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Cage Culture in Indian Reservoirs

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The yield of Indian reservoirs might be greatly increased through cage fish farming. According to the current study, over 14,000 cages have been put in various reservoirs across the nation, producing roughly 16% of the fish currently produced in reservoirs. In the nation, cage fish farming generates about 7.5 lakh man days of labor. According to an empirical research conducted in the state of Jharkhand, cage culture adoption helped fishers' livelihoods by about 30%. Cage culture decreased occupational migration while also raising monthly family income. Due to an increase in household income, the fishing families who adopted cage farming also gained some durable assets. However, according to the fishermen, some of the main obstacles to adopting the technology were the high initial cost of cage culture operations, the high cost of feed, and the low market price of cultured pangus fish (*Pangasianodon hypophthalmus*). According to the report, state agencies should encourage the use of inexpensive galvanized iron (GI) cages created by the ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI) in reservoirs since they may be crucial to realizing the nation's blue revolution vision.

Keywords

Cage fish farming, Livelihood, *Pangasianodon hypophthalmus,* Reservoir

INTRODUCTION

The term 'enclosure' often being used to describe as cage. Cage aquaculture involves growing fishes in existing water resources while being enclosed in a net cage which allows free flow of water. Cage culture first originated almost 200 years ago in Cambodia where *Clarias sp.* are cultured. Cage culture probably originated in Asia and perhaps was associated with the "boat people" of the Mekong Basin who kept wild-caught fish in cages in their boats for fattening. According to Harada (1970) first started experimenting cage culture in 1954 and commercial culture of yellowtail *Seriola quinqueradiata* followed three years later. In India, cage culture was started with raising major carps in running water in the rivers: Yamuna and Ganga at Allahabad and raising Common carp, catla, silver carp and tilapia in still water body of Karnataka (Yadav *et al*.,2022). According to FAO, cage culture is now practiced in over 62 countries and currently 80 species of finfish are being cultured in cages.

RESERVOIRS

- Man-made impoundments created by obstructing surface flow of a river, stream or water course.
- Indian Reservoirs with water spread area of - 3.51 million ha
- India has 19,386 reservoirs spread over 15 states
- Government of India, has classified
    a) Small (<1000 ha),
    b) Medium (1000 to 5000 ha) and
    c) Large (>5000 ha)
- Small reservoirs are 14.86 lakh ha, Medium reservoirs are 0.53 lakh ha and large reservoirs are 1.14 lakh ha.
- Estimated yield potential of 100, 200 and 500 kg ha y^{-1} for large, medium and small reservoirs respectively.
- It has been estimated that fish production in the range of 15-70 kg m^3 y^{-1}(Sarkar *et al*.,2018).
- Karnataka has the most reservoirs with 12.
- Madhya Pradesh has the maximum area under reservoirs.
- Karnataka and Andhra Pradesh have the maximum number and area of large reservoirs
- While the maximum number and area of small reservoirs are in the state of Tamil Nadu (Sugunan.2000).

Fig.1: Distribution of Reservoirs in India (Sugunan.2000).

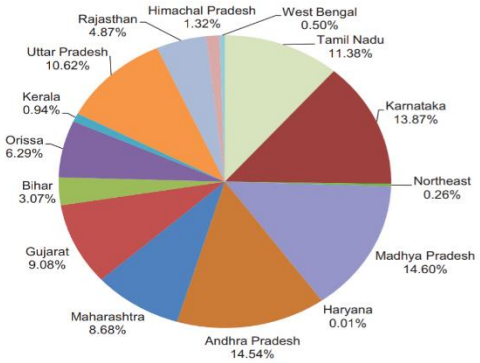


Fig.2: Area under reservoirs (in percentage) in different states of India (Sugunan.1995)

Site selection for cage culture:

There are three major factors which account for site selection.

Characteristics of the site

Water Quality

Temperature, dissolved oxygen, pH etc. (parameters depends on species**).**

Water Depth

Minimum- 1-3 m (below the cage) which should be clear and free from mud**.**

Water Current

Inshore area-minimum requirement is 10-20 cm/sec**.**

Environmental Limitations

- Calm and still water should be avoiding as well as site should have minimum wind and should not be strong.
- Should be safe from frequent disturbance from local people and grazing animals.
- Site should be devoid of algal blooms to avoid fouling.

Service and operational considerations

- Should be access to land and water transportation.
- Electric supply, roads, availability of labour, market are most important factors.

Physico-chemical parameters of Indian reservoirs (Mudgal.2013)

Parameter	Range
Temperature (^{0}C)	12-31
pH	6.5-9.2
Alkalinity (mg L^{-1})	40-240
Nitrate (mg L^{-1})	0.93
Phosphate (mg L^{-1})	0.36
Specific conductivity (µmhos/cm)	76-474

Design of cage:

- Cage design varies with the area of the operation and species of farming.
- Shape of the cage influences the stocking density and production.
- Cages are cylindrical, circular, polygonal, square and rectangular in shape.
- Increased the cage size decreases the ratio of surface area and volume which in turn results in poor water exchange.
- Cage size vary from 1-1000 m^3 and its depends on the size and type of the area where the cages are to be installed and method of harvest.
- Size increases with cost per unit volume decreases and production per unit volume also decreases.
- The most common cage sizes utilized in reservoirs are:
  a) Cylindrical— 4x4 (diameter x depth) feet;
  b) Square— 4x4x4 feet and 8x8x8 feet (length x width x depth); and
  c) Rectangular—8x4x4 and 12x6x4 feet.
- Dyneema (Ultra high molecular weight polyethylene fiber) mooring is introduced for cage mooring in reservoirs.
- It is 15-fold stronger than steel, 4 to 5-fold stronger than polyamide, whereas lighter than water and extremely durable.

Procurement of materials

Criteria of materials for cage construction

They should be strong, light, rot-free, non-corrosive, weather resistant, fouling resistant, amenable for easy workability, easy repairable, non-abrasive to fish and inexpensive.

1. Frame
2. Netting Materials
3. Lids
4. Floats

5. Nuts and bolts
6. Sinkers
7. Anchors

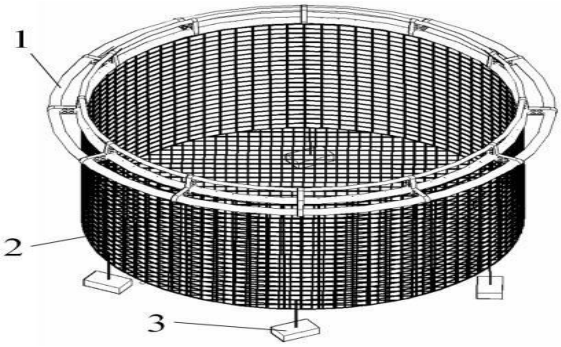
Types of cages

Fixed

- Most basic & widely used in depth of 1–3 m.
- Normally placed in the flow of streams, canals, rivers, rivulets, shallow lakes and reservoirs, not touching the bottom.
- Comparatively inexpensive and simple, but their use is restricted

Floating

- It supported by a floating frame such that the net bags hang in water without touching the bottom.
- Generally used in water bodies with a depth of more than 5 metres.
- Enormous diversity in size, shape & design (Das *et al*., 2009).



(According to A nets fixing device embedded in a circular floating net cage. (Liu *et al.*, 2021).

Submersible

The net bags of submersible cages are suspended from the surface, have adjustable buoyancy, and may be rigid or flexible.

- Cages can be towed away to a different location for harvesting or if unfavorable weather occur.
- It is useful in areas subject to typhoons or cyclones.
- They can withstand wind and waves much better than floating cage.
- A more sophisticated version is use of variable buoyancy synthetic rubber floats that can be filled or emptied with compressed air or reservoirs from the surface.

Submerged

Submerged net bags are fitted in a solid and rugged frame and submerged under the water. Their use is very limited (Das *et al*., 2009).

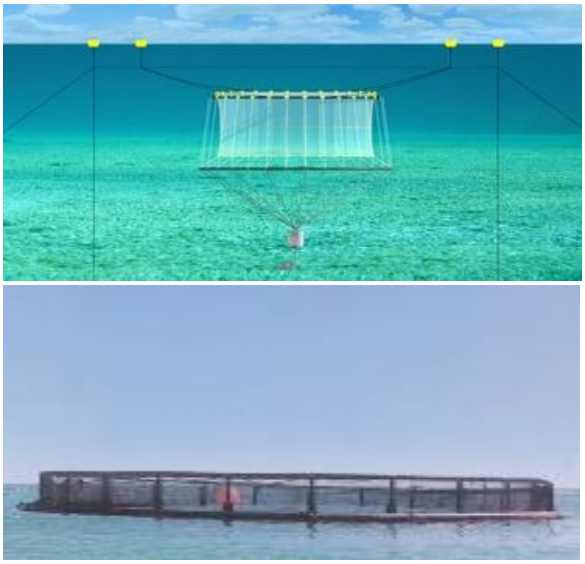


Figure.4: Submersible submerged

(According to Cage Farming Equipment. Badinotto Group1910)

Table.1: Limits set for Cage culture in Reservoirs (Gunkel *et al.*, 2015)

Reservoir Area (ha)	**Maximum Number 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

Species selection

- More than 70 species of fishes belonging to different families have been experimented in cages in more than 35 countries.
- These include inland species such as Indian and Chinese carps (*C. catla, L. rohita, L. calbasu, C. mrigala, Cyprinus carpio, H. molitrix, and Ctenopharyngodon idella*), air breathing fishes *(Anabas testudineus, Channa striata and C. marulius), tilapia (O. mossambicus*), and freshwater prawn *(Macrobrachium rosenbergii* and *M. malcomsonii*).

Culture technique in cage

- Semi-intensive and intensive mono or polyculture techniques are adopted in cage culture.
- Routine management practices are:
  - ✓ Feeding (non-filter feeders) constant supply of feed of good quality at reasonable cost is important to ensure technical and economic viability of carps and live fish in cage:
  - ✓ Removal of left over feed.
  - ✓ Regular inspection of cage.
  - ✓ Cleaning of net and removal of foul materials and organisms.
  - ✓ Avoiding cage damage during typhoons or flood by taking precautions.
  - ✓ Monitoring fish health and disease occurrence, apply medicines for disease prevention.

Cage Culture Experiments by CIFE

(Yadav *et al*.,2022).

1. Location-Walvan reservoir, Lonavla, Maharashtra

- ✓ Culture species- Mahaseer
- ✓ Culture period- fry to fingerling (2 month) and fingerling to advance fingerling (3-4 month)
- ✓ Stocking density-140/m^3
- ✓ Production-1.8kg/m^3

2.Location- Powai lake, Maharashtra

- ✓ Culture species- - IMC
- ✓ Culture period- fry to fingerling (2 month) and fingerling to advance fingerling (3-4 month)

3.Location-Halai lake, Madhya Pradesh

- ✓ Culture species- IMC
- ✓ Culture period- fry to fingerling (2 month) and fingerling to advance fingerling (3-4 month)

4.Location-Gobindsagar reservoir, Himachal Pradesh

- ✓ Culture species- IMC
- ✓ Culture period- fry to fingerling and fingerling to advance fingerling

Dimbhe Jalashay Sharamik Adivasi Machismo Sahakari Society Maryadit, Digad.

- Species culture- Catla, Rohu, mrigal and ornamental fishes like gold fish
- Size of seed -25-35mm
- Number of Seed- 2500/cage
- Mesh size 4-6mm
- Cage size- 3×3×3
- Culture period- 3.5-4 month
- Harvesting size -100-150 mm for carp

and 75-100 mm for ornamental fish

Cage culture experimentation carried out at Bhimtal by DCFR

To optimize in situ rearing density of golden mahseer upto advanced fingerling stage for stock enhancement, fry of golden mahseer (av. Weight 0.061 ± 0.012g and length 1.83 ± 0.23 cm) were stocked in four stocking densities viz. 60 nos/m^3, 70 nos/m^3, 80 nos/m^3 and 90 nos/m^3.

Cage culture experimentation carried out at different places by CIFRI

1. Dahud reservoir, Bhopal, Madhya Pradesh

- ✓ 1st phase species culture- Common carp and Grass carp stocked in 8 cages.
- ✓ Size of cage- 5m x 3m x 3m
- ✓ Culture period- 5 month
- ✓ 2nd phase species culture- Catla, Rohu Common carp and Grass carp (30 to 34mm) stocked in 11 cages.
- ✓ Culture period- 4 month
- ✓ Size of the cage-5m x 3m x 3m

2. Pahuj reservoir, Jhansi, Uttar Pradesh

- ✓ species culture- - Catla and Rohu
- ✓ Stocking- 1 lakh fry
- ✓ Culture duration- 2 month.

Cage culture in reservoirs of Himachal Pradesh

- ➢ Cage culture in Gobindsagar and Pong reservoirs of Himachal Pradesh is being implemented by the Institute in collaboration with Directorate of Fisheries, Government of Himachal Pradesh and ICAR-Central Institute of Fisheries Technology (CIFT), Kochi.
- ➢ A total of forty-eight (48) HDPE floating cages (6m×4m×4m) have been installed at Bhakra in Gobindsagar and Khatiyar in Pong reservoir.
- ➢ Fish seed of *Pangasianodon hypophthalmus* were stocked.
- ➢ The fish seeds are being reared in cages and supplemented with artificial feed to grow to marketable sizes in close association with the fishers' cooperative societies of the two reservoirs.

Cage culture in reservoir of Jharkhand

(Pandit *et al*.,2021)

- ➢ Currently, some 2,000 cages are bobbing in 14 prominent dams/ reservoirs such as Chandil, Tenughat, Koderma, Hatia, etc. Another 1,400 cages will be put in reservoirs, including Ranchi's Kanke dam, soon.
- ➢ Chandil reservior-
- ✓ Species- *Pangasius* sp.
- ✓ cage size- 6m×4m×4m
- ✓ Culture period- 6 month
- ✓ Production- 4-5 tons

Cage culture in reservoirs of Telangana

(Kumari &Sharma.2022)

- ➢ Currently, 700 cages are bobbing in 10 prominent reservoirs such as singur dam, Palair, Koil sagar, nizam sagar, jurala project, Dindi reservoirs etc. Another 300 cages in reservoirs, including mid manair, kadam Dam, Yellam palli dam, musi reservoirs, sriram sagar project.
  a. Species- *Pangasius* sp, Tilapia sp.
  b. cage size- 6m×4m×4m
  c. Culture period- 6 month
  d. Production- 2-4 tons

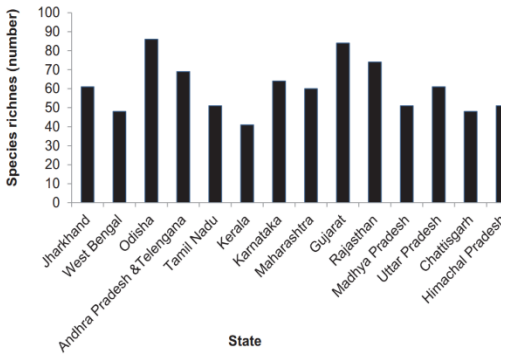


Fig.3: Fish species richness in reservoirs reported from different states of India (Sajina et al.,2021).

Feeding

- Many biological, climatic, environmental and economic factors affect feeding of fish in the cages.
- Growth rate is affected by feeding intensity and feeding time.
- Each species varies in maximum food intake, feeding frequency, digestibility and conversion efficiency.
- These in turn affect the net yield, survival rates, size of fish and overall production from the cage.

Production (Jenkins & Oglesby 1982)

Reservoirs	Area(ha)	Present Production (tonnes)	Production Potential(tonnes)
Small	1,48,557	74,200	743,000
Medium	507,298	6500	127,000
Large	1,160,511	13,000	116,000
Total	3,153,366	93,700	986,000

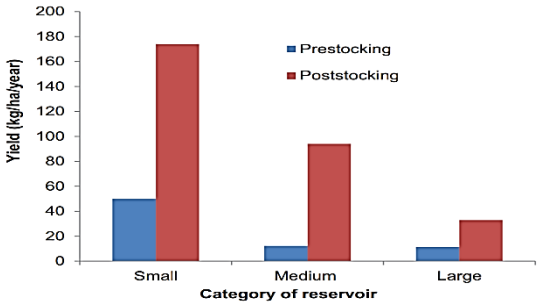


Fig.4: Increase in fish yield through culture-based fisheries in reservoirs of India (Sugunan.2000)

(According to Status of culture-based fisheries in small reservoirs in India **(**Sugunan.2000)

Harvesting

- Harvesting is mainly conducted by way of lifting the cage from water body.
- Harvesting is either full or partial.

Advantages

- There is a possibility of making maximum use of all available water body.
- Construction of cage is comparatively easy.
- Easy observation of the stock, therefore feeding and routine management is easy.
- The major advantages of cage aquaculture are resource ranching and technology benefit.
- Cage reared fish are superior in quality in terms of condition factor, appearance and taste.
- Harvesting is typically less labour intensive in cages.

Disadvantages

- Low Dissolved Oxygen Syndrome (LODOS) is an ever present problem and may require mechanical aeration (Masser.2004).
- The incidence of disease can be high and diseases may spread rapidly.

- Initial cost is high.
- Cage grown fish only have a limited access natural food.
- The risk of disease is high.
- The uneaten feed and metabolic waste released from cages will lead to eutrophication of the site.
- cages face problems like fouling and is more expensive.

Conclusion

Reservoirs undoubtedly represent a significant fishing resource, but they continue to be widely spread within a variety of managed regimes with inconsistent administration and policy support. India's reservoirs are capable of producing significantly more fish than they now do. According to estimates based on average fish yields from more than 400 reservoirs, the yields from various reservoirs (small, medium, and big) fall significantly short of the anticipated output capacity. Large-scale cage culture technology intervention in these reservoirs through public-private partnership (PPP) mode can boost and close the production gap between the current 93,700 tonnes production and the anticipated production potential, which is close to 1 million tonnes, and can greatly increase the overall fish production of the nation.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

Conflict of interest

The authors declare that the manuscript was formulated in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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