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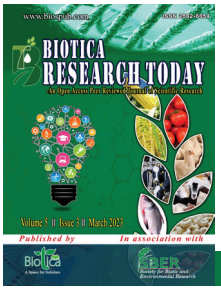

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# Potential Measures towards Reservoir Fisheries Enhancement

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## Abstract

Reservoirs are man-made ecosystems constructed for irrigation or power generation as the primary purpose. India is blessed with such vast water resources that can be effectively utilized for fish production, which in turn will contribute to nutritional and livelihood security. This can be achieved through various fisheries enhancement practices such as culture based fisheries, stock enhancement, species enhancement, habitat enhancement and enclosure culture in reservoirs to attain the fish production potential and socio-economic security of the downtrodden section of society. Reservoir fisheries are an important area for the growth of Indian fisheries due to the abundant resources and untapped fish production potential.

**Keywords:** Enclosure culture, Fisheries enhancement, Reservoir, Stock

## Introduction

Nearly 30% of the animal protein consumed in emerging nations comes from fish, which is also the most affordable protein source. The majority of fish consumed up until lately came from the wild but over the past 20 years, supplies from farms have increased at a rate of 6% annually. Particularly, inland aquaculture has enormous potential for addressing the protein shortage in developing nations. Intensive farming alone cannot fill the supply gap. The rural community benefits greatly from the fisheries sector's provision of nutrient-rich food and support for its means of subsistence. The fishing industry presently employs about 14 million people. By 2025, the Indian domestic market is expected to consume 16 million tonnes (MT) of fish, compared to the 14.73 MT of fish that are currently produced by the inland (11.25 MT) and marine (3.48 MT) fisheries sectors (FAO, 2021). Reservoirs are artificial lakes formed by damming rivers to hold water for irrigation, power production, flood control, and industrial water requirements. In India, reservoirs cover an estimated 3.51 million hectares of area. The reservoirs were divided into three categories by the Indian government: small (1000 ha), medium (1000-5000 ha), and big (> 5000 ha). States like Tamil Nadu, Andhra Pradesh, Karnataka, Odisha, Kerala, Maharashtra, Uttar Pradesh, and Madhya Pradesh in southern and central India are home to significant lakes. Comparatively, fish yields in these water bodies are lower than in feed-based fish production methods. Effective management techniques, such as adhering to ideal stocking densities, using artificial feed, reducing predation, routinely monitoring and harvesting the stock can improve the fish output. Sugunan (1995) reported that the average annual productivity for small, medium, and large reservoirs was 49.9 kg $ha^{-1}yr^{-1}$, 12.3 kg $ha^{-1}yr^{-1}$ and 11.4 kg $ha^{-1}yr^{-1}$ respectively. Later, with the implementation of good management techniques, the fish productivity potential from small, medium, and big reservoirs was recalculated to a level of 500 kg $ha^{-1}yr^{-1}$, 200 kg $ha^{-1}yr^{-1}$ and 100 kg $ha^{-1}yr^{-1}$, respectively (Sugunan, 2015). By implementing management practices like culture-based fisheries in small reservoirs and stock enhancement and enclosure culture in medium and large reservoirs, it could be possible to increase output.

## Culture-based Fisheries

In culture-based fisheries (CBF), fishes are stocked, allowed to develop, fed on naturally occurring sources, and harvested when they are the right size. The number of fish to be stocked, the size at stocking, the period of growth, and the harvesting size determine the success of CBF. The selection

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of species depends on the fish food resources available in the water body, seed availability and stocking density on the basis of production potential, growth, mortality rates, and consumer preference in the local market. In the case of small reservoirs with open sluices, the season of overflow, and the dry season are also to be considered before stocking the reservoirs. Fish yield from small and medium reservoirs has been significantly increased due to the widespread implementation of the culture-based fishery in many reservoirs. In Aliyar reservoir in Tamil Nadu, the technique of staggered stocking of advanced carp fingerlings has proven to be an effective method of fisheries management. The fish yield in this reservoir was comparatively low, averaging just 26.7 kg $ha^{-1}yr^{-1}$ but varying from 2.67 to 54.5 kg $ha^{-1}yr^{-1}$. With the help of ICAR-CIFRI's management intervention, the fish yield rose to an average of 132.6 kg $ha^{-1}yr^{-1}$, and the CPUE in this reservoir more than doubled, ranging from 5.65 to 10.0 kg (Selvaraj *et al*., 1990).

### Stock Enhancement (SE)

When fish populations cannot be sustained through self-recruitment, strategies for stock enhancement must be employed. The process of stock enhancement entails stocking fish in reservoirs, enabling the population to grow by using natural fish food sources, conserving resources to promote natural reproduction and recruitment, and harvesting the fish at the right size according to regulations. Stocking has increased the fish yield in nations like China, Mexico, Sri Lanka, Taiwan, and India. The management strategies like stock enhancement would be appropriate for big reservoirs like Krishnarajasagar (13,000 ha), located in Karnataka. Fish yield as a consequence has increased from 30 kg to over 100 kg $ha^{-1}yr^{-1}$. In order to determine the effects of fish stocking, a comparative analysis of the trophic status and energy flow in the Hemavathi reservoir in India was conducted. The findings showed a decrease in the nutrients flow through the system from before to after stocking. The health of the ecosystem improved, indicating that stocking was beneficial (Khan *et al*., 2015).

### Species Enhancement (SE)

The only way for species enhancement in reservoirs is to stock the appropriate species in the right ratio. Before choosing a species, factors like growth rate, feeding behaviour, consumer preference, food conversion efficiency, ability to use the natural food, and the supply of fish seed should be taken into account. In Indian reservoirs, it is advised to stock Indian Major Carps (IMCs). Different combinations of fish species can be chosen depending on the feeding habits of the fish species and the natural food that is available in the reservoirs. *Catla catla* can be stocked in reservoirs with a high zooplankton population. Likewise, in reservoirs with high phytoplankton density, *L. rohita* can be selected and based on detritus load, *C. mrigala* may be selected for stocking. Species such as *L. calbasu, L. bata, C. cirrhosa, Tor* spp., *Etroplus suratensis, Pangasius pangasius, Puntius pulchellus, L. kontius, P. carnaticus, Gonoproktopterus dubius* and *G. kolus* are also suitable for stocking in reservoirs. The non-availability of adequate seed, due to lack of standardised breeding technology for commercially important indigenous fishes is a constraint for the species enhancement of these fishes in reservoirs. Moreover, the stocking of indigenous threatened fish species will help in conservation of fish biodiversity in the ecosystem.

### Habitat Enhancement (SE)

Supplementing the reservoirs with fertilizers will improve the primary productivity and thus the growth of fish food organisms, which will in turn increase the fish production from the reservoirs. In some reservoirs, such as the Vidur reservoir in Tamil Nadu, the Natkara reservoir in Madhya Pradesh, the Kyrdemkulai reservoir, and the Nongmahir reservoir in Meghalaya, this type of habitat improvement and consequent increase in productivity were accomplished (Sugunan, 1995). The addition of fertilizers may sometimes cause nutrient pollution in reservoirs and affect the water quality and other uses of the reservoir water. Hence, care should be taken to determine the appropriate quantity and type of fertilizer to be applied based on the nutrient composition. Techniques such as the placement of artificial structures, vegetation planting, spawning habitat improvement, *etc*. can also be adopted to improve fish habitat after proper validation of the techniques.

### Cage Culture

Raising aquatic organisms, such as fish or shellfish to fingerling, juvenile or commercial size in a body of water that is completely contained with cage netting material including the bottom, while allowing water to freely circulate through the cages mesh, is known as cage culture. Modern cage culture in open water bodies originated in Japan in the 1950s. Gradually, cage culture became one of the major aquaculture systems around the world and is now an intensive production system that ensures high yield. Eutrophic waters have the potential for low cost fish production through the culture of lower trophic level fishes such as tilapia, carp, and catfish. However, the use of formulated diets and optimal stocking densities is becoming more widespread in cage culture. Cage culture in India started in 1970 in three systems such as culture of air-breathing fishes in swamps, culture of major carps in the lotic waters of the Yamuna and Ganga Rivers at Allahabad, and culture of common carp, catla, silver carp, rohu, snakeheads, and tilapia in the lentic waters of Karnataka. The ICAR-Central Inland Fisheries Research Institute (CIFRI) attempted cage culture of air-breathing fishes in the 1970s with limited success. Further, during 2004-2005, floating cage experiments were conducted for raising fingerlings of Indian major carps for stocking in Kabini reservoir, Karnataka. About 70% survival of fingerlings can be achieved through fingerling rearing in cages if installed in the same reservoir by avoiding transportation from a distant place. Species selection depends on local preference, market value, seed availability, fast growth rate, high survival, capacity to withstand overcrowding, rapid adaptation to artificial feed, high feed conversion rate, quality flesh, and resistance to disease. Species such as Indian major carps, common carp, and grass carp were primarily selected for fingerling production to stock the reservoir for increasing

the fish production. Species such as freshwater prawns, air-breathing species, and seabass are selected for growing table sized fish due to their high market value. Carps, *Pangasius* sp. and small indigenous fishes are also suitable for growing table-fish based on market demand. The locally preferred fishes such as pearlspot, can also be raised profitably in fresh water cages. The stocking density depends on carrying capacity of water, water spread area, water exchange rate, species, size, methods of rearing, and the quantity and quality of the feed input. To comprehend the effects of cage culture on ecosystems and the auto-stocking of native fish in inland open-water systems, extensive research is necessary.

## Pen Culture

Fish pen culture, which began in Japan's Inland Sea area in the early 1920s and later spread to China in the early 1950s for rearing carps in freshwater lakes has proven to be a very effective method for increasing the number of fish in large shallow water bodies. Pens are fenced enclosures created along the margins of watersheds with the natural bottom of the water body forming the bottom of the pen. Polyculture is more suitable for fish pens. Based on the feeding habit, fish may be selected for culture. Herbivores, such as grass carp (*Ctenopharyngodon idella*); omnivores, such as common carp (*Cyprinus carpio*), tilapia, (*Oreochromis niloticus),* crucian carp (*Carassius auratus*), and pearlspot (*Etroplus suratensis*); and filter feeders, such as silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*) can be cultured in different combinations in based on the availability of natural food. The species combination can be 60-80% herbivorous fish, 20-30% omnivores, and 10-20% filter feeders of total stocking weight. Successful pen culture was carried out in Vembanad lake (Kerala) for the culture of *Etroplus suratensis* and in Harangi reservoir (Karnataka) for rearing IMC fingerlings. Large fingerlings are suggested for stocking in pens for higher survival and growth. During the culture period of eight to ten months, fish grow 5-10 times their body weight. Site selection and regular monitoring are important to elude damage to the pen due to natural calamities like floods or cyclones. The impacts of pen culture on the natural environment also need to be considered. When artificial feeding is practiced in pen the unused feed may pollute the water body and thereby affect other important usage of the water body. Artificial feeding should be regulated or natural food from the water body should be utilized for reducing these adverse impacts on the water body.

## Conclusion

The contribution from the fisheries sector towards the income generation and well-being of poor community for their livelihood is immense. It also creates the opportunity for income generation and self-empowerment for women. Reservoir fisheries management will benefit the fishers and fish farmers through uninterrupted protein rich food supply, skill development in various fishery related activities through capacity building to uphold the sector. The research and development of fisheries and aquaculture should encourage farming systems and also assess the socio-economic contribution of aquaculture to conservation and management of our natural resources.

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