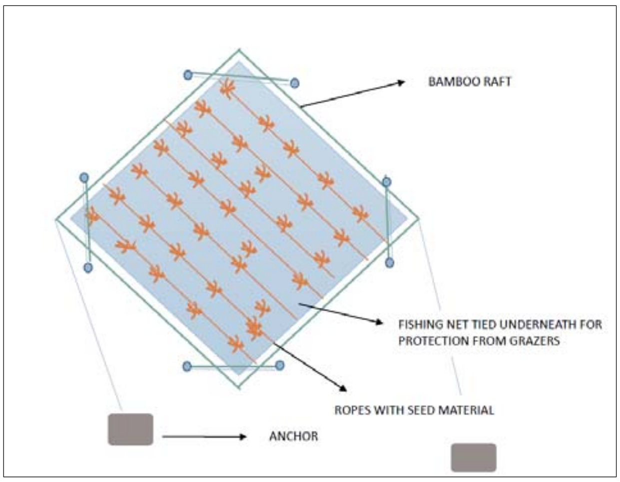
Suitable sites for seaweed cultivation will be selected based on the following criteria:

- Stable seawater with not less than 30 ppt salinity
- Sandy/ rocky bottom with transparent water
- Ideal temperature 26-30 ^{o}C.
- The area should have minimum 1.0 m water depth during low tide.
- Area with mild water currents are preferred.

5. Project Components

A. Raft Preparation and Installation: Each raft measures a minimum of 3×3 m (made of bamboo poles having 7.5 to 10 cm diameter). Rafts may be free floating or fixed.

Each SHG/ Society having at least 3 persons will be provided a minimum of 135 rafts (45 x 3 = 135) in 1 cluster and an individual will be provided a maximum of 45 rafts.



Tying Seedlings of Seaweed on a Bamboo Raft

B. Targeted Seaweed Species: The Red Algae *Gracilaria edulis*, *Gracilaria dura* and *Kappaphycus alvarezii* are highly suitable for cultivation on floating Bamboo Rafts or Tube-Nets held in the sea.

Gracilaria edulis

Gracilaria dura

Kappaphycus alvarezii

C. Seaweed Stocking and Yield: Although stocking densities should be determined by species requirements and operational considerations, the influence of stocking densities on growth and production has been determined empirically. The indicative stocking and harvest details are as follows:

- Crop Duration: 45 - 60 days
- No. of Rafts/Beneficiary: 45 nos.
- Total Number of Rafts per Cluster: 135 rafts
- Seed Material Required Per Raft: 50 – 60 kg/ raft
- Total Seed Material Required/Cluster: 6,750 kg
- Seaweed Harvested from 1 Raft: 250 kg/ raft
- Net Produce from 1 Raft (after deducting seed material): 200 kg/raft
- Total Production per Cluster per Cycle:135 rafts x 200 kg = 27,000 kg
- Annual Seaweed Production per Cluster: 27,000 kg x 6 cycles = 1,62,000 kg

D. Maintenance of Rafts and Harvesting: Maintenance of rafts would be done by the beneficiaries themselves, i.e. SHGs/ Fisherman Society, fish farmers. One person/beneficiary can handle a single raft in a day. Seaweed cultivated on rafts can be harvested every 45-60 days. Seaweed removed from the rafts will be dried on a clean surface and marketed to the seaweed processing industries.

Harvesting Seaweed from Bamboo Rafts

E. Comparing Cultivation of *Gracilaria edulis* with *Kappaphycus alvarezii*

Component	***Gracilaria edulis***	***Kappaphycus alvarezii***
Floating Raft Dimensions (made of bamboo poles having 7.5 to 10 cm diameter)	3×3 m	3×3 m
Crop Duration	45 -60 days	45 days
Quantity of planting/seed material required/raft	5-6 kg	50-60 kg
Biomass harvested/raft	40-50 kg	240-260 kg
States where Seaweed Cultivation is prevalent	Tamil Nadu, Gujarat	Tamil Nadu, Gujarat
Stability in Rough Sea	More sensitive	Less sensitive

6. Probable Unit Cost

Sl. No.	**Components**	**Cost/Unit**
1	Cost of One Bamboo-Raft (3 m × 3 m) or Tube-Net, and Inputs Costs	Rs.2,000
2	No. of Bamboo-Rafts or Tube-Nets per beneficiary	45 nos.
3	Total No. of Rafts per Cluster (3 beneficiaries)	135 nos.
4	Crop Duration per Cycle	45 days
5	Training & Skill Development: 3 days, 50 persons per batch	Rs.1.25 lakh

7. Production Economics

(A) Estimated Output

SL. No.	Particulars	Amount/ Quantity
1	No. of beneficiaries per cluster	3
2	No. of rafts per beneficiary	45
3	Total no. of rafts/cluster	135
4	Harvest cycle (period in days)	45
5	No. of raft(s) handled/ person/ day	1
6	Total seaweed harvested from 1raft (kg)	250
7	Total seed stock required for re-plantation of 1 raft (kg)	50
8	Net produce from1raft after deducting seed stock (kg)	200
9	Annual seaweed production (after retaining 50 kg seed stock for next crop; total seaweed production from 135 rafts; 6 cycles) (wet weight in kg)	1,62,000
10	Total dried seaweed production (from 135 rafts; 6 cycles; @ 10% of wet weight) (dry weight in kg)	16,200
11	Price of dried seaweed (Rs. per kg)	35
12	Gross Revenue (Rs.)	5,67,000

(B) Estimated Project Costs & Returns

SL. No.	Particulars	Amount in Rs.
1	Capital Cost (for 135 rafts) @ Rs.1500/- per raft	2,02,500
2	Recurring Cost for 1st Cycle (for 135 rafts, including seed stock cost) @ Rs.500 per raft	67,500
3	Recurring Cost from 2nd to 6th Cycle (for 135 rafts, excluding seed stock cost)	1,68,750
4	Total Cost [Sl. No. 1+2+3]	4,38,750
5	Gross Revenue [Table A, Sl. No. 12]	5,67,000
6	Net Revenue in 1st year [Sl. No. 5-4]	1,28,250
7	Net Revenue from 2nd year onwards [Sl. No. 5-(2+3)]	3,30,750
8	Net Income per person/month in a cluster (2nd year onwards) [Rs.3,30,750 in12 months for 3 persons]	9,188

8. Project Monitoring Unit (PMU)

The Technology Partner CSIR-CSMCRI would constitute a PMU, and the Project Monitoring Indicators would broadly include:

- Training to the beneficiaries.
- Supply of seedlings to the State Fisheries Departments.
- Formation of local level people-institutions (Cooperatives, SHGs, etc.).

9. Expected Outcomes

- Mass production of Spores: An approach to vigorous seed development for commercial farming of *Gracilaria edulis* by CSIR-CSMCRI MARS, Mandapam, Tamil Nadu.
- Farming of Red Seaweed *Gracilaria dura* on Gujarat Coast for promoting inclusive economic growth in coastal rural settings by CSIR-CSMCRI, Gujarat, through participation of coastal fisher population.
- Large-scale cultivation of commercially important seaweeds in the coastal waters of maritime States would fill the demand-supply gap of Agar and Alginate producing industry in the country

10. Further Reading

Ineke Kalkman, Isaac Rajendran, Charles L. Angell, 1991. Seaweed *(Gracilaria edulis)* Farming in Vedalai and Chinnapalam, India. Bay of Bengal Programme, Madras, India, BOBP/WP/65, 1991, pages 1-16.

Gulshad Mohammed, 2016. Current trends and Prospects of Seaweed Farming in India. *In* Imelda Joseph and Ignatius Boby (eds.), 2016. Winter School on Technological Advances in Mariculture for Production Enhancement and Sustainability. Course Manual, Central Marine Fisheries Research Institute, Kochi, 2016, pages 78-84.

Kapil S. Sukhdhane, K. Mohammed Koya, D. Divu, Suresh Kumar Mojjada, Vinay kumar Vase, K. R. Sreenath, Sonia Kumari, Rajesh Kumar Pradhan, Gyanaranjan Dash and V. Kripa, 2017. Experimental cultivation of seaweed *Kappaphycus alvarezii* using net-tube method. *Mar. Fish. Infor. Serv., T & E Ser*., No. 231, 2017, pages 9-11.

Backyard Recirculation Aquaculture System

1. Introduction

Recirculation Aquaculture System (RAS) is a technology wherein water is recycled and reused after filtration and removal of suspended matter and metabolites. The method is used for high-density culture of various species of fish utilizing minimum land area and water.

It is an intensive approach (higher densities and more rigorous management) than other aquaculture production systems. Instead of the traditional method of growing fish outdoors in open ponds and raceways, in this system fish are typically reared in indoor tanks in a “controlled” environment. Recirculating systems filter and clean the water for recycling it back through fish culture tanks. The technology is based on the use of mechanical and biological filters, and the method can in principle be used for any species grown in aquaculture. New water is added to the tanks only to make up for splash out, evaporation and for that used to flush out waste materials. The reconditioned water circulates through the system and no more than 10% of the total water volume of the system is replaced daily. In order to compete economically and to efficiently use the substantial capital investment in the recirculation system, the fish farmer needs to grow as much fish as possible in the inbuilt capacity. However, in order to encourage small-scale fish farmers and entrepreneurs and also to facilitate fish production in urban and peri-urban areas where land and water are scarce, it is proposed to promote Backyard Recirculation Aquaculture Systems.

2. Resources

Land based aquaculture is most commonly undertaken in dugout earthen ponds and often large stretches of fertile agricultural land gets converted into fish ponds for this purpose. Further, a large quantity of water is needed to fill up aquaculture ponds and the used water is often discharged untreated into the open. Given the fact that traditional methods of fish farming in India is able to produce 2–10 tonne/hectare and at the same time uses more than 20 litres of water per kg of fish, Recirculation Aquaculture System may need only 1/8th of a hectare and 1/6th of water and still would be able to produce up to 60 tonne fish per year. Being highly efficient, utilization of natural resources is very limited and results in conservation of precious natural resources like water, land and environment.

3. Status and Potential

Our country ranks good in freshwater fish production as even traditional methods of fish farming are able to produce anywhere between 2–10 tonne per hectare per year. But, a Recirculation Aquaculture System may produce up to 500 tonne fish per year in same area. Recirculation Aquaculture is a relatively new practice. Establishment of these units will therefore improve the knowledge base of fish farmers about emerging and future technologies in aquaculture.

Operation of these units is more demanding in terms of technology, techniques, biology of cultured fish and stringent water quality parameters. There is deficit of proper knowledge, expertise in technical management of Recirculation Aquaculture Systems (RAS) and entrepreneurial attitude for commercial scale units. The high investment costs may have kept RAS Technology away from our country until now. But there is an amazing potential for it in India and with growing interest RAS Units (big and small) are coming up in Uttar Pradesh, Bihar, Andhra Pradesh and elsewhere. In the next 5 years, these are going to be seen in many places in India for sure and RAS would be the next big thing to happen in Inland Fisheries Sector in the country.

4. Project Location and Implementation

A. **Site Selection:** Selection of a good site is extremely important, although Recirculation Systems are desirable where only limited water is available for removal of fish wastes out of the production system. Passing water through a treatment unit removes ammonia and other waste products achieving the same effect as a flow-through configuration. Land measuring approximately 100 m^2 is required for the construction of a Backyard RAS Unit.

B. **Beneficiaries:** Beneficiaries include women SHGs/ fisherman societies/ fish farmers/ entrepreneurs; selection would be based on their interest and awareness. Beneficiary selection is done through a ‘Call for Application’ via newspaper and NFDB Website.

C. **Project Implementation:**
- Project will be implemented by the beneficiary with technical support from the Designated Technology/Service Provider and Dept. of Fisheries of the State Govt.
- Financial assistance in the form of subsidy will be obtained from Govt. (Central/State) and the remaining amount will have to be borne by the beneficiary through self-finance, bank loan, etc.

5. Project Components

A. **Water Quality:** Water quality is important and optimum range of certain parameters required for successful fish culture in a Recirculation Aquaculture System is given below:

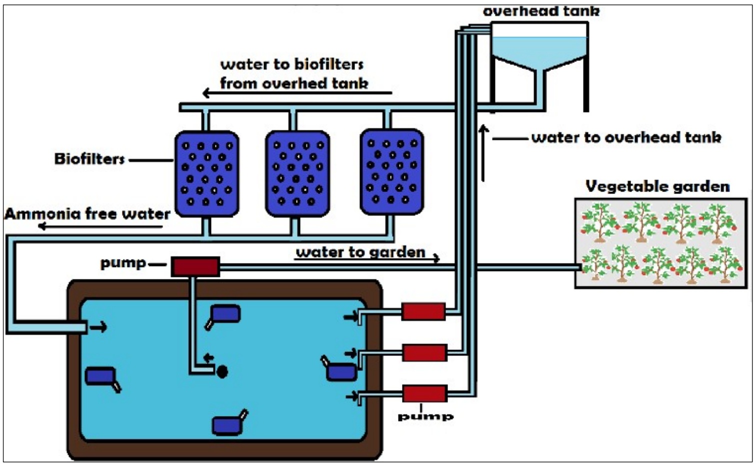
Sl. No.	Water Parameter	Optimum Range
1	Temperature	26 - 30 ^oC
2	Dissolved Oxygen	4 - 6 ppm
3	pH	7 - 8
4	Alkalinity	120 - 150 ppm
5	Ammonia	<0.05 ppm
6	Nitrite	<0.5 ppm
7	Nitrate	<5 ppm

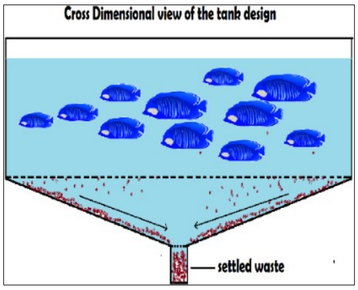
B. **Pond/Tank:** Area required for construction of the Backyard RAS pond/tank is 44.89 m^2. Fish Tank is constructed with RCC/ brick masonry and lined with HDPE sheet; the dimensions are 6.7 x 6.7 x 2 m, having a water volume of 90 m^3 (90,000 litre); bottom is conical with a slope of 18^o; effective water depth is 2.0 m and maximum depth is 3.3 m (at centre of the tank). Details of design of the Backyard RAS pond/tank is given below:

Sl.No.	Particulars	Unit
1	Total Land Area required	Maximum of 100 m^2
2	Tank Area	44.89 m^2
3	Tank Dimension	6.7 x 6.7 x 2 m
4	Tank Volume	90 m^3 (90,000 litre)
5	Effective Depth	2.0 m
6	Bottom Shape	Conical with a slope of 18° and a central slurry accumulating pit
7	Maximum Depth	3.3 m (Centre of the tank)
8	Pump	0.5 HP, Centrifugal Pump
9	Venturi Aeration System	0.5 HP, 4 Systems in a tank
10	Bio-filters	Trickling, Nitrifying Bioreactor

C. Floating Cages: Three cages of 30 m^3 each are floated in the 90 m^3 pond/tank, in series. Cages may be free floating or fixed.

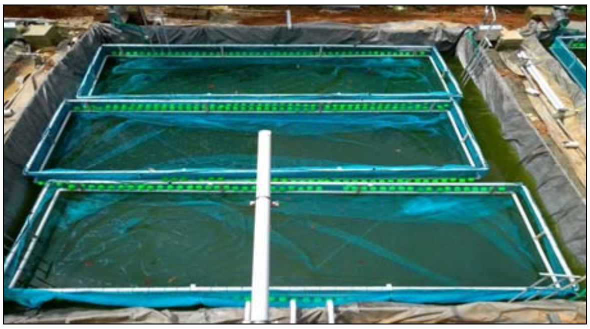
D. Model Backyard RAS Unit: The design of a '*High Density Fish Culture under RAS'* unit developed by CUSAT, Kerala, is given here as an example:





Plan view of 'Backyard RAS Unit' (left) and Cross-Section of Fish Tank Bottom (right)

RAS Fish Tank Setup



Floating Cages Setup in RAS Fish Tank

E. Targeted Fish Species: Monosex Tilapia *(Oreochromis niloticus*), Pearlspot (*Etroplus suratensis*) and Pangasius *(Pangasiandon hypophthalmus***)** are suitable for Backyard RAS.

		
GIFT Tilapia (*Oreochromis niloticus*)	Pearlspot (*Etroplus suratensis*)	Pangasius (*Pangasiandon hypophthalmus*)

F. Stocking and Yield: Although stocking densities should be determined by species requirements and operational considerations, the influence of stocking densities on growth and production has been determined empirically. The indicative stocking and harvest details are as follows:

Sl.No.	Component	Salient Feature
1	Floating Cages Unit	3 nos. (30 m^3 each)
2	Targeted Species	GIFT Tilapia (*Oreochromis niloticus*), Pearlspot (*Etroplus suratensis*) and Pangasius (*Pangasiandon hypophthalmus*)
3	Fingerling stocking rate	1500 nos./Cage; 4500 nos./ 3 Cages
4	Culture period	5-6 months
5	Survival	80% (3600 nos.)
6	Average body weight	450 g
7	Expected yield/unit/cycle	540 kg/cage x 3 cages =1620 kg/ 6 months
8	Total Production per year	1.62 tonne x 2 = 3.24 tonne per year

6. Probable Project Cost

Sl. No.	Components	Unit Cost (Rs. in lakh)
A	***Setup Cost***	
1	Fish Tank Construction	1.0
2	Procurement & installation of Cages, floats, pumps, filters, aerators, pipes, valves, etc.	4.6
	Sub-Total (A)	**5.6**
B	***Inputs Cost***	
1	Seed (4500 fingerlings @ Rs.6/each)	0.27
2	Feed (28-30% protein; floating pellets)	0.72
3	Transportation	0.06
4	Probiotics	0.15
5	Electricity	0.08
6	Others including Service Delivery	0.12
	Sub-Total (B)	**1.40**
	Total Cost (A+B)	**7.0**

7. Estimated Project Costs & Returns

Sl.No.	Particulars	Amount/ Quantity
1	Culture period for fish	5-6 months
2	Fish fingerlings stocked (@ 50/m^3)	4500 nos./unit
3	Expected Survival (%)	80%
4	Total Fish Survived (nos.)	3600 nos.
5	Average Size at harvest (g)	450 g
6	Production (kg/cycle/unit)	1620 kg
	Total Production/unit/year (2 cycles)	3240 kg
7	Sale Price (Rs/kg)	Rs. 150/-
8	Gross Income/year (Rs)	Rs.4,86,000/-

8. Comparison of GIFT Monoculture in Conventional Earthen Pond vs. Backyard RAS

Component	Conventional Earthen Pond	Backyard RAS
Stocking Density (Monosex)	20,000/ha (2-3/m^3)	50/m^3
Culture Duration	4-5 months	4-5 months
Feeding Rate (% Av. body wt.)	3.5 - 1%	8 - 2%
Feed Type (commercial, pellet)	25-32% CP	25-32% CP
Feed Cost	Rs. 28-30/kg	Rs. 28-30/kg
Harvest Size	500-600 g	500-600 g
Farm-gate Price	Rs. 75/kg	Rs. 75/kg (Rs.100-150/kg if sold live)
Total Production/ha area	8.0 - 9.5 t/ha	150 - 160 t/ha
Productivity for Semi-intensive System	10-20 t/ha/yr.	300-320 t/ha/yr.
Commonly Practiced in	TN, Kerala, AP	Kerala
Potential	In all tropical regions	In all tropical regions

9. Project Monitoring Unit (PMU)

A Project Monitoring Unit (PMU) comprising representative of the Designated Technology/ Service Provider, Dept. of Fisheries of the State Govt. and the NFDB would be constituted to monitor the implementation and progress of the Project.

10. Further Reading

Jacob Bregnballe, 2015. *A Guide to Recirculation Aquaculture: An introduction to the new environmentally friendly and highly productive closed fish farming systems*. Published by FAO and EUROFISH International Organisation, 2015, pages 1-100.

Ravindranath, K., 2017. Tilapias – the most amenable fishes Introduced and Farmed Worldwide. NFDB Newsletter *Matsya Bharat*, Vol. 8, Issue 5, January-March 2017, pages 26-38.

Aquaponics System

1. Introduction

Aquaponics is an integrated fish and plant production technology, essentially comprising of two sub-systems, viz., '*Aquaculture*' and '*Hydroponics*'. The underlying principle is to efficiently utilize water to produce two crops rather than one and to partition and share nutrient resources between fish and plants. This farming system is commonly used in resource limited and urban areas to raise both fish and vegetable in an integrated system. Aquaponics involves culture of horticulture plants along with fishes. Many plants are suitable for aquaponics systems, though which ones work for a specific system depends on the maturity and stocking density of the fish.

Green leaf vegetables with low to medium nutrient requirements are well adapted to aquaponics systems, including capsicum, tomatoes, lettuce, cabbage, lettuce, basil, spinach, chives, herbs, and watercress. It is basically a Recirculation Culture System, wherein fish are fed with quality floating pellet feed and waste generated from fish are pumped into bio-filter troughs having horticulture plants, the flow rate of water is to be adjusted with the help of the timer. The fishes and plants grown in aquaponics system are totally organic.

Even though the initial investment of the system is high, the recurring cost is less and gives reasonable returns. This system is having the advantage of using less water, lesser area of land, waste renewal, less labour, etc. Plants and animals in an Aquaponic System have a symbiotic relationship with each other. The fish excreta provide nutrients for the plants, while the plants clean the water, creating a suitable environment for the fish to grow.

2. Resources

Aquaponics is often hailed as the future of food production. Aquaponic Systems are said to utilize only 2 to 10% of the water required in traditional vegetable or crop production and have the potential to produce 10 times the output, without the use of harmful chemicals, pesticides, etc. The most significant aspect of Aquaponics is the minimum extent of land/ space required, leading to what is being dubbed as Urban Aquaponics/ Urban Agriculture/ Urban Farming/ Urban Gardening/ Terrace Gardening/ Vertical Gardening/ Office Farm (indoor), etc. Being highly efficient, utilization of natural resources is very limited and results in conservation of precious natural resources like water, land and environment.

3. Status and Potential

Our country is leading in freshwater fish production as farmers have achieved impressive yields even in traditional methods of fish farming by harvesting anywhere between 2–10 tonne per hectare per year. However, an Aquaponics System can produce up to five times the quantity of fish in same area per year, besides a good crop of vegetables. Aquaponics is relatively a new practice in our country. Establishment of these units will therefore improve the knowledge base of fish farmers about emerging and future technologies in aquaculture.

Operation of these units is more demanding in terms of technology, techniques, biology of cultured fish and stringent water quality parameters. In view of the shrinking resources of land and water, growing population, urbanization and change in life-style, there is a great demand for fresh, hygienically and organically produced fish and vegetables in the cities. Therefore, Aquaponics has a huge potential for integrated fish and plant production in urban, suburban as well as rural settings.

4. Project Location and Implementation

A. Site Selection: Selection of a good site is extremely important, although Aquaponic Systems are suitable where only limited water is available for removal of fish wastes out of the production system. Passing water through a treatment unit removes ammonia and other waste products achieving the same effect as a flow-through configuration. Land/ space measuring at least 150 m^2 for a Backyard-type Aquaponics unit and 2000 m^2 for a Small-scale Commercial Aquaponics unit is required for the construction.

B. Beneficiaries: Beneficiaries include women SHGs/ fisherman societies/ fish farmers/ entrepreneurs; selection would be based on their interest and awareness. Beneficiary selection is done through a notification and NFDB Website.

C. Project Implementation:

- Project will be implemented by the beneficiary with technical support from the Designated Technology/Service Provider and Dept. of Fisheries of the State Govt.
- Financial assistance in the form of subsidy will be obtained from Govt. (Central/State) and the remaining amount will have to be borne by the beneficiary through self-finance, bank loan, etc.

5. Project Components

A. Water Quality: Water quality is important and optimum range of certain parameters required for successful fish culture in an Aquaponics System are as follows:

Sl. No.	Water Parameter	Optimum Range
1	Temperature	26 - 30 ^{o}C
2	Dissolved Oxygen	4 - 6 ppm
3	pH	7 - 8
4	Alkalinity	120 - 150 ppm
5	Ammonia	<0.05 ppm
6	Nitrite	<0.5 ppm
7	Nitrate	<5 ppm

B. Targeted Fish Species: Monosex Tilapia (*Oreochromis niloticus*), Pangasius (*Pangasiandon hypophthalmus*) or any species that can tolerate high density stocking are suitable for Aquaponic System.

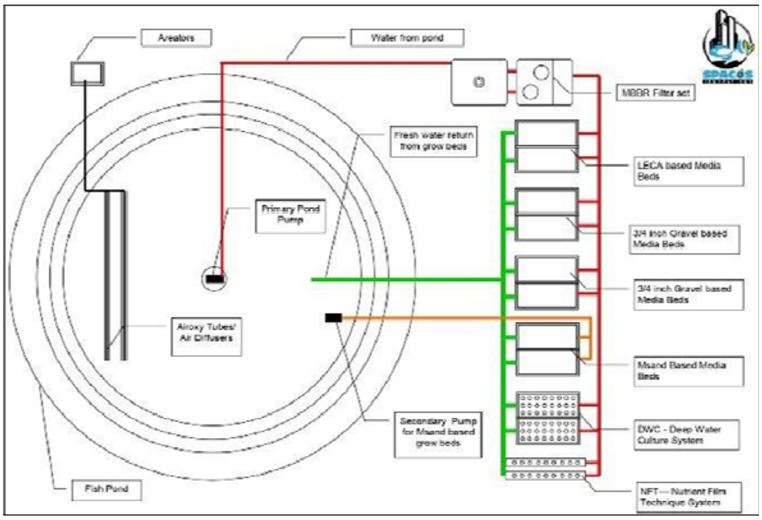
	
GIFT Tilapia (*Oreochromis niloticus*)	Pangasius (*Pangasiandon hypophthalmus*)

C. Model Unit: Particulars of the 'Small-scale Aquaponics Unit' designed by M/s Spacos Innovations, Chitradurga, Karnataka are given here as an example:

(i) Fish Pond/Tank: Area required for construction of the fish pond/tank is 80 m^2; diameter of the circular tank is 7.2 m, having a volume of 60 m^3 (60,000 litre), with effective water depth of 1.68 m and maximum depth of 2.13 m (centre of the pond/tank). The system is designed to handle more than 50 fish/m^3 (total 3000 fish). Details of design of pond/tank are as follows:

Sl.No.	Particulars	Unit
1	Total Land Area required	Maximum of 150 m^2
2	Tank Area	80 m^2
3	Circular Tank Diameter	7.2 m
4	Tank Volume	60 m^3 (60,000 litre)
5	Effective Depth	1.68 m
6	Maximum Depth	2.13 m (centre of the pond)

(ii) Plant Grow-Beds: Number of grow-beds in FRP Tanks 10, dimension of each grow-bed 6 x 2 x 1 ft (1.83 x 0.61 x 0.30 m); different kinds of solid media such as gravel or expanded clay pebbles (hydrotons) or lightweight expanded clay aggregate (LECA) are used to grow plants, through which water from fish tank passes. Design and layout of the fish tank and grow-beds is shown below:



Layout of Small-scale Aquaponics Unit

(iii) Moving Bed Biofilm Reactor & Filtration: One Moving Bed Biofilm Reactor (MBBR) and Filtration Unit is installed for water treatment in the Aquaponic System.

Fish Tank and Filtration System

Plant Grow-bed Tanks

(iv) Stocking and Yield: Although stocking densities should be determined by species requirements and operational considerations, the influence of stocking densities on growth and production has been determined empirically. The indicative stocking and harvest details of fish and plants are as follows:

Sl.No.	Component	Salient Feature
I	**Fish Culture**	
1	Fish Tank volume	60 m^3
2	Moving Bed Biofilm Reactor & Filtration Unit	One Set
3	Targeted Species	GIFT Tilapia (*Oreochromis niloticus*) and Pangasius (*Pangasiandon hypophthalmus*)
4	Fingerling stocking (50/m^3)	3000 nos.
5	Fish Culture period	5-6 months
6	Survival	90% (2700 nos.)
7	Average body weight	750 g
8	Expected Yield/unit/cycle	2700 fish x 750 gm = 2025 kg
9	Total Production/unit/year	2025 kg x 2 cycles = 4050 kg per year
sII	**Vegetable Cultivation**	
1	No. of Plant Grow-beds	10 nos.
2	Plant varieties	Tomato, Mint, Chilly, Lettuce, Basil
3	Planting density	15 – 20 saplings / bed
4	Total no. of Plant	150-200 plants
5	Plant cultivation period	Throughout the year
6	Harvest type	Partial harvest
7	Expected yield /bed/year	5-10 kg/ bed/ year

6. Commercial Aquaponics Unit

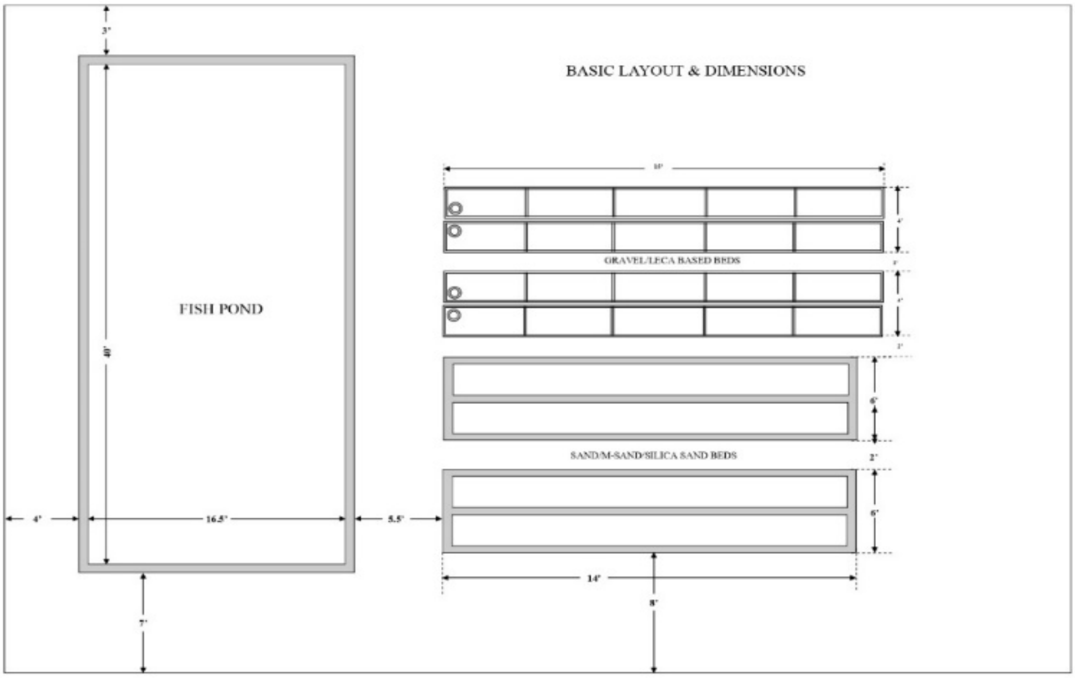
An extent of 0.5 acre (2000 sq m) land would be ideal for establishing a Small-scale Aquaponics Unit to be run on commercial lines. It would essentially comprise of one rectangular fish tank, 10 grow-beds for plants, besides Moving Bed Biofilm Reactor (MBBR) and Filtration Units, Pumps, Aerators, etc. The approximate capital cost would be about Rs. 3.7 lakh and operational costs Rs. 4.1 lakh (total Rs. 7.8 lakh).

The technical details, design and layout, probable project cost, and estimated project costs and returns are given below:

A. Technical Details (Indicative)

Particulars	Details
Fish Culture Tank	
Tank Size & Volume	12 x 5 x 2 m (120 m^3)
Effective Water Volume	100 m^3
Vegetable Growing Beds	
Individual bed size & volume	6 x 2 x 1 ft (12 ft^3) (340 L)
Depth of the bed	0.3 m
Volume of LECA/bed (2 nos.)	150 L/ bed
Quantity of gravel/bed (4 nos.)	150 kg/bed
Quantity of sand/bed (2 nos.)	150 kg/bed
Volume of water/bed (2 nos.)	500 L/bed
Water Filters, Pumps, Aerators, etc.	
Moving Bed Biofilm Reactor & Filter Set	Two Units
Pumps required (2 nos.)	15/18000 LPH
Water flow rate	30/36000 LPH
Aerator (3 nos.)	120 LPM
Auto Timer (1 no.)	20 min.
Fish Species	Tilapia/ Pangassius/ Koi Carps, etc.
Source of Fish	Registered Fish Hatchery/ Seed Farm
Stocking size	Fingerlings (minimum 5 g)
Stocking density	50-60/m^3 (5000-6000 nos.)
Fish Culture period	6 months
Composition of fish feed	28% protein
Type of fish feed	Pelleted feed
Expected weight gain per fish in 6 months	Avg. 500 g
Expected Survival	90% (4500 – 5400 nos.)
Expected Yield/yr	5400 kg/yr
Plant Varieties	Tomato, Mint, Chilly, Lettuce, Basil, Capsicum
Planting Density	15 – 20 saplings/ bed
Total no. of Plant	150-200 plants
Plant Cultivation period	12 months
Harvest type	Partial Harvest

B. Design and Layout (Representative)



C. Probable Unit Costs

Sl.No.	Particulars	Unit Price (Rs.)	Qty.	Total Cost (Rs.)
A	**Capital Cost**			
1	Fish Tank Construction (12 x 5 x 2 m)	1,00,000	1	1,00,000
2	MBBR & Filtration Units	50000	1	50,000
3	Grow-beds for vegetables	70000	1	70,000
4	Coarse sand & ¾” gravel for grow-beds	12000	1	12,000
5	Fish Tank Pump 15000 LPH	9000	1	9,000
6	Air-oxy tube (m)	200	10	2,000
7	Aerators (for Oxygen supply) 120 LPM	10000	3	30000
8	2 KVA solar inverter for power backup	40000	1	40,000
9	Biosecurity fencing for fish tank	20000	1	20,000
10	Plumbing items	30000	1	30,000
	Sub-Total A			**3,63,000**

Sl.No.	Particulars	Unit Price (Rs.)	Qty.	Total Cost (Rs.)
B	**Operational Cost**			
1	Tilapia seed (annually 2 cycles)	5	12000	60,000
2	Feed cost (annually 2 cycles)	35	8500	2,97,500
3	Horticulture sapling	3	1000	3,000
4	Electricity cost (units consumed x cost per unit) per annum (2 cycles)	10	5400	54,000
	Sub-Total B			**4,14,500**
C	**Total (A+B)**			**7,77,500**

D. Estimated Project Costs & Returns

Sl. No.	Particulars	Amount/Quantity
1	Culture period for fish (months)	6 months each crop, total 2 crops
2	Fish fingerlings stocked (nos.)	6,000 nos.
3	Expected Survival	90%
4	Total Fish survived (nos.)	5400 nos.
5	Average harvest size (g)	750 g
6	Expected Production (kg/crop)	5400 nos. x 750 = 4050 kg
7	Total Production per year (2 crops)	4050 kg x 2 = 8100 kg
8	Sale price of fresh/ live fish (Rs/kg)	Rs. 150
9	**Gross Income Per Year** (Rs)	
	From Fish (8100 kg x Rs.150)	12,15,000
	From Vegetables (Rs.)	73,300
	Total Income **(D)** (Rs.)	12,88,300
10	**Net Profit/Year (D-C)** (Rs.)	5,10,800

7. Project Monitoring Unit (PMU)

A Project Monitoring Unit (PMU) comprising representative of the Designated Technology/ Service Provider, Dept. of Fisheries of the State Govt. and the NFDB would be constituted to monitor the implementation and progress of the Project.

8. Further Reading

Christopher Somerville, Moti Cohen, Edoardo Pantanella, Austin Stankus and Alessandro Lovatelli, 2014. "*Small-scale aquaponic food production – Integrated fish and plant farming*". FAO Fisheries and Aquaculture Technical Paper 589, 2014, pp 288.

Ravindranath, K., 2017. Aquaponics – an Integrated Fish and Plant Production System for Urban, Suburban and Rural Settings. NFDB Newsletter *Matsya Bharat*, Vol. 8, Issue 5, January-March 2017, pages 5-15.

Integrated Paddy-Cum-Fish Culture

1. Introduction

Integrated Paddy-cum-Fish Culture is a system of producing fish in combination with paddy cultivation using the same resources in the same unit area. Production of fish in paddy fields is almost as primitive as the practice of paddy culture itself. Paddy farming with fish culture is a type of dual farming system in which paddy is the main enterprise and fishes are grown to obtain additional income. Paddy-cum-fish culture is practiced in many paddy-growing belts of the world including China, Bangladesh, Malaysia, Korea, Indonesia, Philippines, Thailand and India. In India it has been a traditional practice largely in the North-Eastern Region.

2. Resources

Paddy and fish are the staple food of India and the country is very rich in natural water resources in the form of rivers, reservoirs, lakes, flood plains, ditches and large areas of paddy fields. Paddy-fish farming involves the simultaneous culture of paddy and fish in irrigated paddy fields so as to obtain an added production of fish with paddy.

3. Status and Potential

The North-Eastern Region of India has vast paddy fields both in valley and hill areas. The region is known for highest amount of rainfall (2000-4000 mm annual average) in the country and hence, the fields remain under water almost throughout the year. Moreover, there are innumerable streams and rivers that irrigate the fields. Hence, these fields offer a good scope for producing fish along with paddy with little or no additional cost or effort. Further, due to hilly terrain as well as pressure to produce rice for consumption, scope for constructing large fishponds in these regions is limited.

Paddy-cum-Fish Culture is easy, cost-effective, sustainable and environmental friendly. More over it can increase paddy yield as a result of nutrients and pest control by fish. Besides it can enhance farmers' income and provide nutritional security.

4. Project Location and Implementation

A. Site Selection: Fields having an almost uniform contour and high water retention capacity are preferred. Low-lying areas (where water flows easily and is available at any time when needed) are suitable. Groundwater table and drainage system are important factors to be taken into consideration in site selection.

B. Beneficiaries: Beneficiaries include paddy farmers/ fishers. Selection would be based on their interest and awareness. Registered paddy farmers in a village will be grouped into clusters.

C. Project Implementation:

- Management of Paddy-cum-fish culture will be under the technical guidance of the State Dept. of Fisheries.

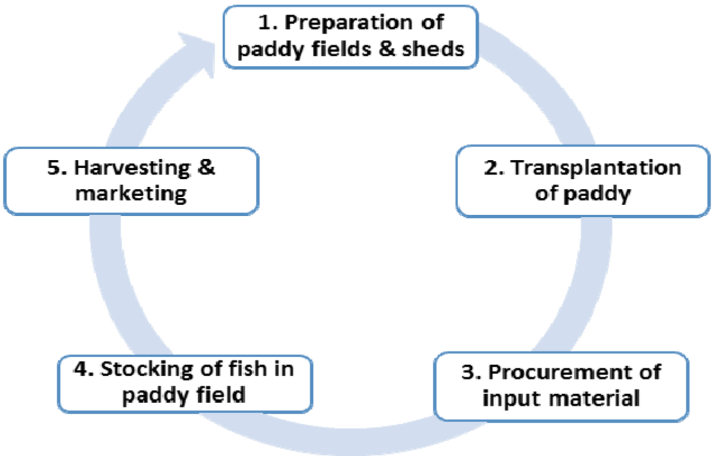
- The Major Components of the project will be established by the Implementing Agency as a common facility and used by the farmers on a shared basis.
- NFDB would provide financial assistance to the States for the development of paddy-cum-fish culture as a livelihood project.

5. Project Components

A. Soil and Water Quality: Soil of the paddy field should be fertile, rich in organic matter and have high water holding capacity. Usually medium textured soils like silty-clay or silty-clay-loam are most suitable for paddy-cum-fish farming/ prawn culture. The soil and water characteristics and their optimum ranges are given below:

Sl.No.	Parameter	Optimum Range
I	**Soil Characteristics**	
1	pH	5.2-5.9
2	Moisture	15-17.3%
3	Nitrogen	0.71-.025 ppm
4	Organic Carbon	1.98-2.71%
5	Organic Matter	3.22-4.85%
II	**Water Parameters**	
1	pH	6.2 - 7.6
2	Temperature	14 - 30
3	Turbidity	55.5 - 96 NTU
4	Light Intensity	760 - 1344 Lux
5	Dissolved Oxygen	4.5 – 9.5 mg/l
6	Total Alkalinity	29 – 34 mg/l
7	Hardness	48 – 62 mg/l

B. Paddy Field Preparation: The plots selected for Paddy-cum-Fish Culture are normally prepared in the month of January-February by raising their embankment all around the plots. Strong bunds in the paddy fields prevent leakage of water, maintain desired depth and prevent escape of cultivated fingerlings/fish during floods. Width of bund should be 1.5 m at the bottom and 1.0 m at the top. The bamboo screen matting should be done along the base of bund for support. The paddy field can be provided with inlet and outlet. After the paddy field is ready paddy seedling are transplanted from the nursery bed. Stocking of fish seed will be done 10-15 days after paddy transplantation.



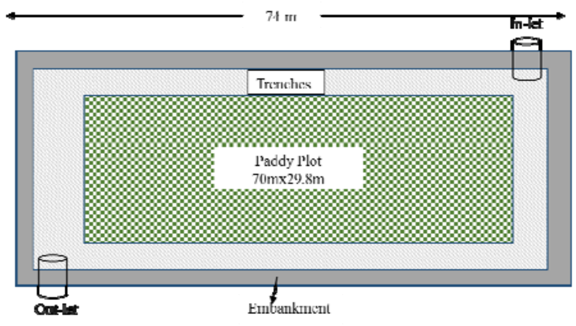
C. Fish Culture Facility:

Sl.No.	Particulars	Grow-Out Zone
1	Type of Pond	Perennial Trench / Refuge Pond
2	Area	0.25 ha
3	Size	74.0 m x 33.8 m
4	Depth	1.0 m
5	Bund Top Width	1.0 m
6	Bund Bottom Width	1.5 m
7	Inner Slope	1:1.2
8	Outer Slope	1:1
9	Inlet & Outlet	1 inlet (10 cm diameter) and 1 outlet (15 cm diameter)

D. Types of Paddy-cum-Fish Culture:

(i) Simultaneous or Concurrent Method where fish and paddy grow together in the same field at the same time. In this method fish are raised in a Trench/ Refuge Pond which may be in the periphery of paddy field or in the centre of paddy field.

(ii) Alternate or Rotation Method where fish are cultured in the paddy field during paddy off-season.



Plan-View of the Plot

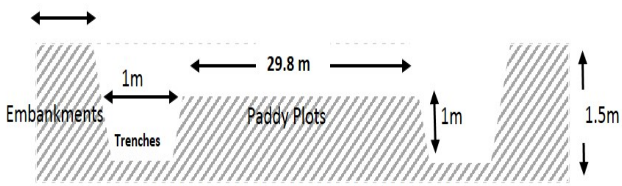


Fig.1 Cross-Section of paddy plot with trenches

Simultaneous Method with Fish in a Trench (above left) or Central Pool (above right) and Rotational Method with Paddy Crop (below left) followed by Fish Culture (below right)

E. Comparison Between Paddy Fields With Fish and Without Fish:

Parameters	Paddy Cultivation Only (without fish)	Paddy Cultivation Integrated with Fish
Size of Paddy Field/Plot	0.1 ha to 1.0 ha	0.2 ha to 1.0 ha
Water Depth	0.2-0.6 m	0.4 m-1.2 m (up to 1.25 m in Refuge Pond)
Bund Width	0.6-1.0 m	1.0-1.5 m
Varieties	Paddy: Heera, Sattari, Kayalni-11, Neela, Tara, TTB 4-7, etc.	Paddy: Local dwarf varieties CRM 10-3630, BG 34-8 Fish: Rohu/ Common Carp/ Tilapia/ Murrel
Density	Paddy: 40-60 kg/ha (spacing 20-24 cm)	Paddy: 40-60 kg/ha (spacing 20-24 cm); Fish Fingerlings: 2,000-6,000/ha (>10 cm)
Culture Period	3-6 months (depends on variety)	3-6 months (depends on variety)
Production	Paddy: 1.7 t/ ha (average)	Paddy: 1.8-2.0 t/ ha (increase by 7.9-8.6%) Fish: 700-2000 kg/ha/cycle
Setup Cost (Rs)	Rs. 9,135/ha	Rs.70,000 /ha (additional cost incurred includes digging trench/refuge pond, strengthening & widening dykes, channels, drains, inlet, outlet)
Operational Cost (Rs)	Rs.42,000/ha (Paddy seed, manure, etc.)	Rs.80,000/ha (Paddy & Fish seed, manure, supplementary fish feed with locally available ingredients, labour, etc.)
Total Cost (Rs)	Rs.51,135/ha	Rs. 1,50,000/ha
Income	Rs.1.70 lakh	Rs. 3.20 - 5.80 lakh/ha (Rs.1.8 lakh from paddy and Rs.1.40 – 4.0 lakh from fish)
Profit	Rs. 1.19 lakh/yr	Rs.1.70 – 4.30 lakh/yr
Advantages	---	Paddy yield increased by 7-14%; 3 times more profitable; 47-51% reduction in stem borer pest
Potential States	Pan India	All North Eastern States

F. Selection of Paddy Varities: The Local dwarf varieties of paddy viz., CRM 10-3630, BG34-8 that can grow under the ago-climatic conditions of the region may be selected. The paddy seedlings are transplanted in the month of April-May.

G. Targeted Fish Species: Common Carp (*Cyprinus carpio*), Murrel (*Channa striata*), Rohu (*Labeo rohita*), Mrigal Carp (*Cirrhinus cirrhosus*), etc., are highly suitable for paddy-cum- fish farming.

	
Common carp (*Cyprinus carpio*)	Murrel (*Channa striata*)
	
Rohu (*Labeo rohita*)	Mrigal Carp (*Cirrhinus cirrhosus*)

H. Fish Stocking and Yield: After a week of transplanting paddy, fish fry of 20-40 mm size or preferably fingerlings (> 100 mm) will be stocked at the rate of 2500-3500 nos. per ha.

Fish Seed Stocked – 3500 nos./ha
Survival (70%) – 2450 nos.
Culture period – 7- 8 months
Avg. Fish Size at harvest – 450 g
Estimated Total Production – 1102.50 kg
Sale Price per kg – Rs. 200/ kg
Gross Income – Rs.2,20,500/-

6. Integrated Project Components and Unit Costs

Sl.No.	Components*	Unit Cost (Rs)
1	Broodstock Pond	As per actual, limited to eligibility
2	FRP Hatchery for Breeding	
3	Nursery & Rearing Ponds	
4	Grow-out in Paddy Field (Trench)	
5	Transport Vehicle (3- or 4-Wheeler)	
6	Capacity-building/ Training (3-day, 50 per batch)	1.25 lakh

*Major Components of the project will be used as a common facility by the farmers in a cluster on a shared basis.

7. Estimated Project Costs & Returns from Fish

Sl.No.	Particulars	Amount/ Quantity
1	Culture Period for Fish	8 - 10 months
2	Fish Fingerlings Stocked (>10 g; nos./ha)	3500 nos./ha
3	Expected Survival (%)	70%
4	Total Fish Survived (nos.)	2450 nos.
5	Average Size at harvest (g)	450 g
6	Total Production (kg/ha)	1102.5 kg
7	Sale Price (Rs/kg)	Rs. 200/-
8	Gross Income (Rs)	Rs.2,20,500/-
9	Total Expenditure	Rs. 1,50,000
10	Net Profit (Rs./ha/annum)	Rs.70,500/-

8. Expected Socio-Economic Outcomes

As the project sites are selected in regions where agriculture is the main occupation of the residents and their livelihood depends on paddy cultivation and its yield, promoting fish culture by integrating it with paddy cultivation will greatly enhance the yield and production of both fish and paddy within the same time and space. It will not only increase the farm yield, but will contribute greatly towards nutritional security and economic upliftment. The project will also act as a demonstration and encourage other farmers in the village and the neighbouring villages to take up similar activities.

9. Further Reading

Paddy cum Fish Culture. *NAIP Agropedia Raichur*, 2012, ICAR, NAIP.
http://agropedia.iitk.ac.in/content/paddy-cum-fish-culture

Sumpam Tangjang and P.K. Ramachandran Nair, 2015. Rice + Fish Farming in Homesteads: Sustainable Natural-Resource Management for Subsistence in Arunachal Pradesh, India. *Journal of Environmental Science and Engineering*, A 4 (2015), pages 545-557.

Prospects on Paddy cum Fish Culture (Nagaland).
https://www.farmer.gov.in/imagedefault/handbooks/BooKLet/NAGALAND/20170517165355_paddy.pdf

Aqua One Center

(An ICT Enabled Aquaculture Support Service)

1. Introduction

Fisheries and aquaculture is witnessing a changed scenario from its traditional role as a supplementary subsistence activity in most of the States to viable and sustainable economic activity. The sector is now gaining importance as an attractive investment destination and a lucrative business activity. With the changing consumption pattern, emerging market forces and recent technological developments, the sector has assumed increased importance with farmers and other stakeholders in the country.

NFDB is facilitating development of the fisheries sector in line with the technological advancement and adoption by way of promoting new technologies and practices to suit local resources and conditions on a continued basis. Strengthening support systems, institutional arrangements and networking at different levels as supportive and complementary systems are some of the initiatives taken to build a new landscape for significant growth in the sector.

The Aqua One Center (AOC), an Information & Communication Technology (ICT) Enabled Aquaculture Support Service, will disseminate proven technologies and innovations and facilitate their wider adoption by registered fish farmers thereby facilitating the sector's overall growth.

2. Objectives

- Establishing an aquaculture technology deliverysystem.
- Setting up Aquaculture units chosen bybeneficiaries.
- Training beneficiaries in the know-how and better management practices.
- Up-scaling innovative and proven technologies through dissemination.

3. ICT Enabled Aquaculture Support Service

- Provide technologies for Pond Culture, Cage Culture in Reservoirs, Culture-based-Capture Fisheries in Wetlands, Recirculation Aquaculture System (RAS), Integrated Farming,etc.
- Better Management Practices (BMPs) including inputs management.
- Data collection and management.
- Setup Water Qualityand Disease Diagnostic Laboratory.
- Provide advisory services with respect to life-cycle of species cultured, water quality, growth, health management, disease diagnosis, surveillance, etc.
- Establish an *e*-traceability system

4. Project Location and Implementation

A. Site Selection: An AOC needs to be establishedpreferably in the fish seed production and farming hub having approachability, road connectivity, conveyance, etc.,and be accessible to fish farmers for interaction and to make periodic field visits by AOC staff.The AOCs will be required to operate within the framework of Terms of Reference developed by NFDB.

B. Beneficiaries: Agencies/Firms/Individual Entrepreneurs having experience in providing aquaculture support services such as: Pond Monitoring, Input Management, Information and Data Management, Advisory Services,and in Setting up and Managing Fish Health Laboratory,etc.would have to get ***qualified throughthe Expression of Interest (EoI) process*** of NFDB.

C. Project Implementation:

- The AOCs will be managed under the technical guidance of the National Fisheries Development Board.
- NFDB would provide financial assistance to establish AOCs.

5. Services of AOC

The selected Beneficiary (Service Provider) will be instrumental in the establishment of AOCs at appropriate location in the fish seed production and fish farming hub. The Service Provider would set up laboratory facilities in the AOC Units located strategically for extending water quality and fish health services under each AOC unit, and ensure minimum lab services of primary water quality parameters (Temperature, pH, Dissolved Oxygen, Ammonia) and general fish health diagnostics to farmers at affordable costs, and as per schedule. Broadly the AOC Service Provider has four major tasks which involve direct involvement:

A Model Aqua One Center

A. Enrolment and Registration of Hatchery Units, Seed Growers and Fish Farmers: The selected Service Provider will be required to identify eligible/willing hatcheries, fish seed growers and fish farmers from within the area of AOC operation/ jurisdiction. Also,enroll farmers identified and listed by NFDB during the specific workshops organized in different States. **Membership drive by the AOC** also involves:

- Mobilization of farmers.
- Creating awareness and sensitizing them to join the network programme.
- Enrolling volunteered hatchery managers, fish seed grower and fish farmers by registering them with an application and a registration fee, as prescribed from time to time by NFDB, for availing all the services of Aqua One Center.
- Creating exclusive/unique ID to each of the enrolled service seekersand tagging them to ICT enabled services that is capable of identifying the source (Farmer) of the Produce and links it with all the Farmer Centric Data like farming practices, certifications and other information like GPS co-ordinates, etc.

The AOC Service Provider will be responsible to provide interface between NFDB and selected hatcheries/ seed growers/ fish farmers in sourcing, procurement, transport and stocking of brood fish/ seed material for further rearing/ stocking grow-out ponds.

B. Hatchery-level Support for Seed Production of Improved Rohu: NFDB will provide brood stock of Jayanti Rohu from its National Freshwater Fish Brood Bank (NFFBB) in Odisha to the selected hatcheries for purpose of spawn production.The registered hatchery will also be supplied fry/ fingerlings of Jayanti Rohu strain initially, on certain terms and conditions,and facilitated to pursue rearing of seed and fish productiondepending on availability of facilities. The AOC will facilitate, channelizeand ensure easy flow of seed material within the network of registered farmers, link the supply of spawn to registered seed growers and fingerlings to fish culturists for stocking in grow-out ponds.

Further, the AOC Service Provider will install/ establish a system for growth/ life-cycle stage monitoring support.Tracking of the activities/ operations in respect of each of the seed production, rearing and fish culture activities of the improved fish strain will be carried out by the Service Provider, which would include:

- Regular monitoring activities related to implementation such as type and volume of seed stocked, inputs used, quality standards being followed, process adapted, results as final output generated in each case.
- Monitoring of primary water quality parameters and providing advisory services to the pond user.
- Monitoring of general fish health, recording incidences of diseases and measures to combat such incidences based on sampling.
- Facilitate services of special lab analysis for water, inputs quality, and also health diagnostics on cost basis whenever required on a case to case basis.

	
AOC Labs Technician analyzing water sample	*AOC Service Provider sampling fish*

C. Installation of ICT Enabled Advisory Service System: The AOC Service Provider will install ICT enabled advisory service system to provide:

(i) Periodic Best Practices advisory and technical guidance on BMPs in respect of seed production/ rearing, advisory on Feeding Chart, Fish Health Advisory whenever needed including management of diseases/ preventive measures to be taken and emergency advisory on demand basis.

(ii) Suggestions for enhancing production and profitability.

(iii)Technical guidance/ information support on types of inputs required, *viz.*:

- Basic seed, feed, medicines and supportive equipment/ accessories/ gadgets for different activities of hatchery operations, seed rearing and fish farming.

- Quantification of inputs required with time-frame in case of different rearing/ production processes.
- Sources of input suppliers to establish contacts/ liaison with the suppliers, negotiate supply conditions such as prices and delivery schedule.
- Harvesting and post-harvest value addition, marketing and disposal of fish.

Demonstration of IoT (ICT) driven Mobile App to Aqua Farmer [networkedindia.com]

- Provide information support to facilitate registered farmers in getting benefits such as subsidy/ financial assistance/input support and such others under the on-going Govt. programmes depending on their eligibility.

D. Documentation: The AOC Service Provider would collect all the relevant data within the area of operation and more particularly, data on the following will be mandatory:

- Collection of data on various aspects of fish seed production, seed rearing and fish culture of improved variety under the jurisdiction including data on facilities *viz.*, number and size of ponds/water bodies, seasonality, present status of use, types of seed being produced, reared; farm facilities/ infrastructure available, manpower, present operation levels, farming practices, production output, etc. as per format developed on the basis of set indicators.
- Develop profiles of individual fish farmer data and create a Centralised Data Base including Geo-referenced Data.
- Documentation of data related to hatchery/ pond monitoring (water quality), production/ farming practices employed, and input management (seed quality, stocking, pre- and post-stocking inputs used, feeding data), growth data based on sampling, fish health related data during production cycle, final production/ output, etc.
- The service provider has to collect information and develop profile data related to farmers, farms, ponds activities, etc., based on structured formats in support of uploading data for e-traceability system of network/ chain, assessing the impacts and tracking the changes from time to time due to of interventions.

6. AOC Project Components and Unit Cost

Sl.No	Item	Unit Cost (Rs. in lakh)
1	Laboratory Equipment for Soil & Water Testing and Fish Health Management	3.50
2	Accessories, Furniture, Interior Design, etc.	1.50
3	ICT Tools and its Management	2.50

4	Two-Wheeler and Filed Kit	1.50
5	Manpower (Field Coordinator/ Sales Coordinator/ Lab Clinician/ Expert Service)	6.00
6	Recurring Expenses (Refilling Reagents, AMC for Equipment & ICT, Travel Costs, etc.)	5.00
	TOTAL	**20.00**

7. Details of AOC Service Charges Per Hectare for Fish Seed Rearing & Growout Farms

Service	**Rate (Rs.)**	**Minimum Visits Per Farm (No.)**		**Eligible Amount per Ha. (Rs.)**	
		Seed Grower	**Growout Farmer**	**Seed Grower**	**Growout Farmer**
Registration	50	1	1	50	50
Growth Monitoring through Biomass Sampling & Advisory	100	6	12	600	1,200
Health Monitoring & Advisory	50	6	12	300	600
Water & Soil Quality (10 parameters) & Advisory	150	6	12	900	1,800
Total	--	**19**	**37**	**1,850**	**3,650**

8. Benefits and Outcome

- Enrolment of network hatcheries, seed growers and farmers.
- Supply of inputs like seed, feed & other inputs to farmers.
- Pond management and monitoring that includes water quality analysis, growth and health monitoring.
- Sampling for a passive system of disease surveillance to screen notifiable diseases.
- ICT enabled advisory services related to inputs, better management practices and technologies, pond and fish health management, training and other related activities through ICT service.
- Facilitate identification and mitigation of issues/ hurdles/ problems faced midway by hatcheries, seed growers and fish farmers at ground level, and address new challenges that could be throw up while promoting adoption of improved fish varieties, technologies, processes, approaches.
- Documentation of technology adopted and data management.
- Farmers would be able to adopt new technologies and upscale.
- There would be an overall increase in fish production and productivity.

9. Further Reading

Aqua Clinics & Aquapreneurship Development Programme (AC&ADP) - Sponsored by NFDB. *Training Manual*, Published by MANAGE Incubation Centre, National Institute of Agricultural Extension Management (MANAGE), Rajendranagar, Hyderabad, Revised Edition 2019, pages 1-108.

National Fisheries Development Board

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