Current status of freshwater cage aquaculture in India: Towards blue revolution

Kalidoss Radhakrishnan[1,2], Samraj Aanand[1], P. Padmavathy[1], Ipsita Biswas[3]

1. Fisheries College and Research Institute, Thoothukudi, India – 628008;
2. ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, India – 751 002;
3. College of Fisheries, Dholi, Dr. Rajendra Prasad Central Agricultural University, Muzaffarpur, India – 843 121

A full view of cages.

Aquaculture provides the cheapest source of animal protein to about 13% of the world population and employs an estimated 24 million people. The industry is projected to meet the global deficit of fish protein by 2020 due to stagnant marine fish landings. Although the sector is diverse in terms of species cultured and farming practices, cage culture has been identified as one of the most efficient approaches to utilise untapped water bodies.

The practice of cage aquaculture originated around 200 years ago in Cambodia, wherein fishes especially catfish (*Clarias* sp.) were held in cages with primary objective of keeping them alive until sold[4]. China contributes around 68.4% of the global freshwater cage culture, followed by Vietnam (12.2%), Indonesia (6.6%) and the Philippines (5.9%). Presently, around 70 species are being reared in cages in freshwater globally, with *Pangasius* being the dominant species accounting to 41.1%, followed by Nile tilapia *Oreochromis niloticus* (26.7%), common carp *Cyprinus carpio* (6.6%), *Oreochromis* spp. (5.1%), rainbow trout *Oncorhynchus mykiss* (4.1%), and salmon *Salmo* sp. (3.7%).

In India, the first attempts were initiated using airbreathing catfishes in swamps and Indian major carps in the Yamuna and Ganga rivers. Later, the Central Institute of Fisheries Education conducted cage culture for rearing fingerlings and table sized fishes in the Powai, Govindsagar, Halali, Tandula and Dimbe reservoirs. Several attempts were made but success remained unremarkable until the last decade, when a notable success in cage culture has been achieved. A decision to increase in fish production from cage culture was made and this technology has been promoted by various state government schemes such as the National Mission for Protein Supplements and it has become established in Tamil Nadu and Jharkhand.

Amur carp.

Scope of cage culture

The scope of cage culture in India is bright especially in freshwaters due to the availability of nearly 2.25 million hectares of pond and tanks, 3.0 million hectares of reservoirs and 0.78 million hectares of beels, swamps, and other water bodies. So far, cyprinids, perches, snakehead, and catfishes have been cultured in cages with success. Cage culture can be done in extensive, semi-intensive and intensive modes in selected water bodies. As an extensive method, cage culture does not require supplementary feed but rather utilises phytoplankton and zooplankton from the water bodies. Cage culture as a semi-intensive practice requires a low protein supplementary diet (<30%) and if feed exceeds 30 percent of protein content the practice can be considered to have crossed the threshold to become an intensive method[4]. As a relatively new aquaculture technique in India, skills in cage culture need to be disseminated to farmers. Unplanned expansion of cage culture can lead to undesirable environmental impacts and therefore there is also a need for proper guidelines to be established to ensure sustainable growth of this sector without any undesired impact on the environment.

Site selection for cages

Site selection is one of the most important factors for successful cage aquaculture practices, with considerations including water quality, water depth and currents required to be considered before finalising the site for deploying cages. Optimum water quality is essential to obtain maximum yield from the cage culture units.

Essential water quality parameters such as dissolved oxygen, temperature, pH and ammonia should be routinely monitored during culture.

Dissolved oxygen should not fall below 5mg/l; as wind action and photosynthesis are the primary sources a location with better wind and wave action ensures proper oxygen levels are maintained for the cultured animals. Low dissolved oxygen levels (less than 4mg/l) may cause mortality, lower survival rate and poor growth.

Temperature is a major physical parameter controlling molecular dynamics and biochemical reactions. Unfavourable temperature affects the fish health, feeding behaviour, and reproduction rate. Optimum temperature requirement ranges between 24 to 30^{o}C for most of the warm water species.

pH is another important parameter, which can vary due to intake and release of CO_2 during photosynthesis, respiration and decomposition. An optimum pH of 6 to 9 is necessary for the enhanced fish growth and high pH can lead to a rise in ammonia level in the water bodies. Ammonia comprises of ionized ammonia and unionized ammonia. Ionized ammonia is more toxic to fish. Temperature and pH can influence the ammonia concentration above its optimum (maximum) level of 0.02 to 0.05mg/l.

The appropriate water depth for successful cage aquaculture is about 6 metres. Earlier experiences in cage culture reveal a minimum of 1 m distance as a requisite between the bottom of a cage and the floor of the water body in order to prevent undesirable environmental effects. The selected location should have a water current speed in the range of 20 to 30 cm/second to maintain good water quality conditions within the cages. When the flow speed exceeds 40cm/second, feed may be lost from the cages into the natural system; the shape of the cage also changes potentially stressing the fish, which may adversely affect yield. Hence, proper study of the water current speed and pattern is also an essential consideration in siting cages.

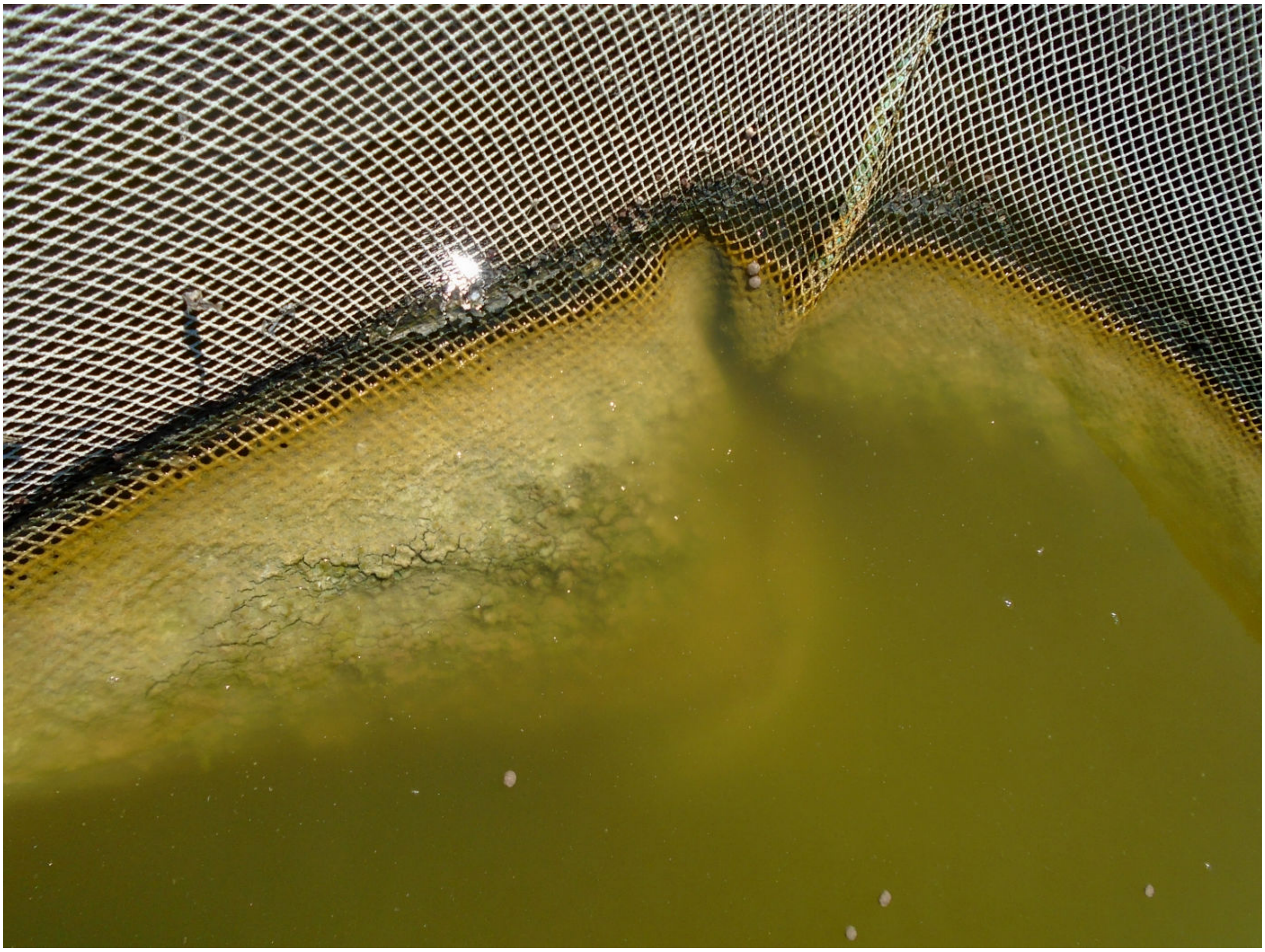
The site should be free from excessive wind and wave action as such conditions can make it difficult to maintain the cages and during extreme weather can even result in collapse of the cage system. It is better to avoid sites prone to flooding, fish breeding grounds, local fishing regions, regions receiving industrial effluent and locations with high fish populations.

Advantages and disadvantages

Cage aquaculture techniques are easy to learn and the activity requires considerably less space as compared to traditional pond culture. Efficient use of extensive water bodies such as reservoirs and lakes is made possible with cage culture. Cages provide an environment for easy monitoring of fish health, diseases diagnosis and health management. Individual cages also provide scope for quick and complete harvest; making it economically viable as compared to other extensive fish culture methods. However, there are certain limitations. Natural calamities may collapse the culture system; there is the risk of water quality deterioration and disease may spread faster than extensive culture systems, due to the high density of the fish. Cages can also create issues with other stakeholder groups such as fishers.

Cage construction

Four types of cages namely surface floating, fixed, submersible and submerged cages can be practiced. Of these, the floating cage is most widely adopted, easy to manage, and most appropriate for the Indian environment. The cage position in water can be easily adjusted according to the water level. Framework materials include aluminium, galvanised iron, rigid PVC and HDPP pipes. Empty barrels, HDPP jerry cans, airtight PVC pipes and fibreglass are used to float



Fouling.

the cages. Netting and cage materials should be strong, durable, lightweight, corrosion, and weather resistant, fouling resistant, easily repairable, inexpensive and readily available.

Cage shape

Cages can be round, rectangular, octagonal and square, there is no impact on production. However, in freshwater reservoirs, rectangular shaped cages are usually prefered due to cost and construction advantages, availability of raw materials, assemblage and transportation of the components. The size of the cage varies with the scale of operation, the habitat of species, the phase of fish (larvae, fry, and finger-lings), financial and managerial management. The World Bank suggested cage size is about 4 x 4 x 3 m, but others have recommended 4 x 4 x 2.5 m or 5 x 5 x 2.5 m with good results. The minimum cage depth should be 0.9 to 1.6 m.

Cage grouping and mesh size

Cage grouping is another important issue, which is similar to the distance between the cages. Cage batteries can comprise perhaps 20 to 24 units arranged in 2 rows of 10-12 cages each. It is essential to maintain a distance between the cages to facilitate water exchange and dissolved oxygen levels. The minimum requisite distance between the cage culture units is 20-25m.

The mesh size can be decided taking into account size of fish stocked. Generally maintaining larger mesh is better for fish stock as it allows for improved water exchange and dissolved oxygen levels and less fouling. Knotless mesh is recom-mended, as it allows better water exchange than normal knotted mesh. A mesh size of 4 – 6 mm^2 for fry rearing and 16 – 20 mm^2 for grow out are recommended. Another study [13] reported 1 cm as the net mesh size and the same can be increased up to 3 cm for an average fish size about 11.6 cm, which equals to approximately 25% of the body length.

Cages should be covered by a net to prevent the fish escape by jumping or bird predation. Larger water bodies are better suited for cage culture rather than small water bodies due to stable water quality that is less easily affected by fish waste. However, 0.5 – 2.5 hectare ponds are also suitable to install cages.

Species selection

The species selected for cage culture depends on the local/ regional market demand, high market value and seed availability. Of this, higher market value species could generate higher income. The most preferred species in one market may be the least preferred in another market thus if overlooked by the fish producer, poor species selection can lead to poor marketability and loss. Another vital aspect is seed availability, if hatchery for a species is absent in the local region, it must be avoided as it could result in dependence on wild collection or incur high transportation cost if purchased from far off places. The selected species should have the fast growth, higher survival, lower food conversion ratio, ready acceptance of feed, a rapid adoption of artificial diet, ability to withstand overcrowding, good flesh, capacity to tolerate wide range physical and chemical parameters and higher resistance to diseases. Species that have been identified as

Figure 1. Top 10 fish seed producing states in India.

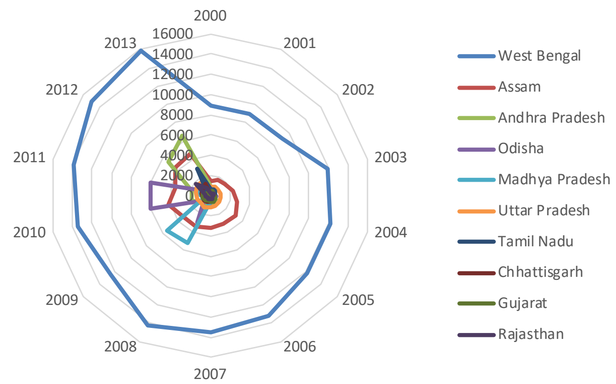
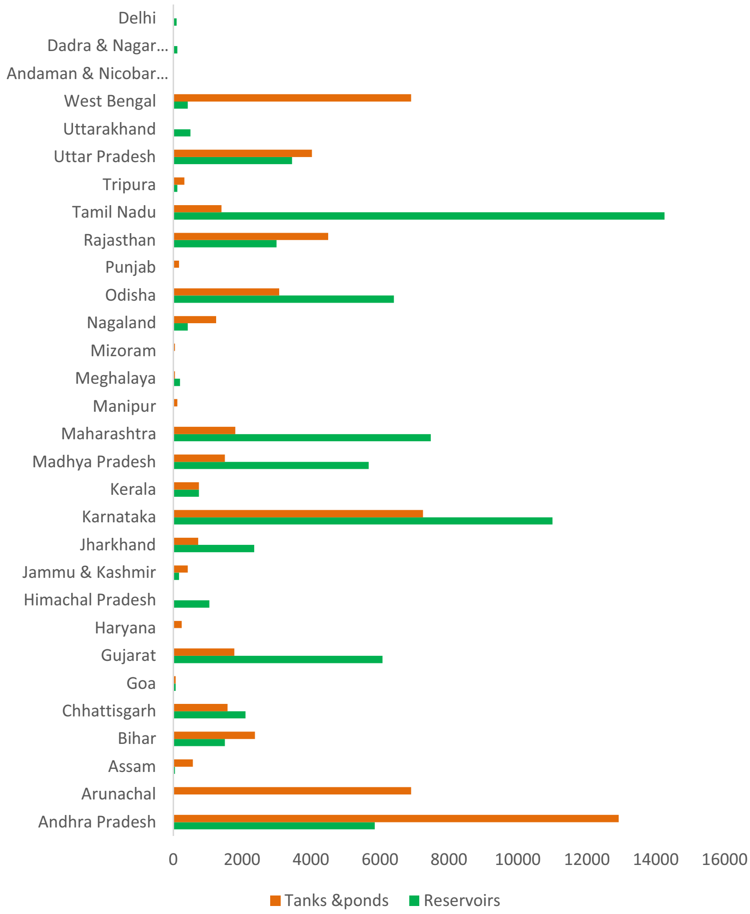


Figure 2. Projected fish production in reservoirs, tanks and ponds through cage culture.



the most suitable candidates for cage culture include tilapia, pangasius, Indian major carps, air-breathing fish, climbing perches, snakeheads and freshwater prawn.

Seed source and transportation

Seed should be obtained from a reliable fish hatchery, after checking for quality to ensure high survival and growth rate. Thus while purchasing farmers should check the seed quality by observing active swimming and ready acceptance of natural or artificial feed. The seed should be packed in plastic bags, with 1/3 water and 2/3 oxygen, however, seed should

Above: Young pangasius. Below: The result of improper cage management.

During sampling.

While feeding.

be transported by the shortest possible way and transport should be in the morning or late afternoon. After arriving at the cage site, float the plastic bags in container with water for 15 to 20 minutes. Open the plastic bags and slowly splash small amounts of water to equalise the water temperature in the bag and container, allowing the fishes to swim out by themselves. Then, give seed a dip treatment using salt (5%) or potassium permanganate (3-5%) to remove ectoparasites prior to release into the cages.

Stocking density

Stocking density in cages refers to the number of fishes stocked per cubic metre, which has an effect on the growth and survival, water quality and health of fishes. Stocking density varies with carrying capacity, feeding habit of fish, and stocking size. In addition to this, an even size at stocking is recommended for easy handling, evading predation and cannibalism and overcoming harvesting difficulties. An optimum stocking density is essential to get good growth and survival. The stocking density is directly proportional to the fish size. Feed accessibility is challenging in higher stocking density but it can be overcome by widely spreading feed within the cage. For cage culture, 15g fish with a stocking density 80 fish/m^3 is ideal and if managed under best management practices can ensure a survival rate of 98 to 100%.

Tilapia

Tilapia has shown higher growth at the stocking densities of 100, 150 and 200 kg/m^3, with an initial stocking size ranged 25 to 30g for *Oreochromis niloticus.* However, 80kg/m^3 produced better growth with lower FCR than stocking densities of 100kg/m^3 and 120kg/m^3. Production cost increased with stocking density. Stocking density in cages of nursery was up to 3,000 individuals/m^3 for 7 to 8 weeks with a weight of 10g.

Carps

The recommended stocking density for Indian major carps is about 80 fish/m^3 with a minimum recommended stocking size of 15g. Fry of Indian major carps up to 25mm are suited and advanced fry 35mm and fingerlings 50mm can be harvested. The stocking size of minor carps, in polyculture (*Labeo rohita, L. calbasu, L. gonius, Gibelion catla* and *Cirrhinus mrigala*) is about 1.3 to 2.6 g (40 – 65 mm) and they can be harvested about 15 – 36g with the survival of around 70%.

Pangasius

For fry (20mm) and fingerlings (50mm), an optimum stocking density of pangasius about 500 to 600 individuals/m^3 and 80 to 100 individuals/m^3 respectively. Periodic sampling is essential to assess the fish growth rate and health condition. In general, the culture duration in cages is from 6 – 8 months.

Feed and feeding

Feed provides balanced nutrition needed by the fish in the form of granules or pellets. Floating pellets are better for cage culture rather than sinking pellets. Floating pellets also help farmers to observe the feeding response and health of fish. If sinking feed is used, extra care must be taken to ensure that feed is not wasted and utilised properly. If automatic feeders are used, floating feed is recommended to avoid feed waste. Fish feed must have the adequate nutritional components to fulfil the requirement of the fish. Although it varies with species, 20-30% of protein is sufficient for larger fishes in semi-intensive cage culture. However, 32 – 36% of protein is requisite for small tilapia and catfish (1 to 25g size). Also, a minimum of 6 to 8 hours is required for the feeding and two feedings per day is satisfactory.

Good feeding practices have to be maintained to reduce the feed wastes. Feed quantity should not exceed 3 to 5% of the body weight. The feeding ration has to be adjusted couple of times in a month through sampling. The percent of feeding can be reduced with increasing culture days but the feed size increased with fish culture days. Mash type feed is not advisable as such feed can be left uneaten, drop out of the cage and can deteriorate the water quality.

Management practices

Water samples should be collected frequently from inside the cages to evaluate the water quality parameters such dissolved oxygen, ammonia, and phosphate, and periodically recorded to observe changes and adjust management accordingly. Cages should be cleaned on a needs basis, to avoid excessive algal growth which may reduce water exchange. The health of stocked fish should be checked regularly, if any infection is observed they need to be quarantined and treated according to the symptoms.

Harvest and marketing

One or two days before harvest feeding should be stopped and harvesting shall be done in a phased manner and sale of larger sized fishes should be first, followed by smaller sized fishes. This ensures maximum returns from the crop. The advantage of cage culture is the facility to harvest the required quantity with minimum labour and maintaining the balance of stock alive at a minimum cost.

Towards the blue revolution

The remarkable emergence of aquaculture as an important and highly productive activity is often called the ‘blue revolution’. Aquaculture is increasing the economic prosperity of fishers and contributes to rural food security through the use of water bodies in a sustainable manner with the concern of biosecurity and the environment.

The projected fish production requirement for India is 13 million tons in 2020 against present production of 10.06 million tons. The Government of India has targeted to increase the present fish production by threefold and thereby implemented various schemes such as the fish brood bank, aquaculture intensification in ponds and tanks, reservoir fisheries development, cage and pen culture, infrastructure for post-harvest, modern fish markets and a disease surveillance program through the National Fisheries Development Board. However, of these, cage culture has been identified as the most promising tool to meet the increasing demand for fish production.

Sampling pangasius for length and weight.

The National Fisheries Development Board plans to install 300 cages in inland water bodies with an anticipated fish production of 5 tons /cage. After the installation of all the cages, the annual fish production would be alike 1,500 tons from these NFDB cages alone.

For the implementation of cage culture, water resources are very important and Figure 1 depicts state wise inland fish production (cage culture production information is not available). The Chandil Reservoir in Seraikela Kharsawan District of Jharkhand State, has a water area of over 18,000 ha. A significant income was generated from the cage culture of *Pangasius sutchi* in addition to the traditional capture fisheries. Similarly, Bhavanisagar Reservoir in Erode District of Tamil Nadu has the water area of 7,876 ha. There 40 cages were installed to enhance the fish production through this culture technique. A total of 60 cages were installed in five reservoirs (Sriramsagar, Sriramsagar, Kadam, Pocharam and Koilsagar) in Telangana State. Two batteries of 6 cages (6 x 4 x 4 m) were implemented in each of these reservoirs.

If cage culture is implemented in around 70% of the available reservoirs, tanks and ponds the anticipated increase in fish production is estimated to be on the order of 94,000 tonnes. This clearly indicates that cage culture is a useful method to enhance the fish production and which also provides economic opportunities for rural communities.