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Toward the Blue Revolution in India: Prospects for Inland Open Waters

M.A. Hassan, Mishal Puthiyottil, Gunjan Karnatak and A.P. Sharma

Food security is now a prime concern with the trend of increasing population growth in India. The need for greater fish production to meet the challenges of food security has drawn the attention of planners and policymakers. The sector holds so much potential that the premier of the country called on practitioners of fisheries and aquaculture to usher in a 'Blue Revolution' through sustainable exploitation of aquatic resources of the country. In this context, fish production from inland open water bodies is a promising approach for production of high-quality protein and providing livelihood options to the rural populace. India is endowed with large areas of reservoirs and wetlands with a large scope for further exploitation and fisheries enhancement.

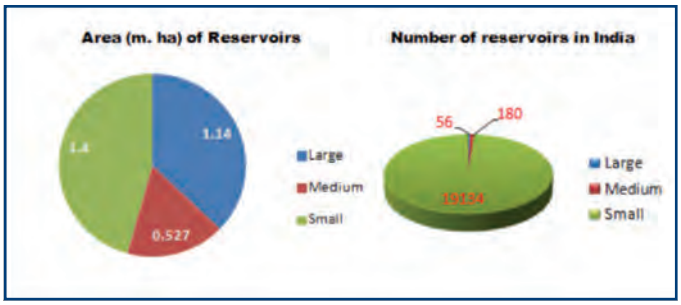

FIGURE 1. *Reservoir resources of India.*

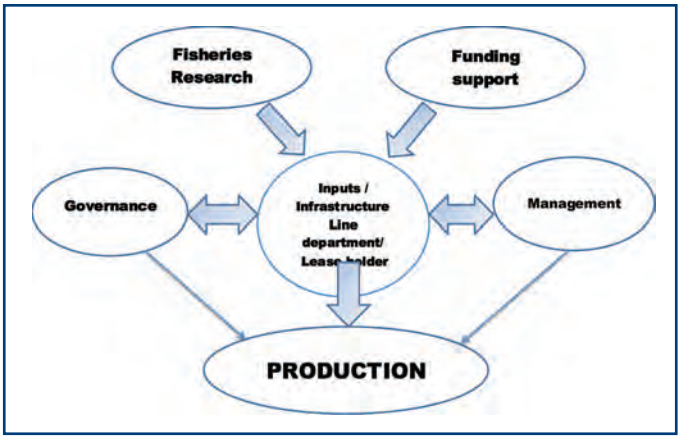

FIGURE 2. *Management strategy for development of inland open water fisheries.*

Globally, India stands second in inland fish production next to China, but there is a colossal gap in fish production between these two leading countries. Nonetheless, there has been a quantum leap in inland fish production in India over the last decade, outpacing the growth of marine capture fisheries. The current contribution of inland open-water resources is estimated to be 1.4 million t, contributing around 25 percent to total inland fish production (FAO 2014).

There are 3.15 million ha of reservoirs in India (Fig. 1), indicating the magnitude of fisheries and aquaculture development potential. In addition, total reservoir area is expected to double in the next decade. Current production from reservoirs based on size is 46 kg/ha per yr (large), 105 kg/ha per yr (medium) and 190 kg/ha/yr (small). This is substantially less than the estimated production potential of 100 kg/ha per yr, 200 kg/ha per yr and 500 kg/ha per yr, respectively. Fulfilling the gap between current and potential production will realize the meaning and scope of the Blue Revolution in India.

There are also 0.5 million ha of open-water areas in foodplain wetlands. These wetlands represent a repository of invaluable biodiversity and support the livelihoods and nutritional needs of millions of people. They are spread mainly across the states of West Bengal, Assam and other northeastern states, Uttar Pradesh and Bihar and have a current production of 400-800 kg/ha per yr, well short of a potential 2000 kg/ha per yr (Sugunan *et al.* 2013). Scientific management of these resources could further enhance the inland fish basket.

The sustainable increase of fish production through stock enhancement, capacity building of stakeholders, reinforcing infrastructure and support services, strengthening institutional and governance instruments are the recommended policies for effective management of reservoirs and wetland fisheries (Fig. 2). Strategies for inland fisheries development include culture-based fisheries management in small and medium reservoirs, stock management in large reservoirs, and table-fish production through enclosure culture (cages and pens) in medium and large reservoirs and in selected wetlands.

Culture-based Fisheries in Small Reservoirs

Culture-based fisheries is an effective management tool to enhance fish yield from open waters when recruitment of desired species is less than the carrying capacity of the water body. Culture-based fisheries is based on direct stocking of fish for recruitment and recapture from open waters. Recruitment of desired fish species in most Indian reservoirs and wetlands is inadequate due to breeding failure from habitat degradation and overfishing.

Surveys of the production potential and existing fish population dynamics are necessary before beginning a program. A policy of regular, sound and sustained stocking will greatly augment fisheries in such water bodies (Figs. 3 and 4). Stocking with the right combination of fish species based on trophic structure, using seed of appropriate size and introducing it at the right time based on the availability of food resources is essential to optimize fish yield from inland open-water bodies. In reservoirs, stocking large fingerlings, staggered stocking and harvesting protocols, and responsible fisheries practices would ensure enhancement of stocked and native fish stocks. The recent experience of 110 kg/ha fish production through culture-based fisheries in Gandhisagar reservoir of Madhya Pradesh

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has dispelled the notion that this approach is suitable only for small reservoirs.

Stock Management in Large Reservoirs

For medium and large reservoirs the management strategy should be capture of self-sustaining stocks. This includes heavy initial stocking, followed by conservation of habitat to allow natural breeding and recruitment, regulated fishing and supportive/corrective stocking as needed. It also requires stock manipulation through adjustment in fishing effort, observance of conservation measures and gear selectivity.

Fisheries management protocols developed by CIFRI based on fish stock manipulation have increased the productivity of some large and medium reservoirs (Nagarjunasagar, Sriramsagar, Ravishankarsagar, Ujjaini, Govindsagar, Gandhi Sagar, K.R. Sagar, Hemavathi and Chandil). Guidelines for optimum fisheries exploitation recommended by the Institute for Sustainable Fish Production are now being practiced in numerous reservoirs across the country. Technologies, region- or site-specific protocols and guidelines developed for reservoir fisheries management, coupled with outreach programs, have enhanced average fish production in some reservoirs to 110 kg/ha per yr from 30 kg/ha per yr.

Bottlenecks that have been identified as constraining potential reservoir fisheries include:

- Ownership of reservoirs lies with non-fisheries departments,
- Insufficient availability of quality seed of desired size for stocking in reservoirs,
- Inadequate fish seed-raising facilities,
- Insufficient funding/credit,
- Disorganized input-output sectors,
- Absence of efficient governance, institutional arrangements and policy support, and
- Difficulty in fishing.

In the case of wetlands the lacunae are:

- Multiple ownership,
- Aquatic weed infestation,
- Siltation/closure of linking channels,
- Insufficient funding/credit,
- Disorganized input-output sectors, and
- Absence of efficient governance, institutional arrangements and policy support.

Strong policies, legislation and budgetary provisions are necessary to fully realize the potential of inland fish production.

Enclosure Culture

Cage culture. Cage culture in inland open waters is being evaluated as an opportunity to use existing reservoirs and meet the increasing demand for animal protein in the country (Fig. 5). The oligotrophic, medium and large reservoirs in India offer substantial scope for implementation of technology for intensive cage farming to realize water productivity, entrepreneurship and employment opportunities.

The CIFRI has facilitated implementation of cage culture through introduction of non-native species and has achieved a production level of 50 kg/m^3 in cages stocked at 60/m^3. Although there is enormous potential for fish production in cages, a modest beginning of 10,000 cages in Indian reservoirs could produce 45,000 t of fish. The concept of carrying capacity must be considered to maintain ecological balance and integrity. Ensuring quality fish seed, eco-friendly and low-cost balanced feed, and disease management are the key approaches for expansion of cage and pen farming in reservoirs and wetlands.

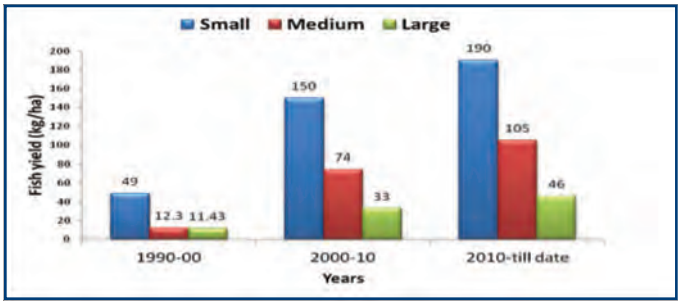

FIGURE 3. *Improvement in fish yield through stocking enhancement in reservoirs Source: CIFRI Archive.*

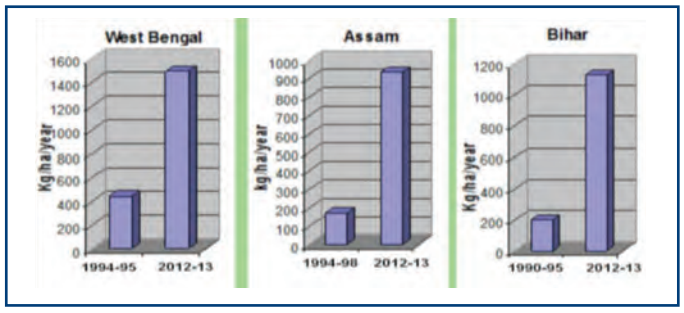

FIGURE 4. *Improvement in fish yield through stocking enhancement in wetlands.Source: CIFRI Archive.*

Success Story: *Cage Culture in Jharkhand.* Jharkhand is the premier state of India to have successfully introduced cage culture in reservoirs. After a humble beginning through demonstration of cage culture by CIFRI in Hatia reservoir, Ranchi, the state undertook cage culture in a big way in Chandil and Tenughat reservoirs under the National Mission for Protein Supplements scheme of Government of India. Galvanized iron cages of average dimension 6 m × 4 m × 4 m (~96 m^3) in a battery of four cages were used for the culture of striped catfish *Pangasianodon hypophthalmus.*

The cost of construction of one battery of four cages was 300,000 rupees (about US$ 4,500) and cost of inputs per cage was 200,000 rupees (about US$ 3,000). Fish were fed with floating pelleted feed. Production was as high as 5 to 7 t/cage in a grow-out period of 8-10 months. During 2013-14, more than 200 t of catfish was harvested from 48 cages. The project was implemented in PPP mode, providing livelihoods for people displaced by dam construction and inundation. Cage fish farming in reservoirs provided livelihood opportunities for the local landless people and improved the socioeconomic status of the target group. The success of cage farming in Jharkhand has demonstrated the potential of cage culture technology in the country. Tapping the huge potential of the vast inland open waters can uplift local communities.

FIGURE 5. *Cage culture of pangasius catfish in Indian reservoirs.*

Pen Culture

Pen culture can be an ideal technology for enhancing fish production from the 0.5 million ha of shallow floodplain wetlands in states like Bihar, Assam and West Bengal (Fig. 6). These shallow and macrophyte-infested water bodies, considered unproductive and unsuitable for other economic activities, can be efficiently utilized for enhancing fish production through scientific management. Bihar is endowed with a vast area of oxbow lakes (*mauns*) and natural depressions (*chaurs*) that can play a major role in enhancing fish production through pen culture. In Bihar, where fisherman cooperative societies for wetland management are non-existent, table-fish production through individual pen farming could be a viable option. States like Assam and Bihar, although self sufficient in fish seed production, are deficient in large fingerlings (>10 cm) suitable for openwater stocking. Pen culture technology can be used for table fish production and seed rearing for stock enhancement purposes in wetlands. Fish species diversification based on regional preference would ensure popularization and profitability of enclosure culture practices.

Success Story: ***Pen Culture in Barela Chaur.*** Bihar state has around 200,000 ha of floodplain wetlands. Barela *chaur* is one such shallow water body situated in Patepur block, Vaishali, North Bihar. Fishermen living in the vicinity are mainly dependent on fish catch from this *chaur* for their livelihood. A group of interested fishermen from this village were trained at CIFRI, Barrackpore to initiate pen culture in a 1-ha area in Barela *chaur* under institute guidance. They were provided HDPE netting and seed material comprised of rohu, catla, mrigal, grass carp and common carp fingerlings (11,600) for stocking the pen. No artificial feed was provided. After five months, and a survival rate of 62 percent, 2.8 t of fish worth US$ 330 were harvested. A cost-benefit ratio of 2.33 was achieved with a per capita profit of US$5.12 with 106 person-days of labor.

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FIGURE 6. *Carp seed rearing in pens installed in beel.*

Improving the Enabling Environment

Infrastructure and Support Services

Development of seed production technology, using suitable strains of preferred native species, will facilitate adoption of cage culture. A cluster approach needs to be taken to develop seed and feed production infrastructure, creating facilities/hubs for brood banks, market links, processing and value addition for easy access and profitability. Small-scale fish feed mills using regionally available ingredients and operated by farmers in a co-operative mode can be encouraged near production sites. Creation of a portal for fish seed hatcheries indicating the availability of quality fish seed will be of great use to entrepreneurs.

Development of processing and marketing facilities will provide employment opportunities and reduce post-harvest losses. Strengthening the value chain system through market links and creation of fish price portals will ensure better prices to producers. Spatial decision support system using GIS and remote sensing will be a very handy tool in reservoir and wetland fisheries management.

Governance and Policy Support

Implementing a suitable policy framework for governance and institutional arrangements to manage open-access, multi-stakeholder aquatic resources is vital. Suitable guidelines, laws and policies and an Inter-Ministerial Committee to resolve governance related issues should be in place for reconciliation of conflicts among various stakeholders of multi-use water bodies. Encouraging participatory and site-specific PPP mode of management will give an impetus to fisheries development and improve the likelihood for a more equitable distribution of benefits. Setting up of exclusive reservoir fisheries development board/authority can focus on the developmental and administrative needs to support management activities.

Conclusion

The huge untapped potential of inland open water bodies can contribute substantially to nutritional security and improving the livelihoods of the rural poor in India. Scientific adoption of culture-based fisheries, stock enhancement and enclosure culture in an ecosystem-based integrated watershed management regime will play a key role in achieving the promise of the Blue Revolution. The success of cage farming in Jharkhand and Chattisgarh has demonstrated the potential of cage culture technology in the country. Pen culture can enhance fish production from floodplain wetlands as evident from experiences in Assam, Bihar and West Bengal states.

Standardization of seed production technology, suitable fish strains, and development of high-quality feeds will facilitate adoption and expansion of cage culture across the country. A cluster approach needs to be undertaken in developing infrastructure and support services. Ensuring a suitable policy framework for governance and institutional arrangement is vital in realizing the productive potential of open-access, multi-stakeholder, inland openwater resources.

Notes

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