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Openwater Fisheries of Assam and Strategies for its Development

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Introduction

Assam is said to take its name from 'Asom' that alludes to the state's uneven topography comprising of both hills and plains. The state, situated in the northeast region of India covers an area of 78,438 sq km. It is bordered by Bhutan, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Bangladesh and West Bengal.

The state can broadly be divided into three distinct geographical regions; the Brahmaputra Valley in the north, the Barak Valley in the narrow protruding south and the Hills Zone (Karbi and North Cachar hills) separating the two valleys. The Brahmaputra valley is the largest zone in the state and is approximately 80 to 100 km wide and almost 1000 km long. It is bisected by River Brahmaputra, which is a large braided river with 16 km width at some places within the valley. The Barak valley is smaller with an average width and length of approximately 40 to 50 km. The state experiences heavy rainfall (average annual rainfall is 120 inches) and high humidity. The hilly areas usually experience sub-alpine climatic conditions whereas excessive sultriness is observed in the plains.

Fisheries resources and production

The undulating topography and high rainfall has given rise to vast and varied fisheries resources (Table 1) in the state in the form of rivers, floodplain wetlands/beels (60,215 ha), derelict water bodies/swamp/low-lying areas (116,444 ha), forest fisheries (5017 ha), reservoirs (2553 ha), individual ponds (55,430 ha) and community ponds (5141 ha).

Fish production in Assam has increased from 188,000 tonnes in 2005-06 to 306,600 tonnes during 2016-17 (Table 2). An increasing trend in fish production was observed during the period, which augurs well for the fisheries sector of the state. Fish seed production in the state increased from 2063 million in 2006-07 to 6758 million in 2016-17. It also showed a more or less rising trend since 2006-07 with slight decline in seed production in 2009-10. The average fish fry production in the state is 4500 million,

Table 1: Fisheries resources of Assam

Sl. No.	Resources	Number	Length/Water spread area
1.	River fisheries	Main rivers: 2 Tributaries:53	4820 km
2.	Floodplain wetlands (Beel/ Ox-bow lakes)	Registered: 430 ---------- Unregistered: 767	60215 (ha) ---------- 40602 (ha)
3.	Derelict water bodies/ swamp/ low-lying areas	3887	116444 (ha)
4.	Forest fisheries	71	5017 (ha)
5.	Reservoir fisheries	2	2553 (ha)
6.	Individual ponds	361393	55430 (ha)
7.	Community ponds	6308	5141 (ha)

Source: Department of Fisheries, Assam (2017)

Table 2: Total fish and seed production of Assam

Sl. No.	Year	Production (thousand tonnes)	Seed production (No. in million)
1.	2005-06	188.00	3208
2.	2006-07	181.48	2063
3.	2007-08	190.32	3207
4.	2008-09	200.15	3429
5.	2009-10	218.82	3326
6.	2010-11	232.340	4264
7.	2011-12	243.870	4490
8.	2012-13	254.270	4364
9.	2013-14	266.700	4545
10.	2014-15	282.700	4585
11.	2015-16	294.200	5678
12.	2016-17	306.600	6758

Source: Directorate of Fisheries, Government of Assam (2017).

Table 3: Resource-wise potential and actual productivity in Assam

Resource	Potential productivity (kg/ha/yr)	Present fish yield rate (kg/ha/yr)
Floodplain wetlands (beels)	300 (Capture fisheries) 1500 (Culture-based fisheries)	221 (Un-stocked) 450 (Stocked)
Reservoirs	100	-
River: Brahmaputra --- Tributaries	900 kg/km/yr --- 450 kg/km/yr	190 kg/km/yr

Note: Average fish yield rates from beels under AFDC Ltd. during 2003-04 to 2013-14.

whereas the production of fingerlings is 135 million against the estimated requirement of 350 million. With a nutritional demand of 11 kg per capita consumption (present per capita consumption is 9 kg), the state needs approximately 3.36 lakh tonnes of fish. The gap between fish production and demand was 0.29 lakh tonnes during 2016-17.

Thus, it is essential to increase fish production from available fisheries resources to fill the gap. Even though Assam has made considerable progress in pond aquaculture and fish seed production (6758 million during 2016-17) in the recent past, there is huge untapped potential for development of openwater fisheries (floodplain wetlands, reservoirs, rivers, etc.) in the state. This will not only improve production but also preserve the fisheries resources and the indigenous species therein for their sustainable utilisation.

ICAR-CIFRI, Barrackpore has been providing research support for openwater fisheries management to the northeastern states in general and Assam in particular through its Guwahati Research Centre since 1971 (upgraded to a Regional Centre in 2008). The present article for openwater fisheries development in Assam has been prepared based on extensive field studies carried out by the Institute in the state over the past four decades and with valuable inputs from the Department of Fisheries, Government of Assam.

With a nutritional demand of 11 kg per capita consumption (present per capita consumption is 9 kg), the state needs approximately 3.36 lakh tonnes of fish. The gap between fish production and demand was 0.29 lakh tonnes during 2016-17.

Productivity and potential of openwater resources

Extensive studies conducted by ICAR–CIFRI in selected floodplain wetlands (beels) of Assam have shown that these wetlands have high fish production potential (1000- 1500 kg/ha/yr). Analysis of data collected by the Assam Fisheries Development Corporation during the past decade have

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Table 4: Proposed expansion of culture based fisheries in floodplain wetlands of Assam

Resource	Area (ha)	Area proposed to be used for different management options (in ha)		Present yield* (kg / ha / yr)	Projected yield (kg/ ha/yr)	Present production (t)	Projected production (t)	Gap (t)	Projected increase (times)
Beels	100815	Capture fisheries	65000	221	300	14365	19500	5135	1.36
		CBF	30000	450	1500	13500	45000	31500	3.33
		Conservation	5815	221	-	1285	-	-	-
		Total				29150	64500	36635	2.21

Note: (i) Decadal average yield from stocked and un-stocked beels are at 450 kg/ha/yr and 221 kg/ha/yr respectively and (ii) *30%, 65% and 5% of the total beel area of the state is proposed to be utilised for stock enhancement, capture fisheries and for conservation of indigenous fish diversity respectively.

shown that the average fish yield rates from un-stocked and stocked beels are 221 and 450 kg/ha/yr respectively. The potential productivity from capture and culture based fisheries of the beels have been gauged to be 300 and 1500 kg/ha/yr based on actual fish yield rates in recent years and their estimated fish production potential. ICAR-CIFRI had calculated the average fish production potential from the Brahmaputra and its important tributaries in Assam at 92.3 and 86.8 kg/ha/yr during 1996-98. Due to the variable width of the rivers, it is fairly difficult to give an exact assessment of their area. Therefore the potential productivity of the Brahmaputra and its tributaries (including Barak) has been approximated to 900 kg/ha/yr. The potential productivity and present fish yield rates from different openwater fisheries resources of Assam are presented in Table 3.

1. Floodplain wetlands (*beels*)

Floodplain wetlands popularly known as beel (in Brahmaputra Valley), anoa and haor (in Barak Valley) are considered to be one of the most potential openwater fisheries resources of Assam both in terms of their high fish production potential (1000- 1500 kg/ha/yr) and large resource size (over 1 lakh ha). Beels have remained the mainstay of capture fisheries in the state and are a repository of a rich variety of indigenous fish species. However, natural fish production in most beels has either reached a plateau or has started declining in recent years due to loss of riverine connectivity, decrease in area/depth due to siltation, heavy macrophyte infestation, pollution, over-fishing and so on. In order to increase their fish production, many beel managers/users are resorting to supplementary stocking. Studies conducted by ICAR-CIFRI on fish stock enhancement in beels of Assam showed that most beels are either under or over–stocked (the Institute recommends a stocking density of 3000 and 3600 fingerling / ha for closed and seasonally open beels respectively). Most wetlands are stocked arbitrarily with seed of IMC and exotic fish species (mostly fry) available in the locality without following species ratio, species composition, size of seed stocked and size at harvest leading to lesser fish yield. Shortage of quality fish seed especially carp fingerlings (10 cm and above) also appears to be an impending factor at many places. In addition, the existing primary fishery managers of beel fisheries need to be supported by technological backstopping and knowledge upgradation from time to time.

Natural fish production in most beels has either reached a plateau or has started declining in recent years due to loss of riverine connectivity, decrease in area/depth due to siltation, heavy macrophyte infestation, pollution, over-fishing and so on. In order to increase their fish production, many beel managers/users are resorting to supplementary stocking.

Culture-based fisheries are effective in improving fish yield when recruitment of desired fish species is low thereby resulting in sub-optimal fish production. The basic strategy for fish yield enhancement here is stocking and recapture. Floodplain wetlands are amenable for this management option as recapture of the stock is feasible here due to smaller area and usually manageable water depths. The growth of fish in the wetlands are expected to be faster in beels than that in reservoirs due to availability of huge reserves of food niches and higher production potential. The success of culture-based fisheries depends on certain parameters such as size of stocking, stocking density, fishing effort, size at capture, selection of species and selection of fishing gear. Fish production is expected to rise by 36,635 kg with the expansion of culture based fisheries in 30% of the beel area and capture fisheries

Fig 1: *Sibasthan beel*: A closed beel in Nagaon district of Assam

Fig 2: Pen culture in *Mer beel* Nagaon district of Assam

Fig 3: Stock enhancement in *Sorbhog beel* Barpeta district of Assam

Fig 4: CIFRI GI cage at Samaguri beel in Nagaon district of Assam

Fig 5: Cage culture in Charan beel of Morigan district Assam during 2013

in the rest (including 5% area kept for conservation of indigenous fish stocks) (Table 4).

It is necessary to undertake scientific management for capture fisheries (includes conservation of fish stock, habitat, control of fishing effort, etc.) and various enhancement options like fish stock enhancement (including culture-based fisheries), species enhancement, enclosure aquaculture, habitat enhancement and so on. 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.

ICAR-CIFRI has classified the beels of the state based on their size and riverine connectivity. This helps to decide applicability of available enhancement options. Demonstration of management modules in a participatory mode through the joint efforts of R&D agencies and beel user communities involved in openwater fisheries in selected wetlands would encourage the beel users to adopt these modules. *In situ* production of carp fingerlings through pen and cage culture and releasing the same in the beels for table size fish production may be practiced for fish yield enhancement. Integrated development of beel fisheries by accommodating capture fisheries with location specific enhancement options may be practiced for sustainable fish production. This must be conducted following ecosystem based management principles.

30% of the total beel area on record (mainly in small sized closed and seasonally open ones) has been reserved for the development of culture-based fisheries considering their present ecological conditions and management regimes. The remaining area may be kept aside for properly-managed capture fisheries by conserving/restoring the beel habitat and natural fish stocks as well as monitoring exploitation levels. This is likely to ensure livelihood of riparian fishers and production of nutrient-dense small indigenous fish (e.g., mola, koroti, magur, singi, etc.) for nutritional security. Such a combined strategy is expected to increase fish production of the state by 36,635 kg, which is 2.21 times the present estimated fish production from the beels (Table 4).

Recent introduction of mola carplet (*Amblypharyngodon*

Table 5: Seed requirements for culture-based fisheries in floodplain wetlands of Assam

Area of floodplain wetlands (in ha)	Available area in ha (approx 30% of total)	Recommended stocking density fingerlings (nos./ha)	Total fingerling requirement for stock enhancement (million nos.)	Total fry requirement (million nos.)	Total spawn requirement (million nos.)	Total brooder requirement	
						Male (kg)	Female (kg)
100815	30000	3600	108	216	864	9600	9600

Note: Assuming survival rate of fry to fingerling as 50%; that of spawn to fry as 25%; and that from egg to spawn as 60%.

Table 6: Potential of pen culture expansion in beels of Assam (fingerling raising and grow- out)

Category	
Area of floodplain wetlands (in ha)	100815
Available area in ha (30% of total)	30000
Stocking density of fry in pens (nos./0.1 ha)	8000
Stocking density of fingerlings in beels for stock enhancement (nos./ha)	3000
Stocking density of fingerlings in pens for grow-out culture (nos./0.1 ha)	1000
Total area available for pen culture (ha) for whole of Assam	3000
Total fingerling requirement for grow-out culture in pens (million nos.)	30
Total fry requirement for grow-out culture in pens (million nos.)	60
Total spawn requirement for grow-out culture in pens (million nos.)	240
Male brooder requirement in kg	2667
Female brooder requirement in kg	2667
Total brooder requirement in kg	5334
Feed requirement in pens in tonnes (FCR-1.5) for table sized fish production at 5.25 tonnes/ha	15750
Expected table fish production in tonnes from pens in one crop at 3.5 tonnes/ha	10500

Note: (i) Survival rate of fry to fingerling is 50%, spawn to fry is 25% and egg to spawn is 60% and (ii) 10% of the total utilisable beel area can be demarcated for pen culture.

mola) on a trial basis in Gurguria-Barsinga beel of Nagaon district by the lessee showed that species enhancement is a sustainable and low-cost option for increasing production of certain nutrient-dense small indigenous fish species in the state.

While doing so, it is advisable that 5% of the total beel area be earmarked for conservation of indigenous fish stocks (keeping in view apparent decline in natural fish stocks in the state over the years due to habitat degradation and over-fishing). Instead of declaring the entire beel as a sanctuary (which may adversely affect livelihood of riparian fishers) approximately 1% of area of certain beels that have high indigenous fish biodiversity can be earmarked as closed fishing areas using permanent brush parks for

Table 7: Fish seed requirements for culture-based fisheries development (including pen culture) in beels.

Enhancement option	Total fingerling requirement	Fry requirement	Spawn requirement	Brooder requirement (Kg)		Total brooder requirement (kg)
	In million numbers			Female	Male	
Culture-based	108	216	864	9600	9600	19200
Pen culture	30	60	240	2667	2667	5334
Total	138	276	1100	12267	12267	24534

Note: Assuming survival rate from fry to fingerling as 50%; from spawn to fry as 25%; and from egg to spawn as 60%.

Table 8: Requirement of feed for various culture operations in floodplain wetlands

Purpose	Feed required (tonnes)
Feed for pen culture	15750.00
Brooder feed	179.09
Nursery feed	231.00
Rearing feed	2608.20
Total	18768.29

Note: (i) Feed requirement for nursery rearing at 210 kg/million spawn (20/days). (ii) Feed requirement from fry to fingerling stage estimated assuming feeding rate at 5% body wt. and 30% mortality in 1st month; at 4% body wt. and mortality of 20% in 2nd month; at 3% body weight and mortality of 10% in 3rd month; Average body weight during 1st month - 2 g/fry, 2nd month - 4 g/fry and in 3rd month - 6 g/fry; Average body weight 4g and average ration 4% of body weight for the entire rearing period and (iii) Brooder pond (maintenance throughout the year); feed ration 2% of biomass.

Table 9: Area requirement for various seed production operations in floodplain wetlands

Type of pond	Stage of fish	Requirement	Stocking rate	Total area required (ha)	Crops per year
Brooder pond	Brooder	24534 (kg)	1500/kg/ha	16.36	1
Nursery pond	Spawn	1100(million nos.)	10 million/ha	27.50	4
Pen	Fry	240 (million nos.)	80000 nos./ha	3000	1

Table 10: Cage culture as an alternative option for fingerling raising in floodplain wetlands

Category	Quantity
Stocking density of fry in cages (nos./m^3)	250
Average stocking density (nos./ha) for stock enhancement in beels of Assam	3000
Total number of fry (nos.) required per ha for stock enhancement in beels	6000
Total number of cages (nos.) required per ha to raise fingerlings from fry stage	4

Note: (i) Dimension of CIFRI GI cage for wetlands is 5x5x2.0 m^3 (extendable upto 4m), which corresponds to an available water volume of 40 m^3 per net cage and a battery can comprise of upto 16 cages and (ii) Stocking density in cages is 250 nos. fry/m^3 and (iii) Survival rate of fry to fingerling is 50%.

conservation of fish stocks. The area under floodplain wetlands in the state need to be re-assessed from time to time through satellite remote sensing and collection of ground truth data considering the shrinkage in beel area due to siltation, reclamation for other uses, etc. Impact of climate change on ecology and fisheries of the beels also need to be studied for evolving suitable climate resilient management measures.

However, to undertake culture based fisheries in 30,000 ha beel area, the state would require 108 million carp fingerlings, in other words, that comes to 864 million spawns. Fish seed and feed requirements for fisheries enhancement in beels have been presented in Table 5 to 10.

Cage culture in beels for in site fish seed rearing: Cage culture technology developed by ICAR- CIFRI can be adopted for rearing fish seed as an alternative to pen culture in deeper beels (depth (> 3m), (land using floating net cages) less macrophytes, etc. Fish fingerlings produced

Table 11: Potential for development of fish stock enhancement and culture-based fisheries in reservoirs of Assam

Reservoir	Total Area(In ha)	Available Area (60 %)(In ha)	Yield potential (In tonnes*)	Stocking rate	Fingerlings/ ha	Fingerling requirement (Million no.)	Expected production in tonnes (at 50% survival); Expected fish growth = 0.5kg/fish	Expected production in kg/ha
Umrang (Small)	979	587.4	293.7	1000	0.587	146.85	250	
Khandong (Medium)	1335	801	160.2	500	0.4	100	125	
Total	2314	1388	3095.2	1500	0.987	246.85		

Note: Potential fish yield is 500 kg/ha for small, 200 kg/ha for medium and 100 kg/ha for large reservoirs.

Table 12: Potential of cage culture expansion in reservoirs

Category	Khandong reservoir
Total area (ha)	1335
Available area (60 %) (ha)	801
1 % area for cage culture (ha)	8
Number of cages required (nos.)	3337
Stocking material for table fish production (million number)	8.41
Feed requirement (tonnes)	10013
Expected table fish production (tonnes) from all cages in one crop	6675

Note: (i) Number of cages required is calculated by keeping 50% units each for table fish production for seed raising and (ii) Stocking density in cages (for Pangas): at 60 no./m3 (5040 no. per cage); Cage dimensions: 6x4x4 m3, width of the catwalk: 0.75 m; Survival rate from fingerling to table size: 85%; Fish production per cage: 4 T; Feed requirement per cage: 6 T, assuming 1.5 FCR; Estimated cost including recurring cost: Rs 3 lakh.

Table 13: Requirement of fish seed for fisheries enhancement in reservoirs

Resources	Total fingerling requirement @ 70% survival	Fry requirement @ 40% survival	Spawn requirement	Brooder requirement (kg)		
	Million nos.	Million nos.	Million nos.	Female	Male	Total
Cage culture	8.41	12.01	30.04	255	250	500
Reservoir stocking	0.987	1.41	3.53	39	39	78
Total	9.397	13.42	33.56	289	289	578

Note: Fecundity: 2,00,000 eggs/kg body weight and survival rate from egg to spawn 60% for Pangas and 150,000 eggs/kg body weight for IMC (for reservoir stocking).

The total feed required to realise the additional fish production proposed for both reservoirs and wetlands is approximately 28,936.26 tonnes/ yr, taking enhancement options into account.

in the floating cages can be used for stock enhancement in the beels. Floating net cages are useful for *in situ* carp fingerling rearing in seasonally open beels receiving flood waters during the southwest monsoon season. The details of seed raising in cages are given in Table 10.

2. Reservoir fisheries

Assam has two reservoirs at present *viz., Umrang* (a small reservoir with an area 979 ha) and *Khandong* (medium-sized, 1335 ha) that can be used to increase fish production. It can either be useful to develop culture-based fisheries based predominantly on the recapture of stocked fish or to enhance/supplement the self-recruiting populations. ICAR-CIFRI has provided technological backstopping to reservoir fisheries management in 23 States resulting in substantial increase in average reservoir fish production in the country. The mean post stocking yield in 225 reservoirs in 12 States, where yield increment was recorded, ranging from 5.3 to 889 kg/ha compared to the pre-stocking yield range of 1.5 to 310 kg/ha. By bringing Khandong reservoir (medium-sized) under fish stock enhancement and Umrang reservoir (small) under culture-based fisheries, fish production can be increased to 246.85 tonnes (Table 11).

The medium-sized reservoir (Khandong) can be used for initiating cage culture initially for Pangas to produce 6,675 tonnes (Table 12). Requirements for fish seed and feed in reservoirs of Assam have been presented in Table 13 and 14.

Infrastructure required: The total feed required to realise the additional fish production proposed for both reservoirs and wetlands is approximately 28,936.26 tonnes/ yr, taking enhancement options into account. In order to

Table 14: Requirement of feed for various enhancement options in reservoirs

Purpose	Feed required (tonnes)
Cage feed	10013
Brooder feed	4.22
Nursery feed	7.04
Rearing feed	143.42
Total	10167.97

Note: (i) Feed requirement for nursery at 210 kg/million spawn (for 20 days) (ii) For fingerling rearing calculated assuming individual average weight as 3.5 g and feed ration at 4% body weight for 90 days and (iii) For Brooder pond (maintenance throughout the year); ration at 2% of biomass.

Table 15: Infrastructure requirement

Infrastructure	Capacity	Target	Nos. required	Existing infrastructure
Hatchery	60 million spawn/ season	1133.56 million spawn	19	391
Feed mill	10 tonne/day	28936.26 tonnes/year	8	8
	20 tonne/day		4	

Table 16: Expected fish production

Sl. No.	Type of resource	Expected production in tonnes
1.	Cage (reservoir)	6675
2.	Reservoir	246.85
3.	Wetlands	64500
4.	Pen (wetland)	10,500
	Total	81921.85

achieve this target feed quantity locally, 8 feed mills of 10 tonnes capacity per day and 4 feed mills of 20 tonnes capacity per day will be required (Table 15).

In order to produce 1,133.56 million additional spawns for fisheries enhancement in reservoirs and wetlands, 28 new hatcheries will be required to be established considering the fact that about 3 m^3 water area is necessary to breed 1 kg of female. To spawn approximately 25-30 kg of female broodfish in one cycle, the optimum dimension of the spawning pool would have to be 6 m X 2.5 m (diameter x depth) with total volume of about 75 m^3 . A total of 30 lakh spawns can be produced per cycle using 30 kg of female and 30 kg of male brooders. If the total operational period is 90-100 days with 3-4 days for each spawning cycle followed by 1-2 days gap for sanitation, a total of 20 spawning cycles can produce 60 million spawn. Therefore, atleast 19 hatcheries need to be established, each having a production capacity of 60 million spawns to produce 1133.56 spawns (Table 15). These 1133.56 million spawns will give rise to 289.42 million fry and 148 million fingerlings which will be required for stocking the beels, reservoirs (including pens and cages) to achieve the production target.

Expected fish production: The total expected fish production from the state after intervention through scientific management (enclosure culture and stock enhancement) is 81,922 tonnes (Table 16).

3. Riverine fisheries

Rivers Brahmaputra and Barak with their tributaries constitute rich riverine fisheries in Assam with a combined length of 4820 km. Brahmaputra flows for 640 km in Assam from Sadiya to Dhuburi before it enters Bangladesh. It has 42 important tributaries in the state (27 in the north bank and 15 on the south bank). The Barak is a smaller river flowing through southern Assam into Bangladesh joining River Padma. These two river systems harbour a variety of indigenous fish species. However, there has been a gradual decline in the stock of many riverine fish species due to indiscriminate fishing and habitat modifications over the years. Effective policy-making and safeguarding the rivers would benefit the riverine resources in the long run.

- Educating the people about the importance of rivers from the fisheries perspective and conservation of biodiversity through government sponsored mass awareness programmes.
- Ranching with selective fish species if required, after proper assessment.
- Enforcing the ban period, craft and gear regulation and ban on destructive fishing practices.
- Developing fish sanctuaries in reserved areas and deep pools.
- Formulating guidelines and action points for declaring selected areas or parts as “Fishery Reserve Area”. This would facilitate fish seed production, propagation and higher availability of catch size fish.

Human resource development

Human resources and manpower development has become imperative to boost fisheries development in the state. The following are some of the steps that can go a long way in strengthening human resources:

- Approximately 5000 farmers can be trained (1 trained farmer/20 ha) for culture based fisheries in beels and another 100 farmers for reservoirs.
- Additionally, 500 innovative farmers may be trained by ICAR-CIFRI on various aspects of cage and pen aquaculture.
- More number of training centres can be established for farmers apart from the already existing ones. Currently, there are 6 training centres under Department of Fisheries for farmers, 1 training centre for government officials and 2 training centres for creating skilled manpower (fishery demonstrators) in the state.
- The subject of Fisheries needs to be strengthened by creating the post of ‘Subject Matter Specialist’ at Krishi Vigyan Kendras in each of the 33 districts. At present there are only 10 fisheries experts in different districts.
- Matsyamitra scheme may be continued in Assam to facilitate the para fisheries workers to disseminate scientific/ technical knowledge at village level.
- The intake capacity of the State Fisheries college at Nagaon can be increased to improve scientific manpower. Currently the college produces 25 fishery graduates every year.
- *Meenmahotsav* may be organised on a regular basis (biennially) to bring about awareness, disseminate knowledge and new technologies. It would act as a common platform for farmers, experts, government officials and private sectors.

Table 17: Human resource requirement for fisheries development in Assam

Category	Sanctioned strength	Existing strength	Requirement
Class I	250	175	75
Class II	29	6	23
Class III	706	563	143
Class IV	361	288	73
Total	1346	1032	314

Source: Directorate of Fisheries, Government of Assam

SWOT Analysis of the state's fisheries scene

Strength	Weakness
• High demand and price of fish as a food commodity. • Rich in openwater fisheries resources. • More than 1 lakh ha of floodplain wetlands (beels), which is second highest in the country. • Presence of R&D Institutes (CIFRI-RC, Guwahati & COF, AAU, Raha). • River Brahmaputra's considerable contribution to total fish production & germplasm. • Reportedly self- sufficient in fish seed (fry stage).	• Over-exploitation of most of the indigenous fish species. • Gap between potential and current production • Deficient in fish production. • Lack of quality fish seed. • Declining auto recruitment of major fish species in most openwater fisheries. • In-sufficient funds for openwater fisheries development.\ • Multiple ownership and users of fishery resources.
Opportunities	**Threats**
• Scope for stock enhancement in seasonally open and closed beels. • Pen culture in marginal areas of beels for raising fish seed and production of table fish. • Cage culture in deeper wetlands and reservoirs for raising fish seed. • Scope for development in ornamental and sport fisheries, aqua-tourism and promotion of SIFs. • Integrated development of openwater fisheries. • Community fisheries management. • Steady development of Fisheries and aquaculture in the last decade.	• Loss of connectivity to parent river & siltation. • Shrinking areas of openwater due to encroachment and urbanisation. • Indiscriminate fishing. • Trans-boundary fish diseases. • Inflow of exotic species.

• Reservoir fisheries can be allowed to be managed by fishermen cooperative societies.

The details of sanctioned strength, existing manpower and requirement under different categories in Directorate of Fisheries, Government of Assam is given in Table 17.

Broad Recommendations

1. Low-input pen/cage aquaculture can be practised in beels/reservoirs of the state (parallel to their capture fisheries/fish stock enhancement) to augment production with emphasis on species diversification.
2. Proper management of open-water fisheries in terms of minimum landing size, closed fishing season, catch quota restrictions, aquatic macrophyte management, etc. are needed for their sustainable utilisation.
3. Community-based fisheries management of wetlands and reservoirs is suggested for equitable distribution of benefits from these open-waters to the riparian community.
4. Appropriate fish species selection with emphasis on indigenous fish species is required for fish stock and species enhancement in wetlands and reservoirs.
5. Breeding and culture of indigenous high value air-breathing fish species like *Clarias magur*, *Anabas testudineus* and *Monopterus cuchia* in marshy wetlands should be promoted in the state.
6. HRD programmes may be organised on a regular basis for capacity building amongst all stakeholders including fishers/fish farmers/ lessees and fisheries officials on open-water fisheries management, enclosure aquaculture, community-based fisheries management, etc.
7. There is need to undertake more demonstrations/ on-farm trials of fisheries management guidelines/ technologies on openwater fisheries management.
8. Extension machineries can be used effectively for the efficient dissemination of technologies/ technical knowledge on openwater fisheries management. ■