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.

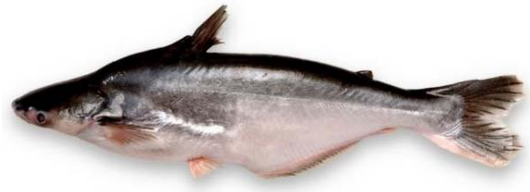
Project Components

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*)

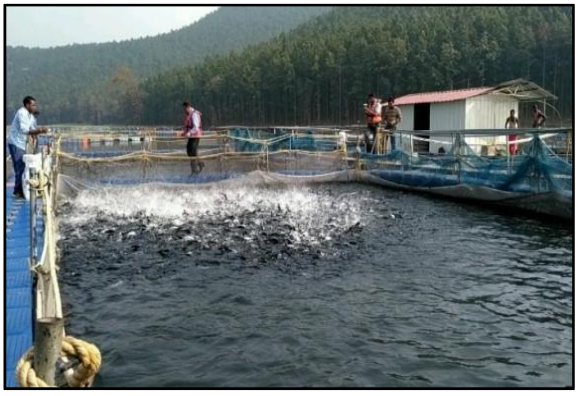
GIFT Tilapia (*Oreochromis niloticus*)

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="4">2</td><td rowspan="4">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></td><td>Predator or Outer Net</td><td>25-30</td><td>35-40</td></tr>
</table>

<table>
<tr><th>Sl. No</th><th>Component</th><th colspan="3">Salient Feature</th></tr>
<tr><td></td><td></td><td>Bird Protection Net</td><td>18-20</td><td>60-80</td></tr>
<tr><td></td><td></td><td colspan="3">* Mesh Bar (knot to knot) is half the length of Mesh Size (stretched mesh)</td></tr>
<tr><td rowspan="8">3</td><td rowspan="8">Carrying Capacity & Limit of Cages in Reservoir</td><td>Reservoir Area (ha)</td><td colspan="2">Maximum No. of Cages Allowed[#]</td></tr>
<tr><td>< 1000</td><td colspan="2">Not allowed</td></tr>
<tr><td>1001 to 2000</td><td colspan="2">500</td></tr>
<tr><td>2001 to 3000</td><td colspan="2">1000</td></tr>
<tr><td>3001 to 4000</td><td colspan="2">1500</td></tr>
<tr><td>4001 to 5000</td><td colspan="2">1900</td></tr>
<tr><td>5001 to 10000</td><td colspan="2">3000</td></tr>
<tr><td>>10000</td><td colspan="2">5000</td></tr>
<tr><td colspan="4">[#]Stand-alone Cages or in Batteries (of 4, 6, 12 or 24 Units), as required</td></tr>
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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]