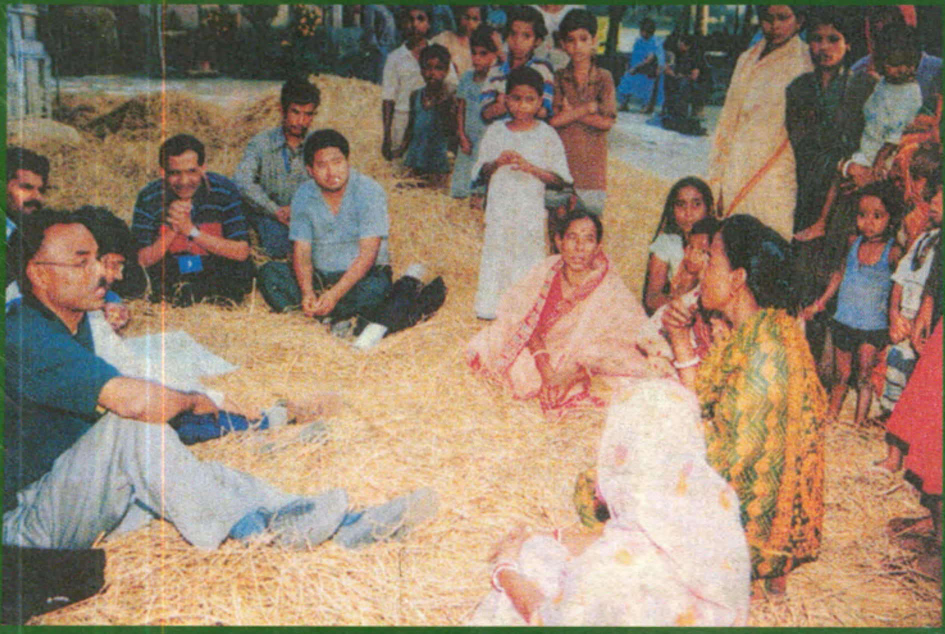
Proceedings Workshop-cum-training on Participatory Approach to Management of Inland Fisheries Resources of North eastern India.



Central Inland Fisheries Research Institute
(Indian Council of Agricultural Research)
Barrackpore, Kolkata - 700 120, West Bengal

Proceedings

Workshop-cum-training
on
Participatory Approach to Management of Inland Fisheries Resources of Northeastern India

NERC, CIFRI, Guwahati
2-12 December, 2003

Edited by
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Bull. No. 135 September 2004

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ISSN 0970-616X
@ 2004

Produced at : **The Project Monitoring & Documentation Section CIFRI, Barrackpore**

Published by : **The Director, CIFRI, Barrackpore**

Printed at : **Classic Printers, 93, Dakshindary Road, Kolkata-700 048**

Preface

The Central Inland Fisheries Research Institute (CIFRI), Barrackpore, Kolkata organized a 12-day long Workshop-cum-training programme on 'Participatory approach to research and development of inland fisheries resources of northeastern India' at its Northeast Regional Centre, Guwahati during December 1-12, 2003. The programme was aimed at developing tools, techniques and methods of participatory approach in the research and development of inland fishery resources. It is part of the efforts made by the Institute to meet the training needs of the Northeast in the field of inland fisheries. A total of 27 fisheries officers from 7 states of the Northeastern region (except for Mizoram, where assembly elections coincided with the training period) participated in the training programme. This is for the first time that a workshop on participatory approach to research and development of inland fisheries resources was held in the region. Mr. S. M. Sangma, Honourable Minister for Fisheries, Govt. of Meghalaya formally inaugurated the training programme on 2nd December, 2003 (since election to the Guwahati Municipal Corporation were held on 1.12.03) at the Centre (Guwahati).

In his inaugural address Mr. S. M. Sangma, noted that the Northeast is endowed with rich aquatic resources in the form of rivers, reservoirs, ponds, lakes, etc. He emphasized that ensuring food security, especially that of animal protein like fish is a major challenge to the region. This is all the more important for the people living in the hilly states like Meghalaya, Manipur, Nagaland, Mizoram and Arunachal Pradesh. On the other hand, the region offers abundant opportunities to grow fish in the existing water resources. He felt that if the rich aquatic resources of the Northeast is utilized for fish production following modern technologies, the region will not only become self-sufficient in fish production but also contribute significantly to employment and income generation. He felt that the farmers of the region are poorly conversant with recent technologies of increasing fish production. Thus, regular trainings by the research institutes like CIFRI are needed to upgrade their knowledge on the modern technologies of increasing fish production. He termed the workshop as a right step in the dissemination of latest concepts like participatory approach of inland fisheries development. The Minister released 3 leaflets prepared by the Centre viz., Pen culture in beels of Assam, NER Centre of CIFRI and Floodplain wetlands management on the occasion.

Delivering the presidential lecture, Dr. D. Nath, Director, CIFRI, Barrackpore emphasized the need for human resources development in the northeastern region for better management of its fishery resources and highlighted the efforts being made by the institute in this regard. In his address, he underpinned the technical and socio-economic constraints impeding growth of the fisheries sector in the Northeast. He opined that many of the recent technologies and concepts developed by the Scientists in India and abroad had not reached the end-users of the region. Accordingly it is needed to change from the conventional "top down" approach to the "bottom up" approach of extension, which is advocated by the PRA method. The participatory rural appraisal is one such recent concept, which is very useful in seeking participations of all the stakeholders in research and development. Throughout the world research, development and extension systems are increasingly adopting the PRA approach. He hoped that the training would be a watershed event in the fisheries development of the Northeast.

The training schedule was drawn in such a way that most of the recent information on participatory approach to research and development in inland fisheries were made available to the trainee fisheries officers. The programme was divided into four parts. In the first part, experts highlighted various management issues and options concerning research and development in inland fisheries with special emphasis on the Northeast. In the second part, the participating officers presented the status and constraints of fisheries development in their respective states. The subject matter specialists explained the latest concepts in participatory rural appraisal in the third part. The last part comprised carrying out the PRA field exercises in villages bordering No. 46 Morakolong beel (floodplain wetland), Morigaon District and in a fishing village (Amingaon) on river Brahmaputra. The results obtained from these exercises were synthesized in the form of a PRA report by the trainees with active collaboration by the facilitators. Various groups presented their findings on the last day of the training.

The valedictory session of the training programme was held on 12th December, 2003 at the Centre. Mr. N. K. Barik, Scientist of the Centre presented the feedbacks received from the trainees. Most trainees were of the opinion that the training increased their self-confidence and that the field and group tasks were interesting.

Mr. K. Ahmed, Director, Indian Institute of Entrepreneurship (Dept. of Industries, Govt. of India), Guwahati distributed certificates to the trainees and delivered the valedictory address. In his address, Mr. Ahmed, who is a noted economist of the Northeast, stressed that there is vast scope for fisheries development in the Northeast in the form of rich fishery resources, high demand and price for fishes. He emphasized that most of the employment and income generation in the region has to come from primary sector (agriculture, fisheries, animal husbandry, etc). He opined that fisheries were the most remunerative among the agricultural enterprises. Mr. Ahmed called for attitudinal changes of the fishery officials to extension for accelerating fisheries development in the region. He expressed happiness that the institute has initiated steps to attune research and development effort in fisheries to suit local conditions. He urged the officers to apply the techniques in their respective areas.

The workshop proceedings contain concepts, management issues and options pertaining to fisheries of the Northeast. A total of 18 papers by distinguished scientists has been compiled and edited in this proceedings. Hope this will contribute in the development of inland fisheries of the region. A separate book on PRA report, prepared by the trainees and facilitators has already been published.

We thank one and all who have directly or indirectly contributed to organize the training programme successfully.

July 2004

M. Choudhury
N. P. Shrivastava
R. K. Manna

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STATUS AND PROSPECTS OF INLAND FISHERIES DEVELOPMENT IN NORTH EASTERN REGION

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INTRODUCTION

The geographic location of northeastern region of India is such that it is bestowed with bountiful of natural resources, both aquatic and terrestrial. It remains to be one of the richest and relatively less disturbed biodiversity zone of the country. The aquatic resources of northeastern region revolve round the mighty Brahmaputra floodplain comprising two major river basins, such as Brahmaputra and Barak. The northeastern region has the distinction of nurturing a series of floodplain wetlands, which in turn are the finest repository of aquatic biodiversity besides being the source of fisheries from time immemorial. A sizable portion of the population, more than 70%, is fish eater, as such fish remains to be the most precious commodity among the local populace. The fact is that in spite of high resource under inland fishery sector, the region remains to be dependent on the import of fish from outside as the shortfall in demand is as high as nearly 50%. The demand of fish is on the rise owing to the ever-increasing population, but the level of production, both from aquaculture and open-waters, is far from satisfactory. There are many attributing factors for the present state-of-art, however, lack of scientific management of aquatic systems of potential fishery resources has been one of the prime reasons for low fish production.

Increasing fish production from rivers is a difficult proposition, as such genuine efforts should be made to conserve the precious fish diversity, which indirectly form the basis for the development or acceleration of aquaculture. The open water fishery resources of the region may have many problems of natural origin, but the increasing anthropocentric activities have virtually ripped apart the ecological integrity of these ecosystems to such an extent that the fishery has converted into a subsistence level. The river valley modifications in and around various river systems of the region have not only degraded the water quality of these rivers and their continuums, but the entire production function including the fish has gone wrong. The floodplain lakes, the most lucrative fishery resource of the region, are in advanced stage of eutrophication leading to swampification at a very faster pace. The natural fishery of the past has lost its pristine glory paving ways for forage and small fishes, which have relatively less market acceptability.

It is time, when concerted efforts are being initiated to enhance the fish production from natural ecosystems like lakes so as to bridge the gap between demand and supply besides generating gainful employment avenues in the rural sector. Effective fishery management of open-water fishery resources is all the more necessary in the face of near stagnant fish out-put from marine source.

OPEN-WATER FISHERY RESOURCES IN NORTHEAST

The status of open-water fishery resources in Northeast is given in Table 1, while the distribution of floodplain wetlands (beels) is given in Table 2.

Table 1 : Fishery resources of Northeast

Resources	Area/Length	National
Rivers	9,000 km	45,000 km
Floodplain wetlands	1,19,713 ha	2,00,000 ha
Reservoirs	2,500 ha	31,000,00 ha
Ponds	>7000 ha	21,000,00 ha

Table 2 : Distribution of floodplain wetlands in Northeast

States	Area (ha)
Arunachal Pradesh	2,500
Assam	1,00,000
Manipur	16,500
Meghalaya	213
Tripura	500

Significantly, under the open-water fishery resources, the northeastern region alone account for 20% of the total rivers and more than 50% of the floodplain wetlands of the country. Evidently, no effort to achieve blue revolution in India is going to make any headway unless the aquatic systems of Northeast are being managed scientifically.

STATUS OF OPEN-WATER FISHERY IN NORTH EAST

The fishery of northeastern region is largely Assam centric being the largest state with maximum resources followed by Manipur and Tripura. Besides, the floodplain wetlands remain as the main source of fish in this region.

Rivers

Data on the status of riverine fishery of the region is still patchy barring river Brahmaputra, mainly due to unorganised fishing activities. A recent survey conducted in river Brahmaputra by CIFRI (2000a) reveals significant decline in fishery from 196.9 kg/day in 1973-79 to 137.3 kg/day in 1996-98 (Table 3). The major carp fishery has shown considerable decline from 19.4% (1970s) to 11% (1990s). Correspondingly, the catch of catfish and miscellaneous fish species has increased. In precise, there has been 30% decline in major carps in river Brahmaputra. Other species like minor carp, hilsa and prawns also declined by 50%, 84% and 58%, respectively. Evidently, the miscellaneous species have filled the vacant niche with an increase of 141% (Table 3). The survey also revealed large-scale destruction of potential fish brooders and juveniles.

Table 3 : Changes in fish yield and fish catch structure in river Brahmaputra

Species	1970s *Average Catch (kg/day)*	%	1990s *Average catch (kg/day)*	%	Visible changes (%)
Major carp	38.2	19.4	18.7	13.6	-30
Minor carp	27.8	14.1	9.6	7.0	-50
Catfish	46.8	23.76	19.5	14.2	-40
Featherback	7.1	3.6	8.0	5.8	+61
Hilsa	22.1	11.2	2.9	2.1	-81
Prawn	9.8	5.0	2.9	2.1	-58
Misc.	45.1	22.9	75.8	55.2	+141
Total	**196.9**		**137.3**		**-30**

Floodplain wetlands

The northeastern region, especially the states of Assam and Manipur, has tremendous fishery resource in the form of floodplain wetlands, locally known as beels and pats respectively. The beels are considered highly sensitive biologically, playing vital role towards the recruitment of fish populations in riverine ecosystems besides providing nursery grounds for prized fish species of commercial value. However, the beels are in a state of total shambles in recent times owing to their irrational exploitation. They offer tremendous scope for fisheries enhancement, if managed on scientific lines. Presently the average fish production from these lakes ranges between 160 and 250 kg/ha against a very high productivity potential in the range of 1000-1500 kg/ha.

Water residence and renewal times as well as the extent of macrophyte infestations are the two most important factors affecting the ecology and fisheries of beels. Based on these characteristics the lakes can be classified as 'open beels' or 'closed beels' for better management of fish and fisheries.

In the face of increased anthropocentric interference and river valley modifications, the beels of northeastern region are reeling under advanced stage of eutrophication as evidenced from the thick stands of macrophytes. Moreover, over the years owing to various man-induced activities leading to loss of connecting channels between the rivers and lakes, the process of auto-stocking of riverine fish seeds has declined. The fish catch structure of this fishery resource has undergone a sea change in recent times, from carp dominant fishery to forage fish dominant one (Table 4).

Table 4 : Fish catch structures in beels

Fish Groups	% contribution
Major carp	5-8
Minor carp	7-11
Featherbacks	4-12
Catfish	15-35
Forage fish	45-60

Reservoirs

The reservoirs are the new addition to the fishery resources of northeast restricted mainly to Assam, Meghalaya and Tripura. Evidently, reservoir fishery is still in its nascent stage and remains to be an un-organised sector. However, this resource also needs careful evaluation for initiating fisheries enhancement on scientific principles, such as *selection of proper species for stocking, stocking density* and *stocking rate* in accordance with the prevalent environmental variables. Suitable measure for enhancing the environment is also essential to support larger community size. Data generated at CIFRI on certain reservoirs of the region like Nongmhir, Khandong (Meghalaya), Umrang (Assam) and Gumti (Tripura) indicate poor to moderate productivity status primarily due to acidic properties of the lake basin and absence of suitable fast growing fish species. The location and nature of available reservoir ecosystems in NE region have all the potential for developing sport fishery like *mahseer* as most of the reservoirs already have sizeable population of endemic *chocolate mahseer*.

CHALLENGES TO OPEN WATER FISHERIES

Rivers

- Revival of riverine fisheries for increasing fish production and conservation of endemic fish fauna.
- Habitat improvements, such as breeding and nursery ground.
- Effective mitigation action plan to control pollution to improve water quality.
- Rationalization of water abstraction from rivers for irrigation, industries and potable use.
- Strict ban on the wanton killing of brooders and juveniles.

Reservoirs

- Rational stocking of reservoirs with relatively larger size of fingerlings to contain unwanted mortality and for faster growth.
- Developing suitable technologies for cage culture, at least to raise stocking materials.
- Scientific management of reservoirs for sustainable yield.

Wetlands

- Scientific management of wetlands through various modes of enhancements, such as species enhancement, stocking enhancement, environmental enhancement and technological enhancements.
- Effective control of prevailing aquatic weeds and strict ban on the use of mosquito-netting to conserve the precious biodiversity including endemic fish germplasms.

Introduction of exotics in open waters

- Careful thinking and adequate feedbacks are essential before the introduction of any exotic species in open waters. Besides, it should be based on scientific principles so as to get sustainable yield without affecting the endemic fish species.

PROSPECTS OF FISHERIES DEVELOPMENT IN NORTHEAST

The Northeastern region of the country has tremendous aquatic resources not only to cater the demands of the region alone but also can contribute sizeably to the national fish basket. However, the essence of fisheries enhancement in this region lies on the effective utilization and rational exploitation of the floodplain wetlands. Increasing fish production from rivers is rather a tough proposition, especially in the backdrop of ever accelerating man-induced catchment modifications. Similarly, the available reservoir resource is too small to create any substantial impact in near future. Evidently, floodplain wetlands need careful monitoring and better management for the advantage of mankind.

The current state of production from the beels, however, is too low (160-250 kg/ha) in spite of high productivity potential (1000-1500 kg/ha). Accordingly, there exists a large gap between the potential and actual yield, which needs to be bridged at the earliest following scientific principles of management. The key of fisheries enhancement from floodplain wetland lies on the adoption of "Culture-based fisheries development", such as:

- Culture-based fisheries management of closed beels
  - Stocking and recapturing the fish remains as the main thrust under this mode of management
- Capture and culture systems in open beels
  - Combining the norms of capture and culture fisheries by utilizing the marginal areas as ponds or pens while leaving the lake proper for capture fisheries only.
- Introduction of pen culture in beels
  - Culture of suitable fish and prawn species in pen enclosures can be a very useful option for yield enhancement, especially in beels with thick stands of weeds.

CONCLUSION

Rivers, estuaries and lagoons, are not expected to play any significant role in meeting the growing demand of fish under inland sector being under the constant threat of environmental degradation. Similarly, irrational and unchecked growth of aquaculture, especially intensive in nature, has all the potential to open up many environmental, social and legal related issues. Evidently, options for inland fisheries development is narrowed down to floodplain wetlands and reservoirs. Thus the eco-friendly fisheries development through various modes of enhancements, such as *species, stock*, *environment* and *technological,* in these ecosystems holds the key for sustainable fisheries development in future.

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Choudhury, M., 2003. Riverine resources of northeastern India: implications on fisheries and fishers, pp. 6-9. *In:* M. Choudhury, N. P. Srivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

RIVERINE RESOURCES OF NORTHEASTERN INDIA: IMPLICATIONS ON FISHERIES AND FISHERS

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INTRODUCTION

The northeastern region of India comprising seven states covers a geographical area of 255,083 sq. km. supporting 39 million people affiliated to more than 100 different tribes and ethnic groups. The region offers diverse topographical conditions ranging from the plains of the Brahmaputra and the Barak valleys in Assam, plains of Tripura, upland flats of Imphal valley in Manipur to predominantly hilly regions of Arunachal Pradesh, Meghalaya, Mizoram and Nagaland. Most of the northeast consists of hills and mountains covering approximately 65% of the total geographical area of the region. These hills/ mountains give rise to 52 major rivers including the mighty Brahmaputra river, which criss-cross the region and have a combined length of 19150 km. Apart from being an abode of a large number of commercially important food fishes, the rivers flowing through different states and their floodplains harbour wide varieties of ornamental and sport fishes.

Riverine Resources

Central Inland Capture Fisheries Research Institute conducted extensive surveys in the following important rivers of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura.

Sl. No.	State	Rivers
1	Assam	Brahmaputra, Manas, Beki, Aai, JiaBharali, Subansiri, Noadihing, Dhansiri, Kalong, Kapili, Dudhnoi, Krishnai etc.
2	Arunachal Pradesh	Kameng, Dikrong, Ranganadi, Subansiri, Siang, Dibang, Lohit, Noadihing and Tirap
3	Meghalaya	Kapili, Shella, Dareng, Bogai, Simsung and Jinjiram
4	Manipur	Minan, Khuga,Thoubal,Iril, Imphal and Manipur
5	Mizoram	Tlawng, Tiurial, Mat, Kolodyne and Karnaphuli
6	Nagaland	Dayang, Dikhu, Tserang, Sidzu, Tezu, Tapi and Itangki
7	Tripura	Deo, Manu, Howrah, Gumti and Feni

The study reveals the presence of vast fisheries resources in the form of rivers (19150 km) along with associated reservoirs (14675 ha) and floodplain wetlands/ swamps (143,740 ha). Amongst these rivers, the Brahmaputra is the largest and mightiest. The Brahmaputra – a moving ocean is an international river. It does not belong to Assam alone. Emerging from the Himalayas from the glacial womb of the Kailash range and flowing as Tsangpo across the heights of Tibetan Plateau it belongs to mystic Tibet. Rushing down in furious haste through deep chasms and narrow gorges as Siang /Dihang, it belongs to Arunachal Pradesh. The floods and alluvia it brings as the Jamuna have induced the people of Bangladesh to make this river their very own. It was not considered as sacred in ancient India and various myths investing it with holy stature grew up separately in Kamrupa (Assam).

A major part of the river and its tributaries pass through the inhospitable terrains of the plains. It drains the northeastern states of Arunachal Pradesh, Assam, Nagaland, Meghalaya and Sikkim, besides the southern slopes of the Himalayan Kingdom Bhutan. Rising from the snout of Chemayungdong mountains, 100 km southeast of Manassarover, running up to 1250 km through Tibet as the river Tsangpo, it enters India near Tutin (Arunachal Pradesh). Known as Dihang or Siang in Arunachal Pradesh, the river after its union with Dibang and Lohit near Sadiya assumes the name the Brahmaputra. Bisecting the Brahmaputra valley, the river flows for 730 km in Assam and finally enters Bangladesh as the river Jamuna. It has 47 major tributaries with a combined length of 4000 km, a catchment area of 580,000 sq km and an average annual discharge of 510450 million cubic meters. Characterized by multiple flood cycles and pronounced seasonal variability in discharge, the river with tributaries maintain most unstable course in the plains with constant movement of their channels. Heavy rains (average about 230 cm annually), topography and frequent earthquakes have made the river capricious and destructive resulting in the formation of floodplain lakes. The flow regime of the Brahmaputra and its tributaries is dependant upon seasonal rhythms of the monsoons and free thaw cycle of glacial mountains. Rain and snow melting process coincide and the extra ordinary volume of water it carries is responsible for the high sediment yield and drainage congestion in the valley. The geologically infant state of the Himalayas contributes to high silt content in the drainage. The northern tributaries are large with steep shallow braided channels carrying high silt discharge (average 6667 m^3km^{-2}) whereas the southern banks are deeper with meandering channels, low gradient and lesser silt load (66.7 to 95.7 m^3km^{-2}).

Fishery resources

The rich icthyofaunistic resource of the region comprise 297 fish species belonging to 114 genera under 38 families and 10 orders and include as many as 31 endemic fishes. The icthyofauna of the region forms about 33% of the total Indian freshwater fishes. The observation reveals that Assam has the highest number of icthyospecies (218) followed by Arunachal Pradesh (167), Meghalaya (165), Tripura (134), Manipur (121), Nagaland (68) and Mizoram (48).

(a) Hillstream fishes

The important hill stream fishes of the region are *Tor tor*, *T. putitora*, *T. progenius*, *Neolissocheilus hexagonolepis*, *N. hexastichus*, *Schizothorax richardsonii*, *Schizothoraichthys progastus*, *Labeo dyocheilus*, *Raiamas bola*, *Garra* spp. In addition, the exotic rainbow trout (*Salmo gairdneri gairdneri)* and the brown trout (*S. trutta fario)* has established in hill stream of Arunachal Pradesh (both species), Meghalaya and Nagaland (brown trout).

(b) Food fishes

A good number of food fishes like *Cyprinion semiplotum*, *Anguilla bengalensis bengalensis*, *Chitala chitala*, *Barilius bendelisis*, *Labeo dero*, *L. gonius*, *Puntius sarana sarana, Aorichthys seenghala*, *Rita rita*, *Ompak bimaculatus*, *Wallago attu*, *Eutropiichthys vacha*, *Bagarius bagarius*, *Channa marulius*, *Channa striatus*, *Mastacembellus armatus* support commercial fishery of the region. Apart from these finfish species, edible shellfishes like prawns (mainly *Macrobrachium birmanicum choprai* and *M. malcolmsonii*) and molluscs (*Pila globosa*, *Lammalideans* spp.) were recorded in the rivers of the region.

(c) Sport fishes

Sport fisheries offer tremendous scope for developing eco-tourism in the region. Important sport fishes occurring in the rivers of the region are *Bagarius bagarius*, *Tor* spp., *Chitala chitala*, *Schizothorax richardsonii*, *Schizothorax projestus*, *Raiamas bola* etc.

(d) Ornamental fishes

Important ornamental fishes of the region are *Botia dario*, *Acanthocobitis botia*, *Balitora berdmori*, *Brachydanio rerio*, *Barilius barna*, *B. barilius*, *Danio devario*, *Danio dangila*, *Hara hara*, *Conta conta*, *Chaca chaca*, *Nandus nandus*, *Badis badis*, *Puntius gelius*, *P. terio,* etc. These ornamental species offer a very good prospect for developing a lucrative trade in the region, which have not yet been properly harnessed.

The Gangetic Dolphin (Sihu), which was in plenty once upon a time, has been dwindling in numbers. They are being exploited for various purposes especially for their fat and oil. This species is a threatened species and needs immediate conservation. The various aquatic species are being exploited without any idea of conservation; hence necessary steps should be taken like protection of breeding sites and special habitats. For the threatened species, special artificial propagation may be tried to replenish the species of the Brahmaputra valley.

Constraints and issues

Despite having vast potential, fish production from the selected hill streams of the northeast was found to be very low. Quantification of the present catch was difficult in most streams owing to absence of specific landing centres and the subsistence nature of fishing. The main reason for the present low fish production may be attributed to inhospitable terrain, prevailing low temperatures and uneven bottom, fast water currents and lack of scientific strategies to judiciously exploit the natural fish stocks. Monsoon rains and snow-melting process in the eastern Himalayas coincide in the region and extraordinary volume of water carried by its rivers is responsible for recurring floods, high sediment yield and drainage congestion in the valleys. Rapid deforestation in the hills has also contributed to the massive siltation of the riverbeds affecting the natural habitat of fishes in recent years. Use of poisons, explosives and small meshed mosquito nets to catch fish has also affected the fish population adversely in many streams. Lack of implementation of existing fishery regulations by the concerned states have resulted in loss of brood stock and juveniles of many commercial fish species. Development and popularisation of effective, non-destructive fishing gear for operation in the hill streams of the region is also urgently required to augment fish production from them.

A typical condition of the river Brahmaputra happens to be that large tracts of breeding grounds of major carps have become inaccessible due to flood protection embankments depriving the breeding activities of the species to a certain extent. Heavy siltation in the canals prevents fishes from entering the floodplains as a result of which breeding activities are being hampered. Problem of pollution is not serious at present but rapid rate of urbanization accompanied by industrialization may turn the situation drastic in near future. Therefore, it is high time that the authority responsible for the development of fisheries in the state takes concrete measures to conserve the natural habitats of fish.

Impact on fishery and fishermen

Agriculture and fishing are the age-old professions in the river valleys. Therefore, increase and decrease in the fish production will not only affect the fish eating population but also the fishing community as a whole who is dependent on the different fishing activities like fishing, fish trade, gears and traps making, basket making etc. for their livelihood. The place of fish in the human society is inseperable because in various traditional and auspicious celebration like birth of a child, marriage, community feast etc., it is a must item. Even in the rituals of dead, fish must be served. Indiscriminate use of the fish germplasm may lead to very critical situation even extinct state of the resource. Hence serious efforts should be made to conserve these fish resources.

River Brahmaputra is closely associated with NE culture and tradition. The culture of the people of this valley is essentially hydrologic; there is a surfeit of allusion to rivers in the folklore of this region. Several myths like legend of the Siang being the progenitor of all rivers in the Abang ballads of the Adi tribe of Arunachal, the folk tales based on how women and plainsmen learnt to weave prevalent among the Hill Mishmis, watching movements of the currents of the river, endearing folk tales of the Brahmaputra valley, Tejimala and Silaner Jiyekar Sadhu, the most popular Lakhinder Beula legend of Lower Assam depicts the intimate relation of the river with the Assamese population and the in-depth knowledge people hold about the rivers. Several community folk-songs based on faunistic and floristic wealth are prevalent which shows the intimacy of the people of the valley with the river. The importance of the R. Brahmaputra in the socio-cultural lives of Assamese populace is well described by renowned artists of the region who carried the message to the other parts of the country.

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Mukhopadhyay, M. K., 2003. Diversified use of Floodplain wetlands in India – Opportunities and threats, pp. 10-15. *In:* M. Choudhury, N. P. Srivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

DIVERSIFIED USE OF FLOODPLAIN WETLANDS IN INDIA – OPPORTUNITIES AND THREATS

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INTRODUCTION

Wetlands on floodplains of major river systems mainly Ganga, Brahmaputra, Koshi, Gondak, Iral, Kameng and Gumti form a rich and varied source for sustenance of rural economy in the states of Assam, Bihar, West Bengal and Northeastern region. From time immemorial these water resources had been the nuclei for development of human habitation. The concentration of human habitation surrounding the wetlands was purposeful and eyeing on the vast and renewable good quality water supply for human consumption, agriculture, cattle raising and over and above explorable animal and vegetable resource potentiality for daily consumption. Over the years, development of scientific knowledge and infrastructure facilities like dams, reservoirs and irrigational networks have resulted considerable decrease in the pressure for agro-irrigation on floodplain wetlands but not to the required level for sustenance of biological potentiality of these natural water bodies. On the other hand, multifarious use and ever increasing demands for more and more water for habitation and industrial growth invited threats for the floodplain wetland resources. Use and reuse of waters posed eco-degradation problems and subsequent loss of diversification of enriched natural bio-communities of the floodplain wetlands.

PRODUCTIVE USE OF FLOODPLAIN WETLANDS

Wetlands are made up of a mixture of soil, water, plants and animals. The biological interactions between these elements allow wetlands to perform certain function and generate healthy wildlife, fisheries and forest resources. The combination of these functions and products, together with the value placed upon biological diversity and the cultural values of certain wetlands, make the eco-systems invaluable to people all over the world. Apart from the repository of inherent biological potentiality, wetlands extend great service for agriculture and forestry.

Agro irrigation

Though surface and ground water irrigation networks cover wide cultivation areas under command, the water resource of wetlands provides critical support in the crop management and sustainability of agricultural production. In short-term cash cropping like horticulture, floriculture etc., the farmers mostly depend on wetland irrigation, which besides supplying water provides nutrients for the plants under cultivation.

Fisheries

Two-third of the fish we eat depend on wetlands at some stage in their life cycle. Fishes are the most important source of animal protein, making up 20-25% of the requirement for human consumption. India's floodplain wetlands in the form of oxbow lakes exist specially in the states of Assam, Bihar, Eastern Uttar Pradesh and West Bengal. The statewise areas of floodplain wetlands shown in Table 1 reveal Assam at the top of the wetland resource states.

Table 1- State wise distribution of Floodplain Wetlands in India

State	River basins	Local names	Area (ha.)
Assam	Brahmaputra & Barak	Beel	1,00,000
West Bengal	Ganga & Ichamati Hooghly & Matlah	Beel Bheries	42,500 40,000
Bihar	Gandak & Koshi	Mauns/Chaurs	40,000
Manipur	Iral, Imphal, Thoubal	Pat	16,500
Arunachal Pradesh	Kameng, Subansiri, Lohit, Dihing & Tira	Beel	2,500
Tripura	Gumti	Beel	500
Meghalaya	Someshwari & Jinjiram	Pat	213
Total			2,42,213

Broadly divided into "open" and "closed" types, the floodplain wetlands are extremely rich in nutrients as reflected by high levels of organic carbon, available nitrogen and phosphorous. Generally, these nutrients are locked up in the macro vegetation and thus unable to contribute to fish production. To break up the disproportionate flow of energy and divert more of the nutrient deposits to fish production processes, CIFRI have developed scientific management norms and culture technologies. The fisheries management norms for floodplain wetlands aim at culture-cum-capture fisheries and in the process of management, adoptions of steps like reduction in macrophyte infestation, control of large size carnivores and supplementary stocking with fast growing major carp species could achieve actual fish production of 1000-1800 kg/ha/year, which is about 5 to 7 times more than the traditional production of 100-300 kg/ha/year.

In view of augmenting fish production from the nutritionally rich, shallow and moderately warm water of floodplain lakes, the technologies of pen and cage culture have been developed. Pens are artificially erected barricades on the periphery of beels which offer scope for utilizing the productively potent water, stocking of high density and preferred species combination, supplementary feeding, health management of the stocks and finally maximum retrieval of the produced fish and prawns. A production level between 3000 and 5000 kg/ha/9 months can be achieved through pen culture technology.

Culture of high-density fast growing species in cage is further advancement in production process for the floodplain wetlands. In a cage, which is cut off from the soil-water interface, the stocked fishes are mainly grown on high quality artificial feeds. Environmental management, health monitoring and control measures, and recovery of the stocks are well assured in cages. The production pattern from the cage culture normally ranges between 4000-5000 kg/ha.

Forestry

Swamp forests develop in areas of still water around the lake margins and in parts of floodplain such as oxbow lakes, where water rests for long periods. The characteristic of the forest varies according to geographical location and environment. In India, the forest resources at the wetland margins and catchment areas provide great support for the associated people either at their regular needs for firewoods or as timbers for own uses or trades. Apart from direct uses, the forest trees and plants provide shelter for thousands of birds and other animals. The ecological complex formed by water, aquatic animals, vegetations, marginal trees and plants is the unique feature of wetlands, which attracts birds of migratory and resident species. To be mentioned, the wetland vegetation can stabilize shorelines by reducing the energy waves, currents or other erosive forces. At the same time, the roots of the wetland plants hold the bottom sediments preventing erosion of valuable agricultural and resident land, and property damages.

Aqua-cropping

Utility of aquatic plant fruits, flowers and vegetation as food items is not unknown to the common people particularly the rurals with low-income potentiality. Species like *Trapa bispinosa* (Panifal) is commonly cultivated almost through out the country for food quality and economic value of its white traingular fruits. Makhana (*Euryale flux*) another species of perennial aquatic herb with distribution throughout temporal and tropical zones of India is cultivated in shallow marshy wetlands and the fruits of the plants are consumed roasted as food. The seeds are also powdered and used as substitute of arrowroot. Cultivation of Makhana and Trapa has been recommended along with the culture of air-breathing and catfishes. Seeds of Kamal (*Nelumbo adans*) and Sapla or Nil Kamal (*N. satellata*) have also food values and scope of culture in wetlands.

Flower of aquatic plants like lily, lotus etc. have religious uses and decorative values. The vegetative parts of many of the aquatic plants have food values like of Gima (*Polycarpon postratum*), Kalmi (*Ipomoea aquatica*) etc.

Plants of aquatic origin have also medicinal values. The chemicals isolated from a number of aquatic plants and plant components viz. fruits, flowers, roots etc are used in modern medicine beside ethnopharmacogonstic application.

Social use of Floodplain Wetlands

Social use of wetlands is equally important as the productive ones. Contribution of wetlands in human life is multifarious and of different magnitudes. However, the dependence on wetlands for human life has been reduced with advancement of scientific knowledge and invention of more and more resources.

Domestic and Industrial Supply

Use of floodplain waters for domestic purposes is common in rural areas even today. The portable waters, water for cattle raising and also to some extent industrial supply is sustained by the floodplain wetlands.

Navigation

Local transport in rural areas is often performed through waterways and wetlands are considered safe for the purpose. Both country boats and mechanized boats are in operation. The cost of traveling and transportation comes cheaper through the waterways and are affordable for the poor rural population.

It is observed that, in countries like USA, Canada, Russia, Netherlands, China, ...to name a few, Inland Water Transport (IWT) has been playing an important role in movement of cargo as a part of multi-modal transport system. India is endowed with a total length of around 14500 km of inland navigable waterways, consisting of rivers, canals, backwaters, creeks and lakes of which presently about 5200 kms of major rivers and 485 kms of canals are suitable for operation of mechanised craft.

Agricultural Processing

Jute is a common cash crop in the floodplain areas of West Bengal, Assam and Bihar. In the process of yielding jute fibres, ratting of the jute plans is the only technique, which requires substantial volume of water. Wetlands, retaining sufficient water with feeble current and considered comparatively safe are preferred for ratting of jutes. It has been recorded that quality of jute fibres is poor when the rain accumulation in the wetlands is less and the water available for ratting is insufficient.

Sanctuary

Growing with every creature on the earth has become a craze for the human beings. Birds are one of the most liked creatures for living with and observation because of their diversified features, colours, tunes, behaviour etc. Other animals are also liked to be observed in their natural habitats. Many of the migratory birds fly all the way from one part of the world to other. These birds migrate for feeding and breeding in the safe food and shelter enriched wetland areas and often trapped and killed for human consumption. Due to uncontrolled and indiscriminate killing, large varieties of the birds species have either totally disappeared or are threatened to be extinct. For the safety and revival of these birds, sanctuaries are declared and the wetlands most dwelt by them are identified for the purpose. Wetlands as sanctuary for the birds and other animals are visited for recreation by the human beings.

Conservatory

With the threats of rapidly loosing bio-diversity and imbalance in the plant animal proportion the need for conservation has been felt. Accordingly, the floodplain wetlands as the richest repositories of numerous known and unknown creatures have been identified and conserved from further loss and also revival of the lost species of plants and animals. The conservation measures would help in restoration of the germplasm resources for human knowledge and benefits.

Tourism

Wetlands with bird sanctuary and also conservatory have been popularized as site for tourism. Accordingly, the facilities and infrastructure have been developed for easy accessibility and comfortable stay for the tourists. Development as tourist spots has not only saved the wetlands from the natural and man made hazards but also generated source of income for the inhabitants of the concerned areas.

Geo-environmental Use

By virtue of being the sources of wide spread water holdings, the wetlands play significantly in various geological processes and also environmental balancing of the ecosystem.

Ground water and flood Control

When water moves from wetland down into an underground aquifer, it is said to recharge ground water. By the time it reaches the aquifer, the water is usually cleaner due to filtering processes, than it was on the surface. Recharging is also beneficial for flood storage because the runoff is temporarily stored underground rather than moving swiftly downstream and overflowing. Recharge in one wetland is linked to discharge in another. Wetlands receiving most of their water from groundwater discharge usually support most stable biological communities because the water temperature and levels of water do not fluctuate as much as in wetlands that are dependent upon surface flow. Recharging of groundwater keeps a balance in moisture content of the surface soil and prevents drying of the surface land. On the other hand, the water stored through the recharging process is used for agriculture and withdrawal for other purposes.

Environmental Purification

The vast area of floodplain wetlands acts as purifier for the atmospheric air by way of liberating oxygen and elevating the level of the same in the environment. Wetlands also help in purification of wastewaters by way of diluting and mineralizing the organics to simple nutrient forms.

THREATS FOR FLOODPLAIN WETLANDS

"Every action has its equal and opposite reaction". So any effort aiming activation or exploitation must have opposite reaction for the floodplain wetland systems. The reaction may not be visible or evaluated so long it is reflected on the biotic entities. Multifarious uses end up with varied problems for the wetland resource.

Agricultural Abstraction

Water abstraction for agro-irrigation is commonly practiced from the floodplain wetlands. The over abstraction results in almost dry state and leave no water for the resident flora and fauna. The bio-communities harbouring the wetland beds are disturbed and in extreme conditions perish due to the sun exposure. From production point of view the shrinkage in water spread area creates negative effect on the fish yield. Frequent alteration in water level and exposure of the wetland areas affect the colonization processes of micro and macro flora and fauna and ultimately results in their biodiversity losses.

Fish production Pressure

The technologies developed for sustainable fish production from wetland need judicious application; otherwise may lead to ecological damages and loss of natural potentialities. Indiscriminate selection of species and their introduction could be detrimental for the resident population.

Injudicious construction of pens for confined culture of fishes and prawns results in encroachment of the habitats for natural flora and fauna of the wetlands. Shortage of space and also food niches affect the movement and growth performances for the resident fishes and prawns. Obstruction in water movement creates stagnation and adverse impact on the ecology and environment.

Cages when increased in numbers occupy more of surface area, hinder solar penetration and obstruct feeding migration of the surface feeders. Further the unutilized highly nutritious supplementary foods get decomposed and create unhealthy environment for the resident flora and fauna.

Sewage fed fish culture though being a commercially viable technology and practiced in some states of the country has problems in respect of the environmental clarity, disease infestation and quality of the products. Uncontrolled inlet of sewage waters creates environmental deterioration and affects the physiological function of the resident population. Unhygienic environment and bacterial/viral proliferation results disease infestation and simultaneous loss in the production quantum. The fishes and prawns grown with disease and accumulation of toxic substances like metals and pesticide suffer from normal and healthy growth and are considered of poor quality.

Deforestation

Deforestation causes denudation of the earth and results erosion of surface soil and subsequent silting of the connected wetlands. Removal of the riparian trees and plants exposes the wetlands to various types of natural and man-made hazards. The allochthonous source for organic enrichment is lost due to deforestation. In addition, the ecology of the wetland habitats for the birds is affected.

Effects of sanctuary and Conservatory

Declaration of wetlands as sanctuaries and conservatories if not followed through proper investigation and research may lead to loss of productive resource. However, in India the sanctuaries and conservatories are very few in numbers and not considered in the light of loss of productive resource.

Tourism Impact on Environment

Considered as an industry, tourism is being popularized and developed at very fast rate. Among many of the chosen spots, wetland sanctuaries are most favored and visited by large number of tourists. Beside the disturbances created by boating activities affect normal movements of the resident animals. Oil refuses from the mechanized boats results in environmental deterioration. Apart from these, the west refuses from the tourists, often thrown into the wetlands, are accumulated and produce detrimental effect on the environment and biological activities.

Effect of Jute Ratting

Ratting of jute plants contributes to the organic load of the wetlands. Whenever, the quantum of rated jute plants is very high, the organic load produced is also equally of high quantum. The increased load of organic material becomes a menace for the wetland environment. The eco-system gets eutrophic and becomes unhealthy for the inhabitant flora and fauna.

Domestic and Industrial Contamination

A greater part of the water used in domestic and industrial activities flow back to the resource like wetlands, rivers and estuaries etc. As a result, the toxicants or other refuses find their way into the recipient water resource. The untoward back flow of pollutants laden waters contaminates the environment and poses serious threats for the aquatic lives.

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Bhaumik, U., 2003. Technology dissemination to achieve sustainable yield from open waters through participatory approach, pp. 16-22. *In:* M. Choudhury, N. P. Srivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

TECHNOLOGY DISSEMINATION TO ACHIEVE SUSTAINABLE YIELD FROM OPEN WATERS THROUGH PARTICIPATORY APPROACH

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INTRODUCTION

The process of technological innovation, technical and scientific communication and technology transfer has been the subjects of considerable research in recent years. From a behavioural point of view, technological change and innovation occur as a result of complex sets of human interactions; information flows and transfers; individual and organisational creativity; individual and organisational risk taking and decision making capabilities. Each of these factors involves human beings with their motivations, perceptions, attitudes, beliefs, abilities, ambitions, personality and prior knowledge and experience.

Generally innovated technologies are sophisticated in nature and high input intensive. It is interdependent on so many inter-related practices each one of which have to be applied rationally in time and in the manner recommended by the scientists. A communicator concerned with open water fisheries, therefore, has to understand its characteristics in order to select appropriate methods and techniques for effective and rapid communication of appropriate technology to the clientele for their easy adoption. To achieve development from within a population requires working with people in their existing situation, with their existing resources and skills.

Strategy for effective communication

The present open water fisheries management strategy in the country calls for rapid dissemination of information on open water fisheries and technical know-how to the clientele in mass scale in the direction and bridging the gap between research system and target groups in the field. The strategy for transfer of technologies on open water fisheries for the members of the resource-poor target group is to be treated henceforth as one of the essential inputs to overall activity in the open water fishery development programmes.

Types of information

Ideally any information system for sustainable fish production from open waters covers,

(i) Information on natural resource and biodiversity
(ii) Information on biology of fishes
(iii) Information on seed availability
(iv) Information pertaining to existing facilities and infrastructure
(v) Information on the available technologies and package of practices

(vi) Information related to environmental impact

(vii) Information on crafts and gears

(viii) Information related to conservation measures

(ix) Information pertaining to Government policies and programmes

It has been felt that negligible effort so far has been made in the country to provide such information to the target groups towards development of fisheries in open waters. Thus, a large gap has been created between awareness and adoption of measures on management of fisheries in open water systems.

Communication planning for mass awareness

The prime objectives of the programmes towards development of fisheries in open water bodies could not be achieved unless communication is taken as an important component and ingredient of development efforts. The constructive application of communication for developmental process calls for proper planning that takes equal note of the national priorities and needs, preferences of individual and of social priorities. An essential ingredient of such communication planning is an understanding of the specific assets and limitation of each of different media. It may be appropriate to have an idea of the impact of each of these on the society.

Face to face oral strategy

Extension personnel through personal contacts will establish rapport with the receiver and will communicate well-tested messages to improve their skills, altitudes and knowledge.

Case studies

The case studies may come from all the areas of extension activities of the fisheries development in open waters. The case studies may be on achievements/activities of individual worker and experience of fishermen. The information can be compiled to give up-to-date data.

Circulation

Information on management measures on open waters could be widely circulated in the form of circular letter, handout, leaflet, pamphlet, mimeograph etc.

Joint field visit

Joint field visits of researcher and extension worker will enable them to understand about success of the development programmes on open water fisheries and to identify the constraints.

Group approach

Instead of the individual approach in communication, the group approach should be emphasized to get the desired results in the field.

Use of Audio-Visual aids for mass awareness of the target group

A.V. aids play important role in effective communication of information on open water fisheries management and resource conservation. The extension functionaries working in fisheries developmental programme must be equipped with audio-visual equipments. Radio and Television have a great potential as a medium of mass communication. The authorities concerned with Radio and TV may be co-opted to plan their programme to broadcast/telecast information on open water fisheries management and conservation regularly for mass awareness of the target group to strengthen open water fisheries development movement.

Extension system and holistic participatory approach

At every step of the management of fisheries in open water bodies, people's participation in all the 4 extension systems *viz.,* Research System, Extension System, Client System and Support System, is of much more importance that the product or process put to use.

Local participation is not the only new criteria by which the management of fisheries needs to be judged. It is equally important that the problems be approached holistically taking into account of the full range of human and community potentials.

Open water fisheries management projects necessarily involve both individual and group action. The need for participatory approaches is probably maximum in such developmental projects. In fact, participatory approaches are indispensable for successful management of such projects.

The very purpose of development activity seen in its broadest socio-political sense is:

- to enable people to critically understand their situations and problems;
- to identify their needs and to prioritise them;
- to evolve methods of resolving these needs and problems;
- to mobilize local resources;
- to implement activity in an organised manner and
- to monitor, evaluate and learn from the effort.

Naturally, the participation of the people is necessary for such an effort. Since, development promoted as an integral part of each practice of fisheries management and should work, within a time frame, towards an ideal (even if it may not be wholly achievable) condition.

People participation - arena for achieving goal

Encouraging people's participation in the management of fishery projects is not a new concept. But, whatever this widely talked of concept's name, the concept or people's participation itself seems to mean many things to many people and there has been much confusion and misapplication in its implementation. Therefore, there is need to clearly understand the level of people's participation, that is necessary to achieve the goals of a specific programme on fisheries. To arrive such an understanding, people's participation should be looked at in terms of:

(i) the quality of participation
(ii) the types of participation possible
(iii) the phases of participation
(iv) the proportion of those potentially affected who really participate in such schemes
(v) the representativeness and accountability of the leader and the local organisations of the potentially-affected community.
(vi) the degree of people's participation in terms of labour and money inputs.

Participation, with its peculiar dual nature of being a tool and an end to be achieved by the tool, suggests that, no matter how little the participation to begin with, it is a positive step towards not merely efficient and socially feasible action but towards development itself. Development, welfare and problem-solving were, in the past, activities that families, kinfolk and communities talked. But, with development and welfare increasingly and unfortunately, often exclusively becoming government responsibilities, or at best, agency functions, the question of who participate in whose activity becomes very relevant.

Generally speaking, it is the Government/Development agencies who, nowadays, do something for the beneficiaries, whether this involves transferring technology or building infrastructure, or whatever other task, the effort is that of the agency.

Organisations in participatory management

Participatory management activity by its very nature means working in management process with groups and communities. The research agency and change agents will have to make the management of the fisheries in open water bodies possible by the people themselves rather than do it to or for them. This shift in thinking and will have dramatic implications to not only management process but to the agency's culture as well. That will emerge or needs to emerge, is a shift from the developer - developee hierarchy to a situation of partnership where both the research/extension agency and the people see themselves as co-workers in the management process. This shift in approach might even require in the research/extension agency to hold back on what it believes to be true, scientific and modern, and begin a dialogue that, in time, will enable the beneficiary to, on his or her own, come to the same learning - perhaps to a learning, which blends the research/extension agencies learning with indigenous learning and realities.

There are two essential aspects to the organizational approach - one.facilitates day-to-day activity, with the community choosing representatives to speak on its behalf or undertake specific talks, the other one is more political aspects, which involves empowering the community to make it sure it gets its rights and to hold external agencies responsible.

Research/extension agencies by their very nature, work with communities only for short periods of time. If the development activity has to be self-sustaining and self-perpetuating, then the participating people's organisation has to have permanence and the ability to sustain the involvement of the community.

An important fact worth considering is that the existence of an organisation in a community does not ensure people's participation. Organizations frequently benefit only the wealthy and influential members of the community. There is also reality that several socio-cultural traditions tend to be authoritarian. In such communities, the leadership would oppose any form of organisation that promotes democratic and egalitarian norms. The research/extension agency would then have to consider whether it should use an existing traditional form of organisation in the community or help it to form a new organisation. Governments and research/extension agencies in relevance to the development of the fisheries in open waters seem particularly attracted to the cooperative form of organisation. If it functions properly it can be an ideal organisation, ensuring democratic management and an egalitarian distribution of benefits. However, while there have been a few spectacular success, the experience in general with fishermen cooperative societies has not been always good.

In India, government perceives the cooperatives as a channel for development benefits to the community. It considers under-development in fisheries as being due to the primitive nature of the traditional technology resulting in low productivity. So, its solution has been to enable fish farmers/ fishermen to acquire assets that would help them to make better yield.

The role of the organisation in participatory management is, understandably very important and almost a necessary condition. However, it places a heavy burden on the Government/Research/ Extension agency, which often has to strengthen the very organisation that not only will eventually have to hold it accountable. Government/Research/Extension agencies with their own objectives can not be depended upon to display such benevolence at all the times. Participation through organisation is, in this sense, therefore, much more difficult to plan and is unpredictable in nature. It suggests that there is need for the research/extension agency to commit itself first to participatory development and to the associated ideologies and attitudes, before it seeks strategies to roster organisation among fish farmers/ fishermen.

Meaningful participatory approach

Participation grows out of meaningful relationships that enable people to share and work together. There are several reasons why participation approaches succeed or fail. The reasons mentioned below could be considered as 'do's' and 'don'ts' for the developmental agencies. But, it might be wiser to consider the suggestions more as guidance giving direction to the activity rather than deterrents to action.

Has a legitimate role: The management of open water fisheries is rather participatory project - where a sort of negotiated activity in which people and the research/extension/ developmental agencies to work together for commonly shared objectives. To be able to negotiate successfully fish fanners/ fishermen, scientists, extension functionaries, developmental officials, have not only to respect each group but it must also feel that there is a legitimate role to play for that group. The agencies and its members must really see a role in the organisational process be considered legitimate and successful participation will result.

Enable 'equalness' to facilitate negotiation: For negotiations to be conducted meaningfully, the fish farmers/fishermen, scientists, extension functionaries and developmental officials involved, must be reasonably equal. Unfortunately, agencies and the people may negotiate with, are often at different levels not only in terms of power but in terms of knowledge and ability as well. This could lead to the activity to be implemented being more agency oriented. So, the agencies has the key role and the responsibility of first creating 'equalness' through educational programmes that develop communication and negotiation skills as well as power of analysis.

Begin with the felt needs of the people: For participatory management to be successful, it is necessary for all the groups (mentioned earlier) involved to know what they want. The agencies have their own mandate and the people have their own. Not only the content, but also the priorities may also vary. But, if successful participation is the aim, the beginning has to be made with what the people consider, are their needs and which the agency agrees, are areas of concern.

Learn from and with people: Participation suggests that the people and the agency are agreed on to do something about the way things are to be moulded. But, the agencies might not fully appreciate the circumstances and predicament of the people unless it is willing to learn from them. Only by learning from, and with, the people - their social dynamics and their needs and priorities, can the right agenda be mutually agreed upon and implemented with wholehearted participation of all in the community.

Build confidence as a prelude: People may be dissatisfied, but they must do something about that dissatisfaction. More important, they must have the confidence that they have the ability to do something about themselves. A whole range of cultural, social and historical factors, including past failures, can weaken this confidence. Thus, confidence-building is a task. The agencies may have to set itself before participation can be assured.

Help organisation to emerge: Some form of organisation *viz.,* Fishermen Cooperative Society, Fish Club etc. is necessary if participation management is to succeed because there is a need to take decision, take responsibility for particular tasks, allocate tasks, all of which can be done better when a community or group is organised.

No autocratic behaviour: Scientists/extension functionaries/developmental officials often feel that they alone know what needs to be done which are not democratic in their own functioning and not participative in their decision making, will find extremely difficult to convince communities they work. In most cases, the agencies and its characteristic and behaviour can be the most important factors determining the success of participatory management.

Flexible approach: The agencies usually tend to specialise in order to be more efficient. Their managerial cultures also tend to make them more rigid and time conscious. In participatory management, where others are involved, these characteristics may work against the activity. The people's needs may not coincide with the agency's capabilities, the time taken to achieve something real in the field may not fit well with reporting and budgeting schedules, mid course corrections may not be easy to bring in. Agencies need to have a far more flexible approach to their work if they wish to promote participation.

No place for unilateral decisions: The participatory approach grow out of the exchange of the agency's knowledge with people's blending in the process, the modern and the scientific with the traditional and the indigenous.

If the agencies really intend to become participative, the directions, objectives and priorities must evolve out negotiation and not out of unilateral decisions.

Need to realise limitations: If the agencies wish to work with a community and help to develop it, it really has only two choices:

- it can diversify its capabilities or bring in other agencies to be able to address the special needs of the people; or

- it can accept its limitations and negotiate for the use of its particular ability, of course keeping in mind that management in these circumstances would only be partial.

The agencies must be more realistic about the objectives that can be achieved, given their limited capabilities.

Getting the people do more: Agencies must do less and help people do more. Since, the goal is to get the people to do it at their own, the agencies should design tools how they can get others to do what agencies have the expertise to do. If the communities are to participate actively in the management process, the technology and techniques will have to be demystified, made simpler and more accessible. The agencies will have to release information freely to the people.

Coping with change: Working with communities, empowering them, enabling them to work with justice, democracy, the agencies will find the community going through basic structural changes. The agencies have to face those changes and its implications; the agencies will have to cope with it.

Conclusion

The experience with people's participation in fisheries related activities was initially limited. Significantly, it was the last sector to change from 'top-down' approach to a 'bottom-up' one. However, at present concerted effort must be prioritized towards participatory management approach for not only getting sustainable production of fishes from the open water bodies of the country but also for alleviating poverty in the rural areas.

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OPPORTUNITIES AND THREATS OF BIO-DIVERSITY OF FLOODPLAIN WETLAND FISHERIES RESOURCES OF INDIA

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INTRODUCTION

The concept of ecosystem management has undergone a series of paradigm shifts in the backdrop of increasing demand of food and nutrition. Ecosystems were to be exploited by human beings from anthropocentric perspectives. Accordingly, with the increasing perturbations in and around our natural resources, the functioning of ecosystems needs re-evaluation, especially in relation to social benefits.

The concept of sustainable development emphasizes that the natural resources are not inexhaustible; as such the development processes should aim at to meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

An aquatic ecosystem is recognized as a storehouse of plant, animal and microbes distributed in and above the benthic soil, with strong interactions between the biotic and the abiotic components. All these when combined together, it forms an integrated whole. The organization of biological factors in an ecosystem depends on certain ecological principles linking to biomass and productivity, energy recycling and energy flow (Fig. 1). The typological features of an ecosystem depend on species composition and the manner in which they are organized. These characteristics of aquatic ecosystems distinguish them as ecosystem types, such as riverine ecosystem, lacustrine ecosystem, estuarine ecosystem, mangrove ecosystem and so on. Besides the species composition, the climate and soil characteristics play an important role in determining these typologies.

The ecosystem in its totality including the biotic communities or biodiversity is subjected to a variety of perturbations. These perturbations either be *intrinsic* and *extrinsic* depending upon the type and nature of perturbation, such as:

- *Change in biological profile owing to grazing pressure or climatic change creates a temporary gap in the ecosystem, which is being filled by other organisms. Such perturbations are intrinsic as created within the system.*
- *In case of extrinsic perturbations larger issues are involved, which alter the biotic communities, such as discharge of pollution load or invasion by alien species.*

The open water ecosystems exhibit multiple ecological stands depending on geography, hydrology and type of a water body. However, they can be classified under two broad groups, such as lotic ecosystem and lentic ecosystem. The reservoirs among the open-water systems, however, occupy a unique position being a combination of both fluvitile as well as stagnant waters in the same system. Accordingly, they portray different sets of biota as compared to a natural lake or a river. In such ecosystem, only generalist type of species, which could adapt to the changed ecological regime, generally dominate. Besides, the biotic properties of a reservoir also subjected to two distinct phenomena, such as *trophic burst* and *trophic depression*, which regulate the biotic communities to a large extent.

Incidentally, however, floodplain natural lakes and rivers rather than reservoirs are the prime open-water aquatic resources in northeast catering to the demands of aquatic production of the region to a large extent. It is prudent, therefore, to understand the biotic profile of these systems of the region at greater length, especially in the context of their role in fisheries enhancement or conservation of precious endemic biodiversity, especially the biota with economic overtone.

BIOTIC COMMUNITIES IN AQUATIC SYSTEMS

Aquatic ecosystems indicate a mixed population of many types of organisms spread over to various ecological niches, such as pelagic, biological covers or benthic organisms. However, broadly they can be classified as autototrophs (algae and few bacteria) and heterotrophs (zooplankton, invertebrates, fish and fungi). Commonly, the biotic communities of aquatic systems are termed as plankton, periphyton, neuston and necton. Besides these, marophytes also form an important component among the biotic communities. It is well known that each organism requires adequate food for its survival and growth; as such many grazing chains are prevalent in an ecosystem. Biological production is basically a function of transfer of energy from lower trophic level to higher trophic level. Evidently, so long as the necessary grazing chains remain functional, the ecosystem continues to provide desired harvestable crop directly related to human welfare. However, aberration in any grazing chain or at any level of a particular grazing chain leads to distortion in production functions. This fact is also holds good in case of fisheries enhancement from any ecosystem, be it small confined water or large open water. The floodplain lakes under Ganga and Brahamputra river systems are the glaring examples of such aberrations, especially in relation to production and productivity of fish. The lakes were known for their rich biodiversity and lucrative carp fishery till recently, but this has now overtaken by minnows and forage fish species mainly due to significant change at the level of biotic communities. These lakes have largely been converted into weed-bowls besides greater dominance of molluscan population at the benthic niche. It is interesting to note that both these dominant biotic communities remain unutilized in absence of efficient grazers, especially fish species, as such the production which is required has nose-dived. Obviously, unless they are gainfully managed by bringing them under the ambit of grazing or they are removed to facilitate the proliferation of useful biota required bio-production, which is economically viable is just not possible.

ROLE OF MACROPHYTES ON BIODIVERSITY AND FISH PRODUCTION IN OPENWATERS

Macrophytes are the integral part of any aquatic ecosystem and they provide elasticity and stability to an ecosystem if present in reasonable quantity. However, they become undesirable when assume the status of weeds. Data generated at CIFRI on aquatic weeds and their related impacts on the ecology and fisheries of floodplain suggest the following:

- Increasing population of forage and predatory fish species at the expense of prized fishes
- Decreasing population of prized carps, the mainstay of fisheries of wetlands
- Decreasing texture and density of plankton, both phyto and zoo
- Lakes are increasingly heading towards swampification owing to strong succession of macrophytes *viz. submerged?emergent?reeds?reedy swamps?floating islands?grassland*
- Locking of important nutrients in hydrophytic chain leading to poor availability of these in the ambient water necessary for the desired growth of phytoplankton community
- Increasing level of alkalinity and higher precipitation of calcium leading to calcifobes, thus eliminating many plankton communities
- Decreasing penetration of sunlight down under making the benthic niche an ecological desert
- Increasing loads of semi-decomposed vegetative matters at the bottom forming canopies over the oxidative-micro-zones and blocking the release of necessary nutrients to ambient water to support the survival and growth of pelagic microorganism.

In view of the aforesaid it is prudent, to have proper understanding on the dynamics of aquatic weeds in an aquatic ecosystem so as to manage them effectively to the advantage of target group, the fisher community. It is necessary to develop effective methodologies to conserve the declining biodiversity and fisheries in the face of increasing stands of macrophytes. Managing aquatic weeds either by removing from the lakes or converting them into beneficial bio-products has assumed the centre stage of fisheries management of floodplain lakes as the stake holders, especially the fisher folks, are losing their livelihood at an alarming pace. Effective and immediate steps for the management of prevailing aquatic weeds is also necessary for environmental enhancement of this lucrative fishery resource so as to enhance the fish production on sustainable basis.

ROLE OF EXOTICS ON FISH PRODUCTION IN OPEN WATERS

In spite of very rich fish fauna, more than 300 exotic fish species have already been introduced in India. A majority of them, however, were ornamental species barring a few introduced with an objective either to broadened the species spectrum in aquaculture or to fill the vacant niche in lakes and reservoirs or to control insect larvae in confined waters. The sad commentary, however, is the entry of a number of exotic fish species in open-water systems like rivers affecting the endemic germplasm and fish catch of endemic species adversely.

Three larvicial fishes viz., *Lebistes reticulates, Notobranchus* spp and *Gambusia affinis* were introduced to control the insect larvae in confined waters. Among the food fishes common carp, silver carp, grass carp, trouts and tilapia have been introduced, especially in culture systems, with varying degree of success. In recent years, bighead (*Aristichthys nobilis)* and African catfish, *Clarius gariepinus* have also got entry into our open waters accidentally without any scientific backup on possible impact on the indigenous fish fauna.

Reasons for the introduction of exotics

Exotic fish species are introduced, generally, to achieve a specific objective or a combination of objectives, such as to accelerate *aquaculture activities, biological control of unwanted biota* or *promotion of sport fishery*. The broad reasons for such introductions are as under:

- Utilization of a vacant niche in an ecosystem
- Increasing food production for food security
- Improving the quality of sports (fishing, hunting)
- Biological control of undesirable species in an ecosystem
- Decorative or ornamental purpose

Beneficial Impacts of Introductions

Introductions of many exotic fishes have shown tremendous promise in specific environment like *Microcystis dominated reservoirs*, *weed-choked canals and wetlands*, *new culture systems* and *wasteland aquaculture*. Many such species can also play important role in the abatement of eutrophication or pollution, genetic improvements of indigenous species and as indicators to measure biotic integrity of an ecosystem. However, improving the fish production has been one of the guiding factors behind the introduction of alien fish species, as has been the case in composite fish culture in India.

Adverse impact

Translocation of exotic aquatic organisms is invariably accompanied by the potential of introducing new diseases disrupting ecological balance and downgrading the social benefits expected from an aquatic resource. Besides, an exotic fish may find adequately favourable aquatic regime to multiply swiftly, monopolize natural food sources and crowd-out native inhabitants. The main concerns associated with the introduction of alien fish species are the risk factors, such as:

- Contamination of endemic communities by foreign species
- Introduction of new diseases
- Disruption of the fish community through competition or perdition
- Degradation of the ecological environment, and
- Affecting the human lifestyles, customs or economic systems.

In absence of adequate database on the history and behaviour of an alien species, before and after introduction, it becomes difficult to determine the extent and magnitude of impact on an ecosystem. Predicting the consequences of introduction is a difficult proposition unless the ecological background of colonization by introduced species is fully understood. However, the impact of introductions could be categorized as *direct*, *indirect* and *resultant tendencies*.

Direct effect

Those impacts, which are caused by the introduced species themselves.

Predation

Many introduced species may affect the endemic fauna through predation on them. Brown trout (*Salmo trutta fario*) introduced in Beas River, for instance, has affected the snow trout (*Schizothorax plegiostomus*) by predation (Singh and Kumar, 1989). Similarly *Gambusia affinis* are reported to attack the eggs and fry of important sport fishes.

Niche competition

According to Gause's competitive exclusion principle, a niche cannot be occupied by two species (Kormondy, 1984). Silver carp introduced into Gobindsagar reservoir, for instance, has virtually displaced Catla. Niche competition has also been reported between exotic and native Salmonids in India (Joseph, 1989). Herbold and Moyle (1986) and Moyle *et al.* (1986) have argued that introduced species do not fill vacant niche, instead they fit into the new environment by compressing the realized niche still further affecting one or more endemic species present there, as the emerging environment can no longer support them.

Competition

Competition for food is another form of impact caused by many introduced species. Successfully introduced species typically exhibit a feeding habit, which displays the trophic opportunism leading to considerable overlap in the diets of introduced and endemic fishes in many systems. Such changes in the food web mediated by the introduction of exotic species likely to alter availability of food for native species leading breeding aberrations and poor recruitment. Besides this, introduced fish may also encroach upon the rearing and spawning grounds of endemic fish either through competition for space, food or breeding pattern.

Breeding

Exotic fish may breed with native species giving rise to offspring of lower survival rate. Though evidence is not very conclusive, indications are that hatchery reared (exotic/native) fishes are less fit for survival in the wild than progeny of wild fish. If this is so, it will result in the introduction of inferior genes into the gene pool of a population.

Indirect Effects

These effects are not ascribed directly to the exotic species but are related indirectly to them.

Introduction of parasites and diseases

Exotic fishes may spread disease especially that of viral nature to the wild fish stock resulting in considerable economic or ecological damage. Many diseases like the whirling disease and Ichthiothyriosis are reported to be exotic in origin. Fish introductions were responsible for importing fish parasites such as fish louse *Argulus* and anchor worm *Lernea cyprinacea*. India has experienced a serious financial set-back because of EUS in fish and white spot disease in shrimps, caused by exotic pathogens. American catfish introduced in Tamil Nadu and Andhra Pradesh have been reported to spread viral disease in many areas. The recent trend towards rearing of imported aquarium fishes in commercial scale has not only increased the risk of introducing new diseases but also the likelihood of their transmission to wild and cultured stocks. Several workers have reported that many of the introduced fishes are infected with parasites previously unknown in India (Mukherjee and Haldar, 1982). The protozoan parasite *Martelia refrigens* was reported to be introduced through Pacific oyster *Crassostrea gigas* and similarly the cestode *Bothriocephalus acheilognathi* and the bacteria *Aeromonas salmonicida* were reported through *Ctenopharyngodon idella* and brown trout respectively.

Besides direct transmission of a disease, introduction of exotic species can also have catalytic effect (Mills, 1982). It is suggested that the natural defense mechanism of the native species to fight diseases could be lost with the introduction of new species or strains of fish.

Niche modification

Some species can modify an environment either by degradation of water quality or by removal of beneficial organisms or other forms of disturbances making it unsuitable for others. European carp, for instance, are known to increase turbidity by causing disturbance at the sediment. In Lake Victoria, introduction of fish resulted in a shift of fish community structure leading to eutrophication and algal blooms, ultimately. Invasion by Eichhornia has altered the niche of all the floodplain lakes making them unsuitable for many beneficial biota, such as IMC.

Exotic Synergism

In some cases, one exotic species may help the other to establish itself in the new environment. This phenomenon is termed as *exotic synergism*. However, negative interactions between two or more exotic species have also been observed, which is termed as "exotic antagonism".

Resultant Tendencies

Bio erosion or erosion of biological diversity

- Introduced fish may reduce the effective population size (Ne) of the native population by direct competition for food and space or predation, which may lead to genetic drift, inbreeding and loss of genetic variations or vigour.
- Alteration/extinction of the gene pools of the species/stock by cross-breeding/ hybridisation and back-crossing. *Inter* and *intra* specific hybridisation between native and exotic fish species results in introgression and contamination of the gene pool and ultimately the loss of adaptation to the local environment.

Bio-universalization

Introduction or invasions of exotic species have become a major phenomenon and perhaps inevitable in biological world. As a result a few species of flora or fauna are set to colonize throughout the globe (bio-universalisation). These few species tend to dominate in behaviour causing appreciable damage to the native species. The resultant tendency thus may allow the existence of fewer dominant species of flora and fauna all over the world leading to severe loss to biological diversity. Brown trout (fauna) and *Eichornnia crassipes* (flora) are termed as *universal* or *universalizing* species owing their wide distribution and ever expanding ranges.

Indian scenario

In India the impact of alien species on indigenous ichthyofauna in wild and culture fisheries has not been properly evaluated, even though reports are available to prove that some introduced fishes have adversely affected the indigenous species. The alien species, which have significant impact on endemic fish species, are as under:

Tilapia

- Their prolific breeding tendency invariably, surpasses the carrying capacity of the water body leading to stunting of individuals.
- Genetic erosion and loss of species diversity or replacement / suppression of indigenous fish species has made our "gene rich" fish population "gene poor".

Tilapia was introduced in Indian waters in early 50s with the intention of increasing fish production in reservoirs, where production was very less. However, barring a few reservoirs tilapia dominated fishery invariably led to low yield rates. In peninsular reservoirs, tilapia has already established with deleterious impact on the indigenous species (Natarajan, 1988; Shetty *et al.* 1989). Tilapia has completely whipped-out the carps in Jaisamand Lake of Rajasthan with a production of more than 95% of total fish catch by weight. In many reservoirs like Krishnagiri and Vaigai also tilapia has adversely affected the fish production.

Common carp

- Destroys pond embankments, makes water turbid due to churning of muds.
- Attains maturity early thereby growth retarded
- Eggs are easily infected by fungus.
- Difficult to harvest, especially in deep waters

Silver carp

- Competes with Catla.
- Quality of flesh poor as compared to IMC
- Long distance transportation of fry needs special care being extraordinarily fragile.

In general, exotic carps are known to affect the endemic fish population as indicated from fish catch from Dal-lake (Kashmir), Kumaon lake (Uttar Pradesh), Gobindsagar (Himachal Pradesh) and Pong (Punjab) reservoirs.

African magur

- Highly predatory and cannibalistic in nature
- African 'magur' can lead to a catastrophe, if escaped to the open waters.
- Production per unit area of a carnivore is relatively less compared to herbivores (theoretically as much as 80-90% less).

ISSUES RELATED TO RATIONAL MANAGEMENT OF BIOTIC COMMUNITIES VIS-À-VIS FISHERIES

- ➢ Changing face of aquatic biodiversity, especially the endemic species with economic overtones
- ➢ Increasing incidence of exotic and invasive species leading to niche modification
- ➢ Conservation of endemic germplasm for maintaining ecological integrity or elasticity.
- ➢ Lopsided growth of biotic communities in lakes and rivers
- ➢ Effective means to curb the tendency of wanton killing of juveniles and brooders.

CONCLUSION

Invasive species or lopsided growth of biotic communities like excessive proliferation of macrophytes or unwanted discharge of wastes have been identified as the potent factors for the loss of endemic biodiversity thereby the productivity. The community structures in an aquatic system are based on a complex relationship among different species. Man-made change to the system may upset this delicately balanced species structures affecting the whole process of community succession. Introduction of any species may fulfill the primary objective of increasing fish production but it may destroy the ecological balance as have been the case in many reservoirs and lakes after tilapia was introduced. Alteration of ecological communities caused by alien and invasive plant or animal species influences the ecological functioning, as such the overall health of the ecosystems. For instance, most of the floodplain lakes have become the victim of *Eichhornia*, an invasive weed. Negative effects of biological invasion include degradation of the host environment, disruption of the host communities through competition and displacement and decline in production and productivity (e.g., fishery).

Combating invasive species in India is relatively difficult because of lack of awareness and adequate initiatives. There is an urgent need for sustained awareness campaign among the target groups so as to motivate them to adopt precautionary and conservation modes during their various activities. Active participation of common man holds the key for rational utilization of resources including the bio-production. This can be done through a chartered protocol and legislation for introduction besides accelerating the dialogues between scientists, developmental agencies and progressive fish farmers.

In addition to the adverse impact of thoughtless introduction of exotics, maintaining the biological integrity of aquatic ecosystem is another area, which needs careful monitoring so as to obtain fish production on sustainable basis. This can be achieved through effective check and balance on the *intrinsic* and *extrinsic* factors responsible for the alteration of biotic communities.

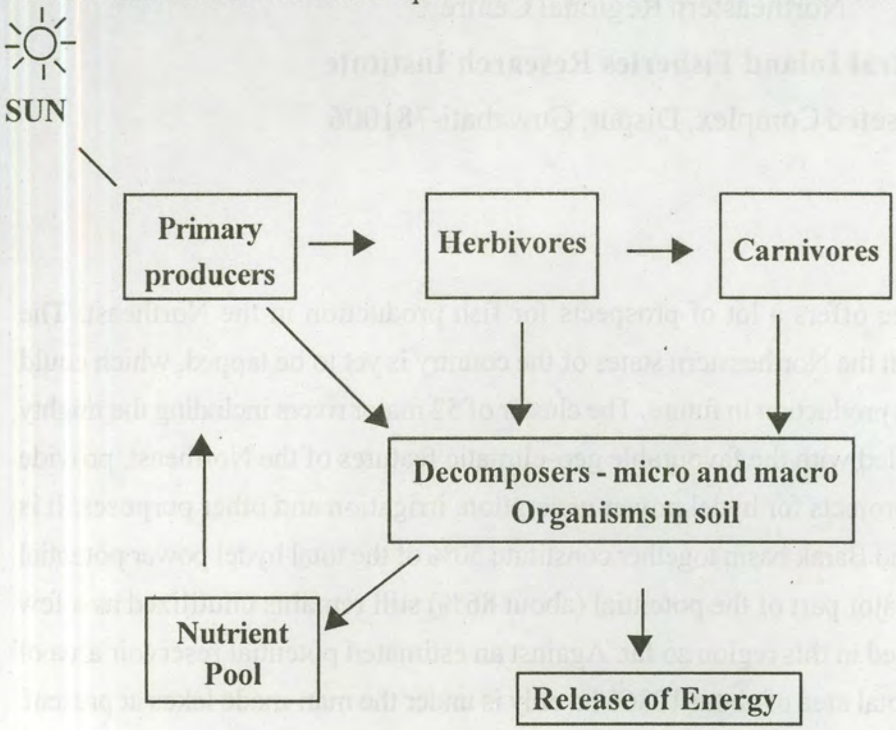

Fig. 1: Simplified Diagram of the transfer of energy and elements in an aquatic ecosystem indicating unidirectional energy flow and cyclic movements of elements.

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Shrivastava, N. P., 2003. Management issues and options of reservoir fisheries of northeastern region, pp. 31-34. *In:* M. Choudhury, N. P. Shrivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

MANAGEMENT ISSUES AND OPTIONS OF RESERVOIR FISHERIES OF NORTHEASTERN REGION

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INTRODUCTION

The reservoir resource offers a lot of prospects for fish production in the Northeast. The potential of reservoir fishery in the Northeastern states of the country is yet to be tapped, which could be a great source of inland fish production in future. The cluster of 52 major rivers including the mighty Brahmaputra and Barak coupled with the favourable geo-climatic features of the Northeast, provide ideal sites for multipurpose projects for hydel power generation, irrigation and other purposes. It is estimated that Brahmaputra and Barak basin together constitute 50% of the total hydel power potential of the country. However, a major part of the potential (about 86%) still remains unutilized as a few reservoirs could only be created in this region so far. Against an estimated potential reservoir area of 76966 ha in the Northeast, a total area of about 10866 ha only is under the man-made lakes at present.

The Brahmaputra Board conceived two large dams on the rivers Subansiri (Subansiri Dam Project) and Siang (Dibang Dam Project) in 1983, which could not be taken up as objections were raised by the Arunachal Pradesh Govt. due to the large submergence of its area and some important towns. Now, the six mega-projects on the two tributaries of the Brahmaputra have been handed over to the NHPC (National Hydroelectric Power Corporation). If all goes well, these dams will come up before the end of this decade. However, the development of hydropower has been retarded due to problems like resettlement and rehabilitation, environmental issues etc. The controversy over the proposal to construct Tipaimukh dam continues to rage in Manipur. The opposition of this dam is on the pretext that it would destroy nearly 276 sq. km of agricultural and settlement land besides massive ecological and environmental disaster. The problem is more serious in a biological diversity-sensitive region like Northeast, which is one of the 12 hotspots of biodiversity in the world.

Reservoir fishery resources of the Northeast

State	Existing area (ha)	Projected additional area (ha)
Arunachal Pradesh	160	-
Assam	2314	-
Manipur	100	40000
Meghalaya	660	-
Mizoram	32	-
Nagaland	2500	24600
Tripura	4500	1500
Others	600	-

Reservoirs of the Northeastern region

Reservoir	State	Area (ha)
Umiam (Barapani)	Meghalaya	500
Kyrdemkulai	-do-	90
Nongmahir	-do-	70
Khandong	Meghalaya & Assam	1335
Umrong	Assam	979
Gumti	Tripura	4500
Khoupum	Manipur	100
Palak	Mizoram	32
Ranganadi	Arunachal Pradesh	160
Doyang	Nagaland	2500
Others	-	600

Management issues and options of reservoir fishery development in Northeast

The initiation of systematic organised fishing activities, fish yield optimisation and the conservation of indigenous fish stocks are some major management issues for development of reservoir fishery in the Northeast. Excepting the Gumti in Tripura, no other reservoir has organised fishing in any of the seven sister states of the Northeast.

Gumti (4500 ha), the largest reservoir of the region was impounded in 1977 across the river Gumti. On an average the reservoir gave an annual fish production of 141.74 t (31.5 kg ha^{-1}). The minnows and catfishes dominated the fish catch of the reservoir. Indian major carps breed in the upper reaches of the reservoir but their isolated breeding success has no desired impact on the recruitment to the fishery. The natural recruitment of economic species is not dependable in reservoirs owing to the limitations imposed by the biotope for carp breeding. Hence, artificial recruitment needs to be generated through stocking fingerlings of desired species. Thus, in the absence of any recruitment of major economic species in the reservoir, sustained stocking is an important management measure to improve upon the fishery of this reservoir. Although, the reservoir was stocked at an annual average rate of 245 fingerlings ha^{-1}, which was later raised to 632 nos.ha^{-1}, it did not have the desired impact on the fish yield. It may be because of the dominance of minnows and catfishes in the reservoir. The minnows compete for food with major carps and as such their control is necessary for the development of major carp fishery. The high concentration of catfishes also needs to be brought down to get the better results of stocking.

Kyrdemkulai (90 ha) and Nongmahir (70 ha) in Meghalaya are two pick-up reservoirs created below the Sumer Power Station of the Umtru-Umiam hydroelectric project in 1979. The feasibility studies for fishery development of these reservoirs were conducted by CIFRI (Sugunan and Yadava, 1991).

The fishery of Kyrdemkulai reservoir is not being managed in an organised manner. The engagement of local tribal people and the employees of Meghalaya State Electricity Board (MeSEB) restricts to subsistance or recreational fishing. The fish catches are not monitored, no catch statistics are available. The number of active fishermen is negligible. They have no proper fishing implements.

The feasibility studies have revealed that there is enough scope for fish yield optimisation in this reservoir through effective management. The reservoir can sustain a fish yield of 534 kg ha^{-1}, which could further be increased to 1000 kg ha^{-1} with the improvement in the fertility status of the impoundment.

Besides, the main emphasis on yield optimisation, the conservation issue of the natural populations of the chocolate mahseer, Neolissocheilus hexagonolepis, the golden mahseer, Tor putitora and Tor tor should also be taken care of. These fish are highly preferred by the sport lovers and commercial fishermen. The chocolate mahseer is specially liked as food fish by the local people. As such this reservoir may be utilized for conservation and development of endangered species and for popularizing eco-tourism. This reservoir provides a suitable habitat for breeding and recruitment of mahseer. The juvenile fishing of mahseer and major carps should completely be banned.

In view of the suitability of the ecosystem to Indian major carps, the stocking is essential to built up their fishery in this reservoir. It needs to be stocked annually @ 1,50,000 fingerlings (above 100 mm) of catla and rohu in the ratio 3:2. In the commercial exploitation, catla and rohu below 400 g should be protected from capture. Following the conservation measures, June 15 to August 15 should be observed as 'closed season' with a complete ban on fishing. The rearing of fingerlings of carps and mahseer in pen enclosures is an important management measure suggested for the reservoir. The reservoir is capable of giving a production of 48 t/A comprising 40 t of carps and 8 t of mahseer. Thus, the fish yield optimisation and conservation of mahseer fishery are two main management issues of this reservoir.

Nongmahir is a pick-up reservoir, formed to store the waters of Kyrdemkulai Reservoir. There is no organised commercial fishery in this reservoir also. The fishing activities are limited to angling and seasonal use of bamboo traps. Angling is a favourite pass time in Meghalaya. The fish catch is very low comprising small common carp. The fish catch of bamboo split mat pens includes weed fishes, H. fossilis and common carp.

As reported by Sugunan and Yadava (1991), Nongmahir reservoir may yield @ 433 kg ha^{-1}, which may further be enhanced to 1000 kg ha^{-1} with the increase in the fertility of the reservoir through manuring.

Nongmahir being a fore-bay of Kyrdemkulai, does not receive runoff from any watershed depriving the reservoir of allochthonous nutrients. There is a negligible native fish stock, the common carp being the only major commercial species. The entry of fish to Nongmahir from Kyrdemkulai reservoir is also prevented due to log guard. In the absence of any streams and rivulets joining the reservoir, the chances of natural recruitment are very remote. Under such a situation, the stocking is the most important management norm for fishery development of this reservoir. In the presence of common carp, which is breeding also in the reservoir, no stocking of bottom feeding detritivore is needed. Annual stocking of 1,10,000 fingerlings (above 100 mm) of catla and rohu in 3:2 ratio has been suggested by Sugunan and Yadava (1991). The phased stocking and multiple harvesting may yield better results.

Umiam (Barapani) is the oldest reservoir in this region, commissioned in 1965 on river Umiam. Of late some fishery development activities have been started in this reservoir. Earlier, the fishing was limited to angling only, which was also not organised. However, the reservoir provides an ideal site for the anglers in and around Shillong. The common carp was stocked in early 1970s, which is now well established in Umiam and forms the main fishery of this reservoir. A slow growth of common carp has been reported due to overpopulation (Sinha, 1990). The city wastes from Shillong enters into the reservoir. The deforestation in the catchment is increasing the siltation rate in the reservoir. The commercial exploitation on scientific lines and regular basis should be started to check the overpopulation and obtain sustained fish yield from this reservoir. A strict mesh-size regulation, ban on juvenile fishing of common carp and proper stocking policy including the IMC also would help in enhancing the fish production of this reservoir.

Khandong and Umrong reservoirs were created under the Kopili Hydro-electric project. Presently these reservoirs are under the North Eastern Electric Power Corporation (NEEPCO). No regular fishing has yet been initiated in these reservoirs. The NEEPCO and CIFRI have conducted feasibility studies for fishery development of these reservoirs, which indicated that the fishery of these reservoirs could be improved through proper scientific management of the ecosystems.

Khandong is a 1335 ha reservoir on river Kopili. The fish yield potential of Khandong has been estimated at 50 kg $ha^{-1}yr^{-1}$. Umrong is a pick-up reservoir (979 ha) receiving water from Khandong. Both reservoirs are reported to be productive for fishery development. The fishery activities should be initiated with scientific management of these reservoirs.

Conclusion

For successful management and development of fishery in reservoirs, it is essential to have the correct understanding of these ecosystems with regard to their production capacities in particular. Studies on fish behaviour under various ecological conditions are of paramount importance. It is a well-known fact now that no common management strategy can be followed uniformly for all reservoirs. Different reservoirs do need different development policies depending on their varying ecological factors.

It is evident that among all the existing reservoirs of Northeast, only Gumti has an organised fishery activity. All other reservoirs are either under-exploited or unexplored. A large number of river valley projects are already coming up in the region, which would increase the reservoir area of Northeast to about 77,000 ha in due course. At a modest yield rate, the existing reservoirs along with the proposed ones are expected to contribute about 12,000 t/A to the total fish production of the region. However, this needs a well-planned fishery development policy, need-based research and development activities.

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Saha, P. K., 2003. Soil and water quality of fisheries resources of Northeastern India: Issues and options, pp. 35-38. In: M. Choudhury, N. P. Shrivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

SOIL AND WATER QUALITY OF FISHERIES RESOUR'CES OF NORTHEASTERN INDIA: ISSUES AND OPTIONS

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INTRODUCTION

The northeastern region of India comprising seven states viz. Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura covers a geographical area of 255,083 sq. km. The region is situated in a high rainfall zone receiving an annual rainfall of 100 to 114 cm. It is an admixture of diverse topographical conditions ranging from the plains of the Brahmaputra and the Barak valleys in Assam, plains of Tripura, upland flat of Imphal valley in Manipur to predominantly hilly region of Arunachal Pradesh, Meghalaya, Mizoram and Nagaland. As much as 65% of the total geographical area of the northeast consist of hills and mountains. These hill/mountains give rise to 52 major rivers including the Brahmaputra and Barrak, which have a combined length of 19,150 km. Besides the region has more than 1.4 lakh ha of *beels*, lakes and swamps, 40,000 ha of ponds/mini barrages, 23,000 ha of reservoirs and 2,700 ha of paddy-cum fish culture.

Fish production from these resources depends primarily on the presence of good quality of fish food organisms and the maintenance of congenial environmental conditions of the water body. Soil and water are the major component of environment of any water body. Therefore, it is necessary to have a proper knowledge of the more important physical and chemical properties of soil and water, which influence the productivity of water bodies.

PROPERTIES OF SOIL

Texture

Soil texture is an indicator of the proportionate composition of mineral fractions in soil and is grouped into sand, silt and clay depending on the particle size. Both sandy and clayey soils are not desirable as in the former nutrients are lost due to heavy leaching while in the later, high adsorption capacity impoverish the water from all its nutrients. Loamy soils with a balanced composition of sand (23-52%), silt (26-50%) and clay (7-27%) are considered most favourable.

Studies conducted by CIFRI on ecological status of *beels,* reservoirs of northeast region and river Brahmaputra and its tributaries indicated the dominance of sand in the sediment.

Soil reaction (pH)

Soil pH is one of the most important factors for maintaining the productivity of any water body since it controls most of the chemical reactions. The availability of nutrient elements native as well as added, rate of mineralization of organic matter, fixation of P and other elements and growth and survival of different biotic communities are greatly influenced by pH. Soils are classified into acidic (pH < 7.0), Neutral (pH 7.0) and alkaline (pH > 7.0) according to its pH or H^+ ion concentration. Soil with pH less than 5.5 or above 8.5 is unproductive and in the range of 6.5-7.5 is considered ideal.

The sediment of river Brahmaputra and its different stretches and tributaries are slightly acidic to near neutral in reaction. Whereas, soils of *beels*, ponds and reservoirs of the region exhibit wide variation in pH and are mostly acidic in nature.

Organic carbon content

Soil organic matter or humus influence the physical, chemical and biological activities in soil, improves soil structure, aeration, increase water holding capacity, buffering and exchange capacity in soil including solubility of soil minerals and serves as a store house of various nutrients essential for biological production. Soils having less than 0.5% organic carbon are considered low productive while those in the range of 0.5-1.5% and 1.5-2.5% are considered medium and high productive respectively.

Soils of floodplain wetlands of the region contain more organic matter than upland field due to accumulation through autochthonus as well as allochthonus sources while sediments of most of the rivers are poor in organic carbon.

NUTRIENT STATUS

Nitrogen

Nitrogen being a basic and primary constituent of protein is required to stimulate primary production in aquatic environments and is essential for the formation of living matter. In soils, nitrogen occurs mostly in organic combinations and inorganic nitrogenous compounds (NH_4, NO_3, NO_2) are released through bacterial decomposition of organic matter for enrichment of water with this element. It is the easily decomposable form of organic nitrogen known as available nitrogen, which is important in aquatic productivity. For any productive soil, available nitrogen must be above 250 mg/l.

Available nitrogen status of most of the floodplain wetlands soils of the region is conducive for biological production while sediments of ponds, reservoirs and rivers are mostly poor in available nitrogen.

Phosphorus

Phosphorus is considered a key element in biological production in aquatic environment and is very often become a limiting factor in plankton production. The native phosphorus status of most soils is rather low compared to nitrogen and potassium. Moreover, phosphorus becomes unavailable as insoluble ferric as well as aluminum and calcium phosphates under acidic and alkaline condition respectively. A productive soil must have above 30 mg/kg of available phosphorus. Sediments of most of the water bodies of the region are poor in available phosphorus.

WATER QUALITY

pH

Alkaline waters are more productive than acid water. The acid and alkaline death points for most of the fishes are 4.0 and 11.0 respectively which seldom occurs in natural waters. Water pH in the range of 7.5 to 8.5 is considered ideal for good fish production. Most of the water bodies of the region have near neutral to alkaline water pH.

Alkalinity

Carbonate and bicarbonate of calcium and magnesium mainly cause alkalinity or acid combining capacity of water. Natural water having 50 mg/l or more total alkalinity is considered productive. At higher range it does not act as limiting factor. Total alkalinity of water of different water bodies of the region varied considerably ranging between 20 and 250 mg/l.

Dissolved oxygen

Dissolved oxygen is considered as the most critical water quality parameter in aquaculture. Physical, chemical and biological processes cause a dial fluctuation in the concentration of dissolved oxygen in water and accordingly remain minimum during early morning hours and gradually increases to attain maximum value in the afternoon. Though most of the fishes can survive at a concentration of dissolved oxygen below 5.0 mg/l but prolonged exposure to such low concentration affect various physiological activities of aquatic animals and in no case the level should drop below 3.0 mg/l. Most of the water bodies of Northeast region have favourable dissolved oxygen concentration.

Carbon dioxide

Carbon dioxide plays an important role in aquatic environment by producing calcium bicarbonate from calcium carbonate and by maintaining pH of the water nearly constant through the buffer system of $CO_2 - CaHCO_3 - CaCO_3$. Most fish species can survive a wide range of carbon dioxide concentration in the presence of sufficient level of dissolved oxygen in water. At lower level of dissolved oxygen presence of appreciable amount of carbon dioxide affect the uptake of oxygen. Free carbon dioxide above 15 mg/l is considered detrimental to aquatic animals.

Dissolved nutrients

Nitrogen and phosphorus are the two important dissolved nutrients in water of great significance. Primary fish food organisms mostly derive their nitrogen requirement in soluble inorganic NH_4 and NO_3 forms and phosphorus in soluble inorganic forms. Waters having inorganic nitrogen and P_2O_5 levels above 0.2 and 0.1 mg/l respectively are considered productive. The concentration of nitrogen and phosphorus in water of beels, rivers and reservoirs are generally low.

MAJOR ISSUES AND THEIR SOLUTIONS

One of the most important factors that influence the productivity of the water bodies of Northeastern States is the acidic nature of bottom soil. Liming may solve this problem in ponds and small water bodies. Depending on soil pH and soil texture 1000 to 2000 kg lime is to be applied in single dose before stocking. In water bodies with soil pH ranging between 6.5 and 7.0 and total alkalinity of water >50 mg/l, liming at 300 kg/ha/yr before stocking the fish is usually recommended in order to neutralize the acidity that develops during subsequent use of inorganic fertilizers and organic manures in semi intensive fish farming.

Poor nitrogen and phosphorus status of most of the small water bodies of the Northeastern States is another constraint, which leads to poor fish production. Application of urea (10-20 kg/ha/month), single super phosphate (40-60 kg/ha/month) and organic manures (500-1000 kg/ha/month) depending on the available nitrogen, available phosphorus and organic carbon content of sediment improve the nutrient status of soil as well as water. It is advantageous to apply phosphate fertilizers in split doses as it ensures a continuous supply of P.

Large scale of deforestation, jhum or shifting cultivation in the region leads to erosion of topsoil, which along with the runoff silts the river basin, *beels* and reservoirs. Studies made by CIFRI in Assam hills indicate that at least 10 cm of soil is washed away even from moderate slope, in each Jhum cycle. The soil erosion problem, particularly in the north bank of Brahmaputra is very acute due to heavy deforestation in Arunachal and Bhutan foothills. This alarming rate of deforestation needs immediate check coupled with massive afforestation programmes in the denuded hill ranges. Besides, sound watershed management programmes should immediately be enforced.

The discharge of industries and municipal wastes along with runoff from tea garden and agricultural plots severely affect the quality of soil and water of fisheries resources. Faulty hydraulic structure and agriculture practices increase the sediment and nutrient load in the water bodies, which increased the risk of eutrophication and eventually deterioration of water quality. Insecticides and pesticides used in agriculture field contaminate sediment and water of nearby water bodies. It is necessary to exercise immediate check on dumping of untreated waste in the drainage. A holistic approach extending beyond both states and international boundaries should be initiated for eco-conservation.

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Moza, U., 2003. Inland fisheries resources of hill region in India- opportunities and threat, pp. 39-43. *In:* M. Choudhury, N. P. Shrivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

INLAND FISHERIES RESOURCES OF HILL REGION IN INDIA- OPPORTUNITIES AND THREAT

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The review emphasizes the hill regions of India having adequate fishery resources. It also highlights the fish diversity potential, and the economic species available in this specific hill aquatic ecosystem. The opportunity this resource provides for the upliftment of socio-economic status of hills and the threat it will pose, if not managed properly is also being discussed.

Introduction

India is bestowed with one of the great mountain chain of the world - Himalayas. This mountain forms great wall to the north of India running continuously for about 2500 Kms, between the Indus in the west and Bhramaputra gorge in the east-Himalayas, are arc shaped having a width of 160-400 Kms., consisting of three Parallel zones. The Greater or Inner Himalayas, is the north most of the ranges with an average elevation of 6100 m. Lesser or Middle Himalayas, range between 3000-4600 m, with an average width of 80 Kms. Outer or Siwalik Himalayas lie between plains and lesser Himalayas, with an average elevation range of 500-1500 m, width range of 8-50 Kms. It is these Siwalik Himalayas, which form the maximum hilly regions of the country. The other hill regions being Vindhya and Satpura situated in central India, highlands of which range between 700-1200 m.; Western ghats, the continuous unbreakable mountain chain of 1600 Kms., parallel to the west coast with mean elevation range of 900 m; Eastern ghats, set of broken discontinuous hills extending roughly parallel to east coast from northern Orissa to Tamil Nadu, where they meet western ghat hills at Nilgiris. The average elevation of these is around 600 m. Hilly region of India particularly Himalayas and Western ghats constitute about 21% of the area of the country (Murugandnan and Samra, 2000). Hill regions of India are home to almost all water sheds of the country, the main being, Indus, Ganga, Brahmapura in the north, Godavari, Krishna, Cauvery in the uplands of Western ghats, Narmada, Tapti and Mahanadi form Vindhyas and Satpura. Thus the region has plenty of aquatic resources in the form of upland streams/rivers, lakes, beels and manmade reservoirs. These aquatic resources hold population of both indigenous and exotic, cultivable and non-cultivable fish species. The occurrence and distribution of which depend mainly on habitat (river bed, altitude), presence of dissolved oxygen and temperature range of the water body, which sustains these species. The optimum temperature range in which fishes present within hills sustain and grow lie at lower level of thermal scale between 10-20°C, as such the fishes inhabiting these resources are termed "Cold Water Fishes". On the basis of temperature tolerance, cold water fishes categories into Stenothermal like Trouts, Loaches and Snow Trouts (having narrow temperature tolerance) and Eurythermal (having broad temperature tolerance) like Mahseer, Lesser barrils and some minor carps like *Labeo dero* & *L. dyocheilus*.

Table 1. Oxygen and temperature tolerance range of some important hill stream fishes

Main Fishes of economic importance	Critical dissolved oxygen value (mg/l)	Water Temperature (°C)
Snow Trouts		
Upper Limit	8.0 and above	20-25
Lower Limit	5.0	5.0
Good growth performance		15-20
Mahseer		
Upper Limit	7.0 and above	25-30
Lower Limit	5.0	10.0
Good growth performance		15-25
Exotic Trouts		
Upper Limit	8.0 and above	15-20
Lower Limit	6.0	4.0
Good growth performance		10-16
Exotic Carps		
Upper Limit	6.0 and above	25-32
Lower Limit	3.0	5-7
Good growth performance		20-25

(Source. Vass & Gopakumar, 2002)

Distribution

The fishery resources within hills mainly orient into 3 groups on the basis of altitude. Above 1500 m, upland fast flowing streams mostly have loaches, *Noemachilus* species and Snow trout, *Diptychus maculatus*. Medium altitude range between 700-1500 m contain mostly exotic trouts, Snow trouts, minor carps like *Garra* species, catfishes like – *Glyptothrax* and *Glyptosternum* species. Low altitude hills below 700 m contain maximum resources in the form of Mahseer, Snow trouts, Lesser Barrils, minnows, minor carps, catfishes and eels, mostly eurythermal species. The region is important from fishery point of view because of high biological productivity.

Fish Diversity

There are 258 cold water fish species both indigenous and exotic belonging to 76 genera reported from hilly regions of the country by NRC on cold water fisheries. These belong mainly to five different families – Cyprinidae, Salmonidae, Cobitidae, Sisoridae and Mastacembledae. However, the number of some important forms and their economic value is given in Table 2.

Table 2. Number of important Hill Region Fishes (both indigenous & exotic)

	No. of taxa	Importance
A. Indigenous Species		
1. Snow Trouts	10	Food Fishes
2. Mahseer	05	Food & Sport Fishes
3. Minor Carps	04	Food Fishes
4. Minnows	04	Ornamental Fishes
5. Lesser Barrils	05	Ornamental Fishes
6. Cat Fishes	02	Food Fishes
B. Exotics		
1. Trouts	03	Sport Fishes
2. Others	04	Food Fishes

Fishery Resources in Hill Regions of India

Fishery resources in Hill Regions are confined mainly to watersheds present within northwestern, central and northeastern Himalayas and to lesser extent to Nilgiri Hills of Deccan Plateau. Northwestern Himalayan hills are present in the state of Jammu & Kashmir and Himachal Pradesh. Central Himalayan Hills constitute Uttaranchal and Northeastern Himalayas extends into state of Sikkim, Arunachal Pradesh, Assam, Meghalaya, Mizoram, Manipur, Nagaland, Tripura and the part of West-Bengal – Darjeeling hills. Natural resources of these states in the form of rivers, reservoirs and lakes and the species diversity within these resources is given in table 3.

Table 3: Inland Fishery Resources in Hill regions of India

	Rivers (km)	**Name of watershed**	**Lakes**	**Reservoirs**	**Fish diversity**
Himalayas					
Northwestern Kashmir hills	400 (Jhelum)	Indus system	4190.6 (Low altitude)		37
Jammu hills	1935 (Chenab, Ravi, Sutlej, Beas)	-do-	74		218
Himachal Pradesh	(Ravi, Jamuna)	Indus + Yamuna system	23	22050	83
Central					
Uttaranchal	2138 (Ganga, Yamuna)	Ganga system	400	13300	28
Northeastern					
Sikkim	900 (Teesta, Rangit)	Brahmaputra system	1536.88		125

Darjeeling Hills (North Bengal)	3397.63 (Teesta and its tributaries)	-do-	4000 (Jhora ponds)		
Arunachal Pradesh	2000 (Siang & Dibang)	-do-	2500		167
Assam	5050 (Brahmaputra)	-do-	10,000	10,730	211
Manipur	2000 (Barak & Imphal)	-do-	19,150 (Loktak) 21,000 (Others)	100	121
Meghalaya	Southern tributaries of Brahmaputra	-do-	375	8430	165
Mizoram	1700 (Tributaries of Brahmaputra)	-do-		32	48
Nagaland (Barrak & Tizu)	1600 -do-	215		68	
Tripura (Longai, Khonai)	1,200 -do-	500	4500	134	
Deccan plateau					
Tamil Nadu	78	Cauvery basin	76	3494	Trout (rainbow)
Kerala	65 Periyar				*L. typhus* (snow trout)

Fish Production

Fishery in hill region are mostly of small size and of subsistence type, mainly capture oriented, caught individually by fisherman and do not form fishery of commercial importance. However, a few forms like Snow trouts (*Schizothoracids*) Mahseer (*Tor* species), Common Carp (*Cyprinus Carpio*) and few minor Carps (*Labeo dero*, *L. dyocheilus*) are some of the important food fishes dwelling in uplands. Truly speaking even these do not form fishery of appreciable magnitude because of their slow growth. Contribution of coldwater fish production to the total inland fishery sector is hardly 1% as reported by Vass & Gopakumar (2002).

Trend in estimated cold-water fish production (in thousand tonnes)

Sector	1996-1997	1997-1998	1998-1999	1999-2000
A. Inland	2381	2438	2566	2823
B. Cold Water Fisheries	20.5	22.5	22.12	27.66
C. % of Total	0.86	0.92	0.94	0.98

(After Vass & Gopakumar, 2002)

Opportunities

As observed, production of coldwater fishes within hills to the total inland production basket is not very significant, but it has natural resources to make dent and contribute to the economy of hill regions.

The upland resources with pristine clear waters harbouring two species of trout mainly Brown and Rainbow within northern hill states and Nilgiris respectively, if managed on scientific lines can contribute to the flourishing sport fishery as well as tourist industry.

Trout as a candidate for aquaculture has assumed importance very recently in India, with the availability of fast growing strain of Rainbow trout, *Oncorhyncus mykiss* and balanced artificial diet. Already the state of J & K and H.P. have initiated such projects and have been able to produce 100 tons/per year (per-comm.) and 40 tons per year of trout crop during 2001-2002 respectively (Kumar, 2002). Such efforts although initiated by states like Uttaranchal and Sikkim should be taken up by Northeastern hill states too.

Spawn rearing business of Mahseer (5 species) if taken up in the hilly region will definitely, grow on the pattern of IMC seed industry, which will not prove short term benefit to few individuals but go long way in enhancing the sport fishery all over India. Spawn rearing only is recommended as many northeastern states do not contain requisite amount of aquatic resources for culture of this fish throughout the year. Short-term activity has resources as well as the market. Mahseer sport fishery is considered a sleeping giant which can become a billion dollar tourist industry in India. Further, this type of activity will not pose much problem to the ecosystem.

Artificial spawning of many species of this fish (Ogale, 2002) and flow through hatchery for production of Mahseer seed has already been designed by NRC on cold water fishes. Respective hill states with Mahseer population in their resources need to take up the programme.

Ornamental fish trade currently stands to be of five billion US dollars ($) globally. India's share is just 0.007%. India exported ornamental fish worth Rs. 158.23 Lakhs during 2000-2001, of this the trade worth Rs. 110.00 Lakh was mainly from resources within Northeastern region (Das. *et al* 2002). If the management of this resource will be taken up on scientific lines, it will be big boost not only to economy of this region, but will enhance the contribution of fisheries to G.D.P. of country as a whole.

The technology for culture of exotic carps, common, silver and grass in the foothills of Himalayas has yielded production @ 1157-2525 kg $ha^{-1}yr^{-1}$ (Anon., 1999). The same technology can be taken up by the other still states.

Aquaculture practices will not only provide food but also can generate employment and go long way in affecting the socio-economic development of hills.

Threats

1. Intensive type of farming in rainfed, runoff fed and Jhora Raceway type ponds will lead to deterioration of aqua resources of uplands. So, all this type of farming, especially the magnitude of it should be taken up keeping in mind the ecological health of the support system.

2. Great care should be taken up for locating ponds etc. for aquaculture of exotic species. Any breach in this will prove a disaster for the existing fish diversity of the hill streams as observed by Johl & Tandon (1983). The same has been confirmed in Gobind Sagar reservoir (Kumar, 2002) and river Yamuna (Mishra & Moza, 1998). Gobind Sagar's natural fish stock consisted of Mahseer (Tor Species), Schizothoracids species and other mountain rheophilic fish species, but in recent years the population is mainly of silver carp (>80%), which made an inadvertent entry into reservoir in 1971 adversely affecting once dominant (constituted) catla fishery.

3. Presence of common carp in river Yamuna first reported by Mishra & Moza (1998) formed only 2.6% of total population between Delhi to Agra during 1989-1994, but this fish has invaded the whole Ganga system now and currently forms 17.8% of total catch of Ganga at Sadiapur Allahabad (Anon, 2003)
4. Inclusion of this fishery into system has affected *C. mrigala* adversely (Mishra and Moza, 1998).
5. Presence of *C. carpio* in Gambhar streams, tributary of river Sutlej at Billaspur has wiped out the population of native fish species (Johl & Tandon, 1983).
6. Similarly escape of *Clarias garripinnis* in river Yamuna between Panipat to Faridabad where the fish is cultured extensively and in river Sutlej at Harike (Per-Comm) is definitely going to pose a great threat to our fish gene pool in near future.

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NUTRITIONAL ASPECTS IN THE MANAGEMENT OF FISHERIES FOR INCREASING PRODUCTION

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INTRODUCTION

The nutritional requirement of fish is one of the most important aspects in the management of fisheries and in describing the concept of fish nutrition, it is first of all needed to categorize the different aspects of nutrition that must be considered, if successful feeds are to be developed. The list appears long and somewhat descriptive but it is emphasized that information on all aspects are not needed simultaneously before attempts could be made to compound commercial rations for fish. It may, however, be kept in mind that in spite of the vast progresses made in the field of aquaculture nutrition, there remains sufficient gap in our knowledge that make ration formulation for fish, an empirical science.

The terrestrial animal nutrition is based on adequate scientific principles, however, the same remains lacking for aquatic animals. Many a variables seem to operate. Sometimes, it appears difficult to keep the other variables constant while unraveling the mystery of one phenomenon.

Since, about 50-60% of the operational cost in a culture system goes to feed, the knowledge of nutritional needs of fish is essential. It appears relevant, on part of an aqua culturist, to manipulate the feed composition in an obvious attempt to minimize the cost and maximize the output without any hindrance in its quality. Secondly, in studies of fish nutrition, a number of different species of fish are involved which varied from time to time and place to place. The results which have been obtained for one species may not apply to other. This may probably be so in few cases but not in all and this has to be continuously kept in mind while investigating the nutritional requirements of fish.

Proteins are required for growth and body buildup, lipids (fats) not only for growth but also for energy production and the carbohydrates, mainly for supplying the energy. When lipids and carbohydrates are supplied in the diet in sufficient quantities, sparing actions of carbohydrates and lipids for proteins and vice-versa are seen to occur for adjustment of the protein/energy ratios (P/E), although in many a cases with uneconomical consequences.

The macro-nutrients of protein, lipid and carbohydrate are needed in the diet in bulk quantities. There are, however, obvious needs for micro-nutrients which are to be supplied in the diet in lesser quantities. These are vitamins and the minerals. The vitamins and minerals act precisely to carry out essential physiological processes. A number of B- vitamins and metal-ions like Ca^{++}, Mg^{++}, etc. act as coenzymes and cofactors respectively for a large number of enzymes that perform biochemical reaction processes in fish.

A number of laboratories are working worldwide on specific nutritional requirements for fish and formulation of feed, yet how much of the different nutrients are exactly required in the diet by different species of fish, have not been fully elucidated. This readily explains why one could see a wide range of feed formulations, even for a single species of fish, as the age, size etc. varies with duration of time.

Table 1. Categorical Aspects of Nutritional Requirements of Fish

Nutritional Requirements	a) Amino acids and protein
	b) Lipid (Fat)
	c) Carbohydrate
	d) Protein/ energy ratio (P/E)
	e) Crude fibre
	f) Vitamin
	g) Mineral
	h) Specific growth promoter

In addition to the categorical aspects mentioned in the above table, there are a number of other aspects, which must be taken care of simultaneously, if a successful ration has to be developed. These are food intake and feeding level, growth and conversion ratio, other dietary evaluations like the specific growth rate etc., net protein utilization (NPU), protein efficiency ration (PER), digestibility of nutrients, texture and palatability of diet, environmental conditions etc., the discussions of which are beyond the scope of the present topic.

Nutritional Requirements

Amino acid, Protein and Protein/Energy (P/E) Ratios

In so far as the amino acid requirements are concerned, C^{14}–tracer technique employing labeled amino acids has demonstrated the qualitative requirement in fish and these, not surprisingly, have shown that the same amino acids are likely to be essential for fish as for other groups of animals. These amino acids are methionine, arginine, tryptophan, threonine, valine, isoleucine, leucine, phenylalanine, histidine and lysine. In short, they could be termed as 'MATTVILPHLy'. However, the radioactive technique does not provide information on the quantitative requirements of these essential amino acids. How much quantities of these ten essential amino acids are required to be supplied in the diet for maximum growth of fish still remain to be work out. Nevertheless, attempts have been made to correlate the amino acids profile of the diet with the growth performance in fish. It has been reported that diets which gave the best growth performance in fish closely matches the body amino acid composition of fish. This interesting finding has prompted the analysis of many species of fish for their proximate biochemical composition and evolved a short-cut process of feed formulation by relating the composition of feedstuffs to those of the fish under culture. It has been observed that in addition to fishmeal, good natural foods, such as short-necked clam, squid meal, mysid meal etc. are excellent components of formulated rations. A survey of literature reveals that requirements of various essentials amino acids for different species of fish have not been fully determined. This area, thus, warrants urgent attention. That the different species of fish have different amino acid profiles are known. Therefore, till the time the amino acids in fish matching with their body composition, particularly in case of synthetic diets.

In so far as the protein requirement of fish is concerned, a wide range has been suggested. A dietary protein requirement of 25-30% for carp has been indicated, the differences in optimal protein requirement are due to the size, age and species differences and the sources of feedstuffs chosen for the culture.

It has also been observed that both the dietary low protein/high energy and high protein/low energy contents exhibit better growth performance than either the low protein/low energy or high protein/ high energy levels. This indicated the importance of adjusting the protein/energy (P/E) ratio of the diets. It thus appears that both the dietary protein and total dietary energy play important roles in exhibiting optimum growth. The availability of protein-calorie from feedstuffs and the importance of the same for growth have been documented for finfishes.

Effect of source

Earlier, dietary formulations for fish utilized many sources including the animal sources, like the fishmeal, slaughter-house offal, silk worm pupae etc. Gradually, vegetable protein sources found their access into the arena of feed formulations. Using soybean meal along with other ingredients high growth rate in fish has been reported against natural food items of molluscan meat, squid meal, clam meat etc. Thus, besides the quantity of dietary protein, the source also plays pronounced growth influence. This naturally refers to quality or the amino-acid make-up of it. Soybean protein exhibits better growth in some fishes compared to menhaden fishmeal, shrimp meal, milk casein or maize gluten. Soybean, therefore, has been demonstrated to be a good source of feed item for cultivable fishes. The level of maximum incorporation of soybean powder has been determined. It is observed that up to 60% incorporation of soybean could be done in a 30% protein diet made from various sources, without any growth diminution in fish. Among the sources of animal origin, squid meal, mysid shrimp meal, clam, oyster, mussel meat, slaughter-house offal, silk worm pupae etc. are considered excellent sources of protein. Squid meal at 6% incorporation level is demonstrated to exhibit pronounced growth effects.

To sum up about the principal controlling factor (protein), it can be inferred that various species of fish are not nutritionally a homogeneous group with respect to their protein requirements and that a level ranging between 25-30% may work well for a large number of the fishes, including the carps.

Lipids

From a discussion of dietary protein and energy contents, let it now be moved on to a discussion of dietary lipids (fats) for fish. Fish, in general, do not require high levels of dietary fat. Unnecessary high levels may exert adverse affect and if not, the feed cost may be prohibitive. In some formulations, a level of 8-10% crude fat is seen to exhibit best results. In yet other formulations, the addition of 4% squid liver oil to a standard ration improved growth. However, inhibition of growth at levels exceeding 15% has also been demonstrated. Using purified synthetic rations, it has been observed that 10% lipid gave better growth than no incorporation and that a level of 6% dietary fat rendered better growth than either no incorporation or 12% incorporation level. It appears, therefore, that fish do not require high levels of dietary lipid and that the optimum level lies somewhere between 5-10% of the feedstuff, on a dry matter basis.

Carbohydrates

The interest for carbohydrates in fish possibly originated from the activities of many enzymes like amylase, maltase, saccharase, cellulase etc. in fish. The carbohydrates are seen to play important role in energy production (TCA cycle), storage of carbohydrate as glycogen in liver and to a lesser extent in muscle, formation of fatty acid etc. Initial indications were that fish is able to utilize quite high levels of carbohydrate and that starch rather than glucose or dextrin exhibits better results with respect to growth. Among carps, grass carp is seen to metabolize huge amounts of grassy or leafy materials, being able to digest cellulosic components of diet. Higher growth performance in fish is reported on a diet containing 40% of corn starch than diets containing 10% starch, 40% glucose or 10% glucose. A standard laboratory diet to which 15% wheat starch has been added showed better growth performance in fish than the same diet to which glucose, oyster glycogen, dextrin or no carbohydrate supplements have been added. From various experiments, it seems probable that fish can digest and assimilate a variety of carbohydrates like wheat starch, corn starch, dextrin, oyster glycogen etc. Potato starch, however, is less well digested. Wheat starch is seen to be less effective. Glucose assimilation is reported to occur in somewhat better way when added along with vitamin C. Cellulosic materials are, however, difficultly digested, although grass carp is quite able to digest a wide range of cellulosic feedstuffs. Generally, oilcakes of various origin supply bulk of carbohydrates in the diet.

Crude fibre

Information on the role of dietary crude fibre in fish is limited. The source for crude fibre in feed owes its genesis to the presence of a number of vegetative ingredients employed in the formulations. In mammals, the presence of a definite amount of fibre in food material helps in proper movement of bowl in the intestine. In domestic land animals, the presence of fibre in the herbivorous diet increases gastro-intestinal movement of the ingested material. Very limited investigations have been carried out on the possible impact of fibre in fish feed. Additionally, crude fibre or the cellulosic and pectinacious materials are difficulty digested (10-20%). The rest (about 80%) is obviously voided. However, the beneficial role of the crude fibre in herbivorous finfishes has been documented. Grass carp is an example. Increased growth rate, survival and conversion efficiency have been reported in fish when fibre is included in the diet from turnip green up to 5% incorporation level. A fibre level of 8.75% in the pelleted diet has supported excellent growth in some fishes. However, more detailed investigation on the possible impact of dietary fibre in fish feed is needed, because a vast majority of the formulations usually contain a number of raw materials of vegetative origin, all of which contain substantial amounts of crude fibre in them.

Vitamins

It has been reported earlier that the members of B-group vitamins are needed in formulated diet along with vitamins C and E. That the fish grow well in the presence of vitamins has been documented, the reported beneficial effects being more when used along with the minerals. The importance of vitamins C (L-ascorbic acid) in the diet for fish has been indicated by many workers. The role of beta-carotene (provitamin A) as a precursor of vitamin A has been demonstrated. Vitamin C deficiency is reported to exhibit sickness and various diseases in fish. An amount of about 0.3% vitamin C is generally needed in diet that can check the occurrence of many disease syndromes. However, the quantitative requirements have not been fully elucidated for each of the vitamins. This, pending such determinations, the use of vitamins in fish feed is most likely to be guided by the requirement patterns of smaller terrestrial species. However, without proper knowledge about vitamin requirements, the additions of excessive vitamins in feed mix are not only inadvisable for probable hypervitaminosis possibilities of A, D, E and K but also for a wasteful process, cost wise. Till the availability of comprehensive information, it would be better to follow the specifications laid down under the nutritional requirements of warm water fishes.

Minerals

The knowledge about the adverse affects of mineral deficiency and ill effects of the presence of excessive minerals has brought the attention of feed formulators to include such items in feed. For long, the use of calcined shells in the diet for fishes, like those of domestic animals, was known, without any scientific basis. The role of Ca and P have been known from the good growth results in fish having 1-2% Ca and 1.04% P in the diet. In contrast, it was pointed out that the requirement of chloride, sodium, calcium and potassium are met through the osmotic regulation. The need for P has been stressed in formulated diets. The role of phytate phosphorous, too, was indicated. However, besides the information about Ca and P, precise requirements of other minerals in fish feeds are not readily available, owing to the paucity of the reported data. Thus, in the case of minerals also, the additions in feed may follow the pattern of small domestic animals or the specifications laid down under the nutritional requirements of warm water fishes.

Specific growth promoters

Lastly, for growing an increased amount of fish within the shortest possible time, little discussion about the use of specific growth promoters can be done. The beneficial growth effects of polyunsaturated fatty acids (PUFA) particularly those of the linolenic series (ω_3) have been reported. Some species of fish is demonstrated to grow faster on diets with a long chain of polyunsaturated fatty acids. Excellent growth performance of fish fed with diet containing 1-2% linolenic acid was reported. High growth rate is observed in some other species fed with rations comprising 1% linoleic acid. A suitable w_3/w_6 ratio (linolenic/ linoleic acids) is seen to exhibit better growth rates. Marine fish oil, in general, is richer in ω_3 series than the ω_6 series of fatty acids that are found in large amounts in vegetable oils. This easily explains why marine fish oil could be better utilized for obtaining increased growth rate compared to the vegetable oils. High amounts of ω_6 fatty acids caused high incidences of mortality in some species of fish and shellfish. Corn oil, a vegetable oil, sometimes used in the formulations, containing high amount of ω_6 fatty acids, risk the chances of mortality. Diets composed of squid meal, brine shrimp and mysid shrimp often exhibit excellent growth result because of the presence of desired fatty acids (ω_3) in them. The essential fatty acid (EFA) requirements are met and higher growth rates are achieved with ω_3 fatty acids and not with ω_6 acids or with saturated fatty acids.

The special requirement of cholesterol in the formulated feed has drawn considerable debate among researchers. The species which are unable to synthesize sterols from its precursor acetate, as can be seen by the failure of incorporation of radioactivity of labeled acetates into the sterol, the dietary requirement of cholesterol is indicated not only for higher growth but also for normal reproductive function. 1-2% cholesterol incorporation in the diet has shown very high growth rates not only in shellfish but also in some species of fish. The dietary requirement of cholesterol is important for the synthesis of various reproductive steroids as well as the rapid growth. It seems that about 0.2-0.5% cholesterol would exert its rapid growth-promoting effects, if incorporated in commercial diets.

Dietary requirement of another fast growth-promoting compound lecithin (a phospholipid) has been indicated. Very fast growth, higher survival and feed conversion is exhibited at 2% incorporation level. It is reported that the presence of lecithin in feed could bring down the cholesterol requirement to 0.1-0.25%.

The growth promoting effects of choline chloride (0.9%) and cholesterol (0.4) together have also been demonstrated in the culture of shellfish.

Formulation of feed must be done taking care of the above nutritional aspects for promoting the commercial fisheries in beels or wetlands.

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Mahapatra, B. K. 2003. Ornamental fishes of northeastern region: opportunities and threat, pp. 51-57. In: M. Choudhury, N. P. Shrivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

ORNAMENTAL FISHES OF NORTHEASTERN REGION: OPPORTUNITIES AND THREATS

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INTRODUCTION

The Northeastern India comprising of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura is gifted with vast aquatic resources in the form of rivers, streams, lakes, reservoirs, floodplain wetlands, ponds and large areas under rice-fish culture system. The rivers Brahmaputra and Barak form the principal drainage of Northeast India with its numerous tributaries flowing through the different states along with myriads of rivulets and lentic water bodies that harbour diversified fish fauna. Owing to the diversity of topographic and climatic features of Northeastern India, the aquatic resources are rich in fish germplasm. The varied freshwater resources of the region harbour 274 fish species out of the 806 freshwater fishes reported in India. The large sized fish species like the *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Labeo calbasu*, *Labeo gonius* and *Neolissocheilus hexagonolepis* have already been identified as good table fish. Considering their commercial importance, attention has been paid to develop their fishery. But, there are many small fish species, which are not important for commercial farming due to their poor growth rate. These small food fishes treated unwanted for conventional farming have good potency as ornamental fish and are popularly known as "Indian Aquarium Fish".

ORNAMENTAL FISHERY – NEW AREA OF FISHERIES

The varied forms and fascinating beauty of some fishes have attracted the people from time immemorial and are named as 'ornamental fish'. In China and Japan, gold fish and koi carp has been used as an ornamental fish since long. Aquarium keeping of fish began in 1805 and the 'first public aquarium' was opened at Regent's Park in England in 1853. Thereafter, aquaria keeping picked up further and by 1928 there were 45 display aquaria opened, with over 500 of public aquaria presently functioning worldwide. However, the global market for ornamental fish for public aquaria is less than 1% at present and over 99% of the market for ornamental fish continues to be confined to hobbyists. The ornamental fish keeping, which started as a hobby has now turned out to be a commercial aqua-business and has taken the shape of an industry. The current value of the entire industry has been estimated at US $ 15,000 million. The South East Asian countries contribute about 69% of the total world production. Singapore is on top with 35% of the total production of South East Asian countries followed by Hong Kong, Malaysia, Thailand, Philippines, Taiwan and Japan. India's share in ornamental fish trade is estimated to be US $ 0.1 million. Considering the enormous and diverse indigenous fish resources of the country in general and Northeast in particular, there is immense scope for its becoming a potential candidate and a strong competitor in the international trade. Indian domestic trade in this area is growing at the rate of 20% annually and demand at domestic level is higher than supply.

STATUS OF ORNAMENTAL FISH GERMPLASM IN NORTHEAST INDIA

The Northeastern India with its diversified freshwater resource harbour diversified native ornamental fish species. These include both classified and non-classified type of aquarium fish. The small fishes like *Botia dario*, *Danio dangila*, *Puntius shalynius* and *Schistura reticulofasciatus* are classified type of ornamental fish, which can be reared in aquarium through out their life span. On the other hand, some larger food fishes like *Neolissocheilus hexagonolepis*, *Labeo gonius*, *Channa marulius* and *Rita rita* are also now treated as ornamental fish in their juvenile stage and termed as non-classified ornamental fish. These fish species are treated as aquarium fish due to their diversified ornamental value like beautiful colour (e.g. *Tetraodon cutcutia*, *Colisa lalia*), stripes and banding pattern (e.g. *Botia dario*, *Botia striata*), attractive appearance (e.g. *Notopterus chitala*), keeled abdomen (e.g *Chela laubuca*), peaceful nature and calm behaviour (e.g. *Ctenops nobilis*), transparent body (e.g. *Pseudambassis baculis, P. ranga*), hardiness (e.g. *Danio dangila*, *Brachydanio rerio*), compatibility (e.g. *Puntius shalynius*), beautiful jumping behaviour (e.g. *Esomus danricus*), chameleonic habit (e.g. *Badis badis*), charming predatory habit (e.g. *Glossogobius giuris*) and longevity (e.g. *Anabas testudineus, Channa orientalis*).

The up-to-date inventory of the fish species of NEH region showed 274 potential fish species, which belonged to 114 genera under 37 families and 10 orders. This includes 265 indigenous and 9 exotic fish species. The diversified fish fauna of NEH includes 272 food fish, 9 sport fish, 48 cultivable and 250 ornamental fish. Out of the total 250 native ornamental fish species of the region, highest numbers of ornamental fish species have been recorded from Assam (187), followed by Arunachal Pradesh (165), Meghalaya (159), Manipur (139), Tripura (103), Nagaland (71), Mizoram (46) and Sikkim (29).

BREEDING AND LARVAL REARING OF NATIVE ORNAMENTAL FISH

Like all other fishes, sexual differentiation is characterized by the male and female reproductive glands i.e. the testes in males and ovary in females. During the spawning period, the female releases the eggs in water and male simultaneously releases milt close to the eggs. The eggs are thus fertilized outside the body of the female, which is called external fertilization. This is seen in most families of tropical aquarium fishes. But, female livebearers are fertilized internally by means of males modified anal fin, the gonopodium, by which milt is transferred to female.

1. Breeding and larval rearing of zebra danio, *B. rerio*

The zebra danio is a prolific breeder and their breeding season commences from April and continues till August. The eggs are non-adhesive and their breeding habit is of egg scatter type. The females were found to be more silvery and larger in size compared to males. The belly is swollen in females, especially in gravid ones; while in males the body is generally slim. The male and female fishes were separated, based on the morphological characters. Aquarium tank of 60 cm long or about 50 lit capacity provided with a perforated tank divider was found to be suitable for the conditioning of the zebra danio. The males were introduced on one side and the females on the other side of the divider, in the same aquarium tank. The fishes when conditioned on a good variety of diets including live feed for about two to three weeks were ready for breeding. Successful spawning was recorded by introducing a shoal of 20 fully matured vigorous males and females in a ratio of 3 males : 2 females into the spawning tank. The spawning tank contained about 10 cm (4 inches) of water with a steady temperature of 28-29°C, and gentle aeration. A water pH of around 7.0 and hardness of normal to 250 ppm was maintained which gave good results. Bottom of the aquarium was completely covered with pebbles of about 6 to 8 mm diameter. After spawning, the eggs fall in between the pebbles arranged at the bottom of the breeding tank. This prevented the eating of eggs by the parent fishes. A net fixed along the bottom of the tank (at a height of 2 inches from the bottom) instead of pebbles was also found to be successful in protecting the eggs from the parent fishes. The eggs require a hatching time of 2 days, if temperature is favourable. As soon as the tiny hatchlings are seen in the aquarium tank, the parents were removed. The hatchlings took 2 days to absorb their yolk sac. After 2 days, they were fed with infusorians for 4 days. Subsequently rotifers, smaller daphnia were fed for a week. After that they were fed with larger plankton and powdered formulated feed.

The moustache danio *D. dangila* and the chameleon fish *B. badis*, which are also egg scatter type of fish, were bred almost in a similar way.

2. Breeding of giant gourami, *Colisa fasciatus*

For breeding purpose, the male and female fishes were kept in separate tanks for few weeks. When the abdomen of the female becomes remarkably swollen with eggs, they were transferred to a smaller breeding tank with water level of 5-6 inches. The tanks were provided with some floating plants. After one or two days, a good male was introduced into the breeding tank. The breeding tank was covered with a transparent plastic sheet or a glass sheet to keep the humidity and temperature high and to help maintain the bubble nest in a good condition. Then the male soon began building a bubble nest. This is possible by taking a large gulp of air at the water surface and converting it into many smaller bubbles that are passed into the gill chamber and coated with an anti burst agent before release.

During and after making the nest, the male displays to the female, which usually ends with both the fishes embracing the nest resulting in deposition of large number of eggs in the nest. After breeding, the female was removed as the male guarded the eggs that remain attached to the floating bubble nest. Hatching took place within 24 hours. The moment the fry began leaving the nest, the male was also removed from the tank. After 36 hours, when young ones remain in free-swimming stage, they were provided with infusoria as a starter feed. After a week, the fry started taking newly hatched Artemia and small cladocerans. During this stage, fry required vigorous feeding. Subsequently, when they had grown little bigger, they were stocked in bigger cement tanks for further growth.

CULTURE OF AQUARIUM FISH

Ornamental fish farming is identified as an alternative income generating activity and is also becoming popular in India. The main advantage of this trade is that besides the rural areas, it can be practiced in urban areas too. Glass aquaria, concrete tanks and net-cages are commonly used for the culture of ornamental fishes.

1. Healthy aquarium environment

An aquarist's primary objective is to keep aquatic organisms alive in captivity. Those animals and plants may come from any of the watery places on earth and may be adopted as individual specimens, in colonies of single species or in mixed communities. Their proper environment must be established initially, by setting up the aquarium with several factors in mind like living space, water quality, heating, lighting, aeration and filtration.

i) **Number of fishes in the Aquarium:** Number of fishes in the aquarium depends on its carrying capacity, which is mainly determined by its surface area. As a thumb rule, freshwater aquarium fish require an area of 20 cm^2 per cm of body length (excluding tail). However, the carrying capacity can be increased by effective aeration and filtration system.

ii) **Water quality:** Aquaculture ecosystem, including aquarium fish culture, are composed of physical, chemical and biological factors that interact individually and collectively to influence culture performance. Some of the important water quality parameters and their optimum ranges for aquarium fishes are temperature – 22 to 30°C, pH – 7.0 to 8.5, $CO_2 < 5$ ppm, dissolved oxygen – 6.0 to 8.0 ppm.

iii) **Heating:** Most of the tropical aquarium fishes are accustomed to live in 22-30°C. A better quality of immersion heater with adjustable thermostat is used for controlling the temperature.

iv) **Lighting:** Proper illumination is important for healthy functioning of an aquarium. Apart from providing visual impact, it also stimulates growth of fishes and plants.

v) **Aeration:** Provision of aerator is also essential for increasing oxygen content in water. It also helps to release free carbon-di-oxide from water and running of filtration system, toys, etc.

vi) **Water filtration:** For keeping water clean and also to remove harmful substances like ammonia and nitrite, filtration is essential. This is done by mechanical filtration, chemical filtration and biological filtration.

2. Feeding

Aquarium fish are dependent upon the aquarist to provide them with a correct balanced diet, the overall effect of which will be seen in their colouration, growth, resistance to disease and their willingness to breed. For fishes cultured in large outdoor concrete aquaria or ponds, the natural organisms in the water provides a rich and balanced source of food. In addition to the natural food, formulated feed as well as live feed like Artemia, Daphnia and tubificid worms can be given.

3. Health care

In ornamental fish farming, proper health management is necessary throughout the culture period. Tap water is kept stagnant for one or two days for dechlorination, if any chlorine is present. In case of pond water, methylene blue is used @ 3.5 mg per litre to purify the water. Quarantine tanks are used for new fish to prevent the entry of new pathogens. Sometimes, some chemicals like copper sulphate, potassium permanganate, malachite green, formaldehyde and antibiotics like oxytetracycline or terramycin are used to prevent the infection.

PACKAGING AND MARKETING

The fishes that are ready for marketing are generally transported in oxygen packed polyethylene bags. Prior to packing, the fishes are conditioned for 1 to 3 days without food, depending on the duration of transport. The produce can be sold directly to the hobbyists or to the nearby hobby shops or can be sold to the brokers or exporters or can be exported directly. The ornamental fish market of Kolkata (locally known as 'Hatibagan Haat') is the largest wholesale market of ornamental fish in the Eastern and Northeastern zone of India. Actually, it is a weekly market of pet animals like ornamental fish, turtles, cage and poultry birds, puppies, white rats, guinea pigs, rabbits, and mongoose. All needed accessories of these hobbies like seed and seedlings of different plants, planting pots, fertilizers, fish feed and aquarium accessories, different types of cages and birdfeed are also available here. The trade of the ornamental fish of ecologically diverse Northeastern states also is routed through this market. West Bengal is now one of the pioneering states in ornamental fish trade. Kolkata is the highest ornamental fish exporting city of India. 90% of Indian export goes from Kolkata followed by 8% from Mumbai and 2% from Chennai.

CONSERVATION STATUS OF NATIVE ORNAMENTAL FISHES

All the native ornamental fishes are becoming vulnerable in NEH region due to degradation of water bodies, pollution, poisoning, over fishing of broods and juveniles. Their populations were abundant in natural habitat, even before one or two decades. But, in these days, some of them are very rare in NEH region and most of the species have been threatened. The conservation status of native ornamental fishes have shown that out of the 250 species, 10 are Critically Endangered (CR), 28 are Endangered (EN), 49 are Vulnerable (VU), 45 are Lower Risk Near Threatened (LRnt), 08 are Lower Risk Least Concern (LRlc), 03 are Data Deficient (DD) and 107 are Not Evaluated (NE).

FUTURE STRATEGIES

The Northeast India, provided with 250 ornamental fish species is one of the global hot spot for faunal diversity and has bright prospect in ornamental fish trade and can also contribute a lion's share in Indian part. To boost up the local economy and for self-employment, this native ornamental fish can play a key role. The value of the entire industry like indigenous germplasm resource of ornamental fish, ornamental plant and support activity in related supplies can help the backward downtrodden people to maintain their livelihood.

To ensure fish welfare and environmental protection as well as sustainable growth of this industry, proper attention needs to be given in the following lines.

1) With proper education and technical guidance, local fisher folk can be organized and trained to judiciously exploit these ornamental fish resources, in which sufficient tracts of their natural habitat including their breeding grounds are conserved.
2) Harvesting can be encouraged only in the "population collapse" phase and not in the "growing" phase.
3) The biology of the fish especially feeding and breeding biology including behavior should be studied properly for right utilization.
4) For stock enhancement, collectors and culturists should adopt the captive breeding process.
5) Export should be made keeping in mind the conservation of gene pool of the indigenous fish.

CONCLUDING REMARKS

Considering the diversity of native ornamental fish fauna and needs of NEH Region and scenario of freshwater aquaculture both nationally and globally, the ornamental fisheries can be given a serious thought from all concerned stake holders like fisher folk, exporters, importers, village headmen, panchayat members, teachers, students, scientists and top level planners in order to sustain the growth of this new sector of fisheries as well as for better employment and foreign exchange earning from this trade.

ACKNOWLEDGEMENT

The author is grateful to the Director, ICAR Research Complex for NEH Region, Barapani for his constant encouragement and support to carry out the work and also to the authorities of NATP-CGP project on "Evaluation of Ornamental Fishery Potential in NEH Region – Its Farming and Export Feasibility" for financial assistance.

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PEN AND CAGE CULTURE: PROBLEMS AND PROSPECTS IN NORTHEASTERN REGION

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INTRODUCTION

The eight Northeastern states are gifted with kaleidoscope of open water fishery resources in the form of rivers, floodplain wetlands, lakes, mini barrages and reservoirs. These aquatic resources offer immense potential for fish production. Fish is an important component in the daily meals of Northeastern people; as a result, there exists an ever-increasing demand for fish. But, the fish production from the water bodies of these states is far below their potentialities and insufficient to meet the requirement of this region. As a result, there is still scope for further enhancement by employing proven tools of fish production. Pen/cage culture, although new to this region, has been successfully demonstrated in Assam can play a pivotal role in increasing fish production from the open water resources of these states

Definition and scope

Pen or cage culture is proved to be a convenient means of raising fish in an enclosure in open water resources like rivers, lakes, reservoirs, floodplain wetlands and irrigation canal. These tools are useful in seed raising, and table fish production. *In-situ* seed production in any open waters, particularly in reservoirs, lakes or floodplain wetlands, where stock enhancement is the only means of increasing fish production, could solve the problem of non-availability of required number and size (advanced fingerling) of seed at desired time. Resource poor fishers living in and around such open water bodies can adopt pen or cage culture as an assured and convenient means of income round the year.

Pen culture is suitable in shallow, stagnant or feebly flowing water body, where hydrological changes are slow and gradual. In pen culture, an area is enclosed with some effectively permeable barricade (nylon net, split bamboo screen etc.,) wherein fishes are reared for fingerling or table fish production. The method is simple and cost effective, making the operation highly profitable.

Cage culture is ideal for all sorts of water body having at least 3 m depth and no or moderate to feeble flow of water. Cage culture of fishes is gaining popularity in different parts of the world, because of its manifold advantages. The water bodies that are not suitable for conventional aquaculture because of the difficulties in harvesting either by siening or draining, could be utilized for cage culture. The other advantages include the flexibility of management, easy and low cost of harvesting, close observation of feeding activity and health status, easy means of treating diseased fishes, relatively low capital investment and lastly, ability to produce any species of preference in a water body, which is full of predators

Open water resources

The Northeast region receives plenty of precipitation leading to creation of numerous fast flowing rivers and streams and fountains in these predominantly hilly states. The major river systems of these states are Teesta and Torsa in Sikkim, Brahmaputra and Barak in Assam, Imphal and Iral, Thoubal, Khuga, Minan in Manipur, Dayang in Nagaland, Kameng, Tirap, Siang, Dibong, Ranaganadi, and Lohit in Arunachal Pradesh (A.P.) and Gumti in Tripura. These rivers along with their tributaries form the riverine fisheries resources of these states. In some states, the fast flowing rivers have been tamed for various reasons leading to the creation of mini-barrages and reservoirs. Ranganadi in A.P., Dayang in Nagaland, Umium, Kyrdemkulai, Nangmahir and Khandong in Meghalaya, Umrangshu in Assam and Gumti in Tripura are some the reservoirs of this region. In addition, natural lakes, like Loktak and Takmu in Manipur and manmade lake, like Rudrasagar in Tripura contribute to the freshwater resources of the region. The rivers after descending down in the plains frequently change their course leaving their previous tracks in the form of ox-bow lakes. Numerous such lakes and their floodplains in two states like Assam and Manipur constitute an important open water fisheries resource of the region.

Production potential and opportunities

Fish production from the rivers of these states is very low and declining with the progress of time. Many reasons are being attributed to this poor fish production. The fish production trend from mini-barrages, reservoirs is found to be almost similar to their parent river. But unlike river, the barrages and reservoirs could be brought under stock enhancement norms of fisheries management. Compared to rivers or reservoirs, the natural lakes and floodplain wetlands offers immense opportunity of increasing fish production. The production potential of natural lakes and floodplain wetlands of this region is also remarkable. However, the fish productivity remained low, because, these resources are lying either in derelict condition or underutilized. Stock enhancement is the simplest, immediate, only and suitable means of increasing fish production from these water body.

The key input in stock enhancement for water bodies like reservoirs, lakes and floodplain wetlands, which are full of piscivores, is the availability of advanced fingerling round the year in sufficient numbers. Barring Tripura, other states of this region are deficient in required size and number of seeds. Raising of seed in pen and cages is a handy tool, which could prove to be a convenient means of *in-situ* advanced fingerling production. Such water bodies like reservoirs, lakes and specially floodplain wetlands offer immense scope for the adoption of these methods.

Rivers, while passing through hills, are very fast flowing; therefore, pen and cage culture method may not be suitable for these rivers. Besides, most of the rivers in these states are rain fed, except Arunachal Pradesh. The volume of water in rain fed rivers is very low during non-monsoon periods, which is also unfavourable condition for this method of fish rearing. However, where there are deep pools and gradient is gentle, may provide a suitable place for pen or cage culture.

The technology

Cage culture: Cages are fabricated using nylon net, which is cheap, durable and light in weight. A convenient dimension of 6 x 3 x 1.5 m could easily be stitched with the help of a tailor. Eight such cages could be hanged from a bamboo frame being floated with the help of empty drums. The cages are hanged in water for 15 days, before they are stocked with fish spawn or fry. The cages can sustain very high stocking density of 4-5 lakh seed per hectare, that could conveniently be reared. Post stocking management includes feeding the fishes with nutritionally balanced diet, since the fishes are deprived of natural food inside the cage and regular cleaning the cage wall of bio-fouling material. Stocking material of advanced fingerling will be ready in 2-3 months of rearing while growing table fishes require 4-5 months of rearing. Using the same cage, 2-3 crops of advanced fingerling and one crop of table fish could be reared in a year. In the two-year life span of cage material, approximately, a net amount of Rs. 65,000/- could be earned over capital invest of Rs.15,000/-.

Pen culture: Locally available bamboo or nylon net could be used for pen construction. Splits of bamboo are interwovened to form a mat using coconut/nylon threads with narrow space between the splits. An area with gentle slope having a depth of 1.5- 2 m, is cordoned off by split bamboo mat/nylon net screen held erect with the support of bamboo poles, followed by removal of macrophytes and unwanted fishes. To correct soil pH, liming in split doses is needed. A stocking density of 20,000-30,000 fry may be maintained with supplementary feeding. The crop of advanced fingerling will be ready for stocking in the open water in 3 months time. Two crops of stocking material (advanced fingerling) could be obtained during Sept-Nov. and Jan-April, thereby, avoiding flood season. It has been estimated that, installation of 500 m^2 pen and rearing of fingerlings therein costs approximately Rs.3260/-, which yields a net profit of approx. Rs. 3000/- in a single crop.

Problems of pen and cage culture

Pen culture

<u>Socio-economic</u>

a) **Awareness:** This is a very important aspect in any developmental process. User groups are to be made aware of the recent technological developments for their social and economic upliftment. Many of the fishers are not aware of such technology, whereby, fishes could be produced in open waters. Strong extension programme is warranted in this regard.

b) **Right to water body:** The State Govt. should have well defined policies pertaining to the harvesting right of the open water resources. Several institutions are the stakeholders of these natural resources. Fishers should be bestowed with the rights of water use, enabling them to utilize the water body for the adoption of such tools of fish production.

c) **Capital:** This aspect is very critical in the adoption of technology, where there is a need for infrastructure development. The resource poor fishers need to be supported financially in order to remove their financial barrier in the adoption of technology. Various developmental agencies including both non-governmental and governmental should come forward with some financial package.

d) **Poaching and predation:** Very important social problem associated with the pen culture is its vulnerability to poaching. Remoteness of the resource and easy of harvest is the main reason of this social problem. The owners of cage/pen ought to be vigilant, especially when the fish is ready for harvesting.

Environmental

a) **Anorexia:** The high stocking density and existing high organic load, particularly in oxbow lakes, sometimes may lead to anorexic condition. Regular bottom raking and watch on water exchange may help to overcome such problems.

b) **Storm and flood:** Precautions in sight selection may save pens from such environmental hazards. However, precaution also should be taken in installing pens by reinforcing the structure with diagonal poles both from in and outside the pen wall. The Brahmaputra valley is very much prone to flood and hence it's better to avoid peak monsoon period. The stationary nature of pen is the drawback of this method.

Biological

a) **Borer:** Organisms like crabs may sometime pose threat to pens. The adjacent area of pen culture may be cleared of crabs either by dropping a piece of carbide in the crabs' hole or they may be harvested by rigging for eating purpose.

Blooms and biofouling: The high organic load coupled with favourable environmental condition during autumn and spring may lead to the occurrence of algal blooms. Good water exchange between pen and open water may reduce the chance of blooming. Choking of pen walls due to the growth of biofouling organisms prevents water exchange. Regular brushing of walls is suggested to avoid such problem.

Cage culture: Problems generally encountered with pen culture remains mostly true for cage culture as well. However, hazards, like flood is not a threat for cage culture, since it is floating and mobile. Growth and disease monitoring and treatment are easier in cage culture. Some of the very specific problems of cage culture are:

a) Tolerance to poor water quality: Generally high stocking density of fishes is maintained in cages; therefore, fishes are highly susceptible to bad water quality. However, the advantages with cage culture, is that, the cages could be dragged to a new location having good water quality.

b) Dependence on nutritive diet: In cages, fishes are deprived of natural food. Provision of nutritionally balanced diet is prerequisite of cage culture; otherwise, fishes may suffer from malnutrition leading to anatomical deformities, reduced growth and susceptible to diseases. The cost of nutritive feed may increase the operational expenditure of cage culture. To compromise the cost, conventional feed mixture of mustard oil cake and rice bran may be fortified with commercially available vitamin, mineral and amino acid mixture in association with some growth promoter (BrewariesYeast) to improve the nutritive quality of feed. Use of wheat flour (*maida)* in the mixture will make the prepared feed more water stable.

c) Greater risk of disease outbreak: Over crowding due to very high stocking density may run the risk of disease outbreak. A safe stocking density of 3-4 lakh fry could avoid such hazards. Regular monitoring of fish growth and incidence of disease is suggested, so that some prophylactic or preventive measures could be taken up.

Conclusion: Considering the vastness of resources, the manpower available and demand for fish, adoption of such tools for judicious utilisation of resources and which offers round the employment opportunity, is the need of the hour. Considering the prospects of such methods of fish production, barring few problems, developmental, extension and financial agencies need to work hand in hand to popularize and facilitate its adoption in the region.

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Suresh, V. R., 2003. Capture fishery resources of Manipur: fishers and gender perspectives, pp. 62-67. *In:* M. Choudhury, N. P. Shrivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

CAPTURE FISHERY RESOURCES OF MANIPUR: FISHERS AND GENDER PERSPECTIVES

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INTRODUCTION

Manipur, situated at the eastern border of northeastern India, within 93°03' to 94°78' E longitude and 28°83' to 25°68' N latitude, is a small state of breath-taking landscape, pristine environment and rich cultural vibrancy. The state holds a population of 18.37 lakh people (1991 census) with high rate of literacy, belonging to different cultural and ethnic groups, in a geographical area of 22327 sq km. Ninety per cent of the state is covered by hills, with a small valley of about 2232 sq km in the center. Almost 90% of the population, both the hill and valley dwelling, relish fish. Fish occupies an important place in the state, not only because of its food value but also of its socio-cultural importance. Even today, people of Manipur prefer fish to meat, egg or milk. Women in Manipuri society are strong, mustering considerable respect and form a major workforce with decision making powers both at home and outside. Altitude variations from 790 to 3000 m msl in the state offer varied environmental conditions. The state is also endowed with a salubrious climate and rich water resources suitable for fishery purposes. Although information on fish and fisheries of Manipur dates back to the works of Hora (1921), Menon (1952, 1954), fisheries in the state as a means for nutritional security, powerful income and employment generator, has been one of the most neglected areas until recently.

Demand and production trends

The consumption requirement of fish in the state (2000-01) was estimated at 25000 t, however the actual production was only 16050 t, with a deficit of 35.8%. The population in the state is expected to grow up to 32.54 lakh by the end of 2010 AD, considering the decadal population growth of 33.1%. Accordingly, the annual demand for fish in the state would go up to 32,540 t. The present per capita availability of fish in the state is 5.7 kg against a desirable 11 kg (Sugunan, 1998). To meet the high demand, the state is importing fish from outside, as a result the market price is very high and the quality of fish often becomes bad due to spoilage. Although, the state has a fish production potential of 39252 t year[1], the actual realization of fish in the year 1990-91 was only 8,500 t, against a demand of 18,000 t. The deficit was 58.8%. Since then, the production, however, showed an increasing trend. Total fish production estimated demand and deficit from 1991-92 to 2000-01 are given in table 1. The average rate of increase in production during the period has been 500 t, while that of the demand has been 608 t. The production deficit, in relation to the demand, shows a desirable decreasing trend; still the production trend needs to be toned up to meet the ever-increasing demand.

Table 1. Total fish production and estimated consumption demand.

Year	Production (t year $^{-1}$)	Demand (t year $^{-1}$)	Deficit (%)
1990-91	8500	18000	52.8
1991-92	9950	18300	45.8
1992-93	11200	18610	39.8
1993-94	11505	18940	39.3
1994-95	12110	19300	37.7
1995-96	12502	20513	39.1
1996-97	12705	20990	39.5
1997-98	13705	21474	36.2
1998-99	14100	22800	38.2
1999-2000	15506	24244	36.0
2000-01	16050	25000	35.8

Source: Directorate of Fisheries, Manipur.

Fisheries resources

Three major river systems drain the state. These are Chindwin, Barak systems with tributaries viz., Irong, Leimatak, Maklang and Makaru passing through the hills and the valley river Imphal with tributaries viz., Nambul, Kongba, Iril and Thoubal. These rivers have an estimated total length of 2000 km providing about 5000 ha area readily available for fishery purposes. The rivers hold a total catchment area of 6332 sq km with an estimated annual run off of 5192 million cusec. Loktak, a freshwater lake in the state and the largest in the region, cover an area of 28,000 ha. The lake supports nearly 38 villages, providing means of living to more than 5,000 fishers, who land about 1374 t of fish annually. The annual catch from the lake is estimated at 80 kg ha^{1}. Manipur valley has about 21,000 ha of floodplains, which can be made suitable for fishery purposes, however the readily available area is about 11,536 ha. The *beels* (pats) such as Pumlen cover an estimated area of 3500 ha while Kharung cover 2000 ha, Ikop (2000 ha.), Takmu (500 ha.), Withou (270 ha.), Leingang (270 ha.), Khullak (300 ha.), Sana (52 ha.) and Utra (41 ha.), besides several swamps, ponds and tanks harboring commercial fish species. The state has an estimated area of 70,000 ha available for culture fishery. This includes reclaimable submerged lands (5400 ha), marshes and swamps (11,380 ha), ponds and tanks (3220 ha), paddy fields (40,000 ha). Reservoirs cover about 10,000 ha suitable for culture-based fishery. These include Khoupum Dam, Singda Dam and the Sekmai Barrage with irrigation potentials varying from 1000 to 5000 ha. Although the total area of water resources available in the state is estimated to be 1 lakh ha, only 68,436 ha are readily available for fishery purposes. The detailed break up of water bodies that is readily available for fisheries and their estimated fishery potential are shown in table 2. These water bodies support as many as 130 species of fishes. Of these, 26 species has commercial food value in the state and 41 are expected to be endemic. Twelve new species has been described from Manipur. The state also holds enormous potential for developing aquarium fishery. More than 60 species of ornamental fishes have been reported from Manipur. About 45,000 fishers exploit these resources for their livelihood. The commercially important species, their local names and abundance are shown in table 2. Rivers in the cool hilly areas harbor *Tor putitora, T. progeneius, T. tor* and *Neolinochilus hexagonolepis* (Arun Kumar, 2000), *Schizothorax* spp. and *Glyptosternon* spp.

Potential for paddy-cum-fish farming is enormous with 40,000 ha of paddy cultivation, of this about 4000 ha is readily available. Molluscs of fishery value in the state are *Lamellidens* sp. and *Pila* sp., which are presently being fished for edible purposes. The annual fish production potential of the state, from these water bodies, is estimated at 39,252 t (Table 3).

Table 2. Commercially important fishes in Manipur, their local names and abundance

Name	Local name	Abundance
Family : Amphipnoidae	-	
Monopterus albus	Ngaprum	Common
Family : Anabantidae		
Anabas testudineus	Ukabi	Abundant
Family : Bagaridae		
Mystus aor	-	Common
M. bleckeri	-	
Family : Channidae		
Channa punctatus	Ngamu	Abundant
C. striatus	Meitei ngamu	Abundant
Family : Cichlidae		
Clarias batrachus	Ngakra	Common
Family : Cyprinidae		
Catla catla	Puklaobi	Abundant
Cirrina mrigala	Mrigal	Abundant
C. reba	Khabak	Common
Ctenopharyngodon idella	Napichabi	Abundant
Cyprinus carpio	Common carp	Abundant
Hypophthalmichthys molitrix	Silver carp	Abundant
Labeo bata	Ngaton	Very rare
L. calbasu	Kalbasu	Abundant
L. dero	Ngaton	Very rare
L. gonius	-	Rare
L. pangasia	Ngaton	Rare
L. rohita	Rou, Rui	Abundant
Osteobrama belangeri	Pengba	Very rare
Tor putitora	Nung-nga	Very rare
Family : Mastacembelidae		
Mastacembelus armatus	Ngarin	Common
M. leucocephalus	Ngassip	Rare
Family :Notopteridae		
Notopterus notopterus	Ngapai	Common
Family : Saccobranchidae		
Heteropneustes fossilis	Ngachik	Abundant
Family : Siluridae		
Wallago attu	Sareng	Common

Table 3. Resource wise area available for fishery purposes, their production rates and potential

Resource	Area (ha)	Production (kg ha^{-1} year^{-1})	Production (t year^{-1})	Potential (kg ha^{-1} year^{1})	Potential (t year^{-1})
Lake (capture)	14600	80	1168	300	4380
(culture)	4500	1500	6750	2500	11250
Beels/marshes/swamps	11536	30	346	50	577
Ponds/tanks (capture)	5000	20	100	30	150
(culture)	4939	1500	7409	4000	19736
River/streams/canals	13888	5	69	10	139
Reservoirs	10000	30	300	100	1000
Paddy + fish farming	4000	200	800	500	2000
Total	68463	—	16942	—	39252

Capture fishery

The major share of the fish production in the state (almost 60%) comes from capture fishery from lakes, swamps, *beels*, ponds and reservoirs. Riverine sources contribute only to a small fraction of the catch due to less intense fishing, inadequate fishing methods and seasonal nature of the rivers. Fishing implements employed in the state are traditional, mostly of non-selective type similar to or variants of those employed elsewhere in the inland areas of the country. Gill nets, cast nets, trawl nets, dragnets, lift nets, pole and line, spears, boxes and traps are the important fishing implements. Fishing with electric current, poison and explosives are also common in hill areas. Fishing crafts are dugout canoes, plank-built boats and rafts.

Table 4 shows the various types of crafts and gears in operation in the state. Fishing implements, except nets, are made of locally available materials, mostly of wood or bamboo. These seldom last for more than 2-3 years. The state does not have any yarn or net making unit, resulting in high cost for those brought from other areas. The existing canoes in the state are of 13 to 24 ft in length, 1.3 to 1.8 ft in width and 1.2 to 1.3 ft in depth, making these unstable in rivers. Timber used to make these canoes have become scarce. Frequent repairing and maintenance also incurred high cost. None of these crafts are motorized.

A unique fishing method is employed in Loktak lake, in which floating circular islands (10-30 m diameter.) are made using aquatic weed mass (*Phoomdi*) as fish aggregating devices. Fishes congregated below these islands are caught using nets. The annual catch from an island varies from 300 to 1000 kg and the lake is dotted with hundreds of such islands (Suresh, 2000).

Table 4. Fishing crafts and gears in Manipur

Name	Number
Crafts	
Dugout canoes	
Motorized	-
Non-motorized	6015
Catamarans	
Motorized	-
Non-motorized	10
Plank built boats	
Motorized	-
Non-motorized	814

Gears	
Trawl nets	413
Gill nets	96095
Drag nets	4846
Cast nets	5733
Others	103396

Source: 15th Quinquinnial livestock census report.

Fishers and gender issues

There are about 45,000 fishers in the state, of these about half engage fulltime in fishing. More than 10,000 of them depend on the Loktak lake alone. Fishing is also a part time vocation or favored hobby for most of the Manipuries. In rural areas almost all the house holds posses fishing implements and every one at one time or other indulge in fishing. More than half the fishing operations are subsistence. Men, women as well as children, including girls, actively take part in fisheries activities. People hunting for fish in every conceivable form of water bodies, with some implements, are a common site in Manipur. Fishes of all sizes, including spawns and fries, of all the available species are fished for consumption. Drying, smoking and preservation of fishes are also done by both men and women with more involvement of women. While marketing of fresh and processed fishery products is almost entirely a domain of women, especially those of the elderly. Cooperative movements have also taken roots in the society. There are several women cooperative societies, both registered and unregistered and local clubs, functioning in fishery activities (Nupi ngayok marup). Manipuri women muster active participation in decision-making, both at home and outside, besides exerting considerable influence in the society. Hence, the programmes oriented towards fisheries development, conservation and management of resources should ensure equal, if not more, participation of women.

PROBLEMS

Indiscriminate exploitation of the water bodies and man's modification of the environment are causing serious danger to several species. *Osteobrama belangeri*, once forming about 30% of the catch from Loktak lake, has now become rare due to the blockage of their migratory route after the construction of Loktak Hydroelectric Project and over exploitation. *Labeo dero, L. bata, L. gonius,* mahseers and most of the other hill stream species are also threatened. Mass fishing of brooders, fingerlings and juveniles using explosives and chemicals like bleaching powder, pesticides and local herbal piscicides, as well as destruction of their natural habitat in the hill areas are attributed to the decline in mahseers (Arun Kumar, 2000). Most of the air breathing fishes is also in the line of danger due to over exploitation. Other important problems in the fisheries sector in the state include

- Most of the water bodies are controlled by departments of Revenue, Forests, Irrigation, Power *etc*, hence priorities of fisheries are not addressed properly
- Inefficient and indiscriminate fishing methods and implements
- Riverine resources are not fully exploited. Incapable fishing crafts to negotiate rivers.
- Decreasing recourse size of commercially important fishes
- Fish biodiversity changes

- Invasion of exotic species like *Cyprinus carpio, Ctenopharyngodon idella, Hypophthalamichthys molitrix etc.*
- Unauthorised introduction of exotics like *Clarius garipeneus, Pangasius sutchi, Oreochromis mossambicus, Puntius gonionotus, Aristichthys nobilis etc*.
- Clandestine trade of indigenous ornamental fishes
- Under utilization of the production potential of natural water bodies like lakes, reservoirs, *beels* and community ponds

Development strategies

- To improve the capture fishery production, more effective fishing implements can be introduced.
- Although the rivers in the state offer vast scope, riverine capture fishery has not received much attention. Effective fishing methods and implements as well as capable crafts to negotiate rivers needs to be introduced. There is also need for river specific gears.
- Fishers have to be trained in making nets locally to overcome dependence on fishing nets brought from outside.
- Though dug out canoes are the most common fishing crafts in the state, making plank built boats has to be encouraged to conserve timber. People have to be trained in making low cost fiber plastic boats, and coating FRP on existing crafts to prolong their life.
- Capture fishery need to be encouraged in a regulated manner, taking into account the stock and recruitment and optimum yield principles of the natural fish populations.
- Although there are fishing regulations in force in the state, none of these are strictly imposed. Destructive fishing methods should be stopped immediately.
- Local NGOs and government organizations should ensure more public participation through participatory approach in fish conservation measures.
- The existing fish ranching programmes in lakes and ponds in the state has to be improved and extended to rivers, both in the valley and hills and a ces be levied from the beneficiary fishermen to meet the cost of the programme.
- There should be greater thrust on developing culture-based fishery in lakes, reservoirs and *beels* as well as in large community ponds, besides encouraging culture fishery in ponds.
- As 90% of the state is hilly, for an all round development culture-based fishery and aquaculture has to be taken on to the hills. The watersheds in hilly areas in the state offer enormous scope for creating seasonal/perennial water bodies. Technologies suitable for this are already available (Prasad *et al*., 1987). As 'run-off-fed" fish ponds in managed watersheds, with integration of other agricultural, forestry and animal husbandry systems, is comparatively a new venture, the vast hill tracts in the state hold good promise for growth.
- The fishery development agencies in the state have to be made more targets oriented with participatory approach to motivate and train people to venture into scientifically managed fish farming, judicious fishing and conservation.
- In depth studies and research support for fisheries problems identified through participatory methods.
- Fisheries awareness through formal and informal means for the young and elderly people.

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Laal, A. K., 2003. Importance of biotic communities in open water fisheries with special reference to beel fisheries, pp. 66-67. *In:* M. Choudhury, N. P. Shrivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

IMPORTANCE OF BIOTIC COMMUNITIES IN OPEN WATER FISHERIES WITH SPECIAL REFERENCE TO BEEL FISHERIES

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INTRODUCTION

Shallow, derelict water bodies infested with weeds are known as beels. To get sustainable fish yield through eco-friendly measure, it is imperative to gather sufficient information about biotic communities of water bodies/beels. Biotic communities depict structure and function of water bodies in term of their nutrient dynamics vis a vis carrying capacity and production potential. Thus, awareness to biotic communities is pre-requisite for better fishery management. Biotic community of any water body (beel) is comprised of plankton, periphyton, benthos, macrophyte and associated fauna.

Plankton

Microscopic organism drifted by water currents are known as plankton, comprising algae known as phytoplankton, microscopic animacules known as zooplankton and very minute microscopic organisms (mainly plants) known as nanoplankton. Phytoplankton comprises algae of various classes viz. bacillariophyceae, myxophyceae, chlorophyceae, desmidiaceae and euglenophyceae. Zooplankton comprises members of protozoa, rhizopoda, rotifera, cladocera, copepoda, isopoda and ostracoda. Their occurrence and abundance mainly depends upon individual's ecotendency and trophicity (nutrient concentration, productivity) of beel. They are an ideal fish feed.

Periphyton

It is an assemblage of algae (mostly members of bacillariophyceae) on various substrata. Their community structure and density (biomass) depend upon nature of substratum, nutrients load, and flow of water. Heavy density (biomass) of periphyton in due course of time serve as feeding, mining and breeding ground for certain rotifers, cladocera and ostracods. Fish browse over periphyton. Periphyton influence primary productivity and saprobity of water bodies.

Benthos

They are sedentary and mobile macro-invertebrates. Their communities and abundance are influenced by structure of beels, their nutrient status and flow of water. They comprise mostly members of diptera, coleoptera, zygoptera, annelids, and mollusca, which act as collectors, scavengers and filterers. They are being used as fish feed and tool for monitoring water qualities.

Macrophytes

Plants found in the water bodies as floating, rooted, submerged. They help in auto-cleaning of water bodies and they provide substrate for micro-invertebrate to adhere and also act as feeding, mining, breeding ground for molluscans, annelids, dipterans. Macrophytes expurgate nutrients of water bodies and abstain light penetration if they are of floating nature. Since, occurrence and abundance of each individual species of different component of biotic communities are attributed to nature of soil, water flow (fluviatile and stagnant water condition), it is often used as bio-indicator for monitoring water quality in term of productivity and degree of pollution, apart from being fish feed. Study of bio-diversity will help in preserving ecology and its rational utilization will be helpful in augmenting optimum production, further application of several indices will be useful in monitoring water qualities and signaling the hazards if at all to occur.

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Barik, N. K. 2003. Livelihood issues in riverine and floodplain wetland fisheries in India: issues and options, pp. 71-78. In: M. Choudhury, N. P. Shrivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

LIVELIHOOD ISSUES IN RIVERINE AND FLOODPLAIN WETLAND FISHERIES IN INDIA: ISSUES AND OPTIONS

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INTRODUCTION

Every individual is associated with certain economic activity of one sort or other for sustaining the life of his/her family. These economic preoccupations are the source of the livelihood, which determine survival and well being of the individual and family. Households generally don't depend on only one source of livelihood; they tend to diversify their sources constituting the diversified baskets. These baskets of different livelihood sources constitute livelihood system. So, it is the array of the economic activity undertaken by the household for their sustenance; which include laboring, agriculture, fishing, small business activity and other subsidiary occupation. Out of these bundles of the activity or the enterprises, one or two of them constitute the major sources with others as supporting livelihood sources.

The fishers are central to the beel fisheries management in terms of their stake in the beels. Beels are primary source of living. They are differentiated from other stakeholders in terms of exclusivity in dependence, traditional association with fishing enterprises and limited livelihood options outside fisheries etc. Therefore, the beel fisheries have deterministic impact on the livelihoods of the fishers.

General characteristics of beels

Beels in the state of Assam are highly diverse in their resource characteristics. The salient characteristic of the beels is

i. *Vastness of resources*- size of beels varies from 5 to 1000 hectare.

ii. *Multiple uses*: the beels are used in multiple purposes like fishing, agriculture, foraging, cultivation of other aquatic organisms, horticulture, navigation, irrigation etc.

iii. *Multiple users*: the beels are multiple users situations and the users are in multiple numbers across and within each use.

iv. *Uncertainness*: the catch from the beels are uncertain. More so in open beels which are dependent upon the natural stocking. The production of the beels and catch per effort are uncertain.

v. *Natural contributions*: the beels are primarily natural resources and flow of goods and services from the resources is dependent upon the natural processes. Therefore, the allocations and distribution of the resources based on the social and political considerations.

vi. *Low productivity*: beels in Assam have low productivity of 150 to 300 kg with the average of 184 kg per ha, which is 15 to 20 % of the productivity potential.

vii. *Common property and open access resources*: These resources are not under the private property regimes. It belongs to the state and community in terms of their ownership and control.

These general characteristics are primarily ecological and social-economic environment that determines the livelihood of the fishers dependent upon it. The characteristics like multiple uses and users, common property regimes, naturalness *etc* enhance the livelihood security by providing greater access to the goods and services of the beels; whereas, uncertainness, low productivity *etc* are constraining factors to the livelihoods.

Relevance, meaning and definition of livelihood

Food and nutrition security is primary concern of fishers as large proportions of their efforts are invested in fetching them. The livelihoods are the means of attaining them. Therefore, food and nutrition security is achievable when livelihood is secured (Farrington, 1991). The process and means of achieving the livelihood security are complex and involves multiple decisions among limited assets and constraining opportunities. These issues cannot be addressed through the sectoral and partial analysis of one or few enterprises. Therefore, the study of livelihoods deals with the complex interaction of the their resources, endowments, capabilities, assets, strategies etc. (Scoones, 1998).

It looks at the issue of poverty and living security in the perspective of the totality of the interaction of the households with the external opportunities and limitations. Therefore, every concerned aspect of living needs to be involved in the livelihood approach. Hence, a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base (Chambers and Conway, 1992). The definition provides the basis for analyzing the livelihoods of fishers.

Components of livelihood systems:

While the definition act as guidelines, the specific issues, concerns and nature of livelihoods of fishers are different from others. In order to devolve livelihoods, it needs to disintegrate into its well-defined components. These components are as follows.

1. Priorities of fishers

Secured access to food: The household priorities of the fishers in Assam are predominantly securing food for the their family.

Coping with seasonality: The fishing activities are seasonal in the beels. The fishing is confined to 3 to 9 months with the average of 5 months.

Reducing uncertainties: capture fisheries are uncertain so also catch from beels. The catch per efforts varies widely across the season as well across efforts in each day. The return per effort forms the basis of livelihoods. Therefore, fishers tempt to reduce the uncertainties.

Increasing income: the fishing activities have limited self-consumption implications and the livelihood operates through the income-generated through it. Therefore, they have the motivations to increase income through additional catch, increase in value and reduction of the cost.

Control over fishing: greater control over the fishing reduces uncertainties as well provide secured access to fishing. The greater control over fishing is achieved by increased accumulation of assets like fishing gears and craft.

2. Strategies to pursuit their priories

Fishing in the beels

Fishers fish in the beels and it is the most important activity of livelihoods for them. Fishing in the beels involves a large number of fishers with multiple craft and gears over a considerable period in the year. The fishing activities in the beels vary from 3 to 12 month in a year depending upon the size and nature of beels. The open beels with areas of more than 100 hectares are harvested through out the season with the selective gears. The small meshed nets (masuri jal) are confined to the end of the fishing seasons and for the period of 4 to 6 weeks in the years, whereas the major fishing through katal and dragnets are spread over 2 to 4 months. The fishing through gill nets and cast nets are for the 9 to 12 months. The smaller gears like dip nets, scoop nets etc are generally for the whole year depending upon the availability of the fish. The catch per efforts in terms of money varies from 20 to 200 rupees per day. In certain period of the years they don't get any fish for the whole day. The share of the fishing to the consumer rupees is around 10 to 15%. In other word, only 10 to 15 rupees goes to all fishers fishing in the beels from 100 rupees of fish consumed from it.

Accumulation of assets

Fishing communities have interest in accumulation of assets required for fishing. The assets are nets of diverse characteristics used in the various conditions. The nets like cast nets, dragnets, scoop nets of various shape and size are used. These assets provides the flexibility to fish in different seasons like rain, winter, summer and in different conditions like weed choked, marginal areas, deep water, flowing water etc. They are also used for different target species like catching different size of fishes, prawns etc. The accumulation of assets is the means of achieving the household priorities.

Diversification of resources

The peculiar characteristics of the livelihood systems of the fishermen are that they have limited options outside the fisheries. The assets are confined to the fisheries and fisheries related activities. They have limited other assets like agricultural land, implements. The education, skill and caste are the main constraining factor for their diversification across other sources. However, in order to diversify their source of livelihood and cope with the seasonality and uncertainty, they diversify across the practices and resources of fisheries. They use dragnets, small meshed net, *katal* net (kind of FAD) in the main fishing season, cast net, gill net in other seasons. They also use small and big scoop net in the running water in rainy season. Other nets like scoop net, other small nets are used in the marginal areas for fishing of small and indigenous fishing. They also diversify to fish in the ponds, rivers and streams in seasons other than main fishing seasons of the beels.

Diversification is also observed across other activities like duckery, goat rearing and cattle rearing in the limited scale. The larger part of the responsibilities of these activities is shared by the woman folk. Each of household maintains about 5 to 10 ducks, 2-5 goats and 1-2 cows. However, a very small proportion of the community also has interest in the agriculture. But, average land holding is 3 to 5 bighas per households. These diversifications are predominant among the fishing communities fishing in the localized areas. The migrating fishermen have limited diversification in these activities.

Wage labours are important source of livelihoods in the off-fishing seasons. The wage labour opportunities are more in the rainy seasons when the fishers are vulnerable to the food insecurity. In the month of June to Septembers, a large proportion of the fishers engage in the wage labours. The average wage is 45 to 50 rupees per day. But, the opportunities are not available for the whole seasons. In a year, fishers engage in 20 to 40 days in wage labours in agriculture. This opportunity is limited to the fishers living in the marginal areas like dykes of beels or riversides.

A small proportion of the fisherman have shifted from fishing to fish marketing related activities like fish transportations, auctioning, selling in market, retailing etc., but, the proportion are very small.

Networking with beel managers

The access to fishing and achievement of it among the competitors is determined by the relationship between the fishers and the beel managers. This is a form of social capital when the relationships act as means of their access. The fishers adopt the strategy of keeping the information about the development and management measures taken by the beel managers. The relationships with many beel managers help them plan their fishing activity and get the access to better fishing grounds.

Networking with other fishers

The relationships among the fishers within and across the communities are part of the social process. It has both social as well as economic functions. The social capitals of trust, sharing and reciprocity are primarily dependent upon these relationships. The economic functions are served by flow of information across the communities on the productivity, preferences, opportunities and limitations for fishing in the beels. This information is vital to plan their livelihood and choose the better alternatives.

Storage of food

The main fishing is seasonal in nature confined to the months of October to January. In these seasons fishers earn about 6 to 9 thousand depending upon the productivity and the type of fishing. This income constitutes about 50 to 70% of total income of the year. For rest 8 month they earn less than 50 to 30% of their annual income. Fishers communities purchase the food matters in these seasons for the rest of the period of the year. The food matters constitute rice. In this season, the cost of rice is also less as it coincides with the harvesting season of rice. This strategy even out the fluctuation in the food consumptions.

Coping and adaptations strategies

These are the strategic plans to cope with the diminishing and increasing income respectively. The strategies to cope with the falling income, seasonal distress or shocks like major disease, accidents, death, social functions are important to their living. The first important coping mechanisms to cope with seasonality are storage of food for the whole year in the major fishing seasons. The other strategies they adopt are selling of assets like ducks, goats or cattle at the time of needs. In order to incur the expenses towards bigger events like social functions, medical expenses; the fishers are primarily dependent upon the loan from beel managers and then moneylenders. The beel managers are first preferred source of loan as it is either interest-less or less interest. But, the interest from the moneylenders is high to the tune of 100 to 120% per annum. In such occasions, they also draw upon the social capitals through reciprocal gifts, exchange or donations from the relatives and neighbourhood. In the extreme case, the fishers go for the selling of fishing assets like boats and nets. They also adjust to the distress by reduction of consumption pattern. The sacrifice the consumption of costlier food item like pulse, vegetable. They depend more on the cheaper vegetable like pumpkin, gourds and grasses. In the extreme cases, they eat only rice with salt and onion.

Adaptations strategies are the approach towards positive directions in a situation when the return has surplus over the expenditure over a period of time. The fishermen adopt strategies to strengthen their livelihoods by investing on the assets and enterprises that bring additional return and that reduce the uncertainties and vulnerability. The adaptation strategies are purchase of nets that are costly but return from the catch is higher. Sequentially, fishers purchase cast net, gill nets of various mesh size, boat operated dragnets, small meshed dragnets etc. They also purchase additional boats with the additional money. For the diversifications, the fishers accumulate number of ducks, hens, goats and cow in the sequence.

3. The institutions, policies and organizations

Institutions:

The institutions are the structures determining incentives and disincentives for action in general sense. In the context of livelihoods, the institution determines fishers access to resources, capitals, share in distributions, and return they can achieve from their efforts. Here, the relevant institutions can be as follows.

Sharing arrangements

The arrangement is the agreement between the lessee and fishing group on sharing of catch. The contract involves catching as well as selling in the market. The sharing arrangement varies between 30 to 70% for the fisherman depending upon the availability of fish, ease of catch, type of catch, prevailing practices, provision of craft and gear, membership in groups etc (Barik and Katiha, 2003).

Sharing arrangement in beels of Assam for fishing		
Condition of beel	**Managers**	**Fishers**
Fishers cooperative managing beels	40	60
fish is not abundantly available the share is	50	50
availability of the fish is more	60	40
fish is quite high and easy to catch	70	30
fish is moderately available and beel is weed choked	40	60
difficult to catch, low availability of fish and highly weed choked	30	70
Extreme difficult condition and catch by small nets like gill nets, scoop net	10	90

The above arrangement is followed when the boat and net is provided by the fishers. Manager takes 20 percent more when boats and nets are provided by him.

Property relationship

The property rights - the fundamental institutions of allocation and access - is wide and varied across the state. The property rights have multiple dimensions like ownership, control, regulation, access etc.

Ownership and leasing

More than 66% of the beels are under state control. These beels are under control of 4 state departments/agencies viz., Assam Fisheries Development Corporation (AFDC), Revenue, Panchayat Raj and Forest department. These agencies except Forest Department, lease out the beels to the individuals or group for fisheries purposes. Beels under the control of Forest departments are not under fisheries use as they distributed in the forest areas like national parks and reserve forests and are used for the conservation purposes.

The non-state players like community, autonomous tribal bodies, school *etc* control about 33% of the beels. These beels are leased out to the individuals and the group. But, they follow their own procedure of leasing. The lease amount or the rent is generally used for common utility creations like school management, road building, and contributions to religious institutions *etc.* Sometimes these money are used for providing assistance to the poor within community, or for social functions like marriage, funerals *etc.*

Most of the beels are leased out to individuals or groups for the purpose of fisheries. The mechanisms and modalities of leasing outs are different and relative to the owners. The state bodies either directly settles the beel with the lessee (individuals or groups) or through close tender system. At least 60% of the beels can be leased out to the cooperative society. Cooperatives also avail favourable terms like chance to take the bid when its bids fall within 7.5% of the highest bidder at the rate of highest bidder. In absence of the cooperative, lease is preferred for members from the fisherman community, or backward classes. A concession of 10% is given to the individual lease under specified conditions. When the above conditions are fulfilled, the individuals get the chance to seek beels for management.

The lease period varies from 3 to 5 years in the revenue department administered beels and it is 7 years in case of the AFDC. The beels are leased out in return for the specified amount as lease value or rent. Such rent varies from 5 to 30% of the fisheries output.

In certain cases, the lessee subleases the beels to some others for fishing of the whole stock or specific stock. The lease amount in the case of partial lease is related with the species, gears and seasons. For example, 10 to 20 rupees per day for fishing with small nets like scoop net, deep net or small prawns and indigenous fishes in the rainy seasons. Where as for the fishing of the larger fishes like IMC, catfishes, the lease are proportion to the catch which varies from 10 to 70% of the catch.

CONTROL AND REGULATIONS

The control over the fishing is transferred to the lessee through the leasing arrangements. The lessee becomes de-facto controller of the beels. He has given the rights to control and regulate fishing in the beels. He regulates it through exclusion of the unauthorized fishing including theft. Such regulation makes the beels exclusive rights of the lessee. The lessee has also the control over all the management and harvesting functions. The fishermen have limited role to play in the control and regulation functions of the beels. This situation positions them at low bargaining ability and limited access to the return earn through control of the beels. This arrangement also put the fishermen's access to the beels at the mercy of the lessee. This adds to uncertainty of access as well as low return from fishing as a large share is taken up by the lessee.

4. Capital and access to capital

The livelihood framework encompasses wide range of the capitals that have significant influence on the life of the people. Such capitals are social, human, physical, financial and natural capital. The social capitals are the sense of belongingness to the community and the institutions of reciprocity at distress. The fishers belong to particular group of community and are identified with their separate identity. The identities like *Muslim*, *Assamese, Bengali* etc are binding principle of fishers community. The supporting each other at the distress can be generalized.

The capital possession are mostly confined to fisheries assets like boats, nets, etc. The fishing communities have tendencies to accumulate the assets relating to the fisheries with the increase in the return from fisheries. As the surplus income is invested in the fishing assets as compared to the other assets like agricultural land, financial assets like gold, saving certificate etc, the fishers go for purchase of costlier assets like boats, dragnets of bigger size. However, the fishers with limited surplus purchase duck, goats or cow as capital. Therefore, the land-based activities are limited to the fishers of Assam.

Natural capitals like rivers and other derelict water bodies are the basis for their primary livelihoods. The typical nature of topography, catchments, rainfall contributes to the fishery productivity of these resources. The fishers move across distances up to 400 kilometers to fish in these water bodies. However, a large number of fishers fish in the nearby localities. The access to the open access fisheries resources like beels, rivers etc are determined by the spatial and temporal convenience as well as alternative employment opportunity. The fishers tend to prefer other well managed fisheries like ponds, beels as the return to efforts from the open access fisheries are lower. But, access to the managed fisheries resources is determined by the transactions and negotiations with the lessee or owners.

5. Context of living

The contexts are the larger issues or factors that are externals to the people and resources but affects the livelihoods. These variables include external trends (economic, technological, demographic, etc), shocks (natural and man-made) and seasonality (Scoones, 1998). The significant contextual variables for livelihoods can be described as follows.

Shrinking of beel resources: the wetlands all over the world are threatened resource by virtue of its ecological process and multiple uses. In Assam, The beels are subjected to destructive practices like diversion of the land for agricultural and industrial purposes, extraction of water for irrigation purpose, manipulations of the habitat by cross bunds, siltation etc. These factors contribute to gradual shrinking of the resource in extent and quality.

Increase in populations: there is considerable pressure of population on the beels in the recent times. The other uses like collection of grasses, collection of aquatic plants, agricultural and horticultural use, grazing of animals etc has increased with the increase in populations. The increase population has made increased number of people dependent upon the beels for their livelihoods and consequently share of each of the fishers has reduced.

Degradation of resources: degradation is the reduction of the quality of the beels in fisheries perspective. The lack of management in many of the beels led to excessive growth of weed, gradual drying and silting of the beels. Many of the beels are getting silted up and the channels are severed from the parent rivers and that lead to reduced auto stocking. These processes contribute towards reduction of the productivity.

Exclusivity of property regimes: In the recent times, many of the open access beels are converted into exclusive rights regimes by leasing. Besides, there are increased practices of pricing of otherwise free services like collection of grasses, catching of small fishes, collection of other aquatic organisms. The fishers are excluded from accessing these resources.

CONCLUSIONS

The issues of livelihoods are much larger the issues of income and employment alone. It is associated with the nature of resources, governance of beels, institutions and policies etc. The livelihood outcomes at the households are the sum total of the interaction of these parameters with the household endowments, assets, priorities and activities. The recent trend in the beel fisheries management has not improved the livelihoods of the fishers in a significant way. But, many of the trends like degradation, exclusive right regimes, marketisation of resource services etc contributed to the insecurity and uncertainty of the livelihoods. The share of the fishers in the total outcome of the beels fisheries management are low because of many reasons viz., the participations of fishers in the economically important functions like owning, regulations etc are low, sharing arrangements in fishing in titled against fishers, the beel managers have better bargaining positions in negotiations etc. For a considerable part of the year, the fishing activities are stopped in the beels and fishers are to depend on other sources like fishing in rivers, streams, open access water bodies. Besides fishing, the fishers are also dependent upon the other sources of livelihoods like duckery, piggery, goatary etc. These assets are used as buffer to maintain consumption level at the period of shortages. Therefore, the livelihoods systems of fishers associated with the beels are complex, diverse and intricately associated with the many issues outside beels fisheries management systems.

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Bhattacharjya, B. K., 2003. Floodplain Wetlands of Assam: Management options and issues from the fisheries perspective, pp. 79-86. *In*: M. Choudhury, N. P. Shrivastava and R. K. Manna (eds.), Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

FLOODPLAIN WETLANDS OF ASSAM: MANAGEMENT OPTIONS AND ISSUES FROM THE FISHERIES PERSPECTIVE

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INTRODUCTION

Floodplain wetlands (beels) are low-lying areas bordering rivers inundated by floodwaters from the main river or from their catchment areas during the rainy season. India has extensive areas covering 2.02 lakh ha under floodplain wetlands. These wetlands - mainly associated with the Ganga and Brahmaputra river systems - are distributed in Assam, West Bengal, Bihar, Manipur, Tripura, Arunachal Pradesh and Meghalaya. They are either typical ox-bow lakes (cut-off portion of river meander bends), meander scroll depressions, back swamps, residual channels or tectonic depressions. These water bodies are locally known as *beel, maun, chaur, haor, anoa, pat,* etc. The beels of Assam are either created by or are associated with the Brahmaputra and Barak river systems. These are also known as *haor* (lake-like wetlands) and *anoa* (ox-bow lakes) in Barak Valley while in Brahmaputra Valley the terms mora nadi/mornai (meaning dead river), *era suti* (abandoned river channel) and *jan* (connecting channel) are also used to describe them. The state has 1392 enlisted beels, of which 423 are registered and the remaining 969 are unregistered ones. The unregistered beels are under the control of both government (505) and semi-government /public bodies like *Mahakuma Parishads, Gaon Panchayats*, etc. (464 no.). Together, the enlisted beels cover a total area of *c* 100000 ha, which is as much as 61.5% of the total lentic water bodies (*c* 162,500 ha) of the state. *Beels* are recognised as the single most potential fisheries resource of Assam both in terms of large resource size and high fish production potential (1000-1500 kg $ha^{-1}yr^{-1}$). However, most of the beels of the state are not properly managed resulting in low average fish yield (*c* 173 kg $ha^{-1}yr^{-1}$) from them (Shrivastava and Bhattacharjya, 2003). Thus, scientific management of the beels of Assam in order to realize their fish production potential is the need of the hour. Against this background, management options available for optimizing fish production from the beels and prominent issues that needs to be resolved are briefly discussed in the following account.

FISHERIES MANAGEMENT

In simple terms, fisheries management can be defined as "the pursuit of certain objectives through direct or indirect control of effective fishing effort or some of its components in a natural fishery". Although scientific fisheries management is a concept of western origin, the general idea that fisheries have to be managed in some way or the other is found all over the world, even in the so-called 'unregulated fisheries'. Management (including occasional development) aims at achieving optimum or best possible use of a fishery resource.

CATEGORIZATION OF BEELS FOR MANAGEMENT

Beels are a heterogeneous group of water bodies that differ from one another in size, shape, riverine connection and habitat variables. Thus, it is difficult to prescribe a uniform set of management guidelines for all the *beels*. For the purpose of fisheries management, *beels* have been broadly divided into perennially open (i.e., *beels* retaining riverine connection throughout the year), seasonally open (connected to rivers only during the rainy season) and closed ones (cut-off from the parent river) depending on the nature of riverine connection. Further, based on size and ease of management, beels can be divided into very small (effective water spread area <20 ha), small (20-99 ha), medium (100-499 ha) and large beels (500 ha and above).

MANAGEMENT OPTIONS

Management options suitable for different types of *beels* (e.g., open/closed, large/small, etc.) can be broadly grouped under capture fisheries and various forms of fisheries enhancements (including culture-based fisheries and aquaculture) depending upon the extent of human intervention in the management process.

Capture fisheries

In most perennially open and large *beels*, natural fish stocks are harvested with little human intervention either on the habitat variables or on the fish stocks. Here, the manager should aim at conservation and sustainable use of natural fish stocks. This can be achieved by allowing natural replenishment of fish stocks (recruitment) through conservation of the habitat and its fish stocks.

Conservation of habitat : Open *beels* are relatively free from aquatic macrophytes, have good water quality and less siltation because of water flow and resultant water exchange. The following steps are suggested for conservation of the habitat:

i) Infestation of aquatic macrophytes hampers water flow, thereby augmenting the siltation rate and deteriorating water quality. These should be regularly cleared/ controlled by suitable means.

ii) Desilting the connecting channel.

iii) Desilting the marginal shallow areas.

iv) Retention of sufficient water levels during winter and pre-monsoon months (by minimizing water outflow and abstraction).

v) Prevention and control of aquatic pollution.

Conservation of natural fish stocks : The following management measures are suggested for ensuring recruitment of natural fish stocks:

a) Allowing free migration of brooders and juveniles of major fishes from the *beel* to the parent river and *vice versa*. This may require desilting the connecting channel and prohibiting fishing (especially barrier fishing) in the channel when the fishes migrate to the beel from its parent river and back to the river.

b) Identification and protection of breeding grounds of commercially important fishes (e.g., closed regions).

c) Conservation measures suggested for the protection of brood stock and juveniles are:

i) Strict adherence to restrictions on minimum landing size for different commercial fish species (more practicable than mesh size regulation for multi-species fisheries of the beels).

ii) Increasing or decreasing the fishing effort for optimising fish production or to prevent over-fishing.

iii) Observing fishing holidays during the monsoon season to ensure spawning success.

iv) Banning or phasing out destructive fishing methods like mosquito nets, dewatering, fishing with explosives/piscicides, etc.

v) Diversification of fishing methods to avoid selective over-fishing.

Community enforced regulation (through mass awareness programmes) is usually more effective than government enforcement.

Fisheries enhancements

Management of the beels purely along capture fisheries lines is increasingly becoming rare because of declining catches and the need to increase their fish production. In most beels, fish production is increased through fisheries enhancements. Fisheries enhancements refer ton the process by which qualitative and quantitative improvement is achieved from water bodies through exercising specific management options (Welcomme and Bartley, 1998). There are several practices that together contribute to enhancement of fish production from a beel through increasing human control on parameters governing fish species composition. These practices are intermediaries between capture fisheries and intensive aquaculture. They are often adopted in a stepwise manner leading to a progressive increase in fish production. Enhancement options suitable for beel fisheries are outlined in the following.

Species enhancement : It involves planting of commercially important and fast-growing fish species from outside the beel. The primary purposes of species enhancement are: (i) to establish new fisheries through the introduction of new species; and (ii) to fill a vacant niche (to utilize all the available food resources and living spaces). Species enhancement can be practiced even in large open beels, where regular stocking is not practicable. Certain indigenous molluscivorous (e.g., *Pangasius pangasius*) and herbivorous fish species (e.g., *Puntius pulchellus*) can be transplanted from other water bodies/ regions of the country into a beel to utilize its unused food resources (Bhattacharjya, 2003a). Introduction of exotic fishes like grass, silver and common carp is not advisable in open beels since there is a possibility of these species escaping into the rivers and establishing themselves there. These species may pose threat to native fish species or the environment.

Stock enhancement : Selective stock enhancement of commercially important, fast-growing fish species is necessary to prevent small, less valuable fishes like *Puntius* spp. from flourishing in the beel by utilizing the available food sources. In most beels, natural stocks of commercially important species have declined because of a number of factors like disruption of the auto-stocking process, habitat degradation and over-fishing. Such beels should be regularly stocked with fingerlings of suitable species to increase their fish yield. *Culture-based fisheries* are practiced in many small closed beels of the country with encouraging results. Here, fish harvest depends solely or mainly on artificial stocking. In managed beels, the Indian major carps (catla, rohu and mrigal) are regularly stocked to increase their fish yield. Important parameters determining the success of culture-based fisheries in a beel are selection of species, species ratio, stocking density, size at stocking, size at recapture, species management, fishing effort and selection of fishing gear.

Fertilization: Since most beels receive a lot of nutrients from their catchments and have large organic matter reserves, external fertilization (i.e., application of inorganic/organic fertilizers) is unwarranted (Sugunan and Bhattacharjya, 2000). Instead of external fertilization, plant nutrients trapped in the beel sediments may be made available to the primary producers through bottom raking (with/without liming) in order to increase the growth of fish food organisms (Bhattacharjya, 2003a). However, fertilization may be required to increase the fish yield of a beel when it is regularly stocked in high densities. Because of the high costs involved, it can be practiced only in very small closed beels. Wherever possible, the beel should be fertilized through discharge of nutrient-rich wastewaters from agriculture/animal husbandry to reduce the cost involved.

Engineering of the environment: This measure aims at improving the levels of reproduction, shelter, food resources and vital habitat. Two types of brush parks, which are popularly known as *katal/jeng* (with submerged bamboo/tree branches underneath) (Yadava *et al.* 1981), and *pit/chek* (without submerged bamboo/tree branches) (Bhattacharjya, 2002a) are the most common environmental engineering techniques practiced in the beels of Assam. These parks mainly act as sheltered areas. These are constructed by barricading a dense patch of floating macrophytes with split-bamboos tied on to bamboo poles driven into the bottom. These are usually erected immediately after the monsoon season (August-September) and harvested during the dry season (January-March) (Bhattacharjya, 2003a).

Elimination of unwanted species: In culture-based fisheries, populations of unwanted (predatory and weed) fishes having lower ecological efficiency should be controlled to ensure better growth and survival of stocked species. However, it is difficult in large beels infested with aquatic macrophytes. Repeated operation of netting using shore seines, boat seines and gill nets of appropriate mesh size; use of long lines, traps etc. are normally employed for controlling undesirable fish populations in beels. Allowing the fishers a greater share in the catch of undesirable fishes is helpful in selective fishing of such species. Biological control of small weed fishes by keeping a limited population of predatory fishes having moderate sized mouth (e.g., *Chitala chitala*, *Aorichthys aor*, etc.) is another low-cost option (Bhattacharjya, 2003a) practiced by many beel some managers of the state.

Habitat modification: Fingerlike projections present in certain beels can be cut-off to create fish ponds. These ponds can be used for raising carp fingerlings for stocking the main beel. The detached areas can also be used for extensive or semi-intensive aquaculture to enhance fish production from them after the rearing operation is over (which usually lasts for 2-3 months).

Pen and cage culture: Fish culture in pen and cage enclosures in beels can be developed parallel to the enhancement of their capture fisheries. Many of the beels of the state are highly acidic and hence not productive. It is not practical to lime and/or fertilize the whole beel. Therefore a manageable part of marginal areas of such beels can be cordoned off as pens both for rearing of carp fingerlings and for growing of table fishes ((Bhattacharjya, 2003b). On the other hand, cages can be installed in deeper areas of the beel to raise fingerlings or to produce table size fish. Cage culture is particularly suitable for raising fingerlings during the rainy season, when erection of pens is difficult in many open beels. Pen and cage culture practices are good management options for weed-choked and unproductive *beels*. This solves the problems created by gear restrictions and catchability. The Institute has successfully demonstrated pen culture technology in the beels of Assam. The field trials were carried out using locally available materials (bamboo) for pen construction and following semi-intensive culture system. The Institute has also successfully carried out experiments on cage culture in selected beels of the state.

Aquaculture: Here, the whole beel is managed as in pond fish culture involving stocking, fertilization, elimination of unwanted species, management of soil and water quality, feeding, health management, etc. Semi-intensive and intensive aquaculture can be practiced only in very small closed beels since the management of culture operations in larger beels is a difficult proposition involving very high material, monetary and management inputs (Bhattacharjya, 2003a). Further, the possible adverse impacts of semi-intensive/intensive aquaculture on the beel environment and the cost-benefit ratio of this option should be carefully considered.

Management enhancement: Management enhancement aims at improving the monetary and aesthetic values of a fishery (e.g., sport fishing, eco-tourism, etc.). This may also involve changing from open to limited access policy (i.e., leasing system) or adoption of a community management approach for more effective management.

MANAGEMENT ISSUES

Though the beels of Assam are recognized as the most potential fisheries resource of the state, their true potential for fish production, revenue and employment generation, etc. is yet to be realized. A large number of technical and socio-economic issues are responsible for this state of affairs. Some of the important issues affecting the effective management of beel fisheries of the state are briefly discussed.

Maintaining the physical entity of beels: Random field surveys conducted by CIFRI in over 50 beels located in different parts of Assam indicated that up to 35-40% of the beel area shown in revenue records have been silted/dried up. The silted areas are encroached by the local inhabitants and gradually converted to private *patta* lands. A number of beels have either dried up completely or diverted to other uses like agriculture, pond construction, housing, etc. This shows that the total beel area is gradually shrinking. As a result, these important fishery resources may be lost forever. Encroachment/diversion of beels is abetted by a number of factors like the absence of clear demarcation of beel boundaries in the field in most cases, increased pressure on land resources for agriculture/housing, lack of effective government control, lack of awareness among the riparian communities about conservation of the wetlands for environmental balance, lack of participation of the local communities in the beel development/management process, economic benefits from the resource used by only a handful of individuals (lessees/fishers' cooperative society members), connivance of revenue officials, etc. Probable solutions to this burning issue include formulation and enforcement of strict laws to prevent reclamation/encroachment, creation of mass awareness about the need for conservation of wetlands, field demarcation of beel boundaries, prevention and control of siltation, etc.

Siltation of beels and connecting channels: Beels receive a lot of silt from the rivers and/or surface run-off from their catchment areas especially during the rainy season. The problem is aggravated by agricultural activities in the catchment areas, which loosens the top soil. Further, aquatic macrophytes cause additional auto-siltation in most beels. Generally, the rate of siltation is more in closed beels because of negligible/reduced flow of water in them, which facilitates settling down of suspended particles to the beel bottom. The connecting channels (*jan*) are particularly prone to siltation since these are usually long and narrow channels through which silt-laden flood waters enter the open beels. Consequences of siltation include: reduced water levels, reduced water renewal/auto-stocking from rivers due to siltation of the connecting channels, faster ageing of beels to swamps/paddy fields, diversion for agriculture/other uses and shrinking in beel area. Siltation is a natural process and cannot be prevented. However, we should aim at reducing the rate of siltation by enforcement of strict laws to prevent deforestation, planting trees around the beel to prevent soil erosion and controlling aquatic macrophytes. Though the constructing embankment all around the beel will reduce the problem, this will disturb the natural ecological processes and therefore is not advisable. Periodical desiltation of the beel and its connecting channel from time to time is required for maintaining its productive area.

Negative impacts of river regulation: Construction of embankments along the banks of rivers for flood control has resulted in negligible auto-stocking of riverine fish species and annual flushing of water in closed beels. Further, since most riverine fish species use the open beels as spawning and nursery ground, river regulation also adversely affects the fish stocks of the parent rivers. In spite of its harmful effects on the ecology and fisheries of beels, river regulation is virtually irreversible, since flood control is given more importance than reviving beel fisheries. Thus, construction and effective operation of sluice gates appears to be a practicable option.

Conflicts between different users of beel resources: In most beels of the state, conflicts arise between lessees/fishers and agriculturists/local residents over the use of marginal land and water for irrigation, jute retting, navigation and other uses. While such conflicts are common in the beels, since they are multiple-use resources, they often interfere with development and management of beel fisheries and may create other social problems like poaching and poisoning. In order to minimize multiple-use conflicts, an integrated basin development plan should be drawn for the beels through participation of all the stakeholders. Further, ensuring equitable distribution of benefits accrued from the resource among the riparian communities will help reduce the resultant social problems.

Regulation of fishing: As a result of years of reckless over-exploitation, stocks of major fishes have been depleted in most beels. This, in turn, has reduced auto-stocking and fish yield in these beels. In extreme cases, it may also result in threatening the existence of certain resident fish species like *Ompok* spp., *Mystus menoda, Puntius sarana sarana*, etc. Regulation of fishing is a difficult task because the fisheries department does not have enforcement machinery unlike that of Forest and have to depend on District administration. Providing alternative employment/financial support to affected fishers during closed season is another tricky issue. Regulation of fishing requires formulation of practicable conservation technique suiting local conditions (e.g., minimum landing size is more practicable than mesh size regulation in case of multi-species fisheries), empowerment of fisheries officials for enforcement, strengthening fishers' cooperative societies and creation of mass awareness among the fishers and beel managers.

Promoting Indian major carps at the cost of other fishes: Many *beels* of Assam, especially the closed ones are regularly stocked with fast-growing Indian major carps (although not done in a scientific way) for enhancing their fish production. In the absence of natural recruitment, stocking with economically important species form the best management option to increase production. The IMC have fast growth rate, effectively utilize most of the available food niches and command good price. However, in many of these *beels* indigenous fish species other than IMC substantially contribute to the total fish catch. Some of these species like *Chitala chitala, Ompok* spp., *Clarias batrachus, Heterpneustes fossilis*, *Amblypharyngodon mola, Gadusia chapra,* etc. fetch higher price than IMC in the local markets. Some beel lessees are interested in stocking minor carps like *Labeo calbasu, L. bata* and *Cirrhinus reba* instead of IMC since they grow to marketable size quickly and fetch good prices. Many of these species naturally spawn in the beels (e.g., *C. batrachus, H. fossilis*, *A. mola, G. chapra,* etc.) and, therefore, save the beel manager money and effort of regular stocking. Thus, it appears that such non-IMC species can also sustain economic fisheries (considering the cost of stocking IMC seed and that of species management). Thus, it is not necessary to manage all *beels* as carp-based fisheries since low yield rates (especially of carnivorous species like *C. chitala* and *Ompok* spp.) are likely to be compensated with the high price fetched by prized species. Further, such a shift in management will prevent the compartmentalization of *beels* and their conversion into ponds. However, seed of these species are not available at most places. Further, scientific studies are lacking on this aspect.

Promoting pen/cage culture at the cost of natural fisheries: Although pen and cage culture help enhancement of fish production and economic returns from a beel, their unregulated growth may cause social (e.g., unemployment for traditional fishers) and environmental (eutrophication) problems as seen in the Laguna De Bay, Philippines (Vinci and Mitra, 1997). Since cage culture is a more intensive culture system than pen, the possibility of encountering long-term adverse effects on the environment are more here. In order to prevent such potential hazards, an integral approach- allocating separate areas for installing pens/cages, capture/culture-based fisheries and other uses of the beel - should be adopted.

Direct *Vs*. indirect management: Earlier, a number of beels of the state were directly managed by the Assam Fisheries Development Corporation. Positive aspects of direct management include higher share of fishers (60:40) in the fish catch and conservation of the habitat/fish stocks. However, because of the problems inherent in bureaucracy and also difficulties in managing the beel (e.g., watch and ward), the Corporation later switched over to indirect management (leasing) system. It helped the Corporation in getting more (and assured) revenue (in the form of lease amount) and saved it the trouble of day-to-day management of the beel fisheries. However, under the indirect system, the fishers usually get much lower share (often as low as 30%) in fish catch. Also, there are concerns that most of the private lessees are recklessly mining the beels for short-term gain adversely affecting the long-term sustainability of the resource.

Shortcomings of the project approach: In the conventional project approach to development (e.g., development of beel fisheries of Assam being undertaken under the ARIAS Project funded by the World Bank), funding for all the developmental works is mainly met from external sources. This often means that when a project ends, so do the activities. Thus, there is a danger of loss of confidence of the target groups in the development programmes. In addition, most fishery development projects have so far been managed almost entirely by the government, with only limited involvement of fishing communities except in harvesting. The development programmes, therefore, suffered from the constraints like excessive bureaucracy, inadequate social mobilization, creation of a dependency syndrome and unwillingness of the fishers to participate in the development process. More importantly, conflicts between agriculture and fisheries (for control of sluice gates/water level) and between established fishing groups and others (who want to fish) are likely to arise following public interventions (Bhattacharjya, 2002b). In order to overcome some of these limitations, the approaches to development of beel fisheries (including enhancements) should be led by the principles of participation and empowerment of all stakeholders; integration of technical, institutional, social and economic analysis; learning from development experience and adaptation of policies and procedures; and accountability. Further, a process approach –wherein options and alternatives to the proposed developmental activities, cost-benefit and uncertainties, etc. - are considered to ensure higher success rates. Here, the outcomes of all interventions are continuously monitored. The feedback, thus obtained is used for improving the policies and procedures in future developmental activities.

Leasing policy: At present, the registered beels under the administrative control of the Assam Fisheries Development Corporation are leased for a fairly long period of seven years. However, such beels are relatively few in numbers. The majority of the beels of the state are under the control of the Revenue Department, local bodies (*panchayats*), temple trusts and local communities that are variously leased for very short period (one year) to medium period (3-5 years). Leasing the beels for longer periods is likely to encourage the lessees to invest in management options like macrophyte control and culture-based fisheries. However, there is also an apprehension that if the beel is leased to a party interested only in maximizing its own profits for such a long period (without a provision to cancel the lease), it may cause irreparable damage to its fisheries. Further, certain lessees not pay the lease amount on the ground of low fish yields. To cope with such situations, the AFDC has installed a provision in its agreement to cancel the lease of a beel midway in the event of non-payment of annual lease value by the parties and a few other conditions.

Other issues: Some more issues requiring detailed analysis of technical (including environmental) and socio-economic ramifications are: conservation *Vs.* maximizing fish production; possible adverse impact of enhancements on aquatic biodiversity; reduction in productive beel area because of declaring Bird sanctuaries; control of aquatic pollution; absence of a clear policy on other uses of beels; non-availability of funds for development; lack of alternative employment increasing fishing pressure; possible adverse impact of development on the beel ecology, and so on.

CONCLUSION

The beels of Assam includes diverse types of open water bodies presenting different types of opportunities and issues. Therefore, the suitable management options should be carefully selected for individual beels or a group of them depending on local conditions. In many beels, both the capture fisheries and enhancements can be practiced simultaneously. Here, some areas can be used for aquaculture either in detached ponds or in pens/cages erected in the beel. To resolve multiple-use conflicts, an integrated basin development approach should be adopted. Here, the beel and its marginal areas are utilized in a planned manner, wherein separate areas are ear-marked for natural fisheries, cage/pen culture, other enhancements, navigation, bird sanctuary, marginal agriculture, jute retting, eco-tourism and other uses. Such a holistic management plan will benefit the entire riparian community, minimize conflicts and also help in conservation of the habitat and its rich aquatic biodiversity. Participation and empowerment of all the stakeholders in the beel management plan is *sine qua non* for ensuring their optimal and sustainable utilization.

ACKNOWLEDGEMENTS

I am thankful to Dr. B. Lahon, Project Director, AFDC, Guwahati for providing useful inputs regarding management issues affecting beel fisheries of Assam.

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FEEDING THE FRESHWATER FISH AND PRAWN IN CULTURE PONDS FOR SUSTAINABLE LIVELIHOODS OF SMALL AND MEDIUM SCALE FARMERS

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INTRODUCTION

Of the freshwater fish species cultured in India, Cyprinids consisting of three Indian major carp species (catla, rohu and mrigal) alone contributes 75% of the total fish production. They are produced under polyculture systems with different proportion of three species farmed within single pond. This is based on the assumption that they occupy different ecological niches within the pond ecosystem, thus taking full advantage of all possible trophic inputs. Besides these, a host of several other species of medium and minor carps like *Labeo fimbriatus, L. gonius, L. bata, Cirrhinus reba, Puntius sarana, Amblypharyngodon mola* deserves attention. Of the catfishes, *Clarias batrachus, Heteropneustes fossilis, Ompok* spp., *Pangasius pangasius, Mystus* spp., *Wallago attu* also contribute to the bulk production. We also have featherback (*Notopterus spp*), murrels (*Channa spp*), and perch (*Anabas testudineus*) in particular which are also potential freshwater fishes for which seed production technologies are also available for diversification and value addition of freshwater aquaculture. In recent years the prawn species, viz. *Macrobrachium rosenbergii* (commonly called as scampi) has also received great deal of attention, as it grows fastest among all freshwater prawn species available in India.

In aquaculture as in other animal husbandry adequate nutrition plays pivotal role not only to increase yield significantly but also to ensure the product quality, improvement in the reproductive performances and development of immunity towards infection. As the stocking density of fish exceeds the natural carrying capacity of pond, a shift from a dependence on natural food to a supply of more or less nutritionally complete exogenous feed becomes vital. Therefore, feed forms the most important input and it is required in large quantities. Depending on the intensities of the culture systems cost of feed can be between 50-70%. There is ample evidence that supplementary feeding increases output in terms of fish production. In any aquaculture operation, besides the quantity of feed ingredients, efficient feeding system is also crucial for achieving sustained production. Advances in the optimization of the supply of various nutrients through formulated feed with appropriate protein:energy ratios, provision of vitamins and trace elements has led to a production of 17 t/ha/yr in pond in intensive carp culture.

Culture practices

The culture systems comprise of extensive farming wherein there is no external feed and fertilizer inputs. Here, fish thrives solely on natural food organisms present within the system and production of more than 1000 kg/ha/yr is generally not possible. Under semi-intensive system, there can be i) fertilized pond fish culture, ii) fish culture based on simple farm made conventional supplementary feed consisting of rice bran and oil cake, iii) fertilized pond fish culture with additional substrates provided for adherence and growth of periphyton organisms including algae, protozoa, bacteria, annelids, gastropods, insect larvae etc. These adhering materials may be anything from the tree branches, bamboo poles, PVC pipes, plastic sheets, ceramic tiles etc. hung in pond. Production level can be between 4-7 t/ha/yr under various semi-intensive aquaculture systems.

In the intensive system provision of all necessary nutrients for growth in the form of exogenous feed is mandatory. Production level can be between 10-15 t/ha/yr depending on the level of management.

Nutritional requirements

Carps in particular are capable of digesting a large range of complex protein, carbohydrates and lipids due to the presence of several digestive enzymes in their digestive tract. Research efforts directed towards determination of nutritional requirement of various growth stages of carp, catfishes and prawns resulted in valuable information regarding the nutritional requirements. Table 1 summarizes the major nutritional requirement for Indian major carp. It has also been proved that quality of maternal nutrition has a direct influence on fecundity, larval survival, development and growth.

Table 1: Nutritional requirements of carp

NUTRIENTS	REQUIREMENTS
Crude protein, g/kg diet	300-450
Lipid, g/kg diet	100-150
Essential fatty acids, g/k	
18:3 n-3	10
18:2 n-6	10
Phospholipids g/kg	40 (carp larvae)
Carbohydrates, g/kg	300-450
Digestive energy (MJ/kg)	15-16
DP/DE ratio	22
Ascorbic acid (mg/kg)	100

Catfishes are slow growing and having preference for food of carnivorous origin. Thus, their protein requirements are also very high. The non-availability of proper supplementary feed was major hindrance for adopting semi-intensive and intensive catfish culture. This is of particular relevance in rearing of young ones mainly due to lack of suitable nutritionally balanced diet. Complete information on nutritional requirement of various stages of catfish is still not available although requirement of some of the major nutrients is now known. Table 2 summarizes the nutritional requirements of catfishes.

Table 2: Nutritional requirements of catfishes (*Clarias batrachus; Heteropneustes fossilis*)

NUTRIENTS	REQIREMENTS
Crude protein, g/kg diet	300-450
Lipid, g/kg diet	50
Carbohydrates, g/kg	300-450
Crude fibre, g/kg	100
N-free extract, g/kg	430
Energy, Kcal/g	4.5

The nutrient requirement by the freshwater prawn, *Macrobrachium rosenbergii* for growth and other physiological functions are similar to those required for other crustaceans. Unlike finfish, shellfishes are unable to synthesize sterol (especially cholesterol) from acetate and mevalonic acid, prawn feed therefore should contain sources for cholesterol requirement which varies from 0.3% to 0.6% in case of *M. rosenbergii*. Prawn head meal, prawn meal, molluscan meat meal are some of the common sources for the supply of cholesterol required by prawn, which serves as precursors of molting hormones. Prawns also have special requirement of chitin necessary for formation of exoskeleton. Here, also there is paucity of detailed information regarding the nutritional requirements for different stages of prawn. Table 3 summarizes the available information regarding nutrient requirement for prawns.

Table 3: Nutritional requirements of fresh water prawn (*Macrobrachium rosenbergii*)

NUTRIENTS	GROWTH STAGES	REQUIREMENTS (%)
Protein	Brood	38-40
	Larva	40-45
	Post larva (1st month)	39-40
	Juveniles (2nd-4th month)	35-37
	Adult (5th-6th month)	28-30
Carbohydrates	For all stages	25-35
Fat	For all stages	6-8
Cholesterol		0.5
Lecithin		2-3
Vitamin-mineral mixture	For all stages	2-3
Energy	Brood	3.7-4.0 kcal/g feed
	Other stages	2.9-3.2 kcal/g feed

Feed ingredients, feed, feeding

Formulation of well-balanced feed and their adequate feeding are the most important for successful aquaculture. Without intake of adequate feeds, fish will never be able to maintain health and be productive regardless of the quality of environment. Feed ranges from a simple farm-made mixture of rice bran and oilcake to almost "nutritionally complete" industrially manufactured pelleted feed. Several agro-based potential ingredients have been identified and analyzed for their nutrient compositions and are given in table 4.

Table 4: Nutrient composition of different feed ingredients

Ingredients	Protein (%)	Lipid (%)	Fibre (%)	Cost (Rs/kg)
Rice bran	8-10	12-16	10-15	6
Deoiled rice bran	12-16	1-2	·15-20	4
Maize	9-11	4-6	2-3	12
Barley	8-10	2-3	4-6	12
Jowar	13-15	2-3	3-6	11
Coconut cake	23-25	12-13	10-13	8
Ground nut cake	40-43	4-8	6-7	10
Cotton seed cake	27-30	6-9	15-18	8
Rape seed cake	30-35	4-6	6-9	7
Soybean cake	36-40	5-6	4-6	11
Sunflower cake	28-32	4-6	16-22	7
Mustard oil cake	30-35	4-6	6-9	5
Fish meal	50-65	8-12	2-3	12-20
Clam meat	30-40	4-6	0.5	-
Mussel meat meal	30-40	8-10	5	-
Prawn head meal	28-30	8-10	5-10	10
Silk worm pupae meal	60-65	18-20	3-5	16

The major factors are of foremost consideration in the efficacy of formulated feed are as follows:

1) nutritional composition of raw materials
2) nutrient digestibility
3) physical characteristics
4) handling and storage
5) feeding methods
6) water quality
7) standing crop of fish

The basic information includes nutrient requirements of the cultured species, availability of various ingredients to be used, their nutrient composition, cost, ability of the species to utilize the nutrients and type of diet processing equipment. The compositions of some formulated balanced feeds developed by CIFA are summarized in table 5, 6 and 7 respectively.

Table 5: Feed formulation for various growth stages of carp

Ingredients (%)	Fry	Fingerlings	Juvenile/adult	Broodstock
Rice bran	20	40	38	30
Ground nut oil cake	38	20	35	35
Roasted soybean meal	20	25	20	20
Fish meal	17	10	5	10
Vit.-mineral mix.	2	2	2	2
Vegetable oil	2.7	3	-	2.7
Cod liver oil	0.3	-	-	0.3

Table 6: Feed formulation for catfish (Magur)

Ingredients	%
Fish meal	60
Roasted soybean meal	15
Ground nut cake	10
Baker's yeast	3
Sunflower oil	2.5
Cod liver oil	2.5
Tapioca starch	4.5
Vitamin and mineral premix	2
Attractant (powdered seeds of Trigonella and roots of Murrya)	0.5

Table 7: Feed formulation of prawn under different culture systems

Ingredients (%)	For monoculture	For polyculture
Ground nut oil cake	40	40
Soybean meal	32	34
Fish meal/prawn meal	13	-
Rice bran	12	25
Vitamin mineral mixture	3	1

Farm-made formulated feed can be prepared by mixing required ingredients with desired quantity of water (preferably warm water) in a mixer. There is evidence that use of simple techniques such as grinding (decreasing particle size and hence digestibility) and compacting (pellets) can improve the efficiency of farm-made feeds. The choice of ingredients is naturally dictated by the availability of the ingredient closest to farm sites. There is a need for simple region specific data base on nutritional quality of such potential ingredients from where small farmers can choose based on availability, cost etc. It is generally known that physical quality of pellet especially its water stability is affected by physical properties and composition of feed mixtures and the processing method employed. A number of binding agents are now available, any of which can be added to the formulae to improve water stability.

With regard to feeding methods, hand feeding, feeding in bamboo baskets/trays suspended from a long bamboo pole from the side pond are common practices. In some big culture ponds, where a large amount of feed has to be efficiently distributed daily, farmers employ an ingenious method of placing feed pellets in perforated nylon bags. Those are then tied to bamboo poles and fixed with the help of a boat at several sites in the pond. Demand feeders are used occasionally to feed large fish in a few selected farms only. With on-farm feeding, generally the "3Fs" are followed. These are fixed place, fixed time and fixed quality.

Efficacy of feed and fish growth

Fish growth (productivity) together with feed conversion is greatly influenced by various factors such as quality of feed, feed intake and water temperature. The main factors influencing the feed intake that is organoleptically accepted to fish are water temperature and energy density of feed. The dissolved oxygen content helps feed conversion. Water temperature and dissolved oxygen content should always be kept optimum to maintain maximum feed intake and normal metabolic processes. Efficacy of feed is generally measured by feed conversion ratio (FCR) and protein conversion ratio (PCR). But, in some cases, mainly for prawn farming, another index called "profitability index" seems to be more appropriate. Daily growth coefficient and temperature growth coefficients are also important parameters to assess the efficacy of feed. The formula to determine both the parameters are given below:

$$FCR = \frac{\text{Amount of dry feed offered (g)}}{\text{Live weight of fish/prawn produced (g)}}$$

$$PCR = \frac{\text{Protein input in feed (g)}}{\text{Protein gain in fish (g)}}$$

$$\text{Profitability index} = \frac{\text{Value of harvested crop}}{\text{Total cost of feed used}}$$

(Mainly applicable for prawn production)

There is a need for optimizing supply of feed avoiding wastage i.e. supply of feed what the fish stock will consume which are palatable to the fish and the nutrients therein are available to fish. In this context, three basic questions come -

i) How much to feed?
ii) When to feed?
iii) How frequent should be feed distributed?

i) In order to know how much to feed, it is necessary to know the voluntary feed intake (VFI) of the fish. Numbers of techniques are available for monitoring VFI including gut content analysis. Any excess feed supply will decrease feed efficiency. Part of this is due to inconsiderate feeding leading to wastage of feed. One should recognize the allocation of feed (ration size) should be adapted to the nutrient/energy needs and growth rate of the fish. The factors like temperature, fish size, genotype, growth rate, nutrient and energy requirements, dietary energy density, nutrient concentration are crucial to determine the amount of feed to be offered to culture of fish.

ii) It is now established that there are specific feeding rhythms in almost all species of fish. Feeding in the night time corresponding to the endogenous feeding rhythm will improve feed utilization efficiency. For example, Carp show feeding activity during dawn and dusk, while many catfishes are nocturnal in feeding habit. The practice should be to feed when fish needs and not when farmers can or have time.

iii) Besides the quantity of feed to be supplied there is need to know the frequency with which the same amount will be supplied for optimum utilization. The frequency of feeding depends on two factors, i.e. the body size of fish and ambient water temperature. Both these factors affect the rate of passage of food through the digestive tract, In small fishes or in case of spawn or fry, the frequency of feeding can be several times and hours; whereas, for large fish feeding, twice a day seems sufficient. A proper feeding strategy is the one that increases feed efficiency and decreases the environmental load.

Growth of fish is the ultimate aim and in simple terms, growth is the change that results from the difference between the food that enters the body and the waste materials that leave it. This can be presented by,

$$\text{SGR (Specific growth rate; \% per day)} = \frac{\ln Wt - \ln Wo}{t} \times 100$$

Where, Wt and Wo are final and initial weight and t is the culture period in days.

$$\text{Condition Factor (F)} = \frac{100\,W}{L^3}$$; W and L are weight (g) and length (cm) of fish.

$$\text{Daily Growth Coefficient (DGC)} = \frac{FBW^{1/3} - IBW^{1/3}}{\text{duration}}$$

$$\text{Temperature Growth coefficient} = \frac{(FBW^{1/3}) - (IBW^{1/3})}{\text{Degree days (dd)}}$$

Where FBW = Final body weight

IBW = Initial body weight

dd = Av. water temperature x Number of days

Growth depends on consumption, so the intake of food energy is the pacemaker of growth; temperature is the most all-pervasive environmental factor that influences it via its influences on feeding and metabolism. Initially growth increment is directly proportional to the rise of ambient temperature and it declines as the temperature continues to rise above optimum level.

Environmental aspects of sustainable fish production:

Long-term sustained development of aquaculture is dependent on maintenance of water quality. Feeding should therefore be very carefully done. Overall management of undigested material and metabolic end products released by fish into the environment bear greater significance in aquaculture than in other terrestrial animal production system. Undigested and disintegrated feed may pollute the environment and create stress from low oxygen, high ammonia and organic matter that seriously affect on growth and health of fish and prawn. These may stimulate eutrophication in pond. Undigested carbohydrates, nitrogen and phosphorus are mainly responsible for environment degradation. Optimizing protein:energy ratio in the diet can significantly reduce N-excretion. Thus development of highly digestible nutrient and energy dense diet along with controlled feeding systems can reduce possibility of diet-related pollution. However, implementation of improved diets and feeding strategies (daily feed ration. feeding time, feeding frequency) considering nutritional contribution by natural fish food organisms can minimize any potential diet related degradation. It is also essential that culture practices should follow the recommended procedures (avoiding intensive stocking density as far as possible) integrating environmental consideration and social responsiveness. Increasing production alone in a considerate manner can have negative environmental impacts as well as consequences on human health.

General Conclusion :

Development of vertical expansion of freshwater aquaculture is necessary to augment productivity not only for ensuring nutritional security but also for enhancing income and employment potential in the rural sector. The benefit of nutritional research culminated into the development of high efficiency feeds and is helping to increase productivity. To sustain present trend of growth of aquaculture small and marginal farmers who belong to the rural and semi-urban sector should ensure that eco-friendly aquaculture technology be adopted for long term gain. In this context, knowledge on nutritional and feeding strategies can play pivotal role for achieving better returns from aquaculture. The contribution of natural fish food organisms towards the growth of fish must be given due importance in semi-intensive aquaculture in particular. It is hoped that the present information regarding the nutrition and feeding of freshwater fish and prawn will help the farmers to adopt a sustainable farming system based on locally available raw materials as feed resources for better economic return. Besides, aquaculture has a major role in providing bases for better human health. It is known that one can tailor aquaculture product quality through application of nutritional principles. For example, even in a semi-intensive system, it is possible to modify the fatty acid composition of fish (and hence its dietary value as human food) through small changes in feed mixture (presence or absence of oilseed cake, rice bran which is deoiled or not etc.). There are several such examples with carp in particular. Recent data have shown that a simple addition of oil mixture to a common feed mixture can even increase the reproductive performance and improve the quality of carp egg and spawn. It is hoped that these and similar other information accompanied by farmer's traditional knowledge and wisdom will lead to increased fish production from aquaculture.

Appendix:

CRITERIA FOR DIET SELECTION		
For the farmer		**For the fish**
Availability		Taste
	Consumption	Size
Cost efficiency		Texture
Simplicity		Digestibility
	Nutrition	Nutrient requirement
Versatility		Energy requirement

FISH: SOME NUTRITIONAL FACTS

1. Fish protein contains high available lysine compared to all other animal meat; moreover in fish, protein is accompanied by very little calories making at an ideal complementary food along with vegetable sources.

2. Compared to all other animal meat like beef, mutton, chevon, pork, chicken etc, fish contains much less connective tissue making it more digestible and nutritionally superior.

3. In contrast to other animal meat, fish lipid rich in mono and poly–unsaturated fatty acids particularly of n-3 type. This alone gives fish an incomparable nutritional merit over all other animal meat, which is rich in saturated fatty acid.

4. The two n-3 polyunsaturated fatty acids that confer greatest health benefit to human viz, eicosapentaenoic acid (20: 5 n-3) and docosahexaenoic acid (22: 6 n-3) are present in fish lipids.

5. Fish flesh is an excellent source of vitamins like Vit. A, B_{12}, D, E and K in particular, besides being rich in calcium, phosphorus and iodine.

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Mishra, R. N. 2003. Role of abiotic factors on fisheries enhancement of open water ecosystems, pp. 96-99. *In*: M. Choudhury, N. P. Shrivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

ROLE OF ABIOTIC FACTORS ON FISHERIES ENHANCEMENT OF OPEN WATER ECOSYSTEMS

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INTRODUCTION

India in general and the northeastern region of the country in particular is bestowed with rich aquatic ecosystems, such as rivers, lakes, reservoirs, streams and ponds. Aquatic systems besides being the source of aquatic biodiversity also serve many utility functions, which have direct social overtone. Fish production is one such benefit directly associated with the welfare of mankind, both in terms of economic gain and nutritional security. Enhancing fish production from open waters has gained importance, in recent years, in the backdrop of increasing cost of aquaculture, diminishing fishery of Indian seas and to generate gainful employment opportunities among the rural poor.

It is a paradox, however, that the open-water fishery resources, such as rivers, natural lakes and reservoirs have developed many aberrations as subjected to irrational exploitation like excessive water abstraction, sedimentation, pollution/eutrophication, habitat destruction and encroachment. Lack of proper understanding of ecological principles, especially the limno-chemical features and their impact on production functions, has been one of the key factors for deteriorating water quality besides getting low biological production, such as fish. Evidently, thorough understanding of various ecological variables related to production and productivity is a *sin qua non* for effective and sustainable aquatic production. Besides, proper understanding of such factors are also essential to draw effective management plan for fishery enhancement in accordance with the scientific principles.

A BRIEF ACCOUNT OF SALIENT ABIOTIC FACTORS OF AQUATIC ECOSYSTEMS

- **Turbidity**, originated from loading of excessive silt, is considered to be limiting factor for the productivity of fish food organisms. However, turbidity due to planktonic growth is welcome as indicative of productive water. Turbidity due to organic and inorganic colloids plays an important role in keeping the ions of nutrient adsorbed/absorbed on their surface, which in turn provides necessary equilibrium of these ions in water phase to be utilized by organisms at various trophic levels. The fact remains that the clear water is as much undesirable as highly turbid water.
- Water **temperature** plays a significant role in metabolic and physiological process in living organisms including the fish. Fortunately, however, in tropical waters temperature is never a limiting factor, as most of the aquatic systems possess adequate heat budget for higher fish production as compared to temperate conditions.

- **Dissolved oxygen** (DO) is considered a critical factor in natural waters, as it is necessary for regulating the metabolic processes of biotic communities. Besides, it also indicates the status of water quality of a particular aquatic system. Good productive water should have DO concentration of more than 5 mg/l is considered as good supporting reasonably high productivity. DO concentration below 5.0 mg/l is not desirable for good bio-production as it may impede with the growth, feed conversion and breeding of biotic communities. However, high concentration of DO, beyond 9-10 mg/l, as recorded in many weed infested beels, is also undesirable and lethal to fish, especially young ones.
- The presence of **CO_2** in reasonable concentration is essential for photosynthesis of autotrophic organisms. However, CO_2 concentration above 15 mg/l is considered sub- lethal to aquatic communities. In India, such conditions are rare, but strict vigil is necessary in aquatic systems where external loading of organic matters and weed infestations are generally high.
- A **pH** in the range of 7.0-8.0 is considered optimum for production and productivity of biotic communities. However, water pH above 10 & below 4 affects the aquatic productivity, adversely. It has been observed that waters either with acidic pH of less than pH 6.5 or highly alkaline pH of 9.5 is not considered good for production. Moreover, pH above 11.0 is lethal to fish. Relatively, low productivity of beels in Assam is primarily due to their acidic pH.
- **Specific conductivity** is an index of water-soluble salts present in water. Specific conductivity also gives an indication of state of mineralisation in an ecosystem. Specific conductance value between 200 and 500 µS/cm is considered as productive in nature. However, in polluted waters, this value often crosses its limit affecting the aquatic productivity adversely.
- The **Total Alkalinity** or acid combining capacity in natural waters is generally affected due to carbonates and bicarbonates of calcium and magnesium. Natural waters with an alkalinity above 40 mg/1 are considered productive. Alkalinity value above 300 mg/1 is not conducive for production and productivity, as maintaining the availability of CO_2 at such high concentration becomes difficult.
- The importance of **nutrients** like nitrogen and phosphorus in aquatic productivity has been well recognized. **Nitrogen,** being a major constituent of protein occupies a preeminent place between the two. Dissolved inorganic nitrogen in the range of 0.2 to 0.5 mg/l is considered favourable for fish productivity. However, inorganic nitrate like the free NH_3 and NO_2 may be toxic to fish at higher concentrations as ammonia increases oxygen consumption of tissues, damages gills and reduces the ability of blood to transport.
- **Phosphorus** is often considered to be the most critical single element in maintaining aquatic productivity, especially the phytoplankton, which forms the base of aquatic productivity. A phosphorus level in the range of 0.05-0.10 is considered good for aquatic productivity.
- **Silicate** is considered essential for the growth and maintenance of diatoms, an important constituent of aquatic food chain. A silicate range of 8-12 mg/l is considered conducive for aquatic productivity.

FACTORS AFFECTING AQUATIC ECOSYSTEMS

Increasing anthropocentric activities, both within and outside the aquatic systems, have been identified as the prime reasons for deteriorating water quality in all most all open-water aquatic systems. Besides, the direct discharge of industrial, municipal, or agricultural wastes, the diffuse sources of pollutants are also responsible for the present state-of-art making the water bodies unsuitable for fish and fish food organisms. Some important factors affecting an ecosystem in relation to biotic production are as under:

Siltation

Increasing siltation in aquatic systems owing to irrational activities or poor management of catchments has assumed a serious dimension in recent times affecting the ecological integrity and production functions. Most of the lakes of the Northeast are the victims of this phenomenon.

Domestic and Industrial wastes

Excessive loading of organic and inorganic wastes leads to complete disruptions of normal functioning in an ecosystem and it may reflect in many ways, such as depletion of oxygen, poisoning of biota, loss of biodiversity and ultimately the entire production functions. For instances, increasing discharge of chlorine through sewage treatment plants or synthetic detergents through washing has been found to be detrimental for the survival and growth of fish. Free chlorine as well as chlorides in excess is extremely toxic to fish fauna and other organisms. Similarly, detergents impair fish growth and the rate of reproduction.

Eutrophication

Increasing level of eutrophication in natural lakes is a matter of serious concern as it affects the ecosystem adversely. Eutrophication is a function of excessive enrichment of nutrients, which in turn affects the biodiversity and production functions adversely. The floodplain lakes of northeast are the glaring examples of this phenomenon as most of them are reeling under acute to very acute stage of eutrophication. Depletion of oxygen, increase in BOD and COD levels, increasing growth of unwanted biotic communities etc. are some of the symptoms of eutrophication.

Agricultural runoff

Fertilizer and pesticide pollution through agricultural runoff is of common occurrence in floodplain wetlands and rivers, which in turn upset the ecological function including the production functions in an ecosystem.

Encroachment

Encroachment of river corridors including the floodplain wetlands is rampant in recent times affecting the production and productivity of aquatic systems. Encroachment either for agricultural land or for human settlements has been the cause of resource loss, both physical as well as biological, and it has assumed an alarming pace during the last few decades.

Heavy metals and pesticides

Heavy metals Zn, Pb, Hg, As, Cd, Cr coming through domestic, industrial or agricultural wastes are highly toxic to biotic communities affecting them in various ways. Industrial units like polyfibre, rayon factory, automobiles etc. are the main source of such heavy metals in an aquatic system. Bioaccumulation of heavy metals and pesticides, being non-biodegradable, has been reported from various aquatic systems; as such a strict vigil is necessary on this aspect of aquatic ecology.

SYMPTOMS OF STRAINS OR ISSUES RELATED TO FISH PRODUCTIVITY IN NORTHEAST

- Decreasing or lopsided growth of biotic communities, such as decreasing fish production and increasing growth of weeds

- Deterioration of water quality
- Sedimentation and shrinkage of effective water area
- Increasing levels of eutrophication in floodplain lakes
- Acidic soils affecting production and productivity of lakes
- Relatively low hours of sunshine affecting primary production

CONCLUSION

Northeastern region of the country has bountiful of natural aquatic resources, highly suitable for the enhancement of fish production as well as productivity. However, certain issues like effective management of acidic properties of waters as well as halting the process of increasing eutrophication in natural lakes need immediate attention and meticulous planning.

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Das, Manas K. 2003. Fish disease and their remedial measures in Beel ecosystem, pp. 100-109. *In*: M. Choudhury, N. P. Shrivastava and R. K. Manna (eds.). Participatory Approach to Management of Inland Fisheries Resources of the Northeast. Workshop proceedings, 2-12 December, 2003. NERC, CIFRI, Guwahati.

FISH DISEASE AND THEIR REMEDIAL MEASURES IN BEEL ECOSYSTEM

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INTRODUCTION

The stability of a fish population in a particular habitat is very often disrupted by various factors *viz.*, disease, habitat destruction, depletion of resources, or the application of other environmental stressors. Fish is in a state of equilibrium with the environment and a change in the environmental parameters beyond the tolerance limit disturbs this equilibrium resulting in stress response in fish and making it vulnerable to fish disease.

In culture-based fisheries practiced in beels, bheries or small reservoirs, which constitute approximately 1.3 m ha of inland fisheries resource, the average yield is 120-300 kg ha^{-1}. The ecological status of various beels reveals that they are in various stages of eutrophication and choked with submerged or floating vegetation showing sub-optimal water quality. The adverse environmental conditions have a profound effect on the health status of the resident fish population. The succeeding pages will elaborate on the water quality parameters of importance, the stress being created and the various fish diseases being encountered in these water areas.

ENVIRONMENTAL PARAMETERS OF IMPORTANCE IN RELATION TO FISH HEALTH

Oxygen

Often fishes swim on the surface of water gulping air with mouth wide open. This stressed condition of fish is due to oxygen depletion in water. Three main factors influence the amount of oxygen, which a water body can hold.

a) Temperature - water holds less oxygen at higher temperature.

b) Salinity - water holds less oxygen at higher salinities.

c) Atmospheric pressure - Water holds less oxygen at low atmospheric pressure. Other factors, which affect the amount of dissolved oxygen (DO) in water include phytoplankton blooms, organic loading and respiration of fish and other aquatic vertebrates and invertebrates.

Ammonia

It is commonly the second important parameter after DO. The total ammonia concentration in water consists of two forms.

NH_3 - unionised ammonia

NH_4 - ionised ammonia

The unionised fraction is most toxic to fish. As a general rule, the higher the pH and temperature, the higher the percentage of total ammonia i.e. the toxic unionised form. Ammonia in water originates from

i) decomposing organic matter
ii) excretion of aquatic organisms
iii) death of phytoplankton bloom

Hydrogen sulphide

Very often the muck in the sediments smells like rotten eggs and the bottom dwelling fishes surface and die. This is due to accumulation of H_2S gas, which is produced by chemical reduction of organic matter.

Nitrite

Fish gills frequently turn brick red in colour. This is because of excess nitrite in the water, which is absorbed by fish and reacts with haemoglobin to form methaemoglobin and this gives brick red colour to the gills.

Suspended solids

It originates from phytoplankton blooms, uneaten food particles and fish feacal matter. Suspended solids are important in reducing the penetration of light thus reducing productivity.

pH

It is an important parameter affecting fish health. The optimum range of pH for most of the freshwater fishes is 6-9. The factors, which affect the toxicity of acid to fish, are:

CO_2

Free CO_2 is toxic to fish. High concentration of 12-50 mg/l of free CO_2 hinders uptake of DO by fish and thus the effects of high CO_2 are accentuated at low DO concentrations.

Alkalinity

Water with low alkalinity of less than 20 mg/l have low buffering capacity and consequently are very vulnerable to fluctuations in pH due to rainfall or phytoplankton bloom.

STATUS OF WATER QUALITY IN WETLANDS CREATING STRESS TO FISH

Freshwater wetland (beel): Ganrapota beel a typical open type beel with 40% macrophyte infestation was investigated. The diel variation of the chemical parameters indicate the important stress factor to be dissolved oxygen. The DO level is reduced to nearly 3.5 mgl^{-1} around 10 PM at night and remain below this level for more than 8 hours causing stress to resident fish. Unionised ammonia recorded in the range of 0.05 to 0.25 mgl-1 is also acting as a stress factor. As a result, the normal growth of fish has been affected and the average yield from this beel was 550 kg ha-1. The results obtained has similarity with the ecological status of the various beels in West Bengal, Assam and Bihar which are mostly in various stages of eutrophication and choked with submerged or floating vegetation and sub-optimal water quality. As a result the average yield from these wetlands is only 120-300 kg ha^{-1} against the potential yield of 1000-1500 kg ha-1.

INDICATORS OF HEALTH CONDITION OF FISH STOCK

Escape reflex

Healthy fish react to external agitation such as quick motion, stamping on the bank, sound, etc and quickly submerge under water. Sick fish do not react to external agitation and can be caught easily.

Defensive reflex

A freshly caught fish from water toss about quite violently when laid on ground. After a while the fish calms down. Sick fishes are sluggish in water as well as out of it.

Tail reflex

When a live fish is held by the head and the posterior portion is free, it exhibits the tail reflex which occurs irregularly. Here, the fish keeps the posterior and caudal fin in a horizontal position or even slightly obliquely upward, while the caudal fin is always stretched in a fan-shape.

FISH DISEASE COMMONLY ENCOUNTERED IN BEELS

Trichodiniasis : The disease is very common in the fry and fingerlings of cultured fishes. The most common symptom in an affected fish is pale colour of the gills with a creamish coating due to excessive secretion of mucus. The causative organism is urceolariid ciliates of the genus *Trichodina* and *Tripartiella.*

White gill spot disease : The gills of fishes predominantly *Catla catla* are covered with whitish cysts of different sizes. This infection reduces the absorptive surface of gills. Excessive mucus secretion occurs and fishes surface for gulping air. The causative organisms are *Thelohanellus catlae* and *Myxobolus bengalensis.*

Scale spot disease : The scales are covered with whitish cysts. In acute cases, scales become perforated and degenerated. Scales become loose with ulceration. The causative organisms are *Myxobolus rohitae* in *L. rohita* and *Myxobolus sphericum* in *C. mrigala.*

Dactylogyrosis and Gyrodactylosis: The causative organism for the disease is *Dactylogyrus* sp. and *Gyrodactylus* sp. While *Dactylogyrus* sp. predominantly infests the gills, *Gyrodactylus* sp. mostly infests different body surface and occasionally gills. When gills are infected, there is hypersecretion of mucus affecting respiratory surface and very often the fishes are irritable and surfacing takes place. There is growth retardation and loss of weight.

Black spot disease : The fingerlings and young ones of mostly *Catla catla* are affected with black ovoid patches on the body surface. These are pigment patches overlying metacercarial cysts of digenetic trematodes; *Diplostomum* sp. The presence of these black spots is the diagnostic feature of the disease.

Ligulosis : The pleurocercoid larva of the cestoda *Ligula intestinalis* cause this disease. This larval stage is very often found infecting *Catla catla.* The symptoms are abdominal distension, reduced growth and dark colouration.

Lernaeosis : The disease is caused by parasitic females of genus *Lernae,* commonly known as anchor worms. They are relatively large, 5-22 mm and during attachment to the host, they assume a vermiform shape with anterior attachment organ buried deep in host tissue. An infested fish exhibits symptoms of rubbing against the sides or bottom of the pond. Heavy infestation leads to lethargy, emaciation and retardation of growth. The parasite destroys scales and causes haemorrhagic and ulcerated areas at the point of penetration. A large number of fish species *viz., C. catla, L. rohita, O. gouramy, C. idella* and a number of minor carps are susceptible to lernaeosis.

Ergasilosis : The disease is caused by the parasitic females of the genus *Ergasilus, Neoergasilus* sp. They have a cyclops like body, narrowing posteriorly and have a total length of 1.5-2.5 mm. They predominantly attach to the gills and fins of fish by means of the second antenna which is stout and clawed and feed on the blood and epithelium. Sometimes infestation may be to the tune of 150 numbers per square cm. Heavy infestation results in respiratory distress, anemia and retarded growth. Prominent symptoms exhibited by heavily infested fishes are frequent surfacing, listlessness and mortality under oxygen depleted conditions.

Epizootic ulcerative syndrome

Fish species affected: *Channa sp., Mastacembelus sp., Puntius sp., Nandus sp.,* C. *catla, L. rohita,* C. *mrigala,* C. *carpio* and G. *chapra.*

Symptoms : The fishes become lethargic and float on the surface of the water, sometimes with the head projected out of water. Initially, the disease appears as red coloured lesions, haemorrhagic in nature. These red lesions spread and enlarge gradually becoming deeper and assuming the form of ulcers. With further advancement, scales falloff, ulcers become deep necrotizing ulcerative lesions. Histopathologically, it is characterized in having mycotic granuloma in epidermis.

Causative agents : Role of suspected causative agents namely, virus, bacteria and fungus could not be established conclusively. In India, so far 20 species of pathogenic bacteria have been isolated from affected fishes of which *A. hydrophila* has been consistently found along with fungus *Saprolegnia.* The latest investigations point out the prime causative agent to be a fungus called *Aphanomyces* sp.

Treatments : can be tried only in lakes below 40 ha.

Prophylactic : During post-monsoon period, the disease prone water areas can be treated with lime, CaO @ 50 kg/ha followed by application of bleaching powder @ 0.5 ppm after one week.

Therapeutic : At the initial stage of lesion formation, lime (CaO) is applied @ 100 kg/ha followed by application of bleaching powder @ 1 ppm after one week.

STRESS IN FISH AND ITS METHOD OF DIAGNOSIS

Fish is in a state of equilibrium with the environment and fish disease organism, many of which are always present in the environment. A change in the environmental parameters beyond the tolerance limit disturbs this equilibrium resulting in stress response in the fish and making it vulnerable to disease. The response of fish to stress from the environment is known as stress response. The most extreme response is mortality but below this level there may be several other responses *viz.*,

i) changes in fish behaviour

ii) reduced growth/food conversion efficiency

iii) reduced reproductive potential

iv) reduced tolerance to disease

v) reduced ability to tolerate further stress.

Several of the many changes that occur in response to stress can be used as measurable indices of the severity of stress on fish. These changes are a direct or indirect result of the physiological response to environmental changes and can be quantified and used as predictive indices.

Methods for stress diagnosis

Several biochemical and physiological procedures have been developed to assess the severity of the physiological effects resulting from stress. The physiological parameters of importance for assessing stress in fish at the primary, secondary and tertiary levels are discussed below.

Primary stress response

Plasma cortisol: A relatively direct assessment of the severity and duration of the primary stress response can be obtained by monitoring the rise and fall of plasma cortisol or catecholamines (epinephrine and nor epinephrine) concentrations.

Secondary stress response

The secondary changes that occur mainly in the blood chemistry also characterize the severity of stress in fishes *viz.*, blood glucose, chloride, lactic acid. They are frequently used for assessing stress response. Hyperglycemia for blood glucose and hypochloremia for blood chloride is the physiological effect of concern during stress response. Accumulation of lactic acid in muscle or blood hyperlacticemia is also an indicator of stress due to bright or severe exertion.

The haematological parameters also provide useful information about an animals' tolerance to stress.

Haemoglobin/Haematocrit: It increases or decreases following acute stress can indicate whether haemodilution or haemoconcentration has occurred.

Leucocyte decrease (leucopenia) commonly occurs during the physiological response to acute stressors. The blood clotting time and changes in the leucocyte count are among the most sensitive parameters indicating stress response.

Histopathology: Since many of the biochemical changes that occur in response to stress are the end result of cellular pathology, histological examinations can frequently provide information on the effect of stress factors on fish. For example, interrenal hypertrophy, atrophy of the gastric mucosa and cellular changes in gills are indicative of stress response.

Tertiary stress response : Experience have shown that several tertiary stress responses including changes in the metabolic rate, health, behaviour, growth, survival and reproductive success can indicate that unfavourable environmental conditions have exceeded acclimation tolerance limits of fish.

Common fish diseases, their symptoms and control measures

Specific fish disease	Species prone to disease	Symptoms	Control measures
Environmental diseases			
Depletion of oxygen		Mouth remains open. Gills look pale	Aeration of the water areas growth of water hyacinth
Growth of algae		Pond water turns green, fishes gape for like respiration	Sprinkling of cowdung, growth of water hyacinth
Increase of hydrogen sulphide		Pond muck smells like rotten eggs resulted is respiratory process	Raking pond bottom and exchange of water
Excess of CO_2 or high pH of water		Excessive secretion of mucus by gills and body surface	Aeration of the water areas
Protozoan diseases			
Trichodiniasis	Indian major and exotic carps	Pale colour of gills with a coating of cream layer of mucus	3-5% common salt bath 25-ppm formalin treatment in pond
White gill spot disease	Catla	Gills covered with white spots like pox	3-5% common salt bath Decreasing density of fish from affected pond.
White scale spot disease	Rohu, Mrigal	Scales covered with white spots	3-5% common salt solution bath Decreasing density of fishes in pond.
Helminth diseases			
Dactylogyrosis and	Catla, Rohu, Mrigal	Excessive secretion of mucus in gills	3-5% common salt solution bath
Gyrodactylosis		Irritability and surfacing	200 ppm formalin bath
Black spot disease	Catla	Black oval shaped patches on body	Removal of moluskan population from water area
Ligulosis	Catla	Abdomen enlarges abnormally and body becomes dark	Removal of birds from around affected areas
Crustacean disease			
Lernaeosis	Catla, Rohu, Mrigal	Rubbing against pond dykes or even bottom	Gammaxene @ 1 ppm application in the pond.
Ergasilosis	Grass carp	Irritation and emaciation sometimes	5% common salt bath to the affected fishes
Argulosis		Parasites visible on gills and body surface	Removal of eggs of Argulas by hanging corrugated sheets in water and removing them and drying after a week to kill eggs.

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