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Potential of cage aquaculture in Indian reservoirs

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Abstract
Indian reservoirs with water spread area of 3.15 m ha and yield potential of 50, 20 and 8 kg/ha/yr. from small, medium and large reservoir respectively, leave enough scope of enhancing fish yield from such resources through culture based capture fisheries and aquaculture. Inland fish production from capture fisheries in India has declined during the last few decades. Factors such as increasing consumption of fish, declining wild fish stocks and climate change have produced strong interest in fish production from aquaculture. Prioritizing production of fish from reservoirs holds the key for increasing inland fish production in India. Cage culture is being looked upon as an opportunity to utilize existing reservoirs with great production potential to enhance production from inland open waters and posed as an answer to increased demand for animal protein in the country.

Keywords: Reservoirs, Cage culture, Production potential

1. Introduction
Cage culture is an emerging technology through which fishes are reared from fry to fingerling, fingerling to table size or table size to marketable size while captive in an enclosed space that maintains the free exchange of water with the surrounding water body. A cage is enclosed on all sides with mesh netting made from synthetic material that can resist decomposition in water for a long period of time. The on-growing and production of farmed aquatic organisms in caged enclosures has been a relatively recent aquaculture innovation. Although the origins of the use of cages for holding and transporting fish for short periods can be traced back almost two centuries ago to the Asian region (Pillay and Kutty) [1], marine commercial cage culture was pioneered in Norway in the seventies with the rise and development of salmon farming (Beveridge) [2]. The cage aquaculture sector has grown very rapidly during the past 20 years and is presently undergoing rapid changes in response to pressures from globalization and growing demand for aquatic products in both developing and developed countries. It has been predicted that fish consumption in developing countries will increase by 57 percent, from 62.7 million metric tons in 1997 to 98.6 million in 2020 (Delgado *et al.* [3]. By comparison, fish consumption in developed countries will increase by only about 4 percent, from 28.1 million metric tons in 1997 to 29.2 million in 2020 (Tacon and Halwart) [4]. In India cage culture in inland water bodies was initiated for the first time in air breathing fishes in swamps, for raising major carps in running waters in Jamuna and Ganga at Allahabad and for raising carps snake heads and tilapia in lentic water bodies of Karnataka. Thereafter the cages have been used for rearing fry in many reservoirs and floodplain wetlands to produce advanced fingerlings for stocking main water bodies (Bhowmick) [5].

2. Potential of fish production from reservoirs of India
Government of India defines reservoirs as man-made impoundments created by obstructing surface flow, by erecting a dam of any description on a river, stream or any water course. However, water bodies less than 100 ha in area have been excluded from this definition. The Ministry of Agriculture, Government of India has classified reservoirs as small (<1000 ha), medium (1,000 to 5,000 ha) and large (>5000 ha) for the purpose of fisheries management, although different states have varied classifications. The estimated cumulative areas are 1,485,557 ha, 507,298 ha and 1,160,511 ha of small, medium and large reservoirs, respectively (Sugunan) [6].

India has 19,370 reservoirs spread over 15 states with an estimated 3.15 million ha surface area at full capacity, and this is expected to increase due to execution of various water projects in the country. Tamil Nadu state has the highest reservoir area of small reservoirs, investigated by Sreenivasan [7] followed by the states of Karnataka and Andhra Pradesh.

The state of Madhya Pradesh has the highest total area of small reservoirs as well, whilst Andhra Pradesh, Gujarat and Rajasthan also have a higher area of medium reservoirs. Karnataka has the largest reservoirs (twelve), but the total acreage is less when compared to the cumulative extent of seven reservoirs in Andhra Pradesh.

Fig 1: Experimental cage culture at Maithon reservoirs by CIFRI

Table 1: State-wise area of small, medium and large reservoirs (ha)

State	Small	Medium	Large	Total
Tamil Nadu	315,941	19,577	23,222	358,740
Karnataka	228,657	29,078	179,556	437,291
Madhya Pradesh	172,575	149,259	138,550	460,384
Andhra Pradesh	201,927	66,429	190,151	458,507
Maharashtra	119,515	39,161	115,054	273,750
Gujarat	84,124	57,748	144,358	286,230
Bihar	12,461	12,523	71,711	96,695
Orissa	66,047	12,748	119,403	198,198
Kerala	7,975	15,500	6,160	29,635
Uttar Pradesh	218,651	44,993	71,196	334,840
Rajasthan	54,231	49,827	49,386	153,444
West Bengal	732	4,600	10,400	15,732
North eastern state	2,239	5,835	-	8,074
Himachal Pradesh	200	-	41,364	41,564
Haryana	282	-	-	282
Total	**1,485,557**	**507,298**	**1,160,511**	**3,153,366**

(Vass and Sugunan [8])

Table 2: Physico-chemical features of reservoirs in India

Parameter	Overall range	Productivity		
		Low	Medium	High
Water				
pH	6.5–9.2	< 6.0	6.0–8.5	>8.5
Alkalinity (mg/L)	40–240	<40.0	40–90	>90. 0
Nitrates (mg/L)	Traces–0.93	Negligible	Up to 0.2	0.2–0.5
Phosphates (mg/L)	Traces–0.36	Negligible	Up to 0.1	0.1–0.2
Specific conductivity (µmhos)	76–474		Up to 200	>200
Temperature (^{0}C) (with minimum stratification, i.e. > 50 ^{0}C	12.0–31.0	18	18– 22	>22
Soil				
pH	6.0–8.8	<6.5	6.5–7.5	>7.5
Available P (mg/100g)	0.47–6.2	< 3.0	3.0–6.0	>6.0
Available N (mg/100g)	13.0–65.0	<25.0	25–60	>60.0
Organic carbon (%)	0.6–3.2	<0.05	0.5–1.5	1.5–2.5

(Sugunan [9])

Table 3: Actual and potential production from reservoirs of India

	Area (ha)	Present production (tonnes)	Production potential (tonnes)
Small	1,485,557	74,200	743,000
Medium	507,298	6,500	127,000
Large	1,160,511	13,000	116,000
Total	3,153,366	93,700	986,000

(Sugunan [9])

3. Why cage technology for reservoirs?

Reservoirs contribute considerably to the inland fish production of India, which has been estimated at 93,700 tonnes (Sugunan) [9]. In spite of this fact, reservoir fish production has been treated as a by-product, giving it less importance as a fish production system. For this reason, reservoir fisheries have not made significant progress in the country and do not contribute to the inland fish production of the country to the extent they could. Reservoirs in India offer ample scope for fish yield optimization through effective management. The sheer magnitude of the resource makes it possible to enable a substantial increase in production by even a modest improvement in yield. Further, the importance of reservoirs derives mainly from the advantages from environmental and social perspectives. There is need to dovetail the twin objectives of yield optimization and environmental conservation.

The reservoirs of India have a combined surface area of 3.25 million hectares (ha), mostly in the tropical zone, which makes them the country's most important inland water resource, with huge untapped potential. Fish yields of 50 kg/ha/year from small reservoirs, 20 kg/ha/year from medium-sized reservoirs and 8 kg/ha/year from large reservoirs have been realized while still leaving scope for enhancing fish yield through capture fisheries, culture-based fisheries and cage culture. The success rate of auto-stocking is very low in Indian reservoirs, especially in smaller ones. Many of the smaller reservoirs dry up during the summer, partly or completely, with no stock surviving. A policy of regular, sound and sustained stocking would greatly augment fisheries in such water bodies. The prime objective of cage culture in inland open water is stocking of reservoirs and culture of economically important fishes for augmenting fish production. Stocking with the right fish species, using seed of appropriate size and introducing it at the right time are essential to optimizing fish yield from reservoirs. Though 22 billion fish fry are produced every year in India, there is an acute shortage of fish fingerlings available for stocking reservoirs. Where fingerings are available, transporting them to reservoirs usually incurs high fingerling mortality. In this context, producing fingerlings *in situ* in cages also offers an opportunity for supplying stocking materials, which are vital inputs towards a programme of enhancing fish production from Indian reservoirs (Das *et al.*) [10].

4. Cage culture operations

Cage culture operation involves:

A. **Stocking:** The stocking density of fish depends on the carrying capacity of the cages and feeding habits of the cultured species. For those species which are low in the food chain, stocking will also depend on the primary and secondary productivity of the sites. The optimal stocking density varies with species and size of fish and ensures optimum yield and low disease prevalence.

B. **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. The shortage of suitable fish feed is a major problem in many countries with large scale cage farming.

C. **Farm management:** Farm management must optimize production at minimum cost. Efficient management depends heavily on the competence and efficiency of the farm operator with regard to feeding, stocking, minimizing loss due to diseases and predators, monitoring environmental parameters and maintaining efficiency in technical facilities. Maintenance works are also very vital in cage culture (Gopakumar) [11].

5. Advantages of cage culture

I. Resource use flexibility

Cage culture can be established in any suitable body of water, including lakes, ponds, mining pits, streams or rivers with proper water quality, access and legal authority. This flexibility makes it possible to exploit underused water resources to produce fish.

II. Low initial investment

Relative to the cost of pond construction and its associated infrastructure (electricity, roads, water wells, etc.), cage culture in an existing body of water can be inexpensive. At low densities (relative to pond surface acreage) cages often do not require aeration or any electrical source. Cage materials are not especially expensive and many kinds of cages can be constructed with little experience.

III. Simplified cultural practices

Cages lend themselves to straightforward observation of the fish. The observation of fish behavior, especially feeding behavior, is critical to anticipating and avoiding problems with stress and diseases, which often occur in cage culture.

IV. Simplified harvesting

Cages are usually harvested by moving them into shallow water, crowding the fish into a restricted area, and simply dipping the fish out of the cage. Or, the cage can be lifted partially out of the water so that the fish are crowded into a smaller volume, and then the fish dipped out. This makes it possible to partially harvest fish from cages as needed for local niche markets or personal consumption.

V. Multi-use of water resources
The confinement of fish in cages should not hinder other uses of the water resource, such as fishing, boating, swimming, irrigation or livestock watering (Masser) [12].

6. Constraints of cage culture
Cages occupy space on the surface of water bodies and, if poorly positioned, may disrupt navigation or diminish the scenic value of the reservoir. Poorly placed cages may alter current flows and worsen sedimentation. Inappropriately intensive or poorly managed cage culture may pollute the environment with unconsumed feed and fish faecal waste, causing eutrophication.

During the summer or rainy seasons, cages may be damaged by strong winds or flooding, but this risk can be avoided by properly anchoring batteries of cages in protected inlets away from strong currents. Theft is rarely a problem in culturing fish to fingerling size. As particular problems exist where intensive cage aquaculture is practiced for producing marketable fish or prawns, the technology has been used in Indian reservoirs only to rear fingerlings, with limited use of supplemental feed. As most of the reservoirs are in transition from an oligotrophic to a mesotrophic state, with very few in danger of eutrophication, the controlled discharge of waste products from cage culture can be immensely helpful in maintaining water nutrient levels (Das *et al.)* [10].

a. Complete diets needed
Feed must be nutritionally complete and kept fresh. Caged fishes get very less natural food and so depend on the manufactured diet for all essential nutrition. Feed must provide all necessary proteins (down to specific amino acids), carbohydrates, fats (including essential fatty acids), vitamins and minerals for maximum growth. Nutrients start to deteriorate quickly when exposed to heat and moisture.

b. Water quality problems
Localized water quality problems, particularly low dissolved oxygen, are common in cage culture. The high fish densities, along with the high feeding rates, often reduce dissolved oxygen and increase ammonia concentration in and around the cage, especially if there is no water movement through the cage. Low dissolved oxygen within cages may not affect other organisms in the lake, pond or stream.

c. Diseases
Diseases are a common problem in cage culture and they can cause catastrophic losses. Wild fish around the cage can transmit diseases to the caged fish. The crowding in cages promotes stress and allows disease organisms to spread rapidly.

d. Vandalism and poaching
Caged fish are an easy target for poachers and vandals. Cages must be placed where access can be controlled and poaching risks reduced.

e. Predation
Predation can be a problem if cages are not constructed or managed properly. Turtles, snakes and fish-eating birds will take fish or damage cages unless precautions are taken.

f. Overwintering problems
It is difficult to over winter warm-water fish in cages. There is usually a high mortality rate because of bacterial and fungal diseases (Masser) [12].

7. Conclusion
Reservoirs for sure are a major fishery resource but they remain highly dispersed under a plethora of controlled regimes with variable governance and policy support. The reservoirs of India can produce much more fish than current production level. Based on average fish yields of over 400 reservoirs, it has been estimated that yields from these reservoirs (small, medium and large) is far behind the expected production potential. Intervention of cage culture technology at large scale through public private partnership (PPP) mode in these reservoirs can boost and bridge the gap between the current 93,700 tonnes production and expected production potential which is nearly 1 million tonnes and can contribute immensely to increase overall fish production of the country.

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9. References
1. Pillay TVR, Kutty MN. Aquaculture: Principles and Practices, Second Edition. Blackwell Publishing Ltd, Oxford, England, 2005, 624.
2. Beveridge M. Cage Aquaculture, third edition. Oxford, UK, Blackwell Publishing Ltd, 2004, 368.
3. Delgado CL, Wada N, Rosegrant MW, Meijer S, Ahmed M. Fish to 2020: Supply and Demand in Changing Global Markets. International Food Policy Research Institute (IFPRI), Washington and World Fish Center, Penang, Malaysia, 2003, 226.
4. Tacon AGJ, Halwart M. Cage aquaculture: a global overview. FAO fisheries technical paper, Cage aquaculture Regional reviews and global overview. 2007.
5. Bhowmick U. Cage and Pen culture. Handbook of fisheries and aquaculture. ICAR, New Delhi, 2011.
6. Sugunan VV. Reservoir Fisheries in India. FAO Fisheries Technical Paper No. 345. 1995. Food and Agriculture Organization of the United Nations, Rome.
7. Sreenivasan A. Principles of ecology and fi sheries management in man-made lakes. In: Jhingran AG and Sugunan VV (eds.). Conservation and Management of Inland Capture Fisheries Resources of India. Inland Fisheries Society of India, CIFRI, Barrackpore, 1989.
8. Vass VV, Sugunan KK. Status of Reservoir Fisheries in India. Status of Reservoir Fisheries in Five Asian Countries. NACA, Thailand, 2009.
9. Sugunan VV. Reservoir fisheries. Handbook of fisheries and aquaculture. ICAR, New Delhi, 2011.
10. Das AK, Vass KK, Shrivastava NP, Katiha PK. Cage Culture in Reservoirs in India. (A Handbook) World Fish Center Technical Manual No. 1948. The World Fish Center, Penang, Malaysia, 2009, 24.

11. Gopakumar G. History of cage culture, cage culture operations, advantages and disadvantages of cages and current global status of cage farming. National Training on 'Cage Culture of Seabass' held at CMFRI, Kochi, 2009.
12. Masser M. What is Cage Culture? SRAC Publication No. 160, 2008.