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Strategies for Sustainable Utilization of Openwater Fisheries Resources of Meghalaya: A Way Forward

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Abstract

The Northeast Indian state of Meghalaya with its vast inland fishery resources in the form of rivers (5,600 km), floodplain wetlands (500 ha), reservoirs (650 ha), lakes (50 ha) and ponds (0.02 lakh ha) offers tremendous scope for developing its fisheries sector, but lags behind in harnessing the potential. The state is deficient in fish production; it depends on additional fish supplied from Andhra Pradesh and other neighbouring states to fulfil its demand. There is an urgent need to increase fish production from available resources to fill the gap. To increase fish production, there is a need to utilize openwater fisheries resources of the state in a sustainable manner besides pond aquaculture. Sustainable development requires necessary initiatives in right direction at the right time with appropriate technological interventions. Right direction can result in holistic fisheries development based on proper planning taking into account contribution from all fisheries resources. Implementation of strategies in time with indicators of development can be worked out with proper planning. Strategies to prioritize the developmental work with realistic targets and guidance to achieve the goals are also required. Strategies also clearly depict priority action to be taken on immediate, medium term and long term basis along with milestones to track the progress and to achieve the goal. In this paper, we discuss strategies for sustainable enhancement of fish production from open water fisheries of Meghalaya based on the present scenario along with required infrastructural and human resources development with a realistic approach.

Keywords: Openwater fisheries, Meghalaya, Production enhancement, Sustainability

Introduction

Meghalaya lies in North-eastern region (89°45' to 92°48' E and 25°02' to 26°05' N) of India. The state capital of Meghalaya is Shillong. There are total eleven districts in the state covering an area of 22,429 km^2 with 33,66,710 populations (GoI, 2020). The districts derive their names from that of the tribes inhabiting the region. Prevailing climate in the state is characterized by heavy rainfall, which favours the action of streams to a considerable extent. The geological formations, its resultant topography and tendency of headward erosion by rain water have led to the creation of drainage networks in Meghalaya. The state is blessed with a number of perennial rivers most of which drain into Brahmaputra river of Assam. Fisheries sector has been one of the major sources of livelihood to a large number of masses in the state. It also contributes significantly towards strengthening household nutritional security. Fisheries resources in the state offer scope for development, but lags behind in harnessing their potential. The state has 0.02 lakh ha of tanks and ponds. The FFDA reported average productivity of 1,500 kg ha^{-1}yr^{-1} for pond culture (GoM, 2012). During the last five years, total fish production of Meghalaya followed an increasing trend and reverse is the case for total fish seed production. Meghalaya is predominantly a fish consuming state, constrained by

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inadequate fish supply against demand. Fishing/ fish farming from rivers, lakes, flood prone water bodies, tanks and ponds has been an important source of rural livelihood and food security base. Hence, there is an urgent need to increase fish production from available resources to bridge the ever increasing gap, which can be fulfilled through scientific and sustainable utilization of its openwater fisheries resources of the state besides pond aquaculture. In our previous study, we have suggested strategies for sustainable development of openwater fisheries of Assam (Das *et al*., 2018) and fisheries of Nagaland (Bhattacharjya *et al*., 2018). Behera *et al*. (2009) suggested strategies for sustainable increasing of fish production from Loktak Lake of Manipur. In this paper, we discuss strategies for sustainable enhancement of fish production from open water fisheries of Meghalaya based on the present scenario along with required infrastructural and human resources development with a realistic approach.

Materials and Methods

ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI) has been providing research support for openwater fisheries management to the North-eastern states through its Guwahati Research Centre. The present strategies for open water fisheries development in Meghalaya has been prepared based on extensive field studies carried out by the Institute in the region for the last several decades and with valuable inputs from different stakeholders. The information about the openwater fisheries of Meghalaya state was collected from the Department of Fisheries, Govt. of Meghalaya as well as secondary sources (Sugunan, 1995; GoM, 2012). The information was analysed, SWOT analysis along with identification of issues and challenges. The information of inland fisheries development was utilized through consultation with various stakeholders like scientists, policy makers, entrepreneurs and state fisheries officials. The technologies of ICAR-CIFRI were referred to and their appropriateness for implementation was also analysed. Microsoft-excel 2010 and SPSS software (Version 16.0) were utilized for analysing the information.

Results and Discussion

Openwater Fisheries Resources and Their Production Potential

Fisheries and aquaculture offer an attractive and promising sector for employment, livelihood, and food security in Meghalaya. The state has vast openwater fisheries resources in the form of rivers, reservoirs, floodplain wetland & swamps and lakes have offers tremendous scope for increasing fish production. Openwater fisheries resources of the state have high production potential (Table 1). Fish production in the state followed an increasing trend during last 5 years from 0.11 lakh tonnes during 2015-16 to 0.14 lakh tonnes during 2019-20. Indian major carps alone contributed 0.06 lakh tonnes followed by exotic carps (0.05 lakh tonnes) minor carps (0.02 lakh tonnes) and other freshwater fishes (0.01 lakh tonnes) to the total fish production of the state during 2019-20 (GoI, 2020). Fishes were marketed fresh in the local markets. The state has 16,567 fishermen population (11,547 male and 1,506 female) spread in all the 11 districts with 1,506 fishermen population per district. The fish seed production in the state has reduced drastically from 110.7 lakh fry during 2015-16 to 3 lakh fry during 2019-20 (GoI, 2020), which is a matter of concern. Fish consumption in the state reported to be 10.98 kg per capita during 2019-20 (GoI, 2020). The state is lagging behind in harnessing their potential of the vast fisheries resources and depends on Andhra Pradesh and other neighbouring states (especially Assam) to fulfil its demand of fish.

Table 1: Openwater fisheries resources of Meghalaya and their production potential

Openwater fisheries resources	Area (ha)	Potential productivity (kg $ha^{-1}yr^{-1}$)
Rivers	5,600 km	200 kg $km^{-1}yr^{-1}$
Reservoirs	650	500
Lakes	50	500
Floodplain wetlands & swamps	500	1500

Issues and Challenges for Development

Open water fisheries development in Meghalaya is likely to play an important role in socio-economic development of the state in the coming years by way of enhancement of income, livelihood and nutritional security of riparian population besides creating additional employment avenues and preventing draining out of meagre resources of the region towards fish import. Major challenges envisaged in this regard in the state are:

- Inadequate information about fisheries resources and their management guidelines for sustainable development.
- Inappropriate regulatory framework and mechanisms for controlling access to openwater fisheries resources.
- Poor economic status of the fishers, natural calamities, hilly terrain, *etc*. hinders developmental activities.
- Depletion of biodiversity along with use of destructive fishing gears in natural waters bodies.
- Non-availability of trained human resources and inadequacy of extension services critically hindering openwater fisheries development.
- Lack of proper sufficient fisheries infrastructure facilities, poor monitoring and inadequate enforcement mechanism.

SWOT Analysis

Strength	Weakness
✓ High demand for fresh and processed fish. ✓ Floodplain wetlands, reservoirs and lake fisheries resources have immense potential. ✓ Prospect of developing Coldwater fisheries at higher altitude. ✓ Presence of R&D Institutes viz., ICAR-RC- NEHR, Umiam and ICAR-CIFRI & NFDB Regional Centres (at Guwahati). ✓ Flow of fish seed and feed from Assam.	✓ Hilly terrain. ✓ Low productivity. ✓ Poor infrastructure. ✓ Un-utilization of openwater fisheries resources. ✓ Non availability of fish both in terms of quality and quantity. ✓ Poor economic status of the farmers. ✓ Acid soil and low winter temperature.

SWOT Analysis	
Opportunities	Threats
✓ Pen culture in floodplain wetlands for raising fish seeds and table fish. ✓ Scope for Culture- based fisheries in floodplain wetlands, reservoirs and Lakes. ✓ Scope for cage culture in reservoirs. ✓ Scope for infrastructure development (hatcheries, feed mills, etc.). ✓ Promotion of Coldwater fisheries. ✓ Scope for development of sport fisheries and aqua tourism.	✓ Increased pollution of openwater in coal mining areas. ✓ Lack of financial support. ✓ Shrinking of openwater fisheries resources due to siltation. ✓ Illegal encroachment of floodplain wetland and Lakes area. ✓ Discharge of untreated sewage, industrial and plastic waste emanating from Shillong to Umiam Lake.

Reservoir and Lake Fisheries Management

The North-eastern states of Meghalaya have massive potential for harnessing hydro-electricity. Hydel projects such as Umiam and Umtrew have caused construction of artificial reservoir/ lakes for the generation of electricity. The state Meghalaya has three important reservoirs namely Umiam, Kyrdemkulai and Nongmahir with immense fish production potential. Umiam reservoir is the largest of three with an area of 500 ha followed by Kyrdemkulai (80 ha) and Nongmahir (70 ha). The area under theses reservoirs comes to 650 ha. Besides these reservoir fisheries resources, there are 23 small lakes (50 ha) in the state spread across the districts with water areas ranging from 0.4 to 11.5 ha. These lakes are large resources whose productivity has not been harnessed by the state.

Stock enhancement is augmenting the stock of desired fish species through stocking or encouraging natural recruitment. The main aspects of stock enhancement are selection of species for stocking, determination of stocking rate and the size at stocking. Stock enhancement can be either to create a culture-based fisheries based predominantly on the recapture of stocked fish or to enhance/ supplement the self-recruiting populations. The technological backstopping provided for reservoir fisheries management of India by ICAR-CIFRI resulting in substantial increase in average fish production. The average annual fish productivity realized from reservoirs of India was very low (small: 49.9, medium: 12.3 and large: 11.4 kg $ha^{-1}yr^{-1}$) against the annual potential yield of 100, 75, and 50 kg $ha^{-1}yr^{-1}$ for small, medium and large reservoirs, respectively. The fish yield from Indian reservoirs has enhanced through fingerling stocking and adoption of improved management practices and the average productivity increased to 33, 94 and 174 kg ha^{-1} yr^{-1} from large, medium, and small reservoirs, respectively (Sarkar *et al*., 2018).

We proposed to practice stock enhancement regime of reservoirs and lakes of Meghalaya for enhancing fish production in a sustainable manner by stocking fingerlings of carps @ 2,000 fingerlings ha^{-1} for small reservoirs and @ 2,000-3,000 fingerlings ha^{-1} for lakes (Table 2). By adopting culture-based fisheries (CBF), we can produce 142.8 tonnes fish yr^{-1} from the reservoirs and 15.31 tonnes fish yr^{-1} from lakes of the state (by considering yield potential of 500 kg ha^{-1} for small reservoirs), which can be enhanced further by adopting cage culture in the reservoirs. As per guidelines of Govt. of India, reservoirs having area below 1,000 ha, cage culture is not permitted (NFDB, 2016). However, if any amendment of rule occurs, then cage culture can be practice to increase fish production from the reservoir with proper scientific guideline from ICAR-CIFRI and cooperation from fisheries department and local administration. Recently, ICAR-CIFRI, Regional Centre, Guwahati in collaboration with ICAR-Research Complex for NEHR, Umiam, Meghalaya and Department of Fisheries, Govt. of Meghalaya evaluated

Table 2: Estimation of requirements for culture-based fisheries in reservoirs and lakes

Reservoir (Small)	Total area (ha)	Available Area (ha)	Yield potential (tonnes)	Stocking rate (Fingerlings ha^{-1})	Fingerling requirement (Million Nos.)	Survival % (Assumed)	Expected production in tonnes (Expected fish growth = 0.35 kg $fish^{-1}$)
Reservoirs							
Umiam	500	300	150	2000	0.600	50	105.0
Kyrdemkulai	80	48	24	2000	0.096	60	20.16
Nongmahir	70	42	21	2000	0.084	60	17.64
Grand Total	650	390	195	-	0.780	-	142.8
Lakes							
< 1.0 ha	5.4	3.78	1.89	3000	0.01134	65	2.58
1 - < 5 ha	17.42	12.95	6.10	2500	0.03049	60	5.87
5-10 ha	15.0	10.50	5.25	2000	0.02100	55	4.04
> 10 ha	11.52	8.06	4.03	2000	0.01613	50	2.82
Grand Total	49.32	34.54	17.27	-	0.07895	-	15.31

Note: Available area for reservoirs is 60% and 70% for lakes of the total area

the feasibility of cage culture in Umiam reservoir using CIFRI-GI cage and CIFRI-CAGEGROW floating feed through community participation from fishers of Ri-Bhoi Farmers' Union, Umiam (Das *et al*., 2022a). They reported that Amur carp, Koi carp and Kuria labeo can be reared successfully in cages in reservoirs located in mid-altitude region of North-eastern India for enhancement of production, income, and livelihood of fishers.

Floodplain Wetland Fisheries Management

Floodplain wetlands are locally known as *Beel, Anoa, Haor, Jheel, Tal, Maun, Char, Pat, Dhal, Charha,* and *Baor* in different parts of Ganga-Brahmaputra-Irrawaddy basin (Sugunan and Bhattacharjya, 2000; Acharjee *et al.*, 2009; Das *et al*., 2009; Nath *et al*., 2017; Das *et al*., 2018; Borah *et al*., 2020; Sarkar *et al*., 2021). Fish production from this resource remained suboptimal over the years. There has been a decline in indigenous fish fauna from the wetland resources. Depths of wetland were declining over the years due to accumulation of silt and organic matter reducing water volume. Failure of natural recruitment of prized species due to closure of link channels also playing a negative role in wetland fisheries. Dense growth of macrophytes in several wetlands also prevents the harness its potential. In addition, the existing primary fishery Managers of the resources needs to be supported by technical manpower and knowledge upliftment.

CBF are effective in increasing fish yields when recruitment of desired fish species is lower than that of the water body. The basic strategy for fish yield enhancement here is stocking and recapture. Floodplain wetlands can be used for this management mode as recapture of the stock is possible. The growth of fishes in these water bodies will be faster compared to that of reservoirs due to availability of huge reserve of food niches. The success of CBF depends on the parameters such as size at stocking, stocking density, fishing effort, size at capture, selection of species and selection of fishing gear. Therefore, it is necessary to introduce the scientific management and techniques for improvement of fish yield in a sustainable manner from the wetland fishery resource of the state. Demonstration of management norms in a participatory mode in selected wetlands would encourage their adoption. *In-situ* production of fingerlings by pen culture and releasing the same in the beels for table size fish production may be practiced following the sustainable ecosystem management principles. Positive impact of CBF on fish yield in floodplain wetlands with special reference to North-eastern India has been reported by Borah *et al*. (2022a). Das *et al*. (2018) suggested CBF and enclosure culture are important production enhancement options for floodplain wetlands of Assam to increase fish production of the state. Successful adoption of CBF and pen culture in Bamuni beel of Assam reported an increase of 117% in total fish production and 153% in net income of 65 tribal fisher families (Das *et al*., 2022b). Similarly, CBF in Charan beel led to 64% increase in total fish production and 106% increase in net income and livelihood of 133 tribal fisher families dependent on the beel (Borah *et al*., 2022b). Das *et al*. (2017b,c,e) reported that fish stock enhancement by supplementary stocking of carp fingerlings in Mer beel of Assam resulted an increase in fish production of 507 kg $ha^{-1}yr^{-1}$ (2007-11) to 1,326 kg $ha^{-1}yr^{-1}$ (2011-16), which further increased to 1,465 kg $ha^{-1}yr^{-1}$ (2016-17) by stocking stunted carp fingerlings produced in pens as a stocking material. This leads to 188.95% increase in fish production during 2016-17 as compared to 2007-11 (intermittent stocking practice). Yadav *et al*. (2021) reported fish production of 206.4 kg $ha^{-1}yr^{-1}$ from beels without supplementary stocking regime and 455.2 kg $ha^{-1}yr^{-1}$ with supplementary stocking from beels of Assam.

Floodplain wetland (beels) and swamp fisheries resources contribute 500 ha to the total openwater resource of Meghalaya *viz*., Bor beel (80 ha), Katuli beel (36 ha), Kumligaon beel (20 ha) and others (364 ha). A total of 312.5 tonnes of fish can be produced annually from the floodplain wetland (beels) and swamp fisheries resources of the state by adopting stock enhancement regime and pen culture by stocking 3,000 fingerlings ha^{-1} for CBF and 10,000 fingerlings ha^{-1} for pen culture (Table 3). A total of 225 tonnes of fish can be produced annually from the floodplain wetland (beels) and swamp fisheries resources of the state by adopting culture-based fisheries by considering yield potential of 1,500 kg ha^{-1}. A total of 87.5 tonnes of fish by adopting pen culture in 10% of the total available area by considering average fish production in pens in beels of neighbouring state Assam is 3,500 kg ha^{-1} (Das *et al*., 2018). Total fingerling requirement for the stock enhancement regime in beels and grow out culture in pens (1 million fingerlings) can be obtained from 10% of the total available area by rearing 2 million fry (by assuming survival

Table 3: Potential of culture-based fisheries and pen culture (grow-out) expansion in floodplain wetlands

Floodplain wetlands (Beels, Swampy & Marshy lands)	Total Area (ha)	Available Area (50 %) (ha)	Total area available for CBF and pen culture (ha)	Yield potential (tonnes)	Stocking rate (Fingerlings ha^{-1})	Fingerling requirement (Million Nos.)	Survival % (Assumed)	Expected production in tonnes (Expected fish growth = 0.50 kg $fish^{-1}$)
CBF	500	250	225	375	3,000	0.75	60	225
Pen culture			25	87.5	10,000	0.25	70	87.5
Total	500	250	250	462.5	13,000	1.00	130	312.5

* Ideal pen size for fish culture: 1000-2500 m^2

rate of fry to fingerling is 50%). Total 25 ha pen area used for production of fish fingerling from fry stage can be re-used for production of table fish. Hence, the cost of fish seed and table fish production will be reduced to a greater extent. After rearing the fry for a period of 3 months, the same pen can be used for production of table fish for a 6 month culture period.

Requirement of Input and Infrastructure

A total of 1.859 million fish fingerlings will be required for increasing fish production (Table 4) and 25 ha water area will be required for producing the same (Table 5). A total of 160.722 tonnes of feed will be required for culture operations in openwater bodies of the state (Table 6). A hatchery with capacity of 15 million spawn per season with a target of 14.96 million spawn will be required to fulfil the seed requirement. A feed mill with capacity of 1 ton day^{-1} with a target of 160.722 tonnes yr^{-1} will be required. Feed is calculated based on its requirement from fry to fingerling stage @ 5% body wt. and mortality of 30% in 1st month, @ 4% body wt. and mortality of 20% in 2nd month and @ 3% body weight and mortality of 10% in 3rd month. The average body weight considered during 1st month is 2 g fry^{-1}, in 2nd month 4 g fry^{-1} and in 3rd month 6 g fry^{-1}.

Table 4: Requirement of fish seed for openwater fisheries of Meghalaya

Category	Total fingerling requirement (Million Nos.)	Total fry requirement (Million Nos.)	Spawn requirement (Million Nos.)	Egg requirement (Million Nos.)	Brooder requirement (kg)		Total brooders requirement (kg)
					Male	Female	
Pen culture	0.250	0.50	2.00	3.33	26	26	52
Stock enhancement	0.750	1.50	6.00	10.0	79	79	158
Lake fisheries	0.079	0.16	0.64	1.07	9	9	18
Reservoir fisheries	0.780	1.58	6.32	10.53	83	83	166
Total	1.859	3.74	14.96	24.93	197	197	394

Note: Survival rate of fry to fingerling is 50%; Survival rate of spawn to fry is 25%; Survival rate from egg to spawn is 60%; fertilized egg is 85%; average fecundity 1,50,000 nos. kg^{-1} brooders

Table 5: Area required for fish seed production

Type of pond	Stage of fish	Requirement	Stocking rate	Total area required (ha)	Cropsyear^{-1}
Brooder pond	Brooder	394 (kg)	1,500 kg ha^{-1}	0.263	1
Nursery pond	Spawn	14.96 (million nos.)	10 million ha^{-1}	3.74	4
*Rearing pond	Fry	1.74 (million nos.)	0.2 million ha^{-1}	4.35	2
**Pen	Fry	2.0 (million nos.)	0.08 million ha^{-1}	25	1

* Required for production fingerling for stocking in reservoir and lake; ** After production of fingerling, the pen structure will be used for production of table fish (6 month culture period)

Table 6: Requirement of feed for various culture operations

Purpose	Fish	Feed required (tonnes)
Brooder feed	394 kg	2.88
Nursery feed	14.96 million Nos.	3.142
Rearing feed (pond)	1.74 million Nos.	18.72
Pen (fry)	million Nos.	4.73
Pen (table fish)	87.5 tonnes	131.25
Total	-	160.722

Nursery @ 210 kg feed million spawn-1 (20 days); Average body weight = 4 g and average ration is 4% of body weight; Brooder pond (maintenance throughout the year); ration 2% of biomass; 1.5 FCR for table fish production in pen.

Expected Fish Production from Openwater Fisheries

Sustainable utilization of Inland open water fisheries resources of Meghalaya can lead to total annual fish production of 470.61 tonnes (excluding riverine fisheries). This will lead to gross revenue generation of INR 705.92 lakh by assuming cost of fish is INR 150 kg^{-1} (Table 7). The openwater fisheries sector not only increases fish production and revenue of the state but also provides employment, livelihood, and food security for the people.

Riverine Fisheries Management

Major rivers of the state harbors a variety of fish species, but due to indiscriminate fishing, their population is sharply declining. River being an inter-state subject, national policies aimed at safeguarding riverine fisheries can be of great benefit.

• Educating masses on the importance of riverine fisheries and conservation of biodiversity through awareness programmes.

Table 7: Expected fish production

Sl. No.	Type of resource	Total area (ha)	Total available area for fish production (ha)	Expected production in tonnes	*Gross revenue (in lakh INR)
1	Reservoir	650	390	142.8	214.20
2	Lake	49.32	34.54	15.31	22.97
3	Wetlands	500	250	225.0	337.50
4	Pen (wetland)	500	25	87.5	131.25
	Total	1699.32	699.54	470.61	705.92

• Ranching with selective indigenous fish species, after proper assessment.

• Enforcing ban period, craft and gear regulation and blanket ban on destructive fishing practices.

• Developing fish sanctuaries in potential fish breeding grounds.

• Formulation of guidelines and action points for declaring selected areas of rivers as "Fishery Reserve Area" for facilitating fish seed production, propagation and higher availability of catch.

Human Resource Development

• Technical and financial support for empowering fisher/ local communities for managing their resources.

• Training and capacity building programmes for state fisheries department officials, Farmers organisations, Cooperatives, Self Help Groups and NGOs.

• Wide scale dissemination of information/ knowledge and adoption of technology through all available means of ToT including KVKs, mass media, *etc*.

• Publication and dissemination of state specific technology packages in regional languages.

• Reservoir fisheries management through fishermen cooperative society regime/ community participation.

• Development of linkage among all R&D institutes in the field of fisheries.

• Implementation of e-connectivity facility within the department officials.

• Integrated approach of management within different departments.

• Strengthening institutional and governance instruments.

Broad Recommendations

• Implementation of fish stock enhancement regime by supplementary stocking carp fingerlings in reservoirs, lakes and floodplain wetlands for production enhancement including pen culture for fish seed raising/ grow-out culture in *beels*. Cage culture in reservoirs and deeper beels with proper scientific guidelines and its compliance by local administration of the state.

• Proper management of openwater fisheries resources of the state in terms of minimum landing size, closed fishing seasons, catch quota restrictions, aquatic macrophyte management, *etc*. are needed for their sustainable utilization.

• Community-based fisheries management of wetlands and reservoirs is suggested for equitable distributions of benefits from these openwaters to the riparian community.

• Appropriate fish species selection with emphasis on indigenous fish species is required for fish stock and species enhancement in wetlands and reservoirs.

• Breeding and culture of indigenous high value fish species in marshy wetlands should be promoted in the state.

• HRD programmes may be organized on a regular basis for capacity building amongst all the stakeholders including fishers/ fish farmers/ lessees and fisheries officials on openwater fisheries management, enclosure culture, community-based fisheries management, *etc*.

• There is a need to undertake more demonstrations/ on-farm trials of fisheries management guidelines/ technologies on openwater fisheries management.

• Extension machineries can be used effectively for the efficient dissemination of technologies/ technical knowledge on openwater fisheries management.

Significant Interventions of ICAR-CIFRI

ICAR-CIFRI has carried out different research and development activities for production enhancement from openwater fisheries resources of Meghalaya through its Guwahati Research Centre.

• Studied ecology and fisheries of three unexplored floodplain wetland of Meghalaya *viz*., Boro, Kumligaon and Katuli *beel*. A total of 65, 57 and 54 fish species were recorded respectively for the first time (Das *et al*., 2017d).

• Feasibility of cage culture in Umiam reservoir using CIFRI-GI cage (6 no.; 100 m^3 $cage^{-1}$) and CIFRI-CAGEGROW floating feed was evaluated for the first time (Das *et al*., 2022a).

• Efforts have been made to study ecology, fisheries and livelihood of reservoir fishers of the state. Seasonal study of ecology and fisheries of Umiam reservoir is being carried out.

• Exploratory survey to document biodiversity (including ornamental fishes) of the state. Organized awareness programmes for conservation of fisheries resources of the state.

• Pen culture in *beels* can be effectively used for fish seed production/ grow-out culture. ICAR-CIFRI initiated pen culture using CIFRI-HDPE pen in *beels* of the state.

• CIFRI- CAGEGROW floating feed (26-28% protein and 4-5%

fat) developed by the Institute has been distributed among fish farmers/ fishers of the state through several awareness-cum-training and fish feed distribution programmes.

• Organizing capacity building programmes for the state fisheries officials and other stakeholders (including non-government personnel) on different aspects of openwater fisheries management.

• Training of farmers and fishers of Meghalaya on different aspects of openwater fisheries including different aquaculture practices.

• Prepared a roadmap document for development of openwater fisheries in Northeast India (Das *et al*., 2017a).

Conclusion

The strategies suggested in this paper will help in augmenting the fish production, which will provide food and nutritional security of the state and its neighbourhood and also for livelihood improvement of the underprivileged population. On priority basis CBF and pen culture in the floodplain wetlands and CBF in reservoirs and lakes should be promoted for increasing fish production in the state. Cage culture through community participation can be a viable option towards enhancing fish production from reservoirs with proper scientific guidelines from ICAR-CIFRI and its compliance from fisheries department and local administration of the state. Further, there is also immense potential for sport and recreational fisheries in the state. Long-term planning is needed for renovation and restoration of fisheries resources, developing better human resources, creation of infrastructural facilities and fish seed ranching in rivers.

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