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Commentary

Cage Culture in Inland Open Water Bodies of India- Some Sustainability and Equity Concerns and Guidelines to Address Them

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Cage aquaculture, though relatively new to the inland aquaculture scenario of the country, brings in new opportunities for optimizing fish production from the reservoirs and lakes, and developing new skills among fishers and entrepreneurs to enhance their earnings. Considering the ever-increasing and often conflicting cross-sectoral demands for water and land, there are limitations for growth in pond-based aquaculture. In this context, culture of fish in enclosures such as cages and pens installed in open water bodies offers scope for increasing production obviating the need for more land-based fish farms. However, mindless proliferation of this activity for increased production can lead to some very serious environmental and social problems. Thus, although generally perceived as a boon for increasing production, this mode of production can as well turn out to be a harbinger of doom, if allowed to grow unchecked. This article stresses the importance of exercising caution while aggressively pursuing cage culture in inland open waters of India by highlighting some concerns from environmental and equity angles. It also underscores the importance of following the existing guidelines on cage culture.

Advantages and Scope

'Cage' is an enclosed space in a water body to rear organisms that maintains free exchange of water with the surrounding environment.Usually covered on all sides, cages can be round, square or rectangular in shape. It is made of split bamboo, nylon nets or other synthetic polymers. Cages can be 'fixed', 'floating', 'submersible' or 'submerged'; positioned at the bottom, middle or surface of the water column. Cage culture is an effective tool to augment fish yield from many kinds of inland open water bodies, especially the reservoirs and lakes. It allows maintaining of captive stocks facilitatingdirect and easy observation of stock for feeding, growth and general health. Cage culture helps complete and easy harvesting of the stock and it prevents mortality due to predators. Cage farming can be effectively used to raise fingerlings in large numbers for stocking the reservoirs and lakes in a cost-effective manner, reducing pressure on land for seed farms and nurseries. Cage culture comes handy for augmenting production from weed-choked water bodies and those with obstructions like tree stumps and boulders, where it is difficult to operate fishing gear. Above all, cage culture offers considerable scope for increasing direct and indirect employment opportunities.

At present, fish production in India is estimated at 11.4 million tonnes, which includes 6 million t of aquaculture production. Contribution of Indian major carps to the aquaculture is 87%. Considering the national production target of 15 million t by the end of 2021, there needs to be a higher growth rate for aquaculture during the next few years. This calls for both vertical and horizontal expansion of aquaculture at a higher growth trajectory. The ever-increasing and often conflicting demands for land and waterbodies from different sectors (other than fisheries) constitute a major constraint for the growth of aquaculture. Thus, scope exists to increase production and productivity through enclosure aquaculture from open water resources like reservoirs, lakes and floodplain wetlands. In recent years, cage culture has attracted the attention of inland aquaculturists and the governments. Although some significant achievements have been made in terms of production and yield, these have not reached the necessary scale to impact the national production figures. Many issues of the supply chain management also remain to be resolved.

All water bodies are not suitable for cage culture. Cage culture in rivers are being discouraged all over the world for environmental reasons. Similarly, mangroves in India are generally considered as protected areas where no fisheries activities are permitted except subsistence fishing. Similarly, freshwater and brackish water

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Table 1. Inland fisheries resources of India and scope for cage culture in India.

	Resource size	Management mode	Scope for Cage culture
Rivers (km)	29,000	Capture	No
Mangroves	356,000	Subsistence	No
Estuaries	300,000	Capture	Yes
Freshwater ponds	2,430,000	Aquaculture	No
Brackish water ponds	1,140,000	Aquaculture	No
Estuarine wetlands	40,000	Aquaculture	No
Lagoons	190,500	Capture	Yes
Large & med. reservoirs	1,667,809	Enhancement	Yes
Small reservoirs	1,485,557	Culture-based	No
Floodplain wetlands	202,213	Culture-based	Yes
Lakes	720,000	Capture fisheries	Yes

aquaculture ponds are not suitable for cage culture. However, large scope exists for cage culture in medium and large reservoirs, estuaries, lakes and floodplain wetlands. Small reservoirs with area less than 1000 ha are excluded from the scope of cage aquaculture due to environmental concerns (Table 1).

Concerns

Although culture of fish in enclosures such as cages and pens installed in open water bodies offers scope for increasing production obviating the need for more land-based fish farms, mindless proliferation of this activity can lead to some very serious environmental and social problems. Equally important is the physical obstruction to the fishing activities of traditional fishers and the resultant conflicts. Exotic species, after escapement from cages can play havoc with the ecosystem and its biodiversity. High input of feeds can lead to eutrophication and related damage to the ecosystem. Eutrophication upsets the nutrient cycles and community metabolism of reservoirs making them barren. It must be borne in mind that our reservoirs support fisheries on which the livelihoods of thousands depend.

Environmental concerns

The major environmental concerns are eutrophication, food chain modifications, threat to small indigenous species, chemical pollution, diseases and exotic species. Cage culture involves keeping large stocks of fish in a limited space that results in accumulation of unused feed and metabolic wastes of caged fishes in the environment. Even at most economic FCR (Feed Conversion Ratio), there will be a very heavy input of feed into the cage that eventually percolates to the main water body. This can lead to excessive accumulation of nutrients (eutrophication) in the water body leading to disastrous consequences. Therefore, it is extremely essential to limit the number of cages that can be safely installed in a water body (carrying capacity). The larger the water body, the lesser is the impact of eutrophication. This is the reason for not permitting cage culture in small reservoirs less than 1,000 ha in area. Eutrophication will adversely impact the natural food chain of the water body and in extreme cases, eliminate all species other than the blooming algae. After the recent introduction of pangas (*Pangasianodon hypophthalmus*), which is an air-breathing fish allowing high stocking density, 3-7 t of fish is being produced from a small cage of 6m x 4m x 4m. Considering that at least 6 -14 t of feed goes into the system per cage per production cycle, the staggering scale of artificial nutrient loading it can cause is mind boggling. A mad rush for cage culture in reservoirs has already started in the country and if continued unabated, the situation might go out of control leading to a disaster, much greater in scale than the shrimp culture debacle of the 1990s. Laguna de Bay is a living example of how uncontrolled growth of pen culture triggered off an ecological disaster in the Philippines. Considering the rich and varied fish species, especially the small indigenous species that form an important component of inland fisheries that support livelihood in natural inland waterbodies, caution needs to be exercised while promoting cage culture.

Use of chemicals and antibiotics in cage culture is another cause of concern for the ecosystem. Chemicals

adversely impact the organisms and the antibiotic residues may destroy all useful microorganisms in the ecosystem that play a vital role in natural nutrient recycling process. Captive fish stocks in cages are more prone to diseases that can be transmitted to the natural fish populations in the lake at large. As cage culture of indigenous fish populations are generally uneconomical, exotic species are often used. Accidental introduction of exotic species into open waters is a major concern of cage culture. In case of becoming invasive, such exotics can predate upon or/and compete with indigenous species for food and space. Exotics can also affect the genetic integrity of indigenous and endemic species. Therefore, it is important that only those species which are permitted by the authorities should be used for cage culture.

Equity concerns

The major equity concerns pertain to the access of fishers to their traditional fishing grounds. Our inland waterbodies are used traditionally as common property resource which is freely or easily accessed by fishers. It is important to protect the rights of traditional fishers when the water bodies are leased out for cage culture. If right to cage culture is given to individual investors, the production from the waterbody and the financial gains accrued thereby are enjoyed by a few individuals rather than the community that fish in the waterbody. This could adversely impact the livelihood of fishers in many ways. It can deny access to the fishing grounds to fishers apart from diminishing the number of species in the lake. Therefore, it needs to be ensured that the fruits of higher productivity are shared equitable by all stakeholders. It is desirable that the right to practice cage culture is given to the fishers' group such as Fishers' Cooperative Societies, Self Help Groups etc. Wherever such groups do not exist, the government should encourage to form and empower such community organizations.

The Guidelines

Cage culture is a relatively new area of fish production in India and its environmental impacts are not fully understood. There is a wealth of literature abroad on assessing the nutrient loading, which is directly related to the feed input and FCR. But these models are not directly applicable in India due to the different environmental regimes under which these have been developed, especially the variations in temperature and trophic status. Efforts are on to develop such models in India, but the results will not be available in short time. Research Institutes in India that develop cage culture technologies often neglect studies on its environmental impact, although such studies are essential and complementary. Our research Institutes should pay attention to assess the carrying capacity of reservoirs and inform the government and policy makers how to proceed on developing cage culture in the country. Hasty and arbitrary policy-making at the State level to allow cages in large numbers in reservoirs without assessing the environmental impacts is a matter of deep concern, especially in the backdrop of our bad experience with coastal aquaculture during the 1990s, when unregulated growth without addressing environmental concerns resulted in disastrous consequences to ecosystems. Following the guidelines of the FAO-CCRF for dealing with data-deficient systems, our policy towards EIA of cage culture should be based on a precautionary approach.

Recognizing the importance of cage culture in inland open waters, a set of guidelines has been developed by the Central Government, addressed to all stakeholders including, farmers, SHGs, cooperative Societies, other community organizations, Business process Development Facilitators (BDFs), Farmer Producer Organizations (FPOs), Fisheries Departments of the Indian States, Department of Fisheries, Government of India and its Institutes, Research Organizations and Environmentalists (http://nfdb.gov.in/PDF/DOWNLOADS/Guidelines%20for%20Sea%20Cage%20Farming%20in%20India%20-%20January%202018.pdf).

Major highlights of the guidelines are

- Cage culture in rivers needs to be discouraged due to ecological reasons.
- Subject to other conditions, it can be practised in estuaries, lagoons, lakes, and large/medium reservoirs.
- Cage culture shall be allowed in water bodies having a surface area of 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 fulfilled).
- 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.
- Cage culture should not be attempted in any water body having total phosphorus and total nitrogen levels in the water exceeding 0.02 mg L^{-1} and 1.2 mg L^{-1}, respectively.
- Environmental Impact Assessment is necessary before clearing cage culture projects. This will be done/facilitated by recognised organisations, following the standard procedure.
- The State governments should demarcate, list and notify waterbodies that are suitable for cage culture based on its trophic characteristics and other criteria of site selection and upload the list of water bodies and their suitability on GIS platform with the help of concerned institutions.
- It will be mandatory for the cage culture operators to record the water quality parameters like Dissolved Oxygen, pH, CO_2 and total alkalinity, inside and outside the cages from day one of the operation, keeping in view the need for long-term environmental impact. Any increase in nutrient level away from the cage area should be taken as a warning.
- It will be mandatory for the cage culture operators to collect data on the trophic status in and around the cages as well as the areas away from the cages periodically and report to the authorities to assess the impacts in terms of nutrient loading. Studies on other chemical and physical quality parameters of water and sediments also shall be collected as per the risk perception.
- NFDB and Central Organizations will build capacity at State Governments to interpret such data and arrive at conclusion.
- *Pangasianodon hypophthalmus* and GIFT tilapia, can be cultured, but all other exotic species (including illegally introduced fishes) are strictly prohibited for cage culture. The seed of exotic species should be sourced from authentic and reliable agencies, subject to government stipulations.
- As far as possible, use of antibiotics and chemicals should be avoided. However, in the event of it becoming necessary under exceptional circumstances, the use should be judicious, and it must be clearly understood that only approved drugs/chemicals, permitted by Government regulatory authorities at standard doses shall be used (Table 2).

Table 2. Recommended Drugs/Chemicals for use in cage culture

Drug/ Chemical	Recommended dose	Indications	Administration
Chloramine-T	20 milligrams per litre static bath once per day for 60 minutes on consecutive or alternative days for 3 days.	Columnaris disease associated with Flavobacterium columnare	Immersion
Formalin	External parasites 250µL L^{-1} for 1 hour	Control of external protozoa (Chilodonella spp., Costia spp., Epistylis spp., Ichthyophthirius spp. Scyphidia spp. and Trichodina spp.) and the monogenetic trematode parasites (Cleidodiscus spp., Dactylogyrus spp., and Gyrodactylus spp.) on all finfish	Immersion
Oxytetracycline dihydrate	Catfish – 2.5 to 3.75 g oxytetracycline 50 kg of fish for 10 days through feed. (Active ingredients: 200 g oxytetracycline 0.5kg^{-1}).	Control of Hemophilus piscium, furunculosis caused by Aeromonas salmonicida, bacterial hemorrhagicsepticemia caused by Aeromonas liquefaciens, and pseudomonas disease.	Medicated feeds
Florfenicol	10 mg florfenicol kg^{-1} of fish day^{-1} for 10 consecutive days through feed (Active ingredients: 500 g of florfenicol kg^{-1})	Control of Flavobacterium psychrophilumand Aeromonassalmonicida, Streptococcus iniae, Flavobacterium columnare,	Medicated feeds

Carrying capacity and limit on number of cages

Carrying capacity of a waterbody to hold cages is the most vital input for decision making in cage culture. But unfortunately, we are not in a position to arrive at carrying capacity at decent precision levels due to paucity of data. Therefore, guidelines on carrying capacity have been based on a precautionary approach. Provisions of FAO-Code of Conduct for Responsible Fisheries clearly stipulate to follow the 'precautionary approach' while dealing with data deficient systems. Accordingly, considering the general trend of nutrients in Indian reservoirs and possibility of nutrient loading from cage culture, the guidelines prescribe the carrying capacity on a precautionary approach basis (Table 3).

Table 3. Limits set for cage culture in reservoirs under the guidelines. Maximum number of cages allowed (1 unit is 6m x 4m x 4m) as stand-alone or in batteries (of 6, 12, or 24 units) as required

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

Markets and infrastructure

Large-scale production through cage culture can adversely impact the market price, leading to glut, which can act as a major disincentive to the present and potential entrepreneurs. A few cases of glut have been reported, especially about problems in marketing of pangas. With many newer species such as tilapia, seabass, cobia, etc. lined up for cage culture, a careful strategy involving marketing plans, value addition and market infrastructure should be evolved.

Ownership, Beneficiaries & Governance

Unlike the land-based aquaculture undertaken on private land, cage culture is practised in open waterbodies which are used as common property resource by fishers. 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-controlled agencies which are used by fishers as 'common property resource' with 'free' or 'almost free' access.

(b) Fish produced from the reservoirs is essentially a natural resource in the form of 'ecosystem goods and services', on which the traditional and local fisher communities have the natural primary rights.

(c) Livelihoods of many poor people depend on catching fish from reservoirs.

(d) Reservoir fishing is used sometimes to rehabilitate the people ousted from the dam projects.

Considering the above facts, it is essential to ensure that expansion of cage culture do not impair the livelihoods and income of the fishers. Cage culture can adversely impact the interests of local fishers by denying access to fishing grounds, obstructing their pathways, and decline in fish catch. Fish catch can be adversely affected in many ways such as lowering the natural productivity, eutrophication, algal blooms or impact of exotic species. 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. Pursuing a purely revenue approach (as being followed by some of the state governments) 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 a beneficiary of this technology.

Social relevance

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 a 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. Under any special circumstances, if a private entrepreneur or investor has to be brought to the scene, government, through strong policies, should protect the interests 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. Cage culture in inland open waters is a fast-growing activity and it could have many environmental and social impacts, which may not be predictable. But adequate precautions need to be taken to ensure that it should not lead to any such issues in future. While the goal should be increased fish production through environmentally sustainable and socially inclusive means, the additional income generated from the reservoirs through the growth of cage culture should be shared by the fisher community rather than an investor walking away with all the benefits and the fishers get only the wages. Apart from increase in fish production, a meaningful social impact should be in the form of generating additional income and improved standard achieved by the fisher- the main stakeholder - who incidentally belongs to one of the weakest sections of our society.

Conclusions

Considering India's rich and varied open water resources like reservoirs, lakes and floodplain wetlands, large 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. Although cage culture has not yet reached the desired commercial proportions capable of making any impact on the production figures, it is growing at a very fast pace giving hopes, but causing some concern. Reservoir ecosystem is complex and so are its problems. Concerted efforts by the scientists, government agencies and policy makers and, above all, the community organizations and NGOs will be required to optimize the benefits from reservoirs and to keep off undesirable paths by learning lessons from our past ecological mistakes and that of other countries. Evolving simplistic solutions to problems and drafting hasty policies, without delving deep into the areas such as ecosystem processes, socio-economic milieus and governance regimes will not only be useless, it can also cause irreversible damage to the sector and the ecosystem.